

## ECE 461 – Internetworking Fall 2009

### Problem Sheet 5

**Problem 1.** Assume that we have a TCP connection between A and B. Assume that A uses slow start and congestion avoidance with the following initial values:

Congestion window (at time=0):  $cwnd=12$  segment.

Slow-start threshold:  $ssthresh=5$  segments.

For the purposes of this problem, assume that  $MSS=100$  Bytes.

Assume that the following events occur at A:

Time  $t = 0$ : A sends segment with 100 bytes to B, starting with  $SeqNo=0$ .

Time  $t = 1$ : A receives an ACK with  $AckNo=100$

Time  $t = 2$ : A sends segment with 100 bytes to B, starting with  $SeqNo=100$ .

Time  $t = 3$ : A sends segment with 100 bytes to B, starting with  $SeqNo=200$ .

Time  $t = 4$ : A receives an ACK with  $AckNo=100$ .

Time  $t = 5$ : A sends segment with 100 bytes to B, starting with  $SeqNo=300$ .

Time  $t = 6$ : A receives an ACK with  $AckNo=100$ .

Time  $t = 7$ : A sends segment with 100 bytes to B, starting with  $SeqNo=400$ .

Time  $t = 8$ : A receives an ACK with  $AckNo=100$ .

- a. Describe the actions performed by TCP Tahoe at time  $t=8$ , and describe the values of  $cwnd$  and  $ssthresh$  after the actions are performed.
- b. Describe the actions performed by TCP Reno at time  $t=8$ , and describe the values of  $cwnd$  and  $ssthresh$  after the actions are performed.
- c. For both TCP Tahoe and TCP Reno, describe the actions performed when a timeout occurs between times  $t=5$  and  $t=6$ .

**Problem 2.** Consider the state of a sliding window at the sending side of a TCP connections as shown in Figure 2. (Each number corresponds to one byte).

- (a) Explain the difference between the advertised window and the usable window.
- (b) Start with the state shown in Figure 2. How many bytes can be transmitted in the shown state? What are the sequence numbers of the bytes that can be transmitted?
- (c) Start with the state shown in Figure 2. Show how the advertised and usable windows change when the sender transmits a 2-byte long segment.
- (d) Start with the state shown in Figure 2. Show how the advertised and usable windows change when a segment with (*AckNo*=5, *Window size* = 5) is received.
- (e) Start with the state shown in Figure 2. Show how the advertised and usable windows change when a segment with (*AckNo*=3, *Window size* = 5) is received.

**Problem 3.** Consider a TCP connection that is transmitting over a 1 Gbps (Gigabit per second) with an average roundtrip time of 10 milliseconds. What is the maximum throughput of the TCP connection? How does the throughput change if the roundtrip time increases to 40 milliseconds?

- a) What is approximately the maximum possible throughput of the TCP connection? Explain your answer.
- b) How does the answer change when the average roundtrip time is increased to ms.

Figure 2.