CS 118 Homework 5

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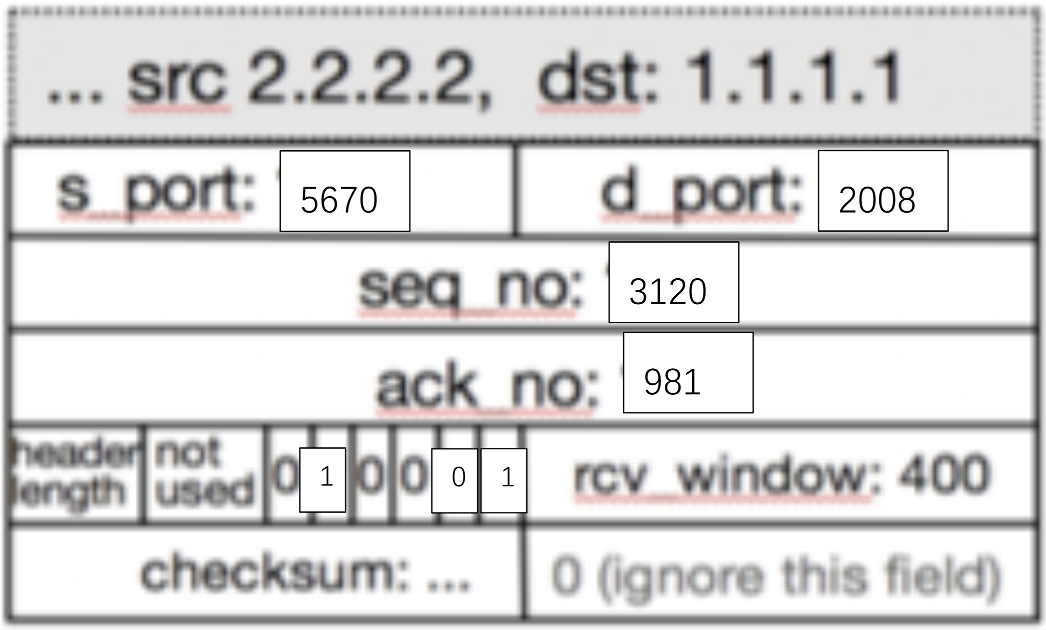
Problem 1

Given that the receive buffer's reading rate 50 Mbps is less than the sender's rate 120 Mbps, the receive buffer would gradually fill up. Then, when the buffer is nearly filled, the receiver advertises free buffer space by sending a segment to the sender with rwnd included in TCP header. Then, the sender would slow down or stop sending data to the receiver, and hence it is guaranteed that the received data will not overflow.

Problem 2



Problem 3

(a)

Along the time between the window size, the connection rate varies between $\frac{W}{2*RTT}$ and $\frac{W}{RTT}$, and there is only 1 packet loss occurs. In total, the number of packets sent in the cycle is $\frac{W}{2} + \left(\frac{W}{2} + 1\right) + L + W = \sum_{n=0}^{\frac{W}{2}} \left(\frac{W}{2} + n\right) = \left(\frac{W}{2} + 1\right) * \frac{W}{2} + \frac{\frac{W}{2}\left(\frac{W}{2}+1\right)}{2} = \frac{3}{8}W^2 + \frac{3}{4}W$. Then, the loss rate is the lost packet over the sent packets: L = $\frac{1}{\frac{3}{8}W^2+\frac{3}{4}W}$.

(b)

Given that L = $\frac{1}{\frac{3}{8}W^2+\frac{3}{4}W}$, we can see that $\frac{3}{8}W^2$ is much greater than $\frac{3}{4}W$ when W is very big. Then, L ≈ $\frac{1}{\frac{3}{8}W^2}$, so W ≈ $\sqrt{\frac{8}{3L}}$.

Thus the average rate is approximately = $\frac{3}{4} * \frac{W}{RTT} = \frac{3}{4} * \sqrt{\frac{8}{3L}}$*MSS/RTT ≈ $\frac{1.22*MSS}{RTT*\sqrt{L}}$.

Problem 4

(a)

To maximize the throughput, ReceiveWindow would be larger than Delay*Bandwidth. Then, ReceiveWindow ≥ Delay * Bandwidth = 400ms * 800Mbps = 320 Mbits = 3.2*10^8 bits = 4*10^7 bytes. Also, this is a byte stream protocol, so one bit for each byte. Since 2^25 is 33,554,432 < 4^10^7, and 2^26 is 67,108,864 > 4*10^7, then there would be at least **<u>26</u>** bits needed for the ReceiveWindow field.

To avoid same sequence number for different segments due to delay or segment loss, SequenceNum would be larger than maximum segment lifetime*Bandwidth. Then, SequenceNum≥maximum segment lifetime * Bandwidth = 25s * 800Mbps = 20000 Mbits = 2*10^10 bits = 2.5*10^9 bytes. Then, since 2^31 is 2,147,483,648 < 2.5*10^9 and 2^32 is 4,294,967,296 > 2.5*10^9, then there would be at least **<u>32</u>** bits needed for the SequenceNum field.

(b)

If ReceiveWindow is 16 bits, then there are up to 2^16 bits data been sent for each RTT. So, the effective bandwidth would be $\frac{ReceiveWindow}{RTT} = \frac{2^{16}bits}{400ms} = 163.84Kbps.$

Problem 5

When ACK 15 is received, the ssthreshold is 3 and cwnd is 4, with (15,16,17,18) in it. Here's process: