1) Consider the effect of using slow start on a line with a 10 msec RTT and no congestion. The receiver window is 24 KB and the maximum segment size is 2 KB. How long does it take before the first full window can be sent?

Solution-

Given-

- Receiver window size = 24 KB
- Maximum Segment Size = 2 KB
- RTT = 10 msec

Receiver Window Size-

Receiver window size in terms of MSS

= Receiver window size / Size of 1 MSS

= 24 KB / 2 KB

= 12 MSS

Slow Start Threshold-

Slow start Threshold

= Receiver window size / 2

= 12 MSS / 2

= 6 MSS

Slow Start Phase-

Window size at the start of 1^{st} transmission = 1 MSS

- Window size at the start of 2^{nd} transmission = 2 MSS
- Window size at the start of 3^{rd} transmission = 4 MSS
- Window size at the start of 4^{th} transmission = 6 MSS

Since the threshold is reached, so it marks the end of slow start phase.

Now, congestion avoidance phase begins.

Congestion Avoidance Phase-

Window size at the start of 5^{th} transmission = 7 MSS

- Window size at the start of 6^{th} transmission = 8 MSS
- Window size at the start of 7^{th} transmission = 9 MSS

- Window size at the start of 8^{th} transmission = 10 MSS
- Window size at the start of 9^{th} transmission = 11 MSS
- Window size at the start of 10^{th} transmission = 12 MSS

From here,

- Window size at the end of 9^{th} transmission or at the start of 10^{th} transmission is 12 MSS.
- Thus, 9 RTT's will be taken before the first full window can be sent.

So,

Time taken before the first full window is sent

= 9 RTT's

= 9 x 10 msec

= 90 msec

2) Consider an instance of TCP's Additive Increase Multiplicative Decrease (AIMD) algorithm where the window size at the start of slow start phase is 2 MSS and the threshold at the start of first transmission is 8 MSS. Assume that a time out occurs during the fifth transmission. Find the congestion window size at the end of tenth transmission.

Solution-

Given-

- Window size at the start of slow start phase = 2 MSS
- Threshold at the start of first transmission = 8 MSS
- Time out occurs during 5th transmission

Slow Start Phase-

Window size at the start of 1^{st} transmission = 2 MSS

- Window size at the start of 2^{nd} transmission = 4 MSS
- Window size at the start of 3^{rd} transmission = 8 MSS

Since the threshold is reached, so it marks the end of slow start phase.

Now, congestion avoidance phase begins.

Congestion Avoidance Phase-

Window size at the start of 4^{th} transmission = 9 MSS

- Window size at the start of 5^{th} transmission = 10 MSS

It is given that time out occurs during 5th transmission.

TCP reacts by-

- Setting the slow start threshold to half of the current congestion window size.
- Decreasing the congestion window size to 2 MSS (Given value is used).
- Resuming the slow start phase.

So now,

- Slow start threshold = 10 MSS / 2 = 5 MSS
- Congestion window size = 2 MSS

Slow Start Phase-

Window size at the start of 6^{th} transmission = 2 MSS

- Window size at the start of 7^{th} transmission = 4 MSS
- Window size at the start of 8^{th} transmission = 5 MSS

Since the threshold is reached, so it marks the end of slow start phase.

Now, congestion avoidance phase begins.

Congestion Avoidance Phase-

Window size at the start of 9^{th} transmission = 6 MSS

- Window size at the start of 10^{th} transmission = 7 MSS
- Window size at the start of 11^{th} transmission = 8 MSS

From here,

Window size at the end of 10^{th} transmission

= Window size at the start of 11^{th} transmission

= 8 MSS

3) Suppose that the TCP congestion window is set to 18 KB and a time out occurs. How big will the window be if the next four transmission bursts are all successful? Assume that the MSS is 1 KB.

Solution-

Congestion Window Size-

Congestion window size in terms of MSS

= 18 KB / Size of 1 MSS

= 18 KB / 1 KB

= 18 MSS

Reaction Of TCP On Time Out-

TCP reacts by-

- Setting the slow start threshold to half of the current congestion window size.
- Decreasing the congestion window size to 1 MSS.
- Resuming the slow start phase.

So now,

- Slow start threshold = 18 MSS / 2 = 9 MSS
- Congestion window size = 1 MSS

Slow Start Phase-

Window size at the start of 1^{st} transmission = 1 MSS

- Window size at the start of 2^{nd} transmission = 2 MSS
- Window size at the start of 3^{rd} transmission = 4 MSS
- Window size at the start of 4^{th} transmission = 8 MSS
- Window size at the start of 5^{th} transmission = 9 MSS

Thus, after 4 successful transmissions, window size will be 9 MSS or 9 KB.