Problem 1

In this problem, you will put together much of what you have learned about Internet protocols. Suppose you walk into a room, connect to Ethernet, and want to download a Web page. What are the protocol steps that take place, starting form powering on your PC to getting the Web page? Assume there is nothing in our DNS or browser caches when you power on your PC. Explicitly indicate in your steps how you obtain the IP and MAC addresses of the first-hop router.

Write your solution to Problem 1 in this box

1. When the PC powers on, it is initially connected to a network, but PC does not have an IP address. It uses DHCP to get an IP address.
   - DHCP request, encapsulated in UDP, encapsulated over IP, encapsulated in 802.3 ethernet as ethernet from broadcast [DHCP discover]
   - DHCP offer: The DHCP router replies to the PC, assigns it an IP address, and provides the IP of the DNS server + name as well as the IP of the first-hop router.
   - DHCP accept: PC accepts the provided IP address.
   - DHCP Ack: Server acknowledges that the client has accepted the IP address.
2. Don't know MAC address of first-hop router, but need it to send requests - only IP is not enough. For this, we can use ARP.
   - The PC will broadcast an ARP query with the router's IP address.
   - The router responds to the client with its MAC address.
   - The router saves the interface to its switching table.
3. Use DNS to get IP address of webpage from the hostname of the web page.
   - Encapsulate DNS query in IP datagram.
   - IP of requested server is found using iterative or recursive querying if local DNS exists, querying the root DNS server, authoritative servers.
   - If doesn't exist, PC will do it itself
4. Need to route to the desired webpage:
   - If server is in the same AS network, use OSPF
   - If server is in different AS network, and we are moving in the same AS network, then use iBGP
   - If server is in a different AS network, and we are moving between different AS networks, the use eBGP.
5. Now we know the IP of the desired server. Create the HTTP request and encapsulate it in TCP packet and IP datagram:
   - TCP connection established with web page via 3 way TCP handshake. This involves client sending SYN and waiting for SYN ACK before sending data.
   - Server receives TCP packet with HTTP request, sends client HTTP response.
   - Client receives TCP packet with HTTP response from the server, and the web browser is able to display the HTML elements for the webpage on the PC.

Problem 2

Suppose four active nodes—nodes A, B, C and D—are competing for access to a channel using slotted ALOHA. Assume each node has an infinite number of packets to send. Each node attempts to transmit in each slot with probability p. The first slot is numbered slot 1, the second slot is numbered slot 2, and so on.

(a) What is the probability that node A succeeds for the first time in slot 5?

(b) What is the probability that any node (either A, B,C or D) succeeds in slot 4?

Write your solution to Problem 2 in this box

(a) $\mathbb{P}$(A succeeds in any time slot) $= p(1-p)^3$

$\mathbb{P}$(A does not succeed in a slot) $= 1 - p(1-p)^3$

$\therefore$ For Node A to succeed for the first time in slot 5 is : FFFFT

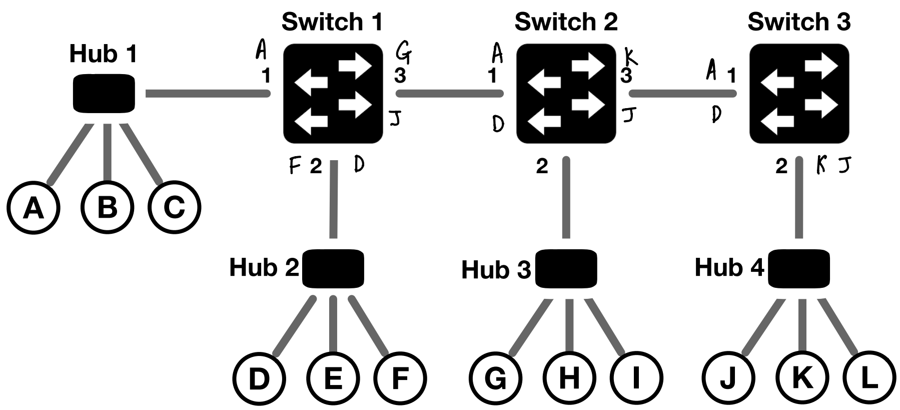
$$\left[1-p(1-p)^3\right]^4\left[p(1-p)^3\right]$$

(b) $\mathbb{P}$(any node succeeds in slot 4) $= 4p(1-p)^3$

Problem 3

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



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

Write your solution to Problem 3 in this box

Switch 1: 3 times
Switch 2: 4 times
Switch 3: 4 times

(b) List the forwarding table of each switch after the seven events.

Write your solution to Problem 3 in this box

Format: <host, interface>	1:	2:	3:
	A,1 F,2 G,3 J,3 D,2	A,1 K,3 G,2 J,3 D,1	A,1 D,1 K,2 J,2

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

Write your solution to Problem 3 in this box

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Problem 4

Suppose there are two ISPs, providing WiFi access in a particular café, with each ISP operating its own AP and having its own IP address block.

(a) Further suppose that by accident, each ISP has configured its AP to operate over channel 11. Will the 802.11 protocol completely break down in this situation? Discuss what happens when two stations, each associated with a different ISP, attempt to transmit at the same time.

(b) Now suppose that one AP operates over Channel 1 and the other over Channel 11. How do your answers change?

Write your solution to Problem 4 in this box

(a) 802.11 protocol will not completely break down. When a wireless device arrives at the cafe, it will associate with one of the two APs even if it is in the range of both APs. When the host sends data to its desired AP, it is typically identified by its MAC address and SSID. The other AP will not process the data because it was not addressed to it - therefore, it will be dropped. Therefore, two APs can operate over the same channel.

If two stations attempt to transmit at the same ~~time~~ when associated with different ISPs, collisions may occur since they are sharing the same wireless bandwidth/channel.

(b) There will be no collisions because the APs operate over different channels.

Problem 5

In Mobile IP, what effect will mobility have on end-to-end delays of datagrams between the source and destination?

Write your solution to Problem 5 in this box

There will be higher delays of datagrams between source and destination. This is because there are two steps that are involved - datagrams must first be forwarded to the home agent and then to the mobile device.

There may be a small chance that the datagram is not routed through the home agent, in which case, the delay may be shorter.