50.012 Networks (2020 Term 6)

Homework 3

Hand-out: 12 Nov

Due: 24 Nov 23:59

Name: _______________ Student ID: ________________

1. (textbook chapter 4, problem P14) Consider sending a 1,600-byte datagram into a link that has an MTU of 500 bytes. Suppose the original datagram is stamped with the identification number 291. How many fragments are generated? What are the values in the various fields in the IP datagram(s) generated related to fragmentation?

Suggested solution:

The maximum size of data field in each fragment = 480 (because there are 20 bytes IP header). Thus the number of required fragments = roundup((1600-20) / 480) = 4

Each fragment will have Identification number 291. Each fragment except the last one will be of size 500 bytes (including IP header). The last datagram will be of size 160 bytes (including IP header). The offsets of the 4 fragments will be 0, 60, 120, 180. Each of the first 3 fragments will have flag=1; the last fragment will have flag=0.

2. (textbook chapter 4, problem P17) Suppose you are interested in detecting the number of hosts behind a NAT. You observe that the IP layer stamps an identification number sequentially on each IP packet. The identification number of the first IP packet generated by a host is a random number, and the identification numbers of the subsequent IP packets are sequentially assigned. Assume all IP packets generated by hosts behind the NAT are sent to the outside world.

a. Based on this observation, and assuming you can sniff all packets sent by the NAT to the outside, can you outline a simple technique that detects the number of unique hosts behind a NAT? Justify your answer.

b. If the identification numbers are not sequentially assigned but randomly assigned, would your technique work? Justify your answer.

Suggested solution:

a) Since all IP packets are sent outside, so we can use a packet sniffer to record all IP packets generated by the hosts behind a NAT. As each host generates a sequence of IP packets with sequential numbers and a distinct (very likely, as they are randomly chosen from a large space) initial identification number (ID), we can group IP packets with consecutive IDs into a cluster. The number of clusters is the number of hosts behind the NAT.

b) However, if those identification numbers are not sequentially assigned but randomly assigned, the technique suggested in part (a) won't work, as there won't be clusters in sniffed data.

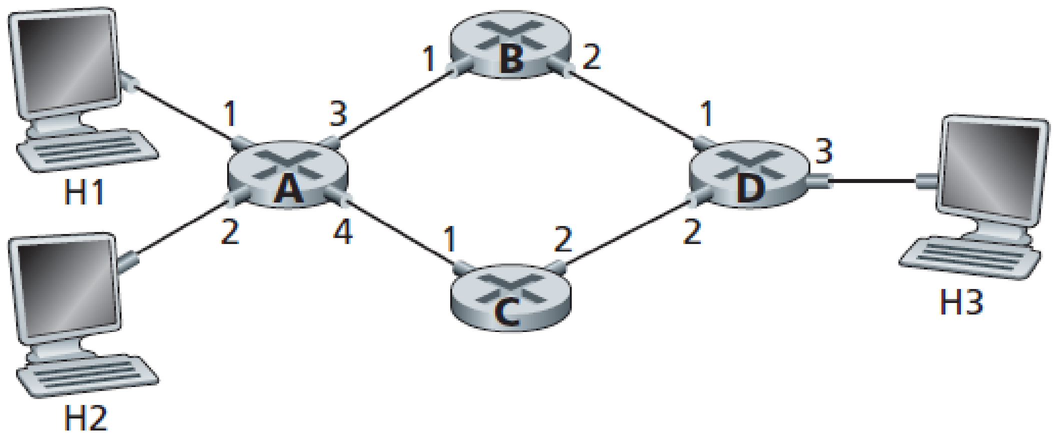
3. (textbook chapter 4, adapted from review problem R33 and problem P1):

a) What is the difference between a forwarding table for destination-based forwarding and OpenFlow's flow table?

b) Consider the network in the figure below. Show the forwarding table in router A, such that all traffic destined to host H3 is forwarded through interface 3.

c) Can you write down a forwarding table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4?

d) Can you write down a flow table in router A, such that all traffic from H1 destined to host H3 is forwarded through interface 3, while all traffic from H2 destined to host H3 is forwarded through interface 4?



Suggested solution:

a) Each entry in the forwarding table of a destination-based forwarding contains only an IP header field value and the outgoing link interface to which a packet (that matches the IP header field value) is to be forwarded. Each entry of the flow table in OpenFlow includes a set of header field values to which an incoming packet will be matched, a set of counters that are updated as packets are matched to flow table entries, and a set of actions to be taken when a packet matches a flow table entry.

b) Data destined to host H3 is forwarded through interface 3

Destination Address	Link Interface
H3	3

c) No, because forwarding rule is only based on destination address

d) Yes, we can define the matching pattern using both src and dest IP addresses in a flow table.

4. (textbook chapter 4, review problem R26): Suppose you purchase a wireless router and connect it to your cable modem. Also suppose that your ISP dynamically assigns your connected device (that is, your wireless router) one IP address. Also suppose that you have five PCs at home that use 802.11 to wirelessly connect to your wireless router. How are IP addresses assigned to the five PCs? Does the wireless router use NAT? Why or why not?

Suggested solution: Typically the wireless router includes a DHCP server. DHCP is used to assign IP addresses to the 5 PCs. Yes, the wireless router also uses NAT as it obtains only one IP address from the ISP.

5. (textbook Chapter 3, problem 45 and 53) Recall the macroscopic description of TCP throughput. In the period of time from when the connection's rate varies from W/(2 · RTT) to W/RTT, only one packet is lost (at the very end of the period).

a. Show that the loss rate (fraction of packets lost) is equal to

$$L = \text{loss rate} = \frac{1}{\frac{3}{8}W^2 + \frac{3}{4}W}$$

b. Use the result above to show that if a connection has loss rate L, then its average rate is approximately given by

$$\approx \frac{1.22 \cdot MSS}{RTT\sqrt{L}}$$

c. Let's assume 1500-byte packets and a 100 ms round-trip time. If TCP needed to support a 1Gbps connection, what would the tolerable loss rate be? How about 100Gbps?

Suggested solution:

a. The loss rate, L, is the ratio of the number of packets lost over the number of packets sent. In a cycle, 1 packet is lost. The number of packets sent in a cycle is

$$\frac{W}{2} + \left(\frac{W}{2}+1\right) + \cdots + W = \sum_{n=0}^{W/2}\left(\frac{W}{2}+n\right)$$

$$= \left(\frac{W}{2}+1\right)\frac{W}{2} + \sum_{n=0}^{W/2} n$$

$$= \left(\frac{W}{2}+1\right)\frac{W}{2} + \frac{W/2(W/2+1)}{2}$$

$$= \frac{W^2}{4} + \frac{W}{2} + \frac{W^2}{8} + \frac{W}{4}$$

$$= \frac{3}{8}W^2 + \frac{3}{4}W$$

Thus the loss rate is

$$L = \frac{1}{\frac{3}{8}W^2 + \frac{3}{4}W}$$

b. For W large, $\frac{3}{8}W^2 >> \frac{3}{4}W$. Thus $L \approx 8/3W^2$ or $W \approx \sqrt{\frac{8}{3L}}$. From the text, we therefore have

$$\text{average throughput } = \frac{3}{4}\sqrt{\frac{8}{3L}} \cdot \frac{MSS}{RTT}$$

$$= \frac{1.22 \cdot MSS}{RTT \cdot \sqrt{L}}$$

c. Let's assume 1500-byte packets and a 100 ms round-trip time. From the TCP throughput equation $B = \frac{1.22 \cdot MSS}{RTT \cdot \sqrt{L}}$, we have

1 Gbps = 1.22 * (1500*8 bits) / (.0.1 sec * srqt(L)), or

sqrt(L) = 1.464 x 10^4 bits / (10^8 bits) = 1.464 x 10^{-4}, or

L = 2.14 * 10^{-8}

Similarly, 100Gbps: L = 2.14 * 10^{-12}