Homework 4 Solutions

Problem 1 (Short-answer questions)

1) If all the links in the Internet were to provide reliable delivery service, would the TCP reliable delivery service be redundant? Why? Or why not?

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Although each link guarantees that an IP datagram sent over the link will be received at the other end of the link without errors, it is not guaranteed that IP datagrams will arrive at the ultimate destination in the proper order. With IP, datagrams in the same TCP connection can take different routes in the network, and therefore arrive out of order. TCP is still needed to provide the receiving end of the application the byte stream in the correct order. Also, IP can lose packets due to routing loops or equipment failures.

2) 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?

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An ARP query is sent in a broadcast frame because the querying host does not know which adapter address corresponds to the IP address in question. For the response, the sending node knows the adapter address to which the response should be sent, so there is no need to send a broadcast frame (which would have to be processed by all the other nodes on the LAN).

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3) RTS/CTS can prevent collisions when hidden terminals exist. However, many Access Point vendors disable RTS/CTS feature? Why do you think they do it?

RTS/CTS causes significant overhead and can reduce throughout.

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4) Why are ACK frames used in 802.11 but not in wired Ethernet?

802.11 does not have any way to know/detect packet loss

10 5) Suppose the RTS/CTS frames were as long as the standard DATA frames. Would there be any advantage to using RTS/CTS frames? Justify your answer.

No, there wouldn't be any advantage. Suppose there are two stations that want to transmit at the same time, and they both use RTS/CTS. If the RTS frame is as long as a DATA frames, the channel would be wasted for as long as it would have been wasted for two colliding DATA frames. Thus, the RTS/CTS exchange is only useful when the RTS/CTS frames are significantly smaller than the DATA frames.

Problem 2:

Consider two nodes, A and B, that use the slotted ALOHA protocol to contend for a channel. Suppose node A has more data to transmit than node B, and node A's transmission probability p_A is greater than node B's retransmission probability, p_B.

10 a. Provide a formula for node A's average throughput. What is the total efficiency of the protocol with these two nodes?

b. If $p_A = 2\,p_B$, is node A's average throughput twice as large as that of
10 node B? Why or why not? If not, how can you choose p_A and p_B to make that happen?

c. In general, suppose there are N nodes, among which node A has
10 retransmission probability $2p$ and all other nodes have retransmission probability p. Provide expressions to compute the average throughputs of node A and of any other node.

Solutions:

a). A's average throughput is given by $pA(1\text{-}pB)$. Total efficiency is $pA(1\text{-}pB) + pB(1\text{-}pA)$.

b). A's throughput is $p_A(1\text{-}p_B)=2p_B(1\text{-}p_B)= 2p_B\text{-}\ 2(p_B)^2$. B's throughput is $p_B(1\text{-}p_A)=p_B(1\text{-}2p_B)= p_B\text{-}\ 2(p_B)^2$. Clearly, A's throughput is not twice as large as B's. In order to make *pA(1-pB)= 2 pB(1-pA)*, we need that *pA= 2 – (pA / pB)*.

c). A's throughput is $2p(1-p)^{N-1}$, and any other node has throughput $p(1-p)^{N-2}(1-2p)$.

Problem 3:

Explain why a minimum frame size is required for Ethernet. For example, 10Base Ethernet imposes a minimum frame size constraint of 64 bytes. (If
20 you have done the previous problem, you might have realized the reason). Now suppose that the distance between two ends of an Ethernet LAN is *d*. Can you derive a formula to find the minimum frame size needed for an Ethernet packet? Based on your reasoning, what is the minimum required packet size for an Ethernet that spans 2 kilometers?

Solution:

Following the same reasoning as in last problem, we need to make sure that one end of the Ethernet is able to detect the collision before it completes its transmission of a frame. Thus, a minimum frame size is required.

Let BW denote the bandwidth of the Ethernet. Consider the worst case for Ethernet's collision detection: 1. At t=0 (bit times): A sends a frame 2. At $t=d_{prop}-1$ (bit times): B sends a frame right before it can sense A's first bit.

3. At $t=2d_{prop}-2$ (bit times): If A finishes its transmission of its last bit just before B's frame arrives at A, then, A won't be able to detect a collision before finishing its transmission of a frame. Thus, in order for A to detect collision before finishing transmission, the minimum required frame size should be >= $2d_{prop}-1$ (bit times).

Assume that the signal propagation speed in 10BASE-T Ethernet is $1.8*10^8$ m/sec. As $d_{prop}=d/(1.8*10^8)*BW$(here, we need to convert the propagation delay in seconds to bit times for the specific Ethernet link), we find the minimum required frame size is $2*d/(1.8*10^8)*BW-1$ (bits). Or approximately we choose $2*d/(1.8*10^8)*BW$ (bits). If d=2km, then minimum required frame size is: 222 bits.