Computer Networks - CS 214

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The goal of this experiment was to emulate the TCP Congestion Control Algorithm where we dynamically varied the sender's congestion window size as per the congestion control algorithm and then plot the change of CW with respect to number of updates made to CW.

It is to be noted that Go-back-N congestion control method has been used, but cumulative acknowledgments are not considered. For each segment, an individual timeout timer and ACK are used.

Throughout the emulation, the number of segments is set to be **40**. The main parameters through which variation in CW size was varied were as follows:

- Ki, the constant which alters the initial CW.
- Km, the multiplier constant of the CW during the exponential growth phase.
- Kn, the multiplier constant of the CW during the linear growth phase.
- Kf, the multiplier constant when the timeout occurs.
- Ps, the probability of receiving the ACK packet for a given segment before its timeout occurs.

The other variables that were involved emulating the Congestion Control Algorithm were as follows:

- CW $\rightarrow$ Congestion Window Size, dynamically changing throughout the emulation.
- MSS $\rightarrow$ Maximum Segment Size is set to **1 KB/4 KB** depending upon user's choice.
- RWS $\rightarrow$ Receiver Window Size is set to **1 MB**.
- N $\rightarrow$ A parameter defined whose value is $\lceil \frac{CW}{MSS} \rceil$.

In the equations, the notation is as per the programming logic. [Same variable on either side of the equation denotes that the variable appearing in the RHS takes its old value and is dynamically changes in the program.]

The ssthresh is the Threshold Limit which is threshold limit considered during the complete emulation of Congestion Control Algorithm. ssthresh is set to **2 KB**.

All the equations used in this report are in correspondence with the research papers provided and are completely proved and verified.

1 Variation of Congestion Window Size with Ki

As it is evident from above mentioned points that, Ki is triggering the changes in the initial congestion window. The variation in Ki was done with other parameters set as follows:

- Km = 2
- Kn = 0.5
- Kf = 0.5
- Ps = 0.03

The iterating values for Ki were:

- Ki value for generation of ki_1.txt was 1.
- Ki value for generation of ki_2.txt was 2.
- Ki value for generation of ki_3.txt was 3.
- Ki value for generation of ki_4.txt was 4.

From Figure 1, it is evident that $CW_{initial}$ is increasing with increasing values of Ki. This further is substantiated by the equation:

$$CW = Ki \times MSS$$

Since Ki is increasing and CW is directly proportional to Ki whilst MSS being constant, CW also increases.

2 Variation of Congestion Window Size with Km

As it is evident from above mentioned points that, Km is the multiplier that is changing initial Congestion Window in the exponential growth phase. The variation in Ki was done with other parameters set as follows:

- Ki = 1
- Kn = 0.5

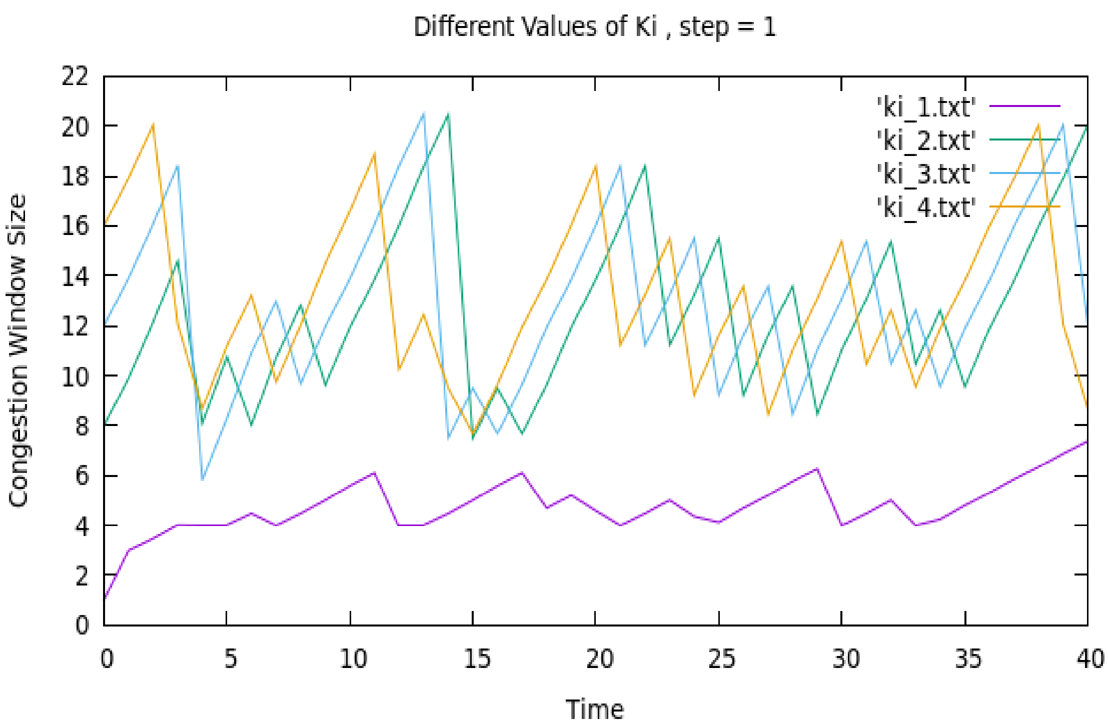

Figure 1: Variation of CW with varying Ki

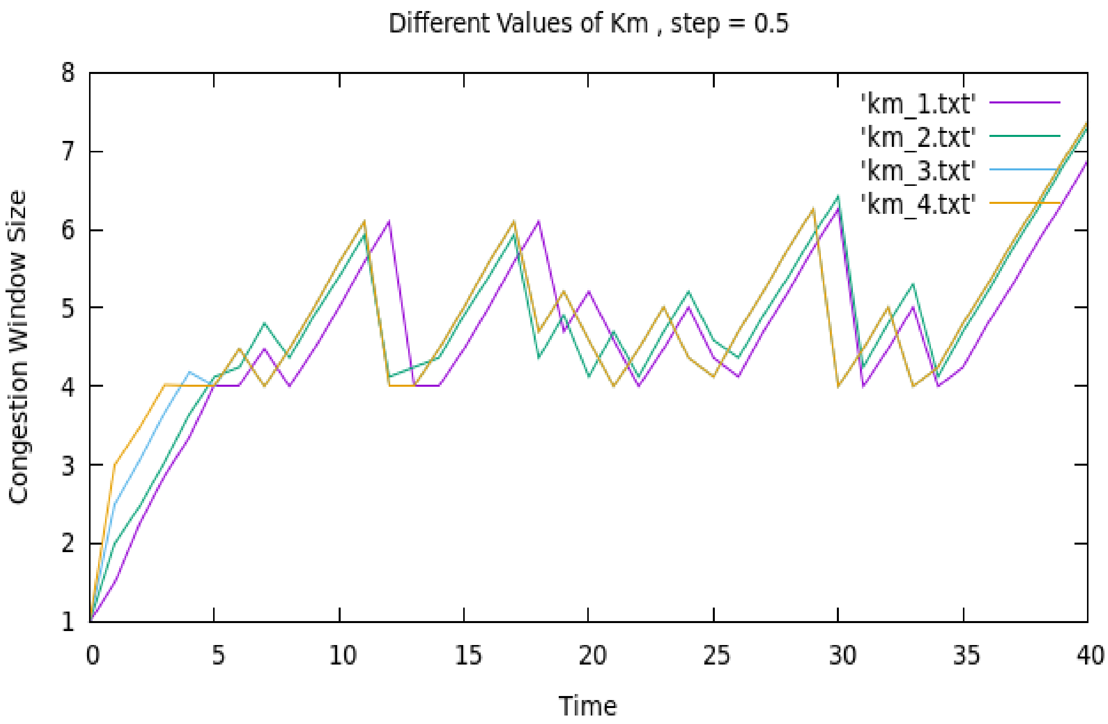

Figure 2: Variation of CW with varying Km

- Kf = 0.5
- Ps = 0.03

The iterating values for Km were:

- Km value for generation of km_1.txt was 0.5.
- Km value for generation of km_2.txt was 1.
- Km value for generation of km_3.txt was 1.5.
- Km value for generation of km_4.txt was 2.

From Figure 2, it is evident that CW is exponentially increasing and nearly converged to same values of CW for different values of Km. Furthermore, the whole variation of CW over different values of Km nearly resulted in same curves of CW vs. Time.

This is governed by the equation:

$$CW = min(CW + Km \times MSS, RWS)$$

Since the CW is governed by Km and old CW and clearly Km is positive and greater than 1, so in the exponential phase it is increasing. Further more we see its range is in between 4 and 7 only. This is due to RWS factor in the above equation. It saturates further increase and if the congestion occurs there, it is by equations that ssthresh will become half of CW and CW will be set there.

3 Variation of Congestion Window Size with Kn

As it is evident from above mentioned points that, Kn is the multiplier that is changing initial Congestion Window in the linear growth phase.

The variation in Ki was done with other parameters set as follows:

- Ki = 1
- Km = 2
- Kf = 0.5
- Ps = 0.03

The iterating values for Km were:

- Kn value for generation of kn_1.txt was 0.5.
- Kn value for generation of kn_2.txt was 1.
- Kn value for generation of kn_3.txt was 1.5.
- Kn value for generation of kn_4.txt was 2.

From Figure 3, it is evident that CW is exponentially increasing and nearly converged to same values of CW for different values of Km. But the variation over the time is very non uniform.

This is governed by the equation:

$$CW = min(CW + Kn \times MSS \times \frac{MSS}{CW}, RWS)$$

This is due to involvement of other variables such as CW and MSS. Due to dynamically changing value of CW, the non-uniform are generated. However at the end we see that all the curves nearly converge to the same values of CW.

4 Variation of Congestion Window Size with Kn

As it is evident from above mentioned points that, Kf is the constant that triggers the changes in the Congestion Window when congestion occurs.

The variation in Kf was done with other parameters set as follows:

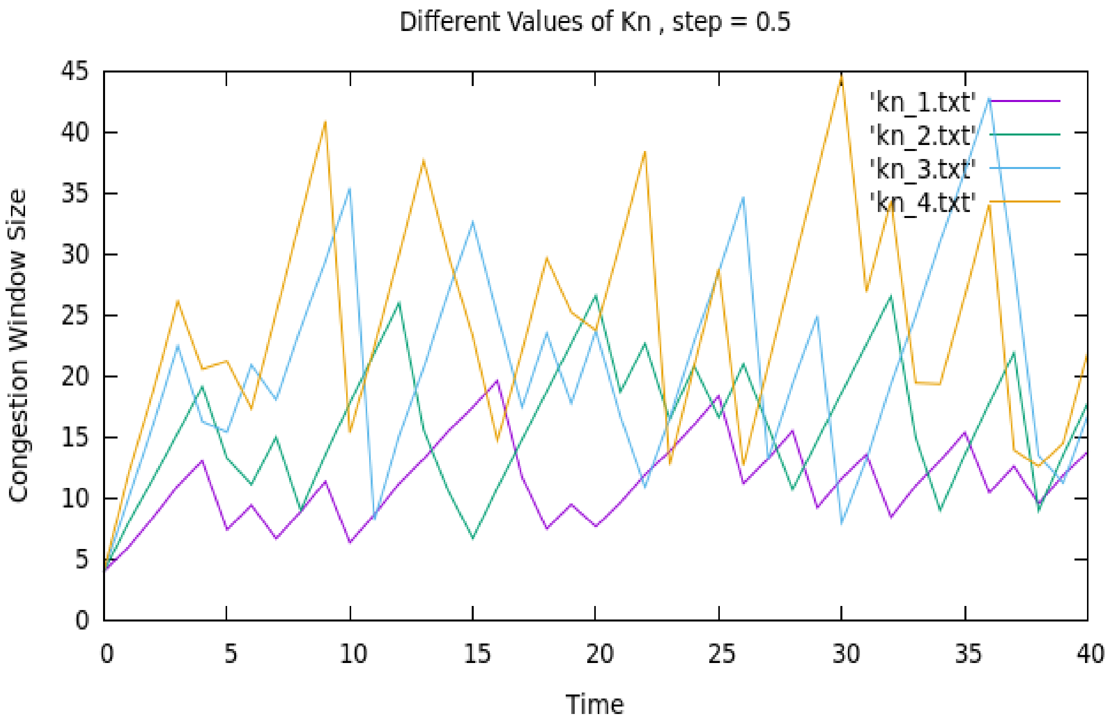

Figure 3: Variation of CW with varying Kn

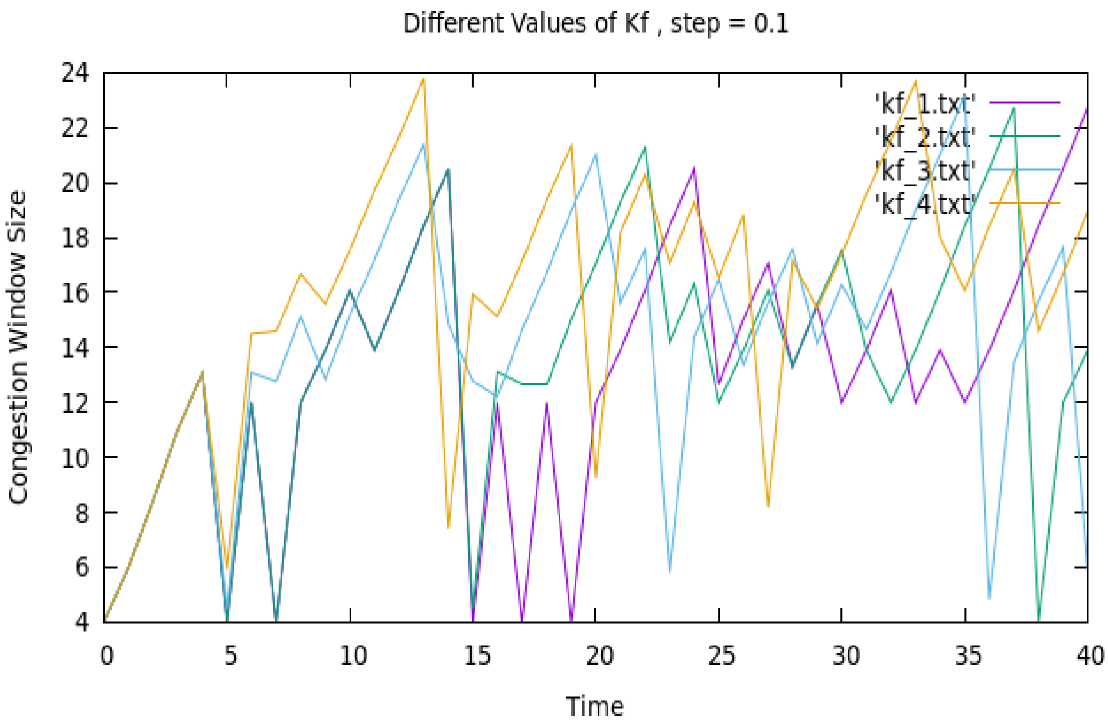

Figure 4: Variation of CW with varying Kf

- Ki = 1
- Km = 2
- Kn = 0.5
- Ps = 0.03

The iterating values for Kf were:

- Kf value for generation of kf_1.txt was 0.1.
- Kf value for generation of kf_2.txt was 0.2.
- Kf value for generation of kf_3.txt was 0.3.
- Kf value for generation of kf_4.txt was 0.5.

From Figure 4, it is evident that CW is uniformly increasing till the 1^{st} congestion has occurred. After that the variation is very random.

This is governed by the equation:

$$CW = max(1, Kf \times CW)$$

As it depends on Kf passed in CLI and also the random number generated between 0 and 1 to compare it with Ps. Basically, there is a contribution of $rand()$ in the decision whether the congestion is going to occur or not.

5 Variation of Congestion Window Size with Ps

As it is evident from above mentioned points that, Ps is the probability of receiving the ACK packet for a given segment before its timeout occurs.

The variation in Ps was done with other parameters set as follows:

- Ki = 1
- Km = 2
- Kn = 0.5
- Kf = 0.5

The iterating values for Ps were:

- Ps value for generation of ps_1.txt was 0.1.
- Ps value for generation of ps_2.txt was 0.2.
- Ps value for generation of ps_3.txt was 0.3.
- Ps value for generation of ps_4.txt was 0.4.

From Figure 5, it is evident that CW is varying non-uniformly.

This is governed by the equation:

$$Ps \in [0, 1]$$

We can see that greater the value of Ps, greater are the chances of congestion.

If the r $<$ Ps, then Congestion occurs, where r is the random number generated by rand() function and r $\in$ [0,1].

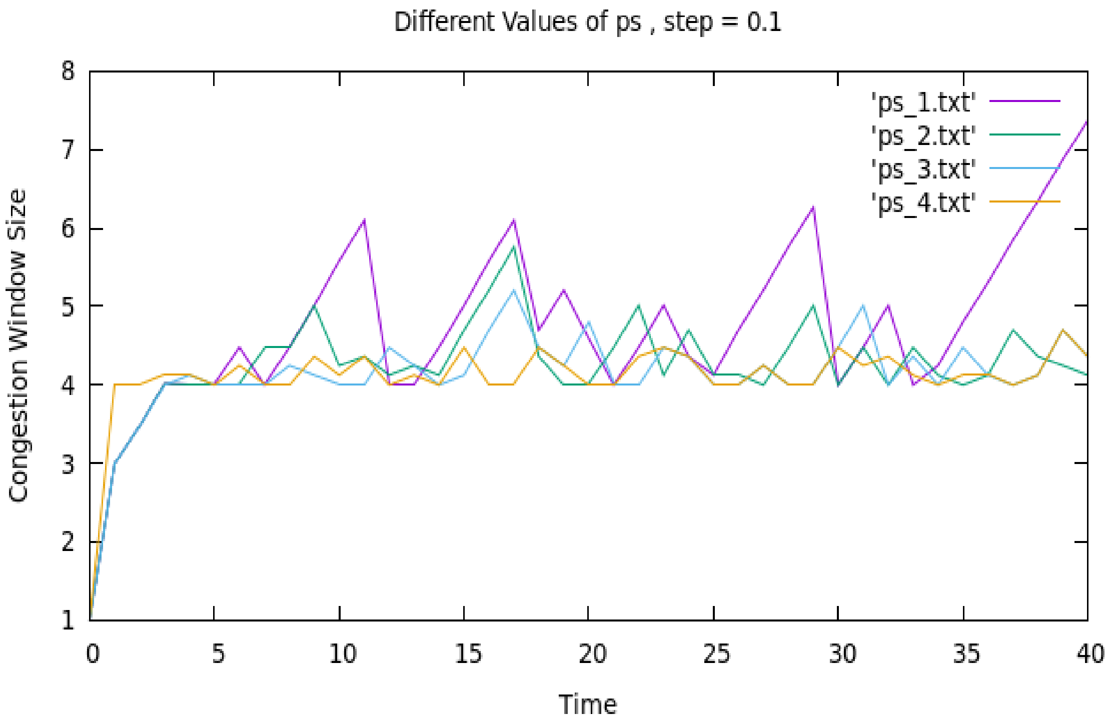

Figure 5: Variation of CW with varying Ps