**CSCE 560 Homework 5**

**Chapter 6 – Link Layer**

**Fall 18**

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**Assigned: Monday, 19 Nov**

**Due: Monday, 3 Dec, 1400**

You must include these questions in your submitted solution. In other words, your submission must include the question listed followed by your solution with the answer clearly indicated (e.g., put a box or circle around the final answer).

Problem 1. Chapter 6, R4

Suppose two nodes start to transmit at the same time a packet of length L over a broadcast channel of rate R. Denote the propagation delay between the two nodes as dprop. Will there be a collision detected if dprop < L/R? Why or why not?

**Sol’n:** Yes, it will detect the collision assuming the two nodes start transmitting at the same. Since dprop < transmission time, it will sense the collision while it is still transmitting.

Problem 2. Chapter 6, R6

In CSMA/CD, after the fifth collision, what is the probability that a node chooses K = 4? The result K = 4 corresponds to a delay of how many seconds on a 10 Mbps Ethernet?

**Sol’n:** n=5 in this case, so min(5, 10) = 5, this means that K can be in [0, 25-1] = [0,31] so there is a 1/32 chance that the node chooses K = 4

Delay in bit times is K\*512 so bit time delay is 2048 bit times and 2048 bits/10\*106bits/sec = 204.8 microseconds

Problem 3. Chapter 6, R11

Why is an ARP query sent within a broadcast frame? Why is an ARP response sent within a frame with a specific destination MAC address?

**Sol’n:** The sender of the ARP query doesn’t know the MAC address of the next host but does know the IP address, so it sends a broadcast frame asking who has the destination IP. The host that has the IP address stated in the broadcast frame then sends back a unicast response to that specific sender because it knows the MAC address of the sender of the broadcast frame.

Problem 4. Chapter 6, R12

For the network in Figure 6.19, the router has two ARP modules, each with its own ARP table. Is it possible that the same MAC address appears in both tables? Why or why not?

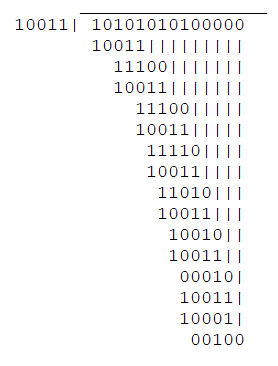
**Sol’n:**

No, it is not possible. The ARP table maps IP addresses to MAC addresses and the ARP table only is populated for devices on the subnet. If the same MAC address is in the ARP table for both interfaces of the router, then that means the same device is in 2 different subnets which is not possible.

Problem 5. Chapter 6, P5

Consider the 5-bit generator, G=10011, and suppose that *D* has the value 1010101010.  What is the value of *R*? You must show you derivation of *R*.

**Sol’n:**



Therefore, R = 0100

Problem 6. Chapter 6, P8

In Section 6.3, we provided an outline of the derivation of the efficiency of slotted ALOHA. In this problem we'll complete the derivation.

a. Recall that when there are N active nodes the efficiency of slotted ALOHA is   
Np(1-p)N-1. Mathematically derive the value of p that maximizes this expression.

**Sol’n:**

Let f denote the efficiency function and its independent variable is p. So

To maximize this expression, we need to find the derivative of this expression with respect to p and set it to 0.

From this we see that we maximize p at the value p such that the following holds:

So we simplify this into:

b. Using the value of p found in part (a), find the efficiency of slotted ALOHA by letting N approach infinity. Hint: (1 - 1/N)N approaches 1/e as N approaches infinity.

**Sol’n:** p = 1/N so then

Then we take the limit as N approaches infinity, so we get

So max efficiency of slotted aloha is 1/e which is approximately 36.78%.

Problem 7. Chapter 6, P18

Suppose nodes A and B are on the same 10 Mbps Ethernet bus, and the propagation delay between the two nodes is 325 bit times. Suppose CSMA/CD and Ethernet packets are used for this broadcast channel. Suppose node A begins transmitting a frame and, before it finishes, node B begins transmitting a frame. Can A finish transmitting before it detects that B has transmitted? Why or why not? If the answer is yes, then A incorrectly believes that its frame was successfully transmitted without a collision. *Hint:* Suppose at time t = 0 bit times, A begins transmitting a frame. In the worst case, A transmits a minimum size frame of 512+64 bit times. (The additional 64 bits are for the preamble and the start frame delimiter.) So A would finish transmitting the frame at t = 512+64 bit times. Thus the answer is no, if B's signal reaches A before bit time t = 512+64 bits. In the worst case, when does B's signal reach A?

**Sol’n:**

No, it will not necessarily detect the collision. Since dprop is 325 bit times and minimum frame size 576 bit times, if A is transmitting bits 325-575 when B starts transmitting, then A will finish before sensing B’s transmission since. In this worst case, the earliest time that A could sense B’s transmission is t=649 bit times since 650 bit times is the round trip time.

Problem 8. Supplemental Problem 1

Suppose two nodes, A and B, are attached to opposite ends of a 800 m cable, and that they each have one frame of 1500 bits (including all headers and preambles) to send to each other. Both nodes attempt to transmit at time t=0. Suppose there are four repeaters between A and B, each inserting a 20-bit delay. Assume the transmission rate is 10 Mbps, and CSMA/CD with backoff intervals of multiples of 512 bits is used. After the first collision, A draws K = 0 and B draws K = 1 in the exponential backoff protocol. Ignore the jam signal and the 96-bit time interframe delay.

a. What is the one-way propagation delay (including repeater delays) between A and B in seconds. Assume that the signal propagation speed is 2x108 m/sec.

**Sol’n:**

The propagation delay is the actual dprop in the medium plus the repeater delay

dprop = 800m/(2\*108m/sec) = 4 μsec

drepeater = 20 bit times \* 4 = 80 bit times/10\*106bps = 8 μsec

Thus, dtotal prop = 12 μsec = 12\*10-6 sec

b. At what time (in seconds) is A's packet completely delivered at B.

**Sol’n:**

Tt = 1500 bits/107 bits/sec = 150 μsec.

Both transmit at t=0, and the collision is sensed at t=12 μsec (dprop total). Then the backoff occurs and A then immediately transmits since it has K=0, so its transmission is completely delivered to B at t=12+150+12 μsec = t=174 μsec = 174\*10-6 sec.

c. Now suppose that only A has a packet to send and that the repeaters are replaced with switches. Suppose that each switch has a 20-bit processing delay in addition to a store-and-forward delay. At what time in seconds is A's packet delivered at B?

**Sol’n:**

There are 5 links between, A, B, and 4 repeaters, the propagation delay for all 5 links is (from part a) 4 μsec. The packet is now transmitted 5 times through 4 switches. The processing delay is the same as part b (2 μsec per switch) so the total delay between A and B is 150 μsec + 4\*(dprocess + d­transmit) = 150 μsec + 4\*(2 μsec + 150 μsec) + 4 μsec = 762 μsec.

Since switches are full duplex, we don’t have to worry about collisions anymore, so A’s transmission is completely delivered to B at t = 762 μsec = 762\*10-6 sec

Problem 9. Supplemental Problem 2

Consider a 100 Mbps 100Base-T Ethernet with all nodes directly connected to a hub. To have an efficiency of 0.50, what should be the maximum distance between a node and the hub? Assume a frame length of 1000 bytes and that there are no repeaters. Does this maximum distance also ensure that a transmitting node A will be able to detect whether any other node transmitted while A was transmitting? Why or why not? How does your maximum distance compare to the actual 100 Mbps standard? Assume that the signal propagation speed in 100Base-T Ethernet is 1.8x108 m/s.

**Sol’n:**

From the book (6th edition p. 458) we have that the equation for efficiency is

Assuming that the frame length includes the header, dtrans = 8000 bits/108 bps = 80 μsec

We want an efficiency of 0.5 and we need to find the distance of our links.

dprop = distance/propagation speed so if we rearrange our equation to solve for dprop we can find the distance.

This is longer than the maximum length of a link that Ethernet allows between nodes which is 2500 meters, and much longer than the standard for 100 Base T which is 100m on a star topology with all nodes connected to a hub.

From above we can see that 5dprop = dtrans since our efficiency is 0.5. This means that A can detect when another node is transmitting since dtrans >= 2dprop