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Homework 2

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1. $1 * RTT = 100\,\text{ms}$
2. $Throughput = \frac{max-data}{RTT} = \frac{1000*6*8}{0.1} = 480\,\text{Kbps}$
3. $size = throughput * RTT = \frac{10^8}{8} = 1.25 \times 10^7\,\text{bytes}$

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$$\begin{aligned} &0110100111110110 \\ &+1110001100011100 \\ =\ &0100110100000011 \text{(1 wrap around)} \\ &+1010101010101010 \\ =\ &1111011110111101 \end{aligned}$$

Taking 1's complement, the internet checksum will be 0000100001000010.

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a. 1RTT to increase to 7MSS, 2RTT to increase to 8MSS. Following this pattern, we can extrapolate to see we will need 6RTT to increase to 12MSS.

b. Total MSS sent $= 6 + 7 + 8 + 9 + 10 + 11 + 12 = 51\,\text{MSS}$

   Average throughput $= \frac{51\,\text{MSS}}{6\,\text{RTT}} = 8.5\,\text{MSS/RTT}$

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1. Number of packets sent during this period,

$$\begin{aligned} \frac{W}{2} + (\frac{W}{2} + 1) + ... + W &= \sum_{n=0}^{W/2} (\frac{W}{2} + n) \\ &= (\frac{W}{2} + 1)\frac{W}{2} + \frac{\frac{W}{2} * \frac{W}{2} + 1}{2} \\ &= \frac{3}{8}W^2 + \frac{3}{4}W \end{aligned}$$

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

2. On average, W is very large, hence $\frac{3}{8}W^2 \gg \frac{3}{4}W$. Therefore, $L \approx \frac{8}{3W^2} \Rightarrow W \approx \sqrt{\frac{8}{3L}}$.

   Average throughput $= 0.75 * \sqrt{\frac{8}{3L}} = \frac{1.22*MSS}{RTT*\sqrt{L}}$

3. $$\begin{aligned} 1\,\text{Gbps} = 0.75 * \sqrt{\frac{8}{3L}} &= \frac{1.22 * 1500 * 8}{\sqrt{L} * 0.1} \\ \Rightarrow \sqrt{L} &= 14\,640 \times 10^{-9} \\ \therefore L &= 2.1433 \times 10^{-10} \end{aligned}$$

   For 100Gbps,

   $$\begin{aligned} 100\,\text{Gbps} = 0.75 * \sqrt{\frac{8}{3L}} &= \frac{1.22 * 1500 * 8}{\sqrt{L} * 0.1} \\ \Rightarrow \sqrt{L} &= 14\,640 \times 10^{-11} \\ \therefore L &= 2.1433 \times 10^{-14} \end{aligned}$$

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1. The two connections are in the "congestion avoidance" state.

   `cwnd` size of connection 1 after loss event $= \frac{80}{2} + 3 = 43\,\text{KB}$.

   `cwnd` size of connection 2 after loss event $= \frac{40}{2} + 3 = 23\,\text{KB}$.

2. Since the connection is in "congestion avoidance" state, cwnd should increase by 1 MSS every 1 RTT. We can see that the connection increases by 10 MSS (10 KB) every 1 second.

   Therefore RTT $= \frac{1}{10} = 0.1\,\text{seconds}$.

   Average for connection 1 $= \frac{(50+80)*8*10^3}{2*0.1} = 5.2\,\text{Mbps}$

   Average for connection 2 $= \frac{(10+40)*8*10^3}{2*0.1} = 2\,\text{Mbps}$

3. For both connections,

   $$\frac{3}{4} * \frac{60 * 8 * 10^3}{0.1} = 3.6\,\text{Mbps}$$

4. For connection 1, `cwnd` will move between 20 KB and 40 KB.

   $$\therefore \frac{3}{4} * \frac{40 * 8 * 10^3}{0.2} = 1.2\,\text{Mbps}$$

   For connection 2, `cwnd` will move between 40 KB and 80 KB.

   $$\therefore \frac{3}{4} * \frac{80 * 8 * 10^3}{0.1} = 4.8\,\text{Mbps}$$