CSCI 5273 Problem Set #2

**Problem 1 (10 points)**

1. Is 10.72.0.255/255.255.254.0 a valid IP address for a host? **[2pts]**

Yes. IP address between 10.72.0.0 – 10.72.1.255

1. Divide the 10.72.0.0/16 subnets into five large networks of 8192 IPs each, 8 medium-sized networks of 2048 IPs each, and 10 small sized networks of 128 IPs each. **[6pts]**

For 8192 IP addresses, we need 13 bits of address space per-subnet. Thus, we could have 16 − 13 = 3 bits to address the subnets. That allows for 23 = 8 subnets of size 8192. Selecting five of these for the large networks, we have:  
10.72.0.0/19, 10.72.32.0/19, 10.72.64.0/19, 10.72.96.0/19, 10.72.128.0/19

For the 8 medium networks, note that 8 ⋅ 2048 = 2 ⋅ 8192, so we will use two of the three remaining /19 subnets, each separated into four /21 subnets.

That is, the 8 medium-sized networks are :  
10.72.160.0/21, 10.72.168.0/21, 10.72.176.0/21, 10.72.184.0/21,  
10.72.192.0/21, 10.72.200.0/21, 10.72.208.0/21, 10.72.216.0/21.

Finally, each of the small networks requires 7 bits for IP addresses, so should have a 25-bit mask. Since we need 10 networks, we need to borrow 4 bits for subnet addressing. Starting with the final available /19 address, 10.72.224.0/19, borrowing 2 bits results in the base IP/mask of 10.72.224.0/21, from which we can borrow 4 bits to divide further into 16 /25 subnets. Define the 10 small networks as:  
10.72.224.0/25, 10.72.224.128/25, 10.72.225.0/25, 10.72.225.128/25,  
10.72.226.0/25, 10.72.226.126/25, 10.72.227.0/25, 10.72.227.128/25,  
10.72.228.0/25,10.72.228.128/25

This leaves total of six /25 subnets and three /21 subnets of IP address space.

1. Is 192.168.2.0/23 and 192.168.3.0/23 representing the same subnet? Please justify your answer. **[2pts]**

192.168.2.0/23 => 192.168.2.0

192.168.3.0/23 => 192.168.2.0

11000000.10101000.00000010.00000000 (192.168.2.0/23)  
& 11111111.11111111.11111110.00000000(Subnet Mask /23)  
= 11000000.10101000.00000010.00000000 (192.168.2.0)  
11000000.10101000.00000011.00000000 (192.168.3.0/23)  
& 11111111.11111111.11111110.00000000 (Subnet Mask /23)  
= 11000000.10101000.00000010.00000000 (192.168.2.0)

After masking both belong to same subnet

**Problem 2 (8 points)**

An organization has been assigned the prefix 192.168.1.0/23 and wants to form subnets for 4 departments which have the following number of hosts:

Department A: 130 hosts

Department B: 120 hosts

Department C: 60 hosts

Department D: 31 hosts

1. Give a possible arrangement of subnet masks to make this possible. **[5pts]**

Dept A: 192.168.1.0/24  
Dept B : 192.168.0.128/25  
Dept C : 192.168.0.64/26  
Dept D : 192.168.0.32/27

First, note that 192.168.1.0/23 is not a valid prefix. The network prefix for the subnet containing 192.168.1.0/23 is 192.168.0.0/23, computed by ANDing with the 23-bit subnet mask. As such, I assume that the organization’s prefix is 192.168.0.0/23.  
• Department A needs 8 bits (28 − 2 = 254 hosts) and a 24-bit subnet mask. Since the organization has prefix 192.168.0.0/23, it has the two 24-bit subnet masks 192.168.0.0/24 and 192.168.1.0/24. Thus, Department A could use the prefix/subnet mask 192.168.0.0/24.  
• Department B needs 7 bits (126 hosts) and a 25-bit subnet mask. Dividing  
192.168.1.0/24 into the two 25-bit masked subnets 192.168.1.0/25 and  
192.168.1.128/25, we can assign Department B the subnet 192.168.1.0/25.  
• Department C needs 6 bits (62 hosts) and a 26-bit subnet mask. We can again divide 192.168.1.128/25 into two 26-bit masked subnets, assigning 192.168.1.128/26 to Department C.  
• Finally, Department D needs 6 bits (62 hosts), since 5 bits (25 − 2 = 30 hosts) is insufficient. As such, Department D can be assigned the remaining 26-bit masked subnet 192.168.1.192/26.

1. Suggest what the organization might do if department C grows to 65 hosts. **[3pts]**

The organization needs to increase the subnet size to /25, but there is no available IP address for that subnet (because most of the IP addresses are fully utilized by other departments). As a result, the organization might need to get a larger prefix such as 192.168.1.0/22, so that there are more IP addresses.

Also, If Department C grows to 65 hosts (or even 63 hosts), they will require a /25 subnet. This is a problem, as the 192.168.1.128/25 subnet includes Department D’s 192.168.1.192/26 subnet. The organization could either request a larger /22 prefix, which would allow for an excessive 1024 hosts, or combine the subnets for Departments C and D, as their combined 96 hosts would fit comfortably in the 192.168.1.128/25.

**Problem 3 (12 points)**

For the network given below in Figure 3, give global distance-vector tables for each node when**:**

5

8

4

2

2

2

4

Figure 3

1. Each node knows only the distance of the neighbors [4 pts]

A table with numbers and letters

Description automatically generated

1. Each node has reported the information it had in the first step (a) to its immediate neighbors. **[4pts]**

A table with numbers and letters

Description automatically generated

1. Repeat step (b) one more time. **[4pts]**

A table with numbers and letters

Description automatically generated

**Problem 4 (10 points)**

Again for the network graph in Figure. 3. Show how the link-state algorithm builds the routing table for node D.

1. Show the detailed steps with the link-state algorithm. **[5pts]**

A screenshot of a game

Description automatically generated

A screenshot of a diagram

Description automatically generated

1. Show the final routing table of node D. **[5pts]**

Destination Cost Next Hop  
D 0 D  
B 2 B  
F 4 F  
A 7 B  
C 8 C  
E 8 F

**Problem 5 (10 points)**

The network graph is shown in Figure. 4.

Diagram

Description automatically generated

Figure 4

1. Host H1 sends a packet to the destination 128.96.34.126. Explain how this packet traverses in the network described below. You need to describe who received the packet and what are their reactions. **[3pts]**

The destination is on the same local network. The packet will be sent from H1 to R1, but R1 will not forward the packet to other networks. This is because it notices that the destination is on the same network as H1

1. Host H3 sends a packet to the destination 128.96.34.250. Explain how this packet traverses in the network. **[3pts]**

The destination is under the red circle network.  
- H3 passes the packet to R2.  
- R2 forwards the packet to the port that connects to the red circle network. Here, the source MAC address is changed to R2’s MAC address.  
- The packet reaches the destination. (R1 also notices the packet but will not do anything.)

1. The subnet of H1 has now two different teams and would like to split it into two subnets. Please add one more subnet and add R3 and change the network configurations as you need. Note that you are allowed to modify the network as least disruptive as possible. **[4pts]**

The subnet of H1 splits into 128.96.34.0/26 and 128.96.64/26 on each side of the R3.  
- IP team1 (128.96.34.0/26) : 128.96.34.0 – 128.96.34.64  
- IP team2 (128.96.64/26) : 128.96.34.65 – 128.96.34.128

**Problem 6 (12 points)**



Figure. 5

Above in Figure 5 is the network graph with 4 routers (R1, R2, R3, R4) and 4 hosts (A, B, C, D). Each router interfaces and hosts are labeled with both IP and MAC address, Routing is enabled so that any two hosts can communicate with each other and also the default gateway of each host is set to its gateway router.

1. Suppose that B send an IP packet to C through R3, R2, R4. Write down the IP packet’s content (src MAC, dst MAC, src IP, dst IP) along the path in the Table given below: **[4pts]**

A black text on a white background

Description automatically generated

Table. 1

1. When A sends out an ARP query for its default gateway, what is the reply to that query? **[4pts]**

The default gateway or router will respond with an ARP reply containing its own MAC address .  
SourceIP:123.123.123.1  
SourceMAC:0C:AF:10:00:1E:1C

DestIP:123.123.123.111  
Dest MAC: 79:AA:EF:AC:11:21

1. Suppose the routers use link-state routing protocol, what will be R3’s routing table entries? **[4pts]**

A table with numbers and symbols

Description automatically generated

**Problem 7 (6 points)**

Suppose a computer just boot up, connected to wireless network and successfully obtained IP, gateway and DNS address. Now it wants to access [www.yahoo.com](http://www.yahoo.com) from its browser. Describe the sequence of packets exchanged to and from this computer until the webpage starts to load. (include what kind of protocol is used and what is the content of the packets)

1.The host sends a DNS query for the host name “www.yahoo.com” to its DNS address, using something like gethostbyname(). It receives a DNS response containing the IP address for the host name, e.g. 74.6.231.21.  
2. The host broadcasts an ARP query containing its gateway IP address to determine the MAC address of the gateway’s interface. The gateway responds with an ARP response containing the MAC address of its interface. The host will encapsulate all subsequent packets with an L2 header containing its MAC address (src MAC) and the gateway’sMAC address (dst MAC).  
3. Since the host is attempting to access the website through a browser, it will attempt to connect to the IP address from (1) using TCP (L4). This requires a three-way handshake with the server. Assuming no packet loss, the handshake will be :  
a. The host sends a SYN message to the server, encapsulated in L3 and L2 headers. The L3 header includes the host’s IP (src IP) and the server’s IP from (1) (dst IP).The L2 header includes the host’s MAC (src MAC) and the gateway router’s MAC (dst MAC) .  
b. The host will eventually receive a SYN-ACK message from the server, similarly, encapsulated in L3 and L2 headers. The src/dst fields of each header will be reversed from (3.a) .  
c. The host will send an ACK to the server, encapsulated with the same L3 and L2 headers as in (3.a) .  
4. Once the TCP connection is established, the host will send an HTTP GET request (L5) over the TCP socket (L4) using the same L3 and L2 headers as in (3.a). The GET request will include the HTTP version, the requested page (just “/” by default), and a number of header fields describing the host’s web browser, OS, and network. The server will respond with a TCP ACK of the packet using the same L3 & L2 headers as in (3.b), followed by one or more TCP packets containing the (possibly segmented) HTTP GET response, again using the headers from (3.b). The host will respond with some number of  
ACK messages for the received TCP packets, with the same L3 & L2 headers as in (3.a) .  
5. Depending on whether the HTTP GET request in (4) contained the “Connection: Keep-Alive” header entry, the TCP connection will either be kept alive until a timeout is reached, or the server will close the connection. Closing the connection involves a 4-way handshake, where the server sends a FIN message, the host responds with an ACK, the host sends a FIN message, and the server responds with an ACK; each of these messages uses the L3 and L2 headers from (3.b), (3.a), (3.a), and (3.b), respectively.

**Problem 8 (12 points)**

Consider the simple network in Figure 5 below. X, Y and Z are routers and their link costs are as specified. Assume the network uses a Distance Vector algorithm is used. Y’s and Z’s routing tables are look like Table 2.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4  1  50  Figure. 5 | |  |  |  | | --- | --- | --- | | Node Y/Distance | Via X | Via Z | | X | 4 | 6 | |  |  |  | | Node Z/Distance | Via X | Via Y | | X | 50 | 5 |   Table. 2 |

1. Now Let assume the cost of link X-Y suddenly changed to 100. Please write down the Y’s and Z’s routing table regarding distance to X, after Y updates this information to Z and then Z updates its information back. **[4pts]**

A table with text and numbers

Description automatically generated with medium confidence

1. Please write down the Y’s and Z’s routing table regarding X after Y updates this information to Z again and then Z updates back again. **[4pts]**

A table with text and numbers

Description automatically generated with medium confidence

1. How many updates did Y get until its distance to X have converged with Distance Vector algorithm? **[4pts]**

Since each update Y receives increases 𝐷𝑌(𝑋) via Z by 2, it will require 50−62 = 22 received updates to reach the state:  
𝐷𝑌 Via X Via Z 𝐷𝑍 Via X Via Y X 100 50 X 50 49  
After the next update sent by Y is received by Z, the table will be  
𝐷𝑌 Via X Via Z 𝐷𝑍 Via X Via Y X 100 50 X 50 51  
The next update received by Y results in the table  
𝐷𝑌 Via X Via Z 𝐷𝑍 Via X Via Y X 100 52 X 50 51  
When Z receives this update, it does not change its routing table. Thus, Z will not send any more updates, and convergence has been reached. Therefore, the total number of updates received by Y before its distance to X converges with the Distance Vector algorithm is 23 updates.

**Problem 10 (10pts)**

Consider a network with MPLS enabled routers as shown in Figure 1 below. We would like to perform traffic engineering using MPLS so that traffic from R1 to R6 will be routed as R1->R3->R5->R6->A and traffic from R2 to R6 will be routed as R2->R3->R4->C.

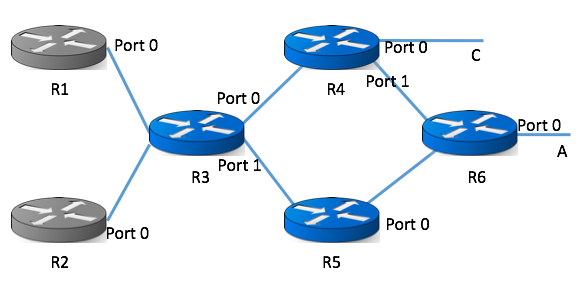


Figure 1. MPLS enabled network for Problem 1

Please fill in the following tables of MPLS entries for each router.

|  |  |  |  |
| --- | --- | --- | --- |
| R1 | | | |
| In  label | Out  label | Dst | Out  interface |
| - | 1 | A | 0 |

|  |  |  |  |
| --- | --- | --- | --- |
| R2 | | | |
| In  Label | Out  Label | Dst | Out  interface |
| - | 2 | C | 0 |

|  |  |  |  |
| --- | --- | --- | --- |
| R3 | | | |
| In  label | Out  label | Dst | Out  interface |
|  |  |  |  |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| R4 | | | |
| In  label | Out  label | Dst | Out  interface |
| 3 | - | C | 0 |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| R5 | | | |
| In  label | Out  label | Dst | Out  interface |
| 4 | 5 | A | 0 |

|  |  |  |  |
| --- | --- | --- | --- |
| R6 | | | |
| In  label | Out  label | Dst | Out  interface |
| 5 |  | A | 0 |

**Problem 11 BGP (10 pts)**

1. Give the types of business relationships in BGP peering and mention who pays whom. What conditions make the Internet stable? Explain each condition in a line or two.

The two main relationships are :  
1. Customer-Provider relationships, wherein the customer pays the provider to ensure that they can reach and are reachable by the larger internet. Customers expect to not provide transit services for their provider. Providers advertise their customers’ routes to their peers and providers, and export routes received by their peers and providers to their customers.  
2. Peer-Peer relationships, wherein two providers exchange traffic between their customers. Typically, no money is exchanged for this service. Providers export only their customers’ routes to other peers and export routes received by peers only to their customers. This ensures that peers never provide transit services between providers . \. . .

Internet stability relies on the following conditions :  
1. Route export: An AS should not export routes learned from its peers or providers to its other peers or providers. This ensures that the AS does not provide transit services for anyone who is not paying for them. The AS should export all customer routes to its customers, peers, and providers.  
2. Global topology: The Provider-Customer graph must be acyclic; that is, customers must not be a provider for their providers or their providers’ providers, etc .  
3. Route selection: Given the option, prefer routes through customers rather than routes through peers and providers. This fulfills the business obligations of a provider to a customer by sending them traffic as directly as possible. Further, prefer peer routes over provider routes .

1. Please identify which of the following paths are valid, which of them are invalid based on the network topology of Figure 3.

Path 1 3 d

Path 1 4 d

Path 8 d

Path 6 d

Path 4 d

Path 7 5 d

Path 7 5 3 d

Path 2 1 3 d

Path 1 4 6 d

A diagram of a customer relationship

Description automatically generated

Figure 2. Network topology for Problem 11

Path 1 3 d – Invalid, 3 should not provide transit service for its provider d  
Path 1 4 d – Valid, each hop is from a customer to their provider  
Path 8 d – Valid, customer to its provider  
Path 6 d – Valid, peer to peer  
Path 4 d – Valid, customer to its provider  
Path 7 5 d – Valid, customer to its provider, then peer to peer  
Path 7 5 3 d – Valid, although I think that 5 should prefer its peer route (5 d) over its  
provider route (5 3 d), but I also think that may be a policy decision. Either way, 3  
would advertise the path to its provider d to its customers, so that path would be a valid choice. But by the same logic, the path 7 5 3 1 4 d is valid, which seems incorrect.  
Path 2 1 3 d – Invalid, 3 should not provide transit service for its provider d  
Path 1 4 6 d – Valid, 1 is a customer of 4, 4 is a customer of 6, and 6 is a peer to d