

Homework 4

1. These ACK packets do not need sequence numbers because the rdt3.0 protocol uses a stop-and-wait procedure, so all the packets must be in order when they are sent and ACK'd.

2.

a) If the receiver is expecting the sequence  $k$ , and the window size is 3, the latest ACK is must've sent could have been  $k - 1$ . Because the window size is 3, the earliest ACK that could be sent is  $k - 3 - 1$ , which is  $k - 4$ . With these two, we know that the possible ACK's being sent back is between  $k - 4$  and  $k - 1$ .

b) If the receiver is expecting the sequence  $k$  next, that means it must have sent ACK's up until  $k - 1$ . If none of those ACK's have been received by the sender, the sender's sequence numbers would be between  $k - N = k - 3$  and  $k - 1$ . Next, if the sender received all of those ACK's, that means that the next sequence numbers would be between  $k$  and  $k + N - 1 = k + 2$ .

3.

a) The minimum possible latency = 2 RTT's + size of object/transmission rate.

The minimum  $W$  that achieves that is:

$$\frac{RTT + S/R}{S/R}$$

Plugging in 28 kbps to the first equation, we get:

$$2 * .1 + \frac{100000}{3500} = 28.77 \text{ seconds}$$

To get the minimum  $W$ , we plug in the values to the second equation:

$$\frac{.1 + 536 / (\frac{28000}{8})}{536 / (\frac{28000}{8})} = 1.6$$

So the minimum window size is 2.

b) The minimum latency for 100 kbps is:

$$2 * .1 + \frac{100000}{100000} = 2 * .1 + 8 = 8.2 \text{ seconds}$$

To get the minimum window size:

$$\frac{.1 + 536 / (\frac{100000}{8})}{536 / (\frac{100000}{8})} = 3.33$$

So the minimum window is 4.

c) The minimum latency for 10 Mbps is:

$$2 * .1 + \frac{100000}{\left(\frac{10000000}{8}\right)} = 2 * .1 + .08 = .28 \text{ seconds}$$

To get the minimum window size:

$$\frac{.1 + 536/\left(\frac{10000000}{8}\right)}{536/\left(\frac{10000000}{8}\right)} = 234.21$$

So the minimum window is 235.

4.

a)  $SRTT = (.9 * (.9 * (.9 * SampleRTT_1 + .1 * SampleRTT_2) + .1 * SampleRTT_3) + .1 * SampleRTT_4)$

b)  $SRTT_n = .9 * SRTT_{n-1} + .1 * SampleRTT_n$