**COL-334/CSL-374/CSL-672: Assignment 3, Semester 2014-2015**

1. Show that in a steady state TCP connection working in the congestion avoidance phase, the throughput ~ 1.22 x MSS /(RTT x sqrt(L), where RTT is the round trip time, MSS is the maximum segment size, and L is the loss rate

Note that in the congestion avoidance phase, all losses are assumed to be detected through fast retransmits and not timeouts, hence the congestion window rises additively and falls to half its value in a saw-tooth pattern.

Hint: If N packets are sent between two consecutive packet loss events, assume that the events happen due to the loss of only one packet in each event, hence the loss rate can be written as 1/N.

Solution:

At steady state, **the congestion window grows linearly one packet (1 MSS) per RTT** and when there is a loss event, **congestion window is set to half its previous value.**

Initial congestion window size = c  
Final congestion window size = 2c  
We know that the congestion window grows linearly one packet (1 MSS) per RTT. Therefore for congestion window to become 2c from c, it will take c \* RTT time.

Total bytes sent = c \* RTT \* Throughput. 🡪 (1)

We know that the number of packets pumped in the network b/w two losses,

N = c^2 + c(c+1)/2

As c+ 1 ~= c, N = 1.5\*c^2

Total bytes sent = N \* MSS = (1.5\*c^2) \* MSS 🡪(2)

Equating (1) and 2 and substituting c in terms of L (loss rate).

L = 1/N = 1 / (1.5\*c^2)

On rearranging, C = 0.812 / sqrt(L) --- (3)

c \* RTT \* Throughput = (3c^2/2) \* MSS

Throughput = 3c\*MSS/ (2\*RTT) = 3\*0.812\*MSS/ (2\*sqrt (L)\*RTT) = 1.22\*MSS/RTT\*sqrt (L)