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.

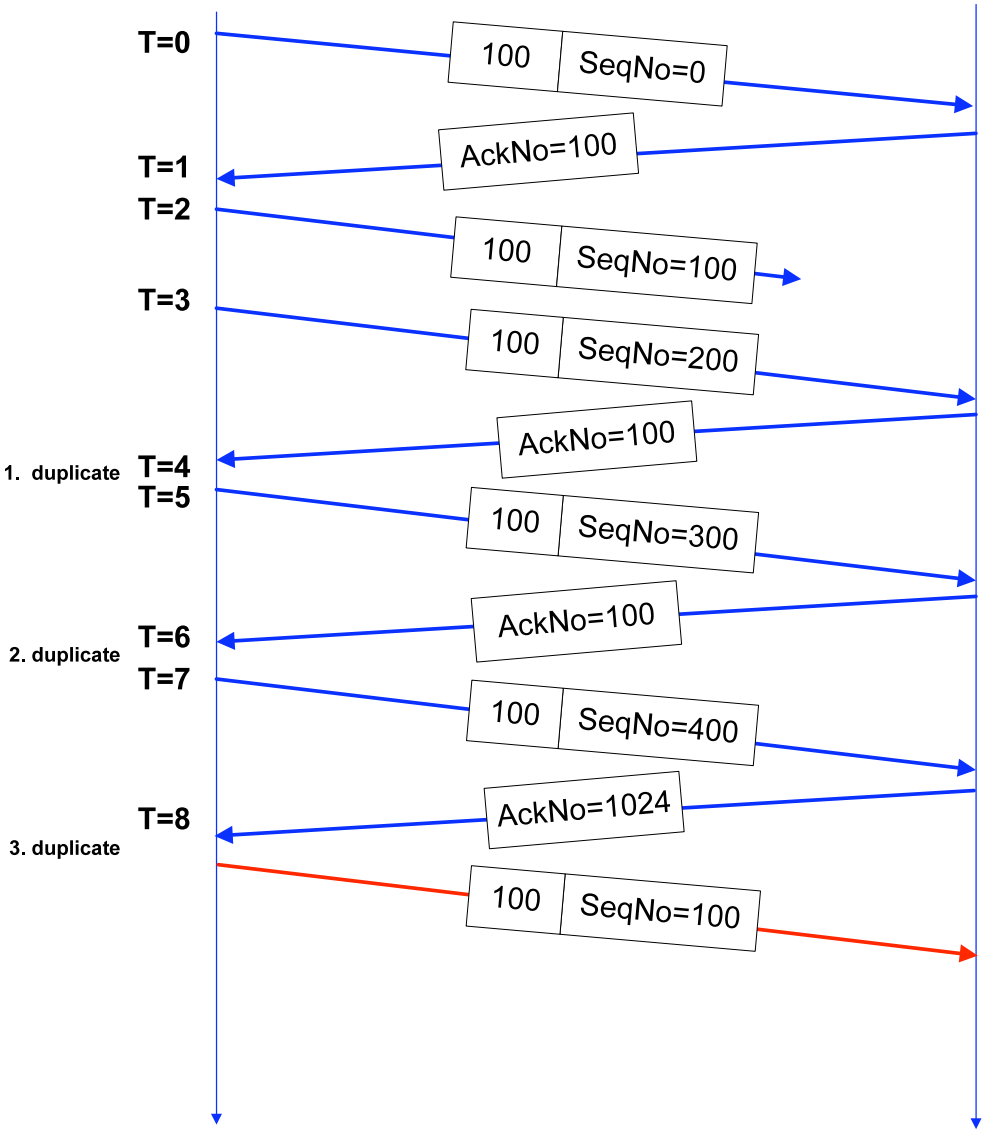
Assume that the following events occur at A:

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.


T=0
100
SeqNo=0
AckNo=100
T=1
T=2
100
SeqNo=100
T=3
100
SeqNo=200
AckNo=100
1. duplicate
T=4
T=5
100
SeqNo=300
AckNo=100
2. duplicate
T=6
T=7
100
SeqNo=400
AckNo=1024
T=8
3. duplicate
100
SeqNo=100

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.

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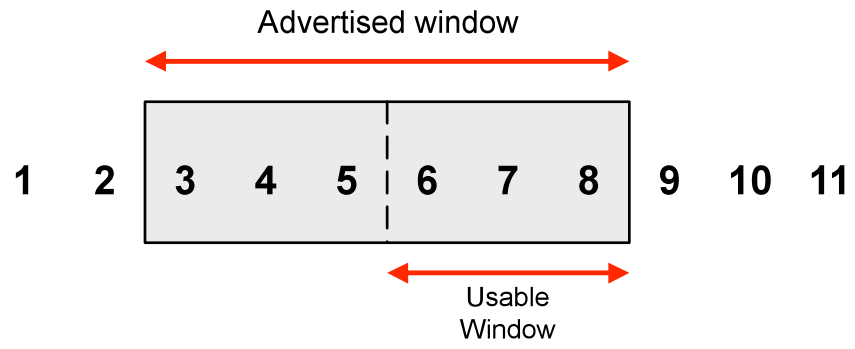
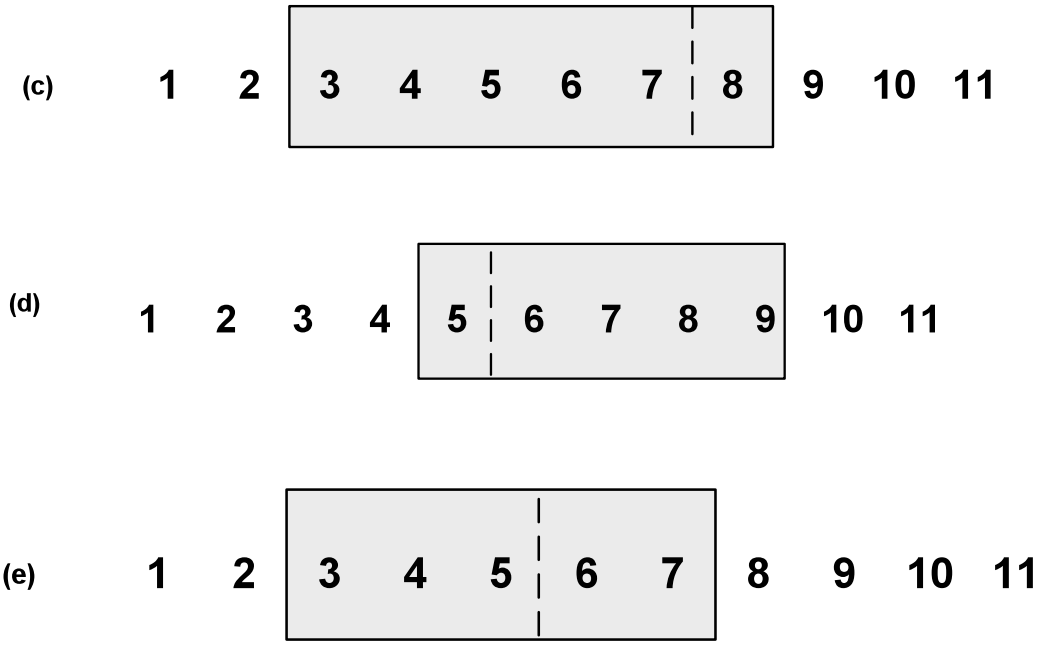


Figure 2.

(a) The advertised windows is the maximum number of unacknowledged bytes that the sender can transmit. The advertised window is set (=advertised) by the receiver. The usable windows is the advertised window minus the number of bytes which have been transmitted but have not been acknowledged.
(b) The sender can transmit 3 bytes with sequence number 6,7,8.



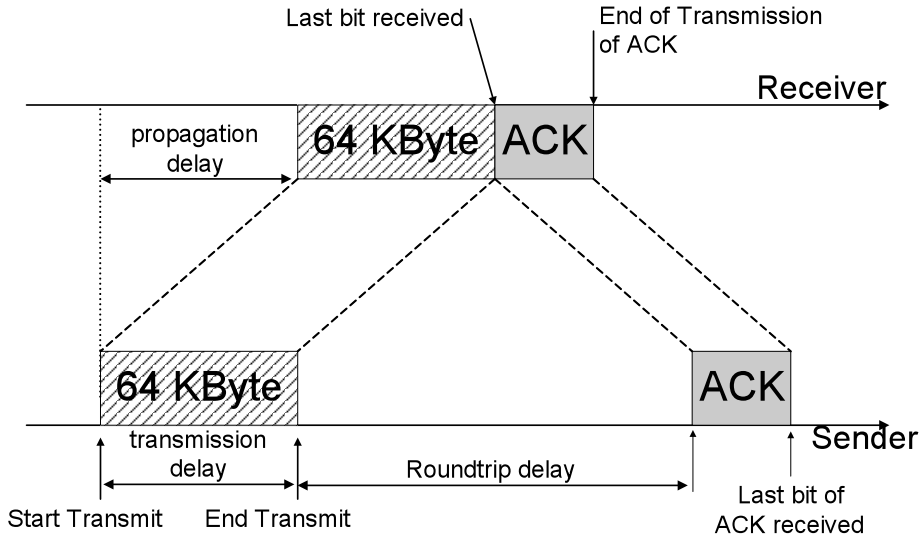
Problem 3. Consider a TCP connection that is transmitting over a 1 Gbps (Gigabit per second) with an average roundtrip time of 10 milliseconds. What is the maximum throughput of the TCP connection? How does the throughput change if the roundtrip time increases to 40 milliseconds?

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.

Solution:

Note: The solution below assumes an unlimited capacity. The problem statement has 1 Gbps capacity.

Since the capacity of the network is unlimited, the transmission delay of the data and the ACKs is zero. The figure shows a "round of transmission".



During one roundtrip time (20msec), the sender can transmit 64 KB) of data. We obtain:
Throughput = 64 KB/20 msec = 3.2MByte/sec = 25.6 Mbit/sec
When the propagation is doubled, the throughput is cut in half.