

50.012 Networks (2021 Term 6)

Homework 2

Hand-out: 7 Oct

Due: 19 Oct 23:59

Name: _____ Student ID: _____

1. (2019 midterm exam question) Consider data communication over a link of RTT 100ms and transmission bandwidth 1Gbit/s. Assume $1\text{G}=10^9$. Consider a pipelined transport protocol that uses ACKs to decide if packets were received successfully. Answer the following three questions:

1.1 After the protocol has sent a packet, what is the minimum amount of time needed for the protocol to infer that the packet was lost?

1.2 If the protocol uses a window size of 6 packets (each of size 1000 bytes), what is the maximum achievable data throughput?

1.3 To fully use the transmission bandwidth, estimate the minimum window size (in bytes) needed.

2. Consider the three 16-bit words (shown in binary) below.

01101001 11110110

11100011 00011100

10101010 10101010

What is the Internet checksum value for these three 16-bit words?

3. (textbook chapter 3, problem P44): Consider sending a large file from a host to another over a TCP connection that has no loss.

3.1 Suppose TCP uses AIMD for its congestion control without slow start. Assuming cwnd increases by 1 MSS every time a batch of ACKs is received and assuming approximately constant round-trip times, how long does it take for cwnd increase from 6 MSS to 12 MSS (assuming no loss events)?

3.2 Again, assume in the first RTT 6 MSS was sent, what is the average throughput (in terms of MSS and RTT) for this connection up through time = 6 RTT?

4. (textbook Chapter 3, problem 45 and 53) Recall the macroscopic description of TCP throughput. In the period of time from when the connection's rate varies from $W/(2 \cdot RTT)$ to W/RTT , only one packet is lost (at the very end of the period).

4.1 Show that the loss rate (fraction of packets lost) is equal to

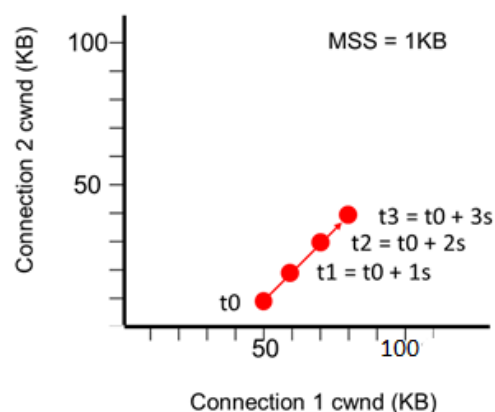
$$L = \text{loss rate} = \frac{1}{\frac{3}{8} W^2 + \frac{3}{4} W}$$

4.2 Use the result above to show that if a connection has loss rate L , then its average rate is approximately given by

$$\approx \frac{1.22 \cdot MSS}{RTT \sqrt{L}}$$

4.3 Let's assume 1500-byte packets and a 100 ms round-trip time. If TCP needed to support a 1Gbps connection, what would the tolerable loss rate be? How about 100Gbps?

5. (2020 midterm exam question) Consider two TCP Reno connections that share one link. The figure below shows the evolution of the size of their respective congestion window (cwnd) over time. As shown, at time t_0 , connection 1's cwnd = 50KB and connection 2's cwnd=10KB. At time $t_1=t_0+1s$, connection 1's cwnd = 60KB and connection 2's cwnd=20KB. At time $t_2=t_0+2s$, connection 1's cwnd = 70KB and connection 2's cwnd=30KB. At time $t_3=t_0+3s$, connection 1's cwnd = 80KB and connection 2's cwnd=40KB. Assume the maximum segment size (MSS) for both connections is 1KB and both connections have constant round-trip time (RTT). We further assume that when the sum of the cwnd of the two connections reaches 120KB, both connections experience a packet loss event as indicated by triple duplicate ACKs. We also assume these are the only moments that the two connections experience packet losses.



5.1 From time t_0 to t_3 , the two connections are in which state of the TCP congestion control? After the packet loss event at t_3 , what will be the cwnd size of connection 1 and connection 2 respectively?

5.2 What is the RTT for the two connections respectively? What is the respective average throughput of these two connections from t_0 to t_3 ?

5.3 Assume the two connections run for a long time. What will these two connections' respective average throughput converge to?

5.4 Assume now connection 1's RTT reduces by 50% and connection 2's RTT remains unchanged. After a long time, what will these two connections' respective average throughput converge to?