CS 5600 – Computer Networks

Homework 3

Due date: 10/11 Tuesday in class

Total Points: 100 (Each question carries 25 points)

Individual work: However, **collaboration is allowed**. Please feel free to discuss with your peers to brainstorm. But every student has to write his/her solution by himself/herself and make a separate submission. **Any two submissions that look exactly alike will not be graded.**

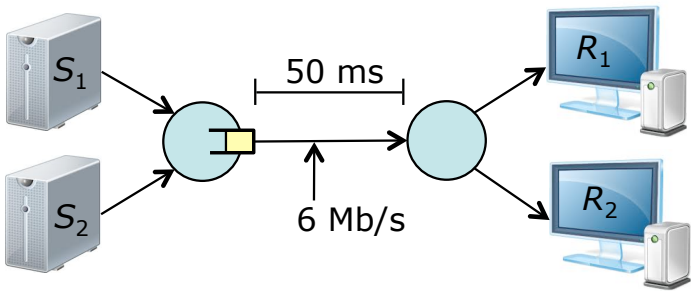
1. A radio is called *full-duplex* if it can both transmit and receive simultaneously. A radio is called *half-duplex* if it can either transmit or receive but cannot do both simultaneously. Consider a protocol between a sender node A and a receiver node B, where each node is equipped with a half-duplex radio. The protocol allows A to transmit periodically with a period of 100ms. That is, after every 100ms node A transmits a frame to node B. It takes 2ms for A to transmit each frame. As soon as the complete frame is received at B, it sends a piggybacked acknowledgement (ACK) to A. The transmission time of each piggybacked ACK is also 2ms. Assume a propagation delay of 0 in each direction. Also assume that no transmission fails.
   (a) What is the channel utilization at sender node A?
   (b) What is the channel utilization at receiver node B?

2. You have studied the Stop-and-Wait protocol between one sender and one receiver. Now consider a Stop-and-Wait protocol between one sender and n receivers, where $n \geq 1$ and a single channel is used for communication between the sender and the receivers. The sender needs 1ms to transmit each frame. The protocol allows the receivers to acknowledge in a round robin fashion where the first node acknowledges immediately after receiving the complete frame. For others, a node sends ACK immediately after the preceding node completes sending its ACK. Assume a propagation delay of 0 in each direction. Each ACK takes 0.5ms to be transmitted. The sender transmits again after the last ACK is received and repeats the same procedure. Each node is equipped with a half-duplex radio.
   (a) What is the time interval between 2 transmissions at the sender?
   (b) What is the channel utilization at the sender?
   (c) If each radio is full-duplex, what change will you make for this Stop-and-Wait protocol between one sender and n receivers?

3. (a) Consider Go-Back-n Sliding Window Protocol. The protocol needs to transmit k frames with sequence numbers 1 to k (i.e., 1, 2, 3, …, k) and then needs to transmit another 2k frames with sequence numbers 1 to 2k (i.e., 1, 2, 3, …, 2k). Then it needs to repeat these two steps infinitely. What can be the maximum sender window size? Explain the reason for your answer.

(b) You have studied sliding window protocol for full-duplex radio and noisy channels. Write a version of sliding window protocol where each node's radio is half-duplex and the channel is noisy.

4. The diagram below right shows two TCP senders at left and the corresponding receivers at right. The first sender uses TCP *Tahoe*, the second uses *Reno*. Assume that the MSS (maximum segment size) is 1 KB, that the one-way propagation delay for both connections is 50ms, and that the link joining the two routers have a bandwidth of 6Mbps. Let $cwnd_1$ and $cwnd_2$ be the values of the senders' congestion windows.



(a) What is the smallest value of $cwnd_1 + cwnd_2$ for which the link joining the two routers stays busy all the time?

(b) Assume that the link buffer overflows whenever $cwnd_1+cwnd_2 \geq 150$ KB and that at time t, $cwnd_1=30$ KB and $cwnd_2=120$ KB. Approximately, what are the values of $cwnd_1$ and $cwnd_2$ one RTT later? Also, what are the values of *ssthresh* for each of the two connections? Assume that all losses are detected by triple duplicate ACKs.

(c) After 8 more RTTs, approximately what are the values of $cwnd_1$ and $cwnd_2$?