New York University
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Course Title: Data Communication & Networks **Course Number:** g22.2662-001
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Assignment #4 Solutions

Question 1 (Problem 8)

a)

$$E(p) = Np(1-p)^{N-1}$$
$$E'(p) = N(1-p)^{N-1} - Np(N-1)(1-p)^{N-2}$$
$$= N(1-p)^{N-2}((1-p) - p(N-1))$$

$$E'(p) = 0 \Rightarrow p^* = \frac{1}{N}$$

b)

$$E(p^*) = N\frac{1}{N}(1-\frac{1}{N})^{N-1} = (1-\frac{1}{N})^{N-1} = \frac{(1-\frac{1}{N})^N}{1-\frac{1}{N}}$$

$$\lim_{N\to\infty}(1-\frac{1}{N}) = 1 \qquad \lim_{N\to\infty}(1-\frac{1}{N})^N = \frac{1}{e}$$

Thus

$$\lim_{N\to\infty} E(p^*) = \frac{1}{e}$$

Question 2 (Problem 9)

$$E(p) = Np(1-p)^{2(N-1)}$$
$$E'(p) = N(1-p)^{2(N-2)} - Np2(N-1)(1-p)^{2(N-3)}$$
$$= N(1-p)^{2(N-3)}((1-p) - p2(N-1))$$

$$E'(p) = 0 \Rightarrow p^* = \frac{1}{2N-1}$$

$$E(p^*) = \frac{N}{2N-1}(1-\frac{1}{2N-1})^{2(N-1)}$$

$$\lim_{N\to\infty} E(p^*) = \frac{1}{2}\cdot\frac{1}{e} = \frac{1}{2e}$$

Question 3 (Problem 14)

a), b) See figure below.
Ans: a,b. Assigning the MAC addresses and IP addresses to all the interfaces.

Subnet 1 :
    A: IP: 192.168.1.001 MAC: 00-00-00-00-00-00
    B : IP : 192.168.1.003 MAC: 11-11-11-11-11-11

For Left Router Subnet 1 Interface : IP: 192.168.1.002 MAC: 22-22-22-22-22-22
    Subnet 2 Interface: IP: 192.168.2.002 MAC: 33-33-33-33-33-33

Subnet 2:
    C: IP: 192.168.2.001 MAC : 44-44-44-44-44-44
    D: IP: 192.168.2.004 MAC : 66-66-66-66-66-66

For Right Router Subnet 2 Interface : IP : 192.168.2.003 MAC: 55-55-55-55-55-55
    Subnet 3 Interface: IP: 192.168.3.002 MAC: 88-88-88-88-88-88

Subnet 3:
    E : IP: 192.168.3.001 MAC : 77-77-77-77-77-77
    F : IP: 192.168.3.003 MAC: 99-99-99-99-99-99

c)

1. Forwarding table in E determines that the datagram should be routed to interface 192.168.3.002.
2. The adapter in E creates and Ethernet packet with Ethernet destination address 88-88-88-88-88-88.
3. Router 2 receives the packet and extracts the datagram. The forwarding table in this router indicates that the datagram is to be routed to 198.162.2.002.
4. Router 2 then sends the Ethernet packet with the destination address of 33-33-33-33-33-33 and source address of 55-55-55-55-55-55 via its interface with IP address of 198.162.2.003.
5. The process continues until the packet has reached Host B.

d) ARP in E must now determine the MAC address of 198.162.3.002. Host E sends out an ARP query packet within a broadcast Ethernet frame. Router 2 receives the query packet and sends to Host E an ARP response packet. This ARP response packet is carried by an Ethernet frame with Ethernet destination address 77-77-77-77-77-77.

Question 4 (Problem 15)

a). No. E can check the subnet prefix of Host F's IP address, and then learn that F is on the same LAN. Thus, E will not send the packet to the default router R1.

Ethernet frame from E to F:

Source IP = E's IP address
Destination IP = F's IP address
Source MAC = E's MAC address
Destination MAC = F's MAC address

b). No, because they are not on the same LAN. E can find this out by checking B's IP address.

Ethernet frame from E to R1:

Source IP = E's IP address
Destination IP = B's IP address
Source MAC = E's MAC address
Destination MAC = The MAC address of R1's interface connecting to Subnet 3.

c). Switch S1 will broadcast the Ethernet frame via both its interfaces as the received ARP frame's destination address is a broadcast address. And it learns that A resides on Subnet 1 which is connected to S1 at the interface connecting to Subnet 1. And, S1 will update its forwarding table to include an entry for Host A.

Yes, router R1 also receives this ARP request message, but R1 won't forward the message to Subnet 3.

B won't send ARP query message asking for A's MAC address, as this address can be obtained from A's query message.

Once switch S1 receives B's response message, it will add an entry for host B in its forwarding table, and then drop the received frame as destination host A is on the same interface as host B (i.e., A and B are on the same LAN segment).

For $L = 1{,}500$, the delay is

$$\frac{1500 \cdot 8 + 40}{622 \times 10^6} \sec \approx 19.4 \mu \sec$$

For $L = 50$, store-and-forward delay $< 1 \mu \sec$.

d) Store-and-forward delay is small for both cases for typical link speeds. However, packetization delay for $L = 1500$ is too large for real-time voice applications.

Question 5 (Problem 27)

Ans.
a. Detemining the packetization delay in terms of L. Because it is encoded voice and voice is of low bandwidth it has a large packetization. Packetization delay = 8*L / 128,000 = L/16000 milliseconds.

b. Determining the packetization delay for L = 1500 bytes and L = 50 bytes. Packetization delay for L = 1500 bytes = 8*1500 /128000 = 0.09375 milliseconds 5 Packetization delay for L = 50 bytes = 8*50 /128000 = 0.003125 milliseconds

a. Given R = 622 Mbps for L = 1500 bytes and L = 50 bytes. Calculating the store and forward delay with a header of 5 bytes. Store and forward delay for

L = 50 bytes = (50+5)*8/622,000,000 = 0.707*10^-6 = 7.07*10^-7

Store and forward delay for L = 1500 bytes = (1500+5)*8/622,000,000 = 19.35*10^-6

b. Advantages: When the packetization delay is combines with store and forward delay the total delay exceeds the human threshold of 100 milliseconds. And also the packetization delay clearly increases with the cell size, therefore its clearly evident that smaller cell size is more advantageous because it has a shorter creation time.

Question 6 (Problem 33)

Ans. a. The email application will have to use the fourth rack for about 0.1/100 of the time i.e; **0.001** % The video application will also have to use the fourth rack for 0.001 % of time.

b. Assuming email and video usage are independent the fraction of time both the applications need their fourth rack is : 0.001*0.001 = 1*10^-6 % of time = 0.00001

c. Each rack consists of its own switch and that is connected to the tier to tier switch. The first switch is connected to 1st Tier-to-tier switch and next switch is connected to second tier-to-tier switch and the last switch is connected to the last tier-to-tier switch. In this way the topology can be used so that only seven racks are collectively assigned to two applications (assuming the topology can support all the traffic).