

## Problem Set #2 Solutions

### ENEE 426, Spring 2009

Complete the following problems from the textbook (5 points each):

1. Problem 2.49

- (a) Probability two addresses are the same is, by the birthday paradox

$$\frac{1 + 2 + \dots + (N - 1)}{M} = \frac{N^2 - N}{M}$$

where  $N = 1024$  and  $M = 2^{48}$ . Substituting, we get  $p_1 = 1.86 \cdot 10^{-9}$ .

- (b) If there are  $2^{20}$  networks, assuming they are independent, the probability  $p_2$  that one or more of them will have a collision is equal to  $1 - Pr[\text{none have collision}]$ . The probability that a single one does not collide is  $(1 - p_1)$ , thus the probability that none have a collide is  $(1 - p_1)^{2^{20}}$ . Combining everything we get

$$1 - (1 - p_1)^{2^{20}} = 1.99 \cdot 10^{-3}$$

Note that this is roughly equivalent to  $2^{20} \cdot 1.86 \cdot 10^{-9} = 1.95 \cdot 10^{-3}$ , but not exactly.

- (c) Same as (a), but  $N = 2^{30}$ . Unfortunately  $N$  is too large to use the birthday paradox approximation (we get the probability equal to 2048). Solutions which computed this and noticed the inconsistency received full credit.

2. Problem 2.52

Each packet transmission requires  $N/2$  contention time slots, plus 5 slots to transmit, for a total of  $N/2 + 5$  time units to send 5 slots of data. The overall rate of the network is then

$$\frac{5}{N/2 + 5} = \frac{10}{10 + N}$$

As  $N$  increases, the effective rate of the network decreases.

3. Problem 2.54

The source node is responsible for removing a data frame from the network. Therefore a frame would circulate forever if the source address in the frame header was for a non-existent device. This could happen either because the device was powered off before receiving the frame, or because bit errors in transmission caused the address to be undetectably altered to a non-existent device.

A monitor can detect a frame from the same source address passing it twice, and realize this is an error condition, since a source node cannot send two packets consecutively without passing an empty token off first. Also, a monitor can set the monitor bit on a frame to detect it passing more than once.

4. Problem 3.2

|     | Switch | InPort | InVCI | OutPort | OutVCI |
|-----|--------|--------|-------|---------|--------|
| (a) | 1      | 0      | 0     | 1       | 0      |
|     | 2      | 3      | 0     | 1       | 0      |
|     | 4      | 3      | 0     | 0       | 0      |

|     | Switch | InPort | InVCI | OutPort | OutVCI |
|-----|--------|--------|-------|---------|--------|
| (b) | 2      | 0      | 0     | 1       | 1      |
|     | 3      | 3      | 0     | 0       | 0      |
|     | 4      | 3      | 1     | 1       | 0      |

|     | Switch | InPort | InVCI | OutPort | OutVCI |
|-----|--------|--------|-------|---------|--------|
| (c) | 1      | 1      | 1     | 2       | 0      |
|     | 2      | 1      | 2     | 3       | 1      |
|     | 4      | 2      | 0     | 3       | 2      |

|     | Switch | InPort | InVCI | OutPort | OutVCI |
|-----|--------|--------|-------|---------|--------|
| (d) | 1      | 1      | 2     | 3       | 0      |
|     | 2      | 1      | 3     | 3       | 2      |
|     | 4      | 0      | 1     | 3       | 3      |

|     | Switch | InPort | InVCI | OutPort | OutVCI |
|-----|--------|--------|-------|---------|--------|
| (e) | 2      | 0      | 1     | 2       | 0      |
|     | 3      | 2      | 0     | 0       | 1      |

|     | Switch | InPort | InVCI | OutPort | OutVCI |
|-----|--------|--------|-------|---------|--------|
| (f) | 2      | 1      | 4     | 0       | 2      |
|     | 3      | 0      | 2     | 1       | 0      |
|     | 4      | 0      | 2     | 3       | 4      |

5. Problem 3.5

Starting with each source node, we can trace paths through the network using the VCI tables:

- $A \rightarrow S_1 \rightarrow B$
- $A \rightarrow S_1 \rightarrow S_2 \rightarrow S_3 \rightarrow D$
- $B \rightarrow S_1 \rightarrow S_2 \rightarrow S_3 \rightarrow E$

There are no other combinations. Switch  $S_1$  only has source-port entries for  $A$  and  $B$ . Switches  $S_2$  and  $S_3$  only have source-port entries from the switches to their left (port 1), so nodes  $C$ ,  $D$ , and  $E$  cannot be originators.

6. Problem 3.13

$B_0$  is distance 0 from the root.  $B_7$  and  $B_3$  are distance 1 from the root.  $B_2$  realizes it is distance 2 both via  $B_7$  and  $B_3$ , so it chooses the path with the smaller source address and cuts the link to segment  $A$ .  $B_5$  realizes that  $B_2$  is the same distance to the root and has a smaller address, so it cuts its link to segment  $B$ . Since it bridges to no other segments, it also disconnects from segment  $F$ . Both  $B_4$  and  $B_6$  are distance 2 to the root, so  $B_6$  (larger address) disconnects from segment  $I$ . All in all, the following ports are disconnected:

- $B_2$  to  $A$
- $B_5$  to  $B$
- $B_5$  to  $F$
- $B_6$  to  $I$

7. Problem 3.19

- a. M sends to L, B1 and B2 record M as being on port 1. B1 and B2 both send packet and L receives 2 copies. Both packets then loop around to the bridges, who update their tables with M being on port 2. Packets circle forever, due to asynchronous table updates.
- b. After L receives packet from M, it responds. The bridges update their tables with L on port 2. Assume B1 had M on port 2, one of the second packets is dropped. Then assume one of the copies of the first packet arrives at port 2 of B1, it is dropped. This results in one of each packet circulating.

8. Problem 3.21

- a. It will appear to be a short circuit during the execution of the spanning tree protocol, and STP will still function properly, removing loops (though perhaps suboptimally).
- b. If it drops the STP messages, it appears as an open circuit to STP but a short circuit to data messages. This results in loops in the resulting topology.

9. Problem 3.38

- a. Consider all possible locations (i.e. to which switch they are connected) for the endpoints of the two connections. There are 16 total. In those, 4 combinations involve both traversing the switch trunk. Thus collision-free probability is 0.75.
- b. In this scenario, there are 64 combinations, 32 of which involve 2 or more connections traversing the switch trunk. Thus collision-free probability is 0.5.

Complete the following additional problem (50 points):

10. Complete Laboratory 3, "Switched LANs", from the Network Simulations Experiment Manual

- a. Turn in a lab report, as described in the manual, that includes the answers to the questions and graphs generated during the experiments

Major conclusions: performance was much better when the switch was used. Hub-only networks result in many collisions, and using switches to segment network into different broadcast domains significantly improves performance. The purely-switched network performed the best overall.