IK1203
Networks and Communication

Recitation 2 – Transport layer

Solutions

1.

a) Because the retransmission timer can then expire and cause an unnecessary retransmission.
b) The receiver will immediately send an ACK (no more delay). This is what causes the typical "ACK every other segment" pattern in case of bulk transfers over TCP.

2. Flow control is a way for the receiver to regulate the sender's transmission pace. The purpose is to prevent the receiver from becoming overwhelmed with more data than it can process. Congestion control deals with the situation when packets are dropped by routers along the path between sender and receiver. The purpose of TCP congestion control is to regulate the sender's transmission pace based on the current network conditions.

3.

a) A window of data can be sent every 20th ms. It gives a maximum throughput of:
$(65535 * 8)/(20*10^{-3})$ bps = 26 214 000 bps (≈ 26 Mbps).
b) Channel utilization = 26 214 000/1 000 000 000 ≈ 2,6%

4. 35 ms. TCP begins in slow start by first sending 2 kB. After one RTT TCP will send 4kB; after two RTT TCP will send 8 kB; after 3 RTT TCP will send the last 1 kB of data (2+4+8+1 = 15). The last kB will reach the server application 5 ms later. So, in total: 3 * RTT + RTT/2 = 35 ms.

5.

a) Slow start: [1, 6] and [23, 26]
b) Congestion avoidance: [6, 16] and [17, 22].
c) In this case, the packet loss is detected through three duplicate ACKs. This can be concluded since TCP goes to fast recovery and reduces the congestion window to half (roughly) the current size. If the packet loss had been detected through a timeout, TCP would go to slow start and reduced the congestion window to 1 MSS.
d) After the 22nd transmission round, segment loss is detected due to timeout, and hence the congestion window size is set to 1.
e) The threshold is initially 32, since it is at this window size that slow start stops and congestion avoidance begins.
f) The threshold is set to half the value of the congestion window when packet loss is detected. When loss is detected during transmission round 16, the congestion windows size is 42. Hence the threshold is 21 during the 18th transmission round.
g) The threshold is set to half the value of the congestion window when packet loss is detected. When loss is detected during transmission round 22, the congestion windows size is 29. Hence the threshold is 14 (taking lower floor of 14.5) during the 24th transmission round.
h) During the 1st transmission round, packet 1 is sent; packet 2-3 are sent in the 2^{nd} transmission round; packets 4-7 are sent in the 3rd transmission round; packets 8-15 are sent in the 4th transmission round; packets 16-31 are sent in the 5th transmission round; packets 32-63 are sent in the 6th

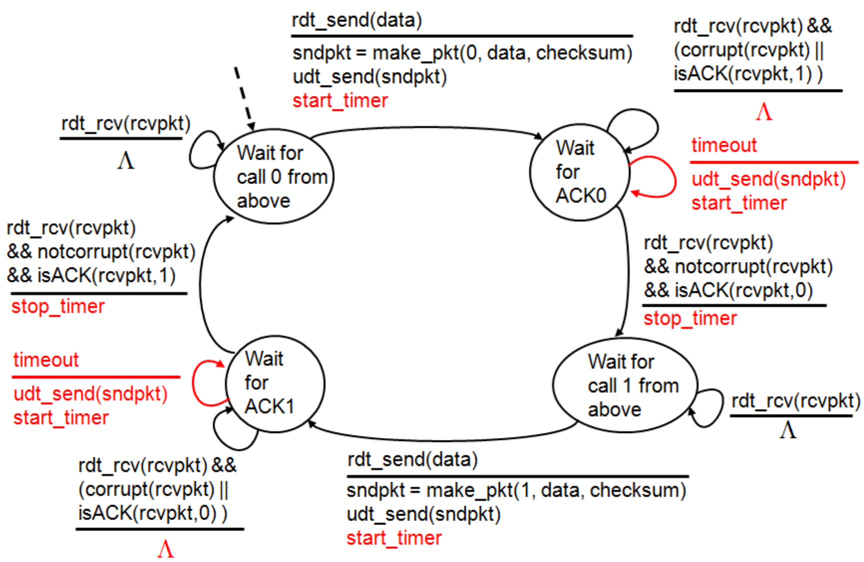
transmission round; packets 64 – 96 are sent in the 7th transmission round. Thus packet 70 is sent in the 7th transmission round.

i) The threshold will be set to half the current value of the congestion window (8) when the loss occurred and congestion window will be set to the new threshold value + 3 MSS. Thus the new values of the threshold and window will be 4 and 7 respectively.

j) Threshold is 21, and congestion window size is 1.

k) Round 17, 1 packet; round 18, 2 packets; round 19, 4 packets; round 20, 8 packets; round 21, 16 packets; round 22, 21 packets. So, the total number is 52.

6. The finite state machine is illustrated below. The receiver's FSM is not changed when the timer-based retransmission mechanism is introduced.



Problems from course book (Kurose and Ross, 7th ed), Solutions

P45.

a) The loss rate, L, is the ratio of the number of packets lost over the number of packets sent. In a cycle, 1 packet is lost. The number of packets sent in a cycle is

$$\frac{W}{2} + \left(\frac{W}{2} + 1\right) + \cdots + W = \sum_{n=0}^{W/2} \left(\frac{W}{2} + n\right)$$

$$= \left(\frac{W}{2} + 1\right)\frac{W}{2} + \sum_{n=0}^{W/2} n$$

$$= \left(\frac{W}{2} + 1\right)\frac{W}{2} + \frac{\frac{W}{2}(\frac{W}{2} + 1)}{2}$$

$$= \frac{W^2}{4} + \frac{W}{2} + \frac{W^2}{8} + \frac{W}{4}$$

$$= \frac{3}{8}W^2 + \frac{3}{4}W$$

Thus the loss rate is

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

b) For W large, $\frac{3}{8}W^2 \gg \frac{3}{4}W$. Thus $L \approx \frac{3}{8}W^2$ or $W \approx \sqrt{\frac{8}{3L}}$. From the text, we therefore have average throughput

$$= \frac{3}{4}\sqrt{\frac{8}{3L}} \times \frac{MSS}{RTT}$$

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

P46.

a) Let W denote the max window size measured in segments. Then, W*MSS/RTT = 10 Mbps, as packets will be dropped if the maximum sending rate exceeds link capacity. Thus, we have W*1500*8/0.15=10*10^6, then W is about 125 segments.
b) As congestion window size varies from W/2 to W, then the average window size is 0.75W=94 (ceiling of 93.75) segments. Average throughput is 94*1500*8/0.15 = 7.52 Mbps.
c) 94/2 *0.15 = 7.05 seconds, as the number of RTTs (that this TCP connections needs in order to increase its window size from W/2 to W) is given by W/2. Recall the window size increases by one in each RTT.