CS/ECE 438: Communication Networks for Computers Spring 2010
Problem Set 3 Due: start of class, Wednesday, February 24th.

Direct Link Networks (II)

Assigned reading: Peterson and Davie: Chapter 2.5 – 2.9. All problems carry equal weight. Please show all your work.

1. Multiple Access

Nodes A and B are attached via a 200 m cable. Signal propagation speed is 2 x 10^8 m/sec, and the transmission rate is 40 Mbps. There is a single repeater between A and B, inserting a 10-bit delay. A has a frame of 175 bytes (including all headers and preambles) to send to B at t=0.

a. What is the one-way propagation delay between A and B?

Signal delay = 200m/(2 x 10^8 m/sec) = 1 μs
Repeater delay = 10bit/40Mbps = 0.25 μs
Propagation delay = 1+0.25 = 1.25 μs

b. Find the time when A's packet is delivered at B.

1400bit/40Mbps = 35 μs
1.25+35 = 36.25 μs

In addition to A's frame, B also has a frame of 175 bytes to send to A. CSMA/CD with backoff intervals of multiples of 512 bits is used. When a collision occurs, A chooses K=0 and B chooses K=1 in the exponential backoff protocol. Ignore the jam signal and assume frame is sent immediately on an idle line. When will B's frame be delivered at A in the following two instances?

c. B is ready to send at t=1μs. Is the line busy? Is a collision detected? When will B's frame arrive at A?

Line is not busy. However, collision is detected at t = 1.25 μs at B, and 2.25 μs at A. A resends starting at 2.25 μs, and the frame is delivered at 2.25+36.25 = 38.50 μs. B will then send at that time, so that B's frame arrives at A at 38.50 + 36.25 = 74.75 μs.

d. B is ready to send at t=20 μs. Is the line busy? Is a collision detected? When will B's frame arrive at A?

Line is busy. B can start sending at 36.25 μs. Thus, B's frame arrives at A at 36.25 + 36.25 = 72.50 μs.

2. Ethernet Timing

This problem is about the Ethernet/IEEE 802.11 access protocol. To be definite, suppose that if a host detects a transmission while it is transmitting a frame, then: (i) if the host has already transmitted the 64 bit preamble, the host stops transmitting the frame and sends a 32 bit jamming sequence; (ii) else the host finishes transmitting the 64 bit preamble and then sends a 32 bit jamming sequence. For simplicity, assume a collision is detected as soon as an interfering signal first begins to reach a host. Suppose the packets are 512 bits long, which is the minimum length allowed. Hosts A and B are the only active hosts on a 20 Mbps Ethernet and the propagation time between them is 6μs, or 120 bit durations. Suppose A begins transmitting a frame at time t = 0, and just before the beginning of the frame reaches B, B begins sending a frame, and then almost immediately B detects a collision.

a. Does A finish transmitting the frame before it detects that there was a collision? Explain.
b. What time does A finish sending a jamming signal? What time does B finish sending a jamming signal?
c. What time does A first hear an idle channel again? What time does B first hear an idle channel again?
d. Suppose each host next decides to retransmit immediately after hearing the channel idle. After the resulting (second) collision: When does A next hear the channel idle? When does B next hear the channel idle?
e. Suppose after the second collision, A decides to wait 512 bit durations to retransmit (if it hears silence after that long) and B decides to retransmit immediately after hearing a silent channel. Is the transmission of host B successful?

f. At the time A was planning to send its second retransmission, it senses a carrier present. Suppose at that particular time A decides to wait 3 x 51.2 µs more until its next retransmission. What time does host A finish sending its packet?

a. No, A does not finish because it hears B after only 240 of the 64+512 bits are transmitted.
b. 13.6 µs, 10.8 µs
c. 16.8 µs, 19.6 µs
d. 30.4 µs, 33.2 µs
e. Yes.
f. Typo: wait time should have been 3 x 25.6 because 20 Mbps ethernet
173.6 µs (with 3 x 25.6 µs wait time)
167.2 µs (with 3 x 25.6 µs wait time, and packet size 64+448)
250.4 µs (with 3 x 51.2 µs wait time)
244.0 µs (with 3 x 51.2 µs wait time, and packet size 64+448)

3. Ethernet

Consider the following two possibilities:
(i) We put 20 hosts on an Ethernet operating at 10 Mbps.
(ii) We create two separate Ethernets, with 10 hosts operating on each of the Ethernets, and each of the Ethernets operating at 5 Mbps.

a. Suggest one potential advantage of approach (i) compared to (ii).

Advantage: Because approach (i) has an Ethernet operating at a rate higher than approach (ii), we can have faster transmissions in approach (i) (when the traffic intensity is low).

b. Suggest one potential disadvantage of approach (i) compared to (ii).

Disadvantage: When the traffic intensity is high, transmissions in approach (i) may incur more delay due to more contention (and possibly more collisions) than approach (ii).

4. Stop-and-wait and Sliding Window

Nodes A and B are connected by a link with bandwidth 100 Mbps. The delay between A and B is 8 ms. Data packet size is 1000 Bytes, and ACKs have negligible size. Timeout for the Sliding Window problems is 2xRTT.

a. What is the maximum throughput using stop-and-wait?
b. What is the throughput using a Sliding Window with SWS=RWS=5?
c. Draw the timeline when the 4th ACK is lost.
d. What is the minimum size of the SWS and RWS that can get the maximum throughput?
e. Using the SWS and RWS size in (c), what is the throughput when every 100th packet is lost (the first send of packet number 100, 200, 300, etc. are lost; resends are not lost)?

a. Time taken for data packet transfer: 1000*8 bits/100Mbps + 16ms = 16.08 ms
Throughput: 1000*8bits/16.08ms = 497.5 Kbps
b. Time taken for five data packets transferred: 5*1000*8bits/100Mbps + 16ms = 16.4ms
Throughput: 5*1000*8bits/16.4ms = 2.439 Mbps
c. (picture below)
d. Bandwidth x Delay = 100Mbps * 16ms = 1600Kb.
1600Kb/8000bits = 200 = SWS = RWS
e. Time for 100th packet to get on line: 1000*8*99bits/100Mbps = 7.92ms
Time until timeout: 12*2 = 24ms
Time for 100th packet resend ack: 1000*8bits/100Mbps+12ms = 12.08ms
299 packets sent in 7.92+24+12.08 = 44ms; Throughput = 299*1000*8bits/44ms = 54.36Mbps

5. Sliding Window

Suppose that we run the sliding window algorithm with SWS = 5 and RWS = 3, and no out-of-order arrivals.

a. Find the smallest value for MaxSeqNum. You may assume that it suffices to find the smallest MaxSeqNum such that if DATA[MaxSeqNum] is in the receive window, then DATA[0] can no longer arrive.
b. Give an example showing that MaxSeqNum - 1 is not sufficient.
c. State a general rule for the minimum MaxSeqNum in terms of SWS and RWS.

a. SWS+RWS-1 = 7
b. Sender sends frames 0,…,4. Receiver receives but then the ACKS are all lost. Now, receiver's SeqNum for LFR=4 and LAF=7%7=0. When Sender resends frame 0, it is interpreted to be frame 7 (when it is actually 0).
c. SWS+RWS possible sequence numbers, so MaxSeqNum = SWS+RWS-1

6. Token Ring Throughput

Consider a token ring with a data rate of 50 Mbps, a ring latency of 120 μsec, and 1000 bit packets.

a. Assuming only one host wants to transmit and the delayed token release scheme is used, what is the maximum effective throughput rate that can be achieved? What is the efficiency?
b. Now assume N hosts want to transmit on the token ring and the token holding time (THT) is 250 μsec. What is the token rotation time? What is the maximum effective throughput rate that can be achieved? What is the efficiency?
c. Under the assumptions of part b, and using the immediate release scheme, what is the throughput rate that can be achieved?

a. Throughput is given by (packet size)/TRT = (packet size)/(2 * ring latency + packet size / bandwidth).
So throughput would be 1000/(2 * 120 μsec + 1000/ (50 Mbps)) = 3,846,154 bps
Efficiency = throughput/bandwidth = 3,846,154/50Mbps = 7.69%
b. TRT <= N * (THT + ring latency) = (N * (250 + 120)) μsec = (N * 370) μsec
Throughput for one cycle is (#packets transmitted)/(actual TRT)
each station can transmit 12 packets before THT expires
Throughput = (N * 12 * (packet size))/ ((N * (12 * (packet size)/bandwidth) + ring latency))
Efficiency = throughput/bandwidth
c. Throughput for one cycle is (#packets transmitted)/(actual TRT)
each station can transmit 12 packets before THT expires
Throughput = (N * 12 * (packet size))/((N * 12 * (packet size)/bandwidth) + ring latency)