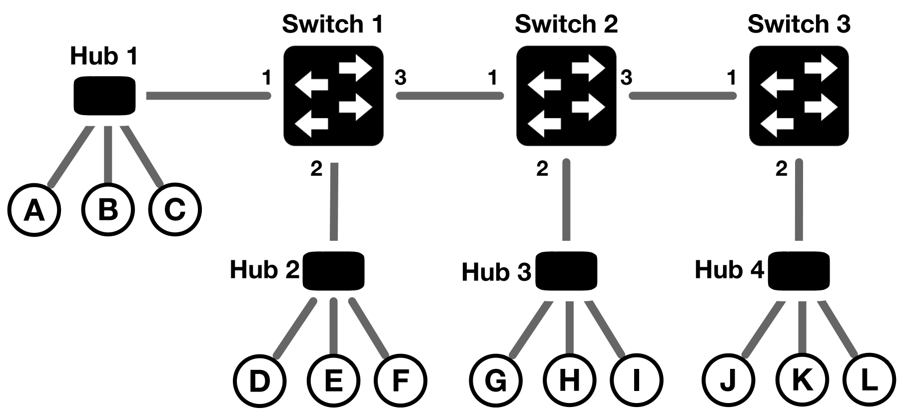
Problem 1

Consider the following network connected by three switches. The circles in the figure indicate the hosts (From host A to host L). At time=0s, the forwarding tables of all three switches are empty. Assume that all the hosts already know MAC addresses of other hosts, therefore no ARP is required. Also, assume that the TTL values of the forwarding table entries are big enough so that it will not expire in this problem. Suppose, the following seven events happen sequentially:

- Time=1s: Host A sends an IP datagram to Host G
- Time=2s: Host G sends an IP datagram to Host A
- Time=3s: Host D sends an IP datagram to Host L
- Time=4s: Host D sends an IP datagram to Host I
- Time=5s: Host F sends an IP datagram to Host A
- Time=6s: Host K sends an IP datagram to Host G
- Time=7s: Host J sends an IP datagram to Host F



1. How many times has each switch broadcasted the received frames? (Considering all seven events above.)

   Switch 1: 3
   Switch 2: 4
   Switch 3: 5

2. List the forwarding table of each switch after the seven events.

Switch 1	
Host	Interface
A	1
G	3
D	2
F	2
J	3

Switch 2	
Host	Interface
A	1
G	2
D	1
J	3

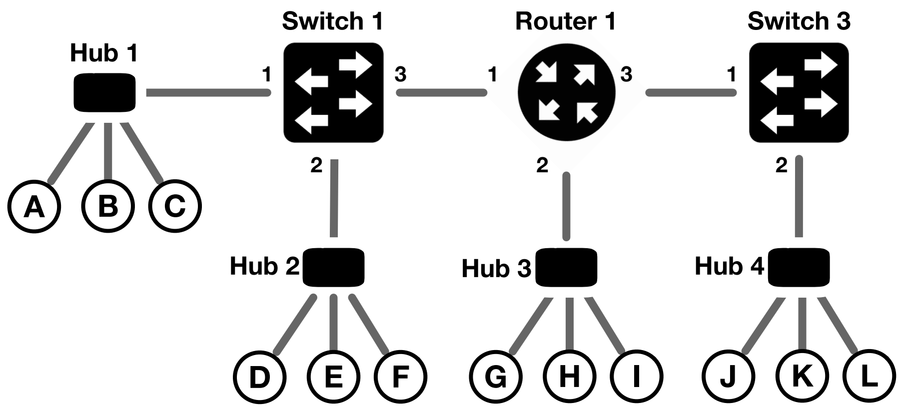
Switch 3	
Host	Interface
A	1
D	1
K	2
J	2

3. At time=10s, Host A sends Broadcast IP datagram in the network. How many hosts will receive this broadcast IP datagram excluding the sender?

   11 – every other host besides A receives it.

Problem 2

Consider, now we replace Switch 2 with Router 1 as shown in the following figure. Assume that all the hosts and the router already know MAC addresses of each other, therefore no ARP is required. The routing table is properly configured, and forwarding tables of switches are initially empty. Suppose we have the same seven events as in Problem 1.



1. How many times have Switch 1 and Switch 3 broadcasted the received frames? (Considering all seven events.)

   Switch 1: 3
   Switch 3: 3

2. List the forwarding table entries of each switch after the seven events.

Switch 1	
Host	Interface
A	1
G	3
D	2
F	2
J	3

Switch 3	
Host	Interface
D	1
K	2
J	2

3. At time=10, Host A sends Broadcast IP datagram in the subnet. How many hosts will receive this broadcast IP datagram excluding the sender?

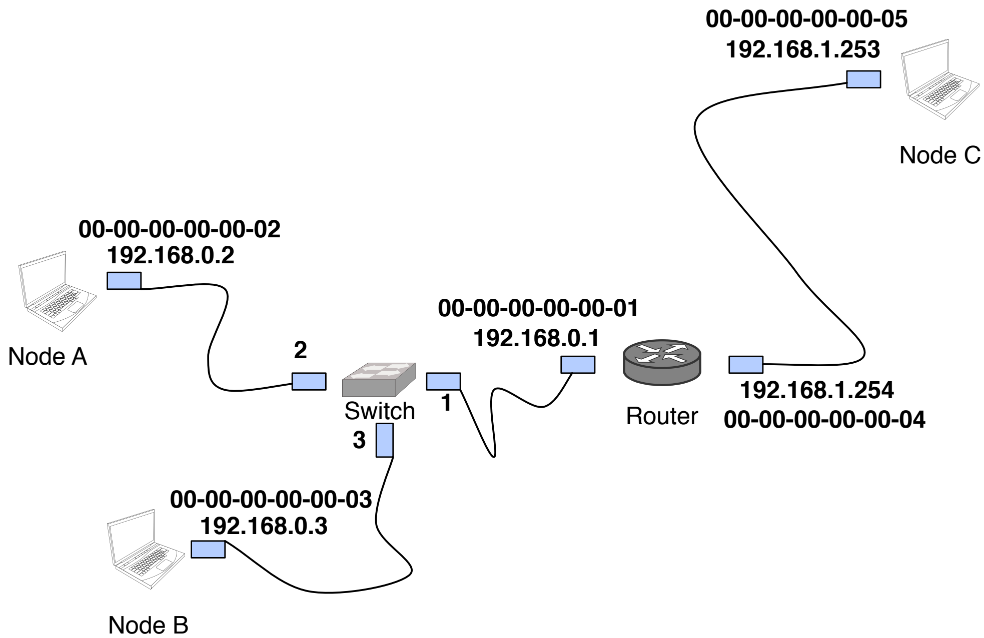
   5 – Stop broadcasting when it reaches router; marks end of subnet.

4. Suppose, we have the following network IP address, `11.22.33.0/27`. Assign IP addresses with IP addresses and proper subnet masks to All hosts. Do not use special IP addresses for host addresses.

Host A: 11.22.33.8/29	Host B: 11.22.33.9/29	Host C: 11.22.33.10/29
Host D: 11.22.33.11/29	Host E: 11.22.33.12/29	Host F: 11.22.33.13/29
Host G: 11.22.33.4/30	Host H: 11.22.33.5/30	Host I: 11.22.33.6/30
Host J: 11.22.33.0/30	Host K: 11.22.33.1/30	Host L: 11.22.33.2/30

Problem 3

Consider the following network topology with specified MAC addresses for network interfaces and the configured IP addresses:



Assume the network mask for both subnetworks is 255.255.255.0.

1. Assume that routing tables are properly configured and the network just started (i.e., all ARP caches and switch tables are empty), fill the following table to enumerate Ethernet frames (in chronological order) needed for node B to send an IP packet to 192.168.0.2 and receive a response back.

frame #	dst MAC addr	src MAC addr	device(s) that can get the frame, excluding the sender	new entries added into the switch's table (if any)
1	FF-FF-FF-FF-FF-FF	00-00-00-00-00-03	Node A, Router	00-00-00-00-00-03: Interface 3
2	00-00-00-00-00-03	00-00-00-00-00-02	Node B	00-00-00-00-00-02: Interface 2
3	00-00-00-00-00-02	00-00-00-00-00-03	Node A	None
4	00-00-00-00-00-03	00-00-00-00-00-02	Node B	None

2. Assume that the previous operation is done, fill the following table to enumerate Ethernet frames (in chronological order) for node B to send a packet to 192.168.1.253 and receive a reply.

frame #	dst MAC addr	src MAC addr	device(s) that can get the frame, excluding the sender	new entries added into the switch's table (if any)
1	FF-FF-FF-FF-FF-FF	00-00-00-00-00-03	Node A, Router	00-00-00-00-00-03: Interface 3
2	00-00-00-00-00-03	00-00-00-00-00-01	Node B	00-00-00-00-00-01: Interface 1
3	00-00-00-00-00-01	00-00-00-00-00-03	Router	None
4	FF-FF-FF-FF-FF-FF	00-00-00-00-00-04	Node C	None
5	00-00-00-00-00-04	00-00-00-00-00-05	Router	None
6	00-00-00-00-00-05	00-00-00-00-00-04	Node C	None
7	00-00-00-00-00-04	00-00-00-00-00-05	Router	None
8	00-00-00-00-00-03	00-00-00-00-00-01	Node B	Router MAC already added

*****This assumes that the router and nodes update ARP-Cache on requests in addition to replies. Class slides on ARP notes that hosts and routers maintain ARP caches.**

Problem 4

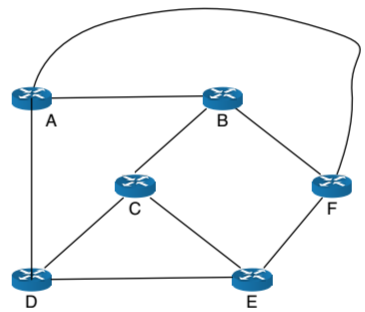
Assume there are two hosts on a private network behind an NAT router with private IP address 10.1.1.2 and 10.1.1.3 respectively. They both initiate a TCP connection at the same time to an external public network web server with public IP address 2.2.2.2 and port 80. The NAT has an internal address 10.2.2.2 and a public IP address 3.3.3.3.

1. Show the four tuple (source/destination address/port) of the two TCP SYN segments on the private network inside the NAT (you may choose any appropriate source port numbers, and use it consistently through questions 1-4).
2. Give an example of NAT binding table content after the NAT router has forwarded the two segments to the public network.
3. Show the four tuple (source/destination address/port) of the two TCP SYNs segments on the public network outside the NAT.
4. Show the four tuple (source/destination address/port) of the two TCP SYN/ACK segments inside and outside the NAT.

1. TCP SYN 1 - Source: [IP: 10.1.1.2, Port: 8080], Destination: [IP: 2.2.2.2, Port: 80]
   TCP SYN 2 - Source: [IP: 10.1.1.3, Port: 8081], Destination: [IP: 2.2.2.2, Port: 80]
2. LAN [IP: 10.1.1.2, Port: 8080] WAN [IP: 3.3.3.3, Port: 3000]:
   LAN [IP: 10.1.1.3, Port: 8081] WAN [IP: 3.3.3.3, Port: 3001]:
3. TCP SYN 1 - Source: [IP: 3.3.3.3, Port: 3000], Destination: [IP: 2.2.2.2, Port: 80]
   TCP SYN 2 - Source: [IP: 3.3.3.3, Port: 3001], Destination: [IP: 2.2.2.2, Port: 80]
4. Outside:
   TCP SYN ACK 1 - Source: [IP: 2.2.2.2, Port: 80], Destination: [IP: 3.3.3.3, Port: 3000]
   TCP SYN ACK 2 - Source: [IP: 2.2.2.2, Port: 80], Destination: [IP: 3.3.3.3, Port: 3001]
   Inside:
   TCP SYN ACK 1 - Source: [IP: 2.2.2.2, Port: 80], Destination: [IP: 10.1.1.2, Port: 8080]
   TCP SYN ACK 2 - Source: [IP: 2.2.2.2, Port: 80], Destination: [IP: 10.1.1.3, Port: 8081]

Problem 5

Consider a network of 6 routers shown in the figure below. The network is running OSPF routing protocol and the cost of each link is 10. Each router is announcing a single unique prefix, in total 6 prefixes are announced (prefix A, prefix B, ... prefix F). Propagation delay for each link is 10msec. Also, assume the processing and transmission delay is negligible. When a router has to choose between two or more equal cost paths to the same destination, it breaks the tie by picking the path whose next hop has smallest name (A < B < C < D < E < F). The network has been up and running for a long time. However, at time T=100 min, link A-F fails.



1. How do node A and node F discover this link failure?

A and F discover the link failure through Link State Advertisement (LSA) messages.

2. Will node C learn about this link failure? If so, does knowing this failure affect C's forwarding table?

Link C will learn about the link failure, since the OSPF routing protocol operates in such a way that each router is aware of the topology of the entire network.
This update will not affect C's forwarding table, since none of its shortest paths from C utilize the A-F link.

3. Overall, how many updates will be generated and propagated in the network as a result of this failure (i.e., not considering periodic updates)? Please explain why.

Both A and F will be notified regarding the link failure. Then both A and F will update their routing tables and broadcast to the whole network. Upon receiving this update, D will also update its routing table and broadcast this to the network. This results in a cumulative 3 updates being generated and propagated.

4. Which routers will make a change in their forwarding table as a result of this failure?

Routers A, F, and D will make changes in their forwarding tables. Router A will update its entry for router F. Router F will update its entry for routers A and D. Router D will update its entry for router F.

Problem 6

Suppose the IP address of home agent is 172.64.3.1. The permanent address of the mobile is 172.64.3.24. The mobile moves to a visited network and get the care-of address 194.54.7.1. A correspondent with IP 183.24.4.1 sends a packet to the mobile. The home agent intercepts the packet, forwards to foreign agent through tunneling. Show the destination IP address of the packet from the correspondent to the home agent, from the home agent to the foreign agent and from the foreign agent to the mobile. (Show both destination IP header in the tunnel header and the encapsulated header if the packet is a tunnel packet.)

Correspondent to Home Agent - Destination IP: 172.64.3.24
Home Agent to Foreign Agent - Tunnelled Destination IP: 194.54.7.1, Encapsulated Destination IP: 172.64.3.24
Foreign Agent to Mobile - Destination IP: 172.64.3.24