Principles of Computer Networks

Tutorial 7

Problem 1 Solution:

Based on the figure and since $\frac{P_{a1}}{P_{d1}} = \frac{1}{2}$ and $\frac{P_{a2}}{P_{d2}} = \frac{1}{3}$:

$P_0 = 2P_1$ $\quad$ $P_0 = 3P_2$ $\quad$ (1)

Also, $P_0 + P_1 + P_2 = 1$ $\quad$ (2)

(1) and (2) ==> $P_0 + P_0/2 + P_0/3 = 1$

==> $11P_0/6 = 1$ ==> $P_0 = 6/11$ $\quad$ $P_1 = 3/11$ $\quad$ $P_2 = 2/11$

In other words: $P_0 \cong 0.55$ $\quad$ $P_1 \cong 0.27$ $\quad$ $P_2 \cong 0.18$

Problem 2 Solution:

$$EstimatedRTT = xSampleRTT + (1-x)EstimatedRTT$$

$$DevRTT = y|SampleRTT - EstimatedRTT| + (1-y)DevRTT$$

$$TimeoutInterval = EstimatedRTT + 4 * DevRTT$$

After obtaining first sampleRTT is

$$EstimatedRTT = 0.125*106 + 0.875*100 = 100.75ms.$$

$$DevRTT = 0.25*|106 - 100.75| + 0.75*5 = 5.06ms.$$

$$TimeoutInterval = 100.75 + 4*5.06 = 120.99ms.$$

After obtaining second sampleRTT = 120ms:

$$EstimatedRTT = 0.125*120 + 0.875*100.75 = 103.15ms.$$

$$DevRTT = 0.25*|120 - 103.15| + 0.75*5.06 = 8ms.$$

$$TimeoutInterval = 103.15 + 4*8 = 135.15ms.$$

After obtaining Third sampleRTT = 140ms:

$$EstimatedRTT = 0.125*140 + 0.875*103.15 = 107.76ms.$$

$$DevRTT = 0.25*|140 - 107.76| + 0.75*8 = 14.06ms.$$

$$TimeoutInterval = 107.76 + 4*14.06 = 164ms.$$

Problem 3 Solution:

a) GoBackN:

A sends 9 segments in total. They are initially sent segments 1, 2, 3, 4, 5 and later re-sent segments 2, 3, 4, and 5.

B sends 8 ACKs. They are 4 ACKS with sequence number 1, and 4 ACKS with sequence numbers 2, 3, 4, and 5.

Selective Repeat:

A sends 6 segments in total. They are initially sent segments 1, 2, 3, 4, 5 and later re-sent segments 2.

B sends 5 ACKs. They are 4 ACKS with sequence number 1, 3, 4, 5. And there is one ACK with sequence number 2.

TCP:

A sends 6 segments in total. They are initially sent segments 1, 2, 3, 4, 5 and later re-sent segments 2.

B sends 5 ACKs. They are 4 ACKS with sequence number 2. There is one ACK with sequence numbers 6. Note that TCP always send an ACK with expected sequence number.

b) TCP. This is because TCP uses fast retransmit without waiting until time out.

Problem 4 Solution:

a) It takes 1 RTT to increase CongWin to 6 MSS; 2 RTTs to increase to 7 MSS; 3 RTTs to increase to 8 MSS; 4 RTTs to increase to 9 MSS; 5 RTTs to increase to 10 MSS; 6 RTTs to increase to 11 MSS; and 7 RTTs to increase to 12MSS.

b) In the first RTT 5 MSS was sent; in the second RTT 6 MSS was sent; in the third RTT 7 MSS was sent; in the fourth RTT 8 MSS was sent; in the fifth RTT, 9 MSS was sent; and in the sixth RTT, 10 MSS was sent. Thus, up to time 6 RTT, 5+6+7+8+9+10 = 45 MSS were sent (and acknowledged). Thus, we can say that the average throughput up to time 6 RTT was (45 MSS)/(6 RTT) = 7.5 MSS/RTT.

Problem 5 Solution:

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

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

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

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

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

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

Thus the loss rate is

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

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

average throughput $= \frac{3}{4}\sqrt{\frac{8}{3L}} \cdot \frac{MSS}{RTT} = \frac{1.22 \cdot MSS}{RTT \cdot \sqrt{L}}$.