CSE 461.
Problem Set 2.
Out: October 22, 2004
Due: November 5, 2004.

**Question 1.**

With Ethernet, the network alternates between periods of TRANSMISSION, during which the network has been acquired for successful packet transmission, and CONTENTION, during which stations attempt to acquire control of the network. A *slot* will be empty when no station chooses to attempt transmission in it, and will contain a collision if more than one station attempts to transmit. When a slot contains only one attempted transmission, the network has been acquired for the duration of a packet, the contention interval ends, and the transmission interval begins.

Let P be the number of bits in an Ethernet packet. Let C be the peak capacity in bits per second. Let T be the time in seconds of a slot (the number of seconds it takes to detect a collision after starting a transmission). Assume there are Q hosts continuously attempting to send data, and that a host transmits with probability 1/Q.

1. What is the probability that a host has nothing to transmit?
2. What is the probability that exactly one host attempts to transmit and acquires the network?
3. What is the probability of having to wait for exactly one slot before sending?
4. What is the probability of waiting *i* slots before successfully acquiring the network?
5. What is W, the expected number of slots (mean) that a host will wait before acquiring the network?
6. Once a host has acquired the network, how long does it take to transmit a packet?
7. What is the mean time to acquire the network?
8. Let efficiency (E) be the ratio of the time spent actually sending useful data and “all the time.” In terms of P, C, W and T, what is the efficiency of the network?
9. How do changes in technology over time impact E?

**Question 2.**

1. Problem 3.18 from the book.
2. For each of B1, B2, and B3 show the messages that each switch will receive, generate, forward and drop as it goes through the spanning tree algorithm. Messages are of the format (Y, d, X) where d is proposed distance from Y to the root X. Label messages received with an R, messages generated with a G, messages forwarded with an F, and messages dropped with a D. For example, if B1 receives (B2, 1, B3) and drops it, you might indicate this within the set of messages processed by B1 as: **(B2, 1, B3) R, D.**

**Question 3.**

Assume two hosts are on a network having bandwidth B and one-way latency D, and that one host wishes to send a 10 megabyte file to the other. Packets are of size M, are not lost and arrive in the order sent.

1. How long will it take to send the file using a stop-and-wait protocol?
2. How long will it take to send the file using a sliding window protocol?

**Question 4**.

Define an experiment for determining the bandwidth delay product between your workstation and www.cs.washington.edu. Describe the experiment. Run it. Describe your results. What are the weaknesses in your methodology?

**Question 5. TCP Packet Trace.**

The following packet trace was output by tcpdump, a common program for monitoring network activity. It shows the exchange of packets seen by the machine "me" while serving a 9287 byte Web page. The output is fairly terse, and explained by the tcpdump man page, which is linked from the course web page for convenience.

```
18:16:35.149595 them > me: S 1629852695:1629852695(0) win 32120  (DF)
18:16:35.149648 me > them: S 2210326433:2210326433(0) ack 1629852696 win 16060 (DF)
18:16:35.242646 them > me: . ack 1 win 32120  (DF)
18:16:35.243773 them > me: P 1:726(725) ack 1 win 32120  (DF)
18:16:35.243809 me > them: . ack 726 win 15335  (DF)
18:16:35.244689 me > them: P 1:1449(1448) ack 726 win 16060  (DF)
18:16:35.244702 me > them: P 1449:2897(1448) ack 726 win 16060  (DF)
18:16:35.332742 them > me: . ack 1449 win 31856  (DF)
18:16:35.332780 me > them: P 2897:4345(1448) ack 726 win 16060  (DF)
18:16:35.332791 me > them: P 4345:5793(1448) ack 726 win 16060  (DF)
18:16:35.334370 them > me: . ack 2897 win 30408  (DF)
18:16:35.334401 me > them: P 5793:7241(1448) ack 726 win 16060  (DF)
18:16:35.334412 me > them: P 7241:8689(1448) ack 726 win 16060  (DF)
18:16:35.334423 me > them: FP 8689:9536(847) ack 726 win 16060  (DF)
18:16:35.425453 them > me: . ack 5793 win 31856  (DF)
18:16:35.425456 them > me: . ack 8689 win 30408  (DF)
18:16:35.425458 them > me: . ack 9537 win 30408  (DF)
18:16:35.440199 them > me: F 726:726(0) ack 9537 win 31856  (DF)
18:16:35.440230 me > them: . ack 727 win 16060  (DF)
```

Draw a packet time sequence diagram (of the kind shown in Peterson with time moving down the page) that shows all packets of the transfer. Your diagram should be approximately to scale. For each packet, label it with the type (SYN, ACK) and sequence number range.

**Question 6. Flood and Learn.**

Suppose we modify the solution for Fishnet Assignment 1 so that when forwarding a packet, each node sends it to the last neighbor that forwarded a packet from that source address, and broadcasts it to all neighbors if the node has never seen a packet from that source address. (This is like learning bridges.) Other rules, such as discarding packets we've already seen and decrementing the TTL at each hop are kept the same.

a) Is it possible packets would loop? If so, give an example. If not, explain why not.
b) What happens when a node moves? Give a simple fix that allows the network to deliver packets to nodes that have moved.

**Question 7.**

Problem 2.25.

**Question 8.**

Problem 2.36

**Question 9.**

Recall the Learning Bridge algorithm discussed in class, where each bridge maintains a table of size T mapping observed hosts to output ports. Consider a network with one bridge having N ports, where each of N hosts is directly connected to the bridge. Assume that traffic destinations are uniformly distributed and that each host generates a message of size M every second, and that the bandwidth of each port is B.

1. What is the maximum aggregate bandwidth of the network? (note that maximum aggregate bandwidth is independent of the host's behavior)
2. In terms of T, M and N, what is the realized bandwidth of the network in steady state?
3. Graph the efficiency of the network of the network in steady state as a function of T, the table size. Mark the points along the X and Y axis where T=1, T=N, and T = 2N. (Efficiency is the realized bandwidth divided by the maximum bandwidth and is a percentage ranging from 0 to 100).