CSE3300/5299: Computer Networking

Homework 6

Due Date: **11:00 am Friday, December 5, 2025**. Submission through HuskyCT. Full score: 100 for CSE3300 students; 120 for CSE5299 students (will be normalized to 100 when entering the grade in HuskyCT).

1. **Media Access Control (MAC) Protocols.** (30 points) We studied a number of MAC protocols, including (1) TDMA, (2) CSMA, (3) Slotted Aloha. Suppose there are N stations on a LAN that has capacity (transmission rate) C bps. All frame/packets have a fixed length L bits and the end-to-end propagation delay of the broadcast channel is P seconds. For each of the protocols listed above, answer the following questions:

   a. (12 points) Suppose only one station ever has data to send (i.e., the other $N-1$ stations generate no traffic). What is the maximum possible throughput seen by this single node under each of the protocols above? **Note:** Here the maximum possible throughput refers to the long-term throughput (i.e., the amount of data transmitted successfully per unit time over a period of time) instead of the instantaneous throughput. We assume packets will be transmitted successfully when there is no collision (i.e., we do not worry about other types of bit errors).

   b. (12 points) Suppose now that all stations are trying to send data at the same rate. We are now interested in the aggregate throughput of the LAN. For each of the above protocols, is it possible to achieve a throughput of C (i.e., have the channel always be fully utilized with user's data)? If not, indicate how/why the protocol limits the maximum throughput to less than C. **Note:** The aggregate throughput refers to the total amount of data transmitted successfully over all the nodes per unit time. Again we assume packets will be transmitted successfully when there is no collision (i.e., we do not worry about other types of bit errors).

   c. (6 points) In a heavily loaded network, what is the worst case amount of time a node has to wait under each of the protocols, before it can send a message?

2. **ARP and addressing.** (20 points) Consider the network topology shown in Fig. 1. The network interface cards (or network adaptors) are marked in the figure. As used in the textbook and slides, the rectangular forwarding devices are switches, and the circular forwarding device is a router.

   a. (3 points) How many subnets are there in the figure? For each subnet, list a possible subnet address (there can be many possible subnet addresses; listing one is sufficient for this problem).

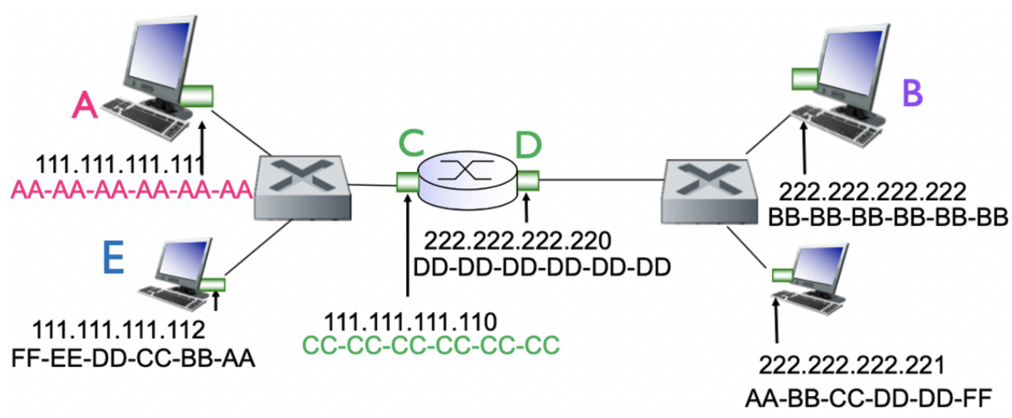

Figure 1: Network topology with a router in the middle.

b. (14 points) Consider sending an IP datagram from Host A to Host B. Suppose all of the ARP tables are up to date. In addition, assume the switches have up-to-date forwarding tables and the router has an up-to-date forwarding table.

   b1. (6 points) List the source and destination IP addresses as well as the source and destination MAC addresses that are used (i) on the hop from A to C, and (ii) on the hop from D to B.

   b2. (4 points) Briefly describe the actions at the switch between A and C.

   b3. (4 points) Briefly describe the actions at the router.

c. (3 points) Now assume that the ARP table in A is empty (and all the other tables are up to date). Will A perform an ARP query to find the MAC address of B? Why or why not?

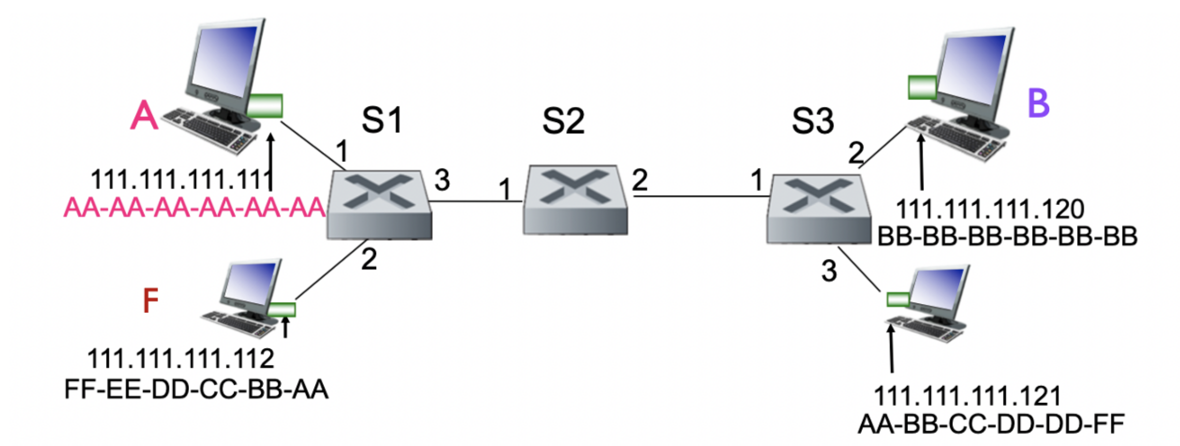

Figure 2: Network topology with only switches.

3. **Switch self-learning.** (30 points) Consider the network topology shown in Fig. 2. As used in the textbook and slides, the rectangular forwarding devices are switches; no router is in this topology. There are three switches, S1, S2 and S3. The ports of each switched are numbered as shown in the figure.

a. (5 points) How many subnets are there in the figure? For each subnet, list a possible subnet address (there can be many possible subnet addresses; listing one is sufficient for this problem).

b. (25 points) Consider sending an IP datagram from Host A to Host B. Suppose that the ARP table in A is empty. The forwarding tables of all the switches are also empty. A will use ARP to find the MAC address of B. Specifically, A will send an ARP query with B's IP address. B will respond with its MAC address.

  b1. (10 points) What are the source and destination MAC addresses in the ARP query? What will happen at each of the switches along the way (i.e., at S1, S2 and S3)? If a switch adds entry (or entries) to its forwarding table, describe what entry (or entries) is added.

  b2. (10 points) Continuing the above question - What are the source and destination MAC addresses in the ARP response? Describe the actions of the switches similarly as above.

  b3. (5 points) After knowing B's MAC address, A sends an IP datagram to B. Describe the actions at each of the switches along the way.

4. **Wireshark Lab (20 points).** Do problems 1-4 in the Ethernet wireshark lab (posted in HuskyCT). Since the capture has to be through Ethernet, while you are most likely using WiFi to access the Internet on your laptop, you may find it easier to just download the trace provided by the author (see footnote 2 on the first page).

5. **Efficiency of Slotted ALOHA (for CSE5299 students only) (20 points).** In this problem, you will derive the efficiency of slotted ALOHA.

   a. Recall that when there are N active nodes, the probability of success of a slot (i.e., there is one and only one transmitting node in the slot) is $Np(1-p)^{N-1}$, where p is the probability that a node transmits in one slot. Find the optimal value of p, denoted as p^*, that maximizes this expression.

   b. Using p^*, find the efficiency of slotted ALOHA by letting N approach infinity. Hint: $\lim_{N\to\infty}(1-1/N)^N = 1/e$.