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Homework 8

1 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.

Upon first starting up the PC, the host will first obtain an IP address from the network's DHCP server(s), by broadcasting a "DHCP discover" IP datagram across the network via Ethernet. The DHCP server(s) then broadcasts its offer for the the host's IP address over the network, which the host can choose to take. Once the host has an IP address, the host can also obtain the address of the first-hop router for the client, the name and IP address of the local DNS server, as well as the network mask for the subnet from the DHCP server. To get the MAC addresses of the first-hop router and the local DNS server, the host can then probe the ARP module to get a mapping for the MAC addresses of the first-hop router and the local DNS servers based on the IP addresses it obtained from the DHCP server and the ARP protocol.

Once the client has the IP addresses and MAC addresses of the local DNS server and the first-hop router, it can now send datagrams to them. Upon trying to access the Webpage by entering the hostname into the browser client, the host will probe the local DNS server to return a mapping of the hostname to the IP address of one of the Website's Webservers, which is done over UDP. With the Webserver's IP address, the host can then send an HTTP request to download the Webpage, which is done at the application layer; the HTTP request is turned into a TCP segment at the transport layer, an IP datagram at the network layer, and an Ethernet dataframe at the link layer and, using all of the requisite protocols. The HTTP request is transmitted to the first-hop router, which then forwards the request to other routers, which use protocols like BGP and OSPF, until it reaches the destination Webserver, where the dataframe is delivered up the protocol stack until it reaches the application layer. The Webserver can then format it's HTTP response and send it back down the protocol stack, where routers will then route the HTTP response downstream back to the host.

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2 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?

a) The probability that node A succeeds for the first time in slot 5 is $[1-p(1-p)^3]^4p(1-p)^3$.

b) The probability that any node succeeds in slot 4 is $4p(1-p)^3$.

Work:

a)
The probability that node A succeeds for the first time in slot 5 is the probability that it fails in the first four slots and succeeds on the fifth. Since each node's probability of success is given by $p(1-p)^{N-1} = p(1-p)^3$:

$P(\text{"A's first success is in slot 5"}) = (1-p(1-p)^3)(1-p(1-p)^3)(1-p(1-p)^3)(1-p(1-p)^3)p(1-p)^3 = [1-p(1-p)^3]^4p(1-p)^3$

b)
The probability that any node succeeds in slot 4 is the sum of each node's probability of success, since this is the union of the events of each node succeeding, which is given by:

$P(\text{"Any node succeeding in slot 4"}) = p(1-p)^3+p(1-p)^3+p(1-p)^3+p(1-p)^3 = 4p(1-p)^3$

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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.)

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

(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?

a) Switch 1 has broadcasted the received frames 3 times, Switch 2 has broadcasted the received frames 4 times, and Switch 3 has broadcasted the received frames 5 times.

Parts (b) and (c) on next page.

b)

Switch 1

MAC Address	Interface	TTL
A	1	∞
G	3	∞
D	2	∞
F	2	∞
J	3	∞

Switch 2

MAC Address	Interface	TTL
A	1	∞
G	2	∞
D	1	∞
K	3	∞
J	3	∞

Switch 3

MAC Address	Interface	TTL
A	1	∞
D	1	∞
K	2	∞
J	2	∞

c) The Ethernet frame of the broadcast IP datagram has a destination MAC address of FF:FF:FF:FF:FF:FF so that the frame will be broadcast to all devices connected to the switch, therefore all 11 hosts will received this broadcast IP datagram, excluding the sender.

Work on next page.

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Work:

a)
At Time=1s, the frame A sent to G will be broadcasted by all three switches:

Switch 1: 1 | Switch 2: 1 | Switch 3: 1

At Time=2s, the frame G sent to A will not be broadcasted, since A's location is known, but switches 1 and 2 learn of G:

Switch 1: 1 | Switch 2: 1 | Switch 3: 1

At Time=3s, the frame D sent to L will be broadcasted by all three switches:

Switch 1: 2 | Switch 2: 2 | Switch 3: 2

At Time=4s, the frame D sent to I will be broadcasted by all three switches:

Switch 1: 3 | Switch 2: 3 | Switch 3: 3

At Time=5s, the frame F sent to A will not be broadcasted, since A's location is known, but switch 1 learns of F:

Switch 1: 3 | Switch 2: 3 | Switch 3: 3

At Time=6s, the frame K sent to G will be broadcasted by switch 3, since switch 3 doesn't know about G, but switches 1 and 2 do:

Switch 1: 3 | Switch 2: 3 | Switch 3: 4

At Time=7s, the frame J sent to F will be broadcasted by switches 2 and 3, since they both don't know about F, but switch 1 does:

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

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4 Problem 4

Suppose there are two ISPs, providing WiFi access in a particular cafe, 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?

a) The 802.11 protocol will not completely break down in this situation, since channels can overlap with different APs. This is because if the two stations associate with different ISPs through their APs, then despite using the same channel, the data frames transmitted by either station will only go to the AP each is associated with and vice versa. However, if the two stations send data frames over the channel at the same time, there will be a collision, as the two stations are in different BSSs and CSMA cannot sense the channel.

b) If the two AP's operate over different channels: Channel 1 and Channel 11, then there is no overlap, as channels that are separated by four or more channels are non-overlapping. This means that the two stations' connection to their respective associated APs will not have an issue with collisions and can utilize the full bandwidth of the channel.

5 Problem 5

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

Mobility could affect end-to-end delays of datagrams between the source and destination in two ways, depending on how the datagrams are routed. The end-to-end delays of the datagrams could be longer, as datagrams must be routed indirectly through the home agent, where the correspondent will forward the datagrams to the home agent, which in turn, forwards the datagrams to the foreign agent that forwards the datagrams to the mobile device. However, it's also possible that the end-to-end delays of the datagrams are shorter, if the datagrams are not routed through the home agent.