CS 224 Programming Assignment -2

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1.

- **Average Throughput: 4.43953883332 Mbps**
  Maximum Expected Value = Link Bandwidth = 5 Mbps
  The average throughput is not approximately equal to the maximum achieved because :
  - Average throughput is the rate of successful bit transfer rate, therefore the dropped packages are not taken in account, whereas maximum expected value does count the dropped package.
  - Moreover the acknowledgements share the bandwidth, hence reducing the average throughput.
- **No. of times cwnd was decreased by tcp : 46**
  By graph we can see that tcp reduced cwnd 14 times when it enters fast recovery because of recieving 3 dupacks . This may happen when the buffer is full but still the sender send packets.
  The rest of the times cwnd reduced was during the start where it searched for optimal cwnd, these drops were due to the logic used in the tcp version used.

2.

- **Average Throughput: 14.5661374308 Mbps**
  Maximum Expected Value = Link Bandwidth = 50 Mbps
  The average throughput is **not** approximately equal to the maximum because :
  - Throughput depends on all types of delay: transmission, propagation, processing and queueing delay. Moreover at larger bandwidth , throughput is prominently dependent on link delay(propagation delay), as observed below.
- **Changing parameters:**
  - **Delay :** Decreasing delay increases avg at
    - Delay = 1ms Avg= 36.6638935034 Mbps
    - Delay = 0ms Avg= 45.3959473382 Mbps

This is because if delay is decreased the RTT reduces and since avg throughput is inversely proportional to RTT, therefore avg increases.

- **Queue Length :**
  - Queuesize=20 Avg = 14.6052035891 Mbps
    Minimal increase with increase in queuesize.
  - Queuesize=5 Avg = 14.2040245927 Mbps
    Minimal decrease with decrease in queuesize.
- **Error Rate :** Avg increase with decrease in error rate
  - Error rate =0.00000001 Avg = 34.279147067 Mbps
    Lower the error rate , more successful packet deliveries would occur therefore higher the average throughput.

Therefore Lower error rate, longer queue length, less delay produces larger Average Throughput

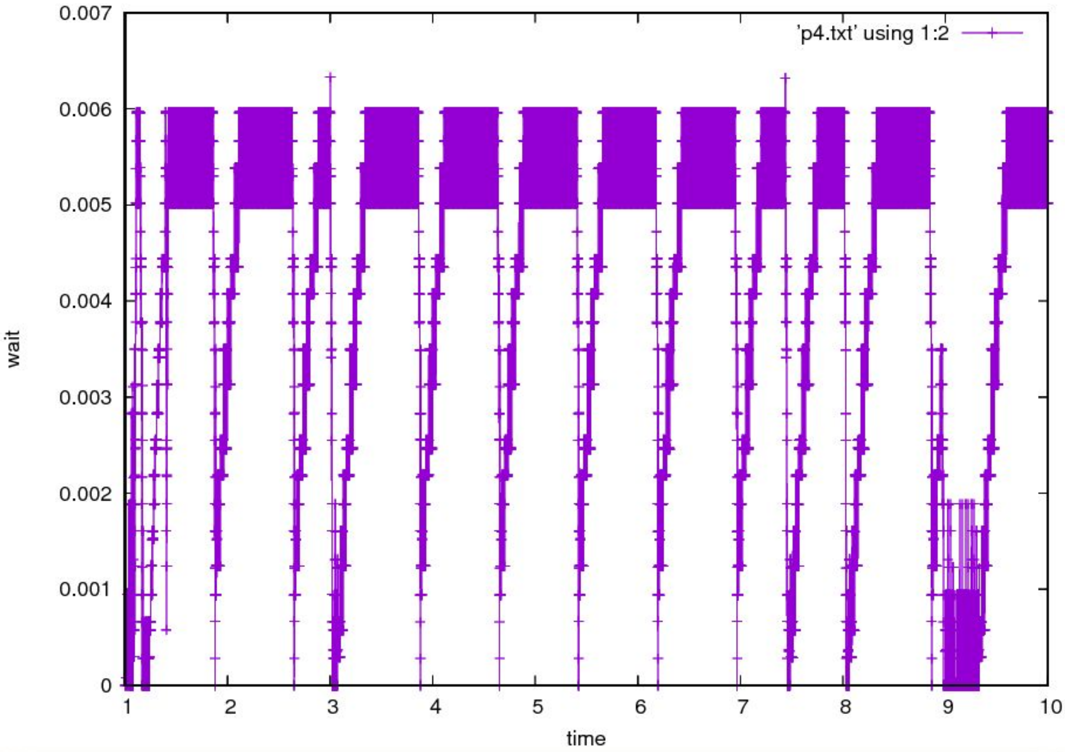
3.

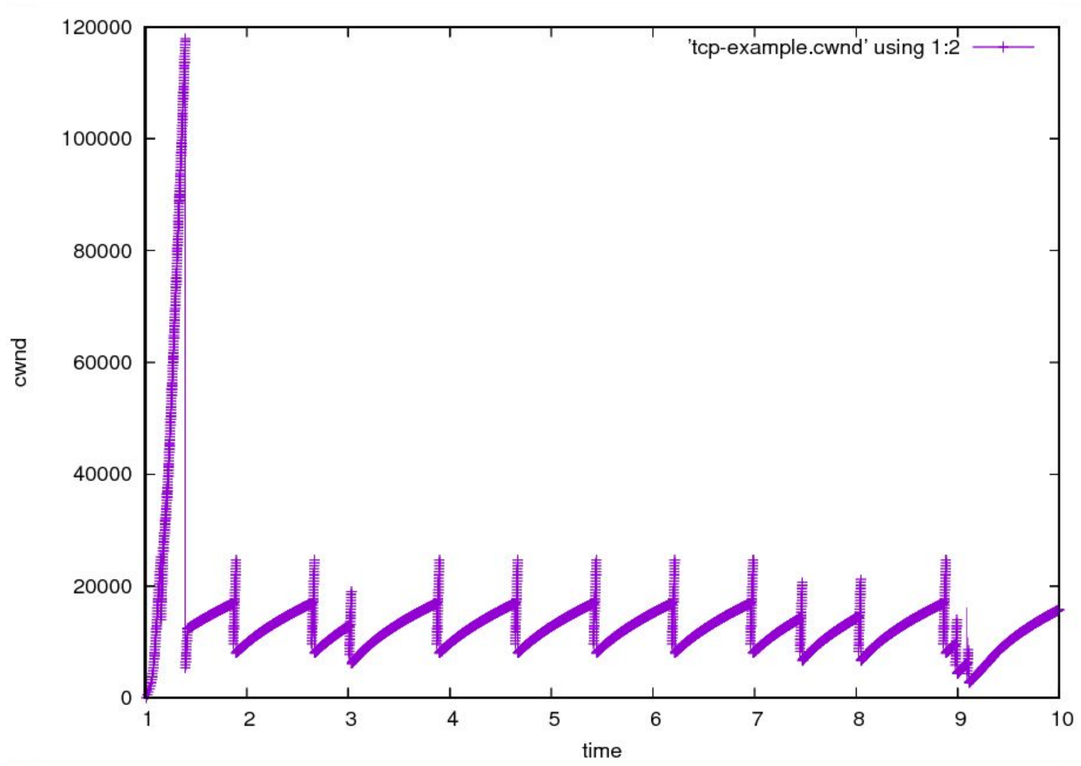
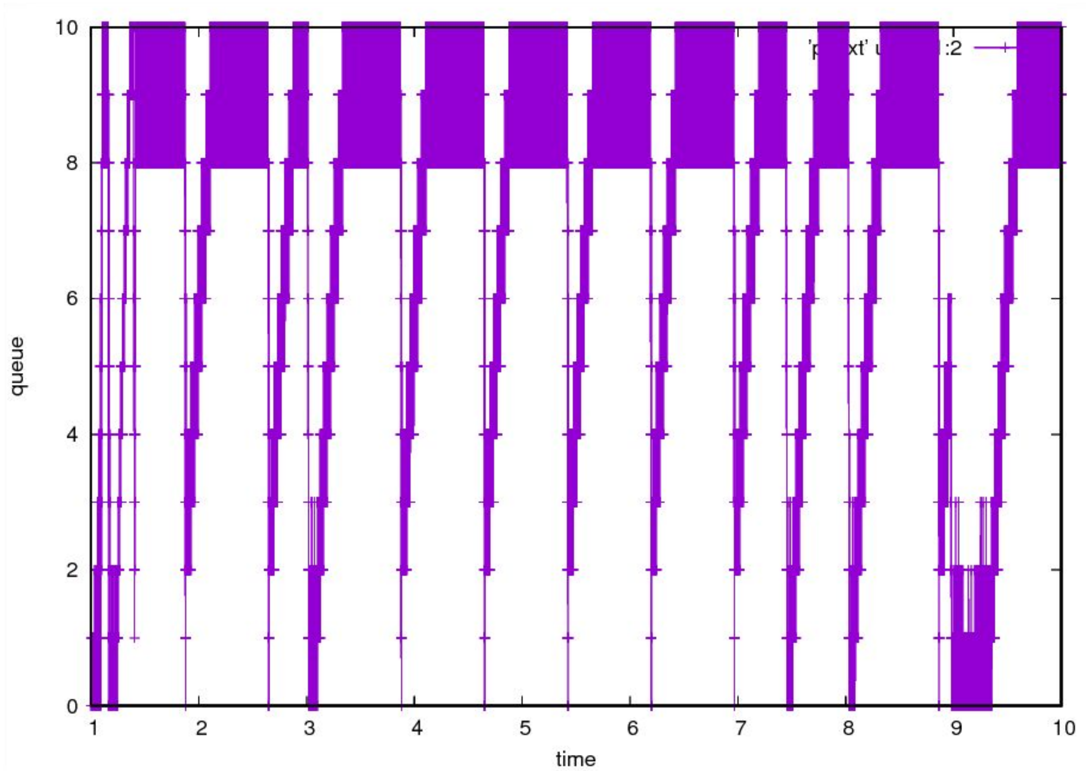
- **Average Throughput: 0.712296776279 Mbps**
  Maximum Expected Value = Link Bandwidth = 5 Mbps
  The average throughput is **not** approximately equal to the maximum because :
  - Throughput depends on all types of delay: transmission, propagation, processing and queueing delay. Due to large propagation delay, average throughput is less than maximum expected value.
  - Moreover due to larger delay the bandwidth is not completely utilised.

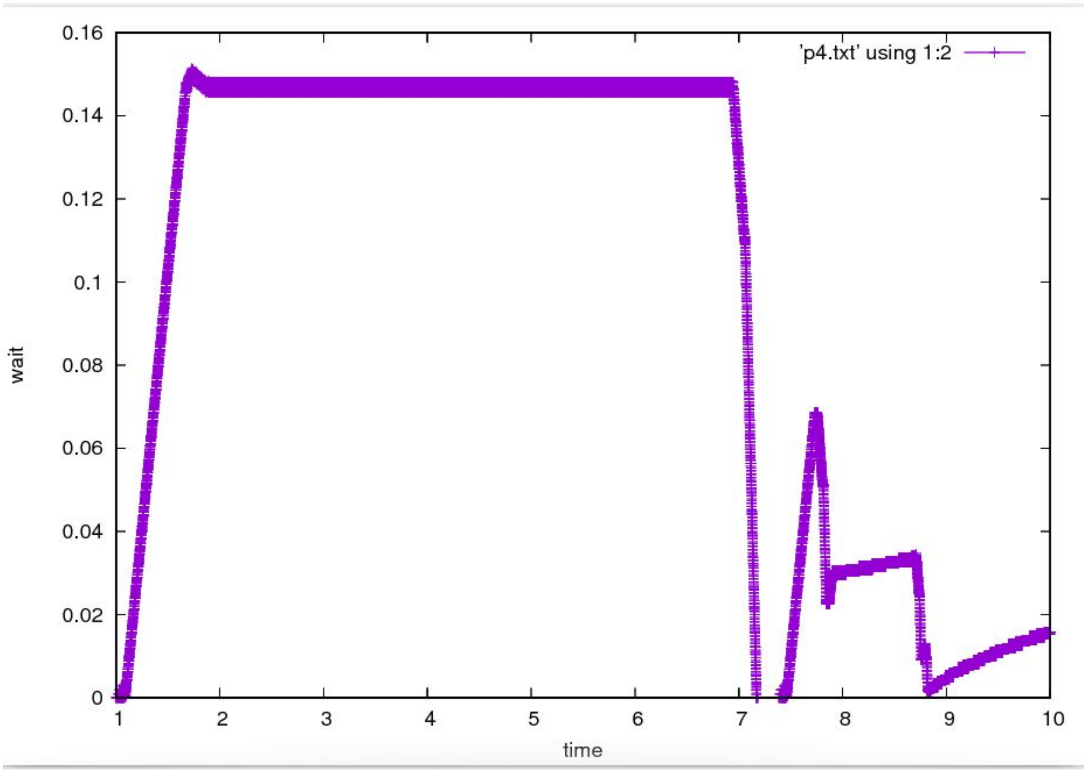
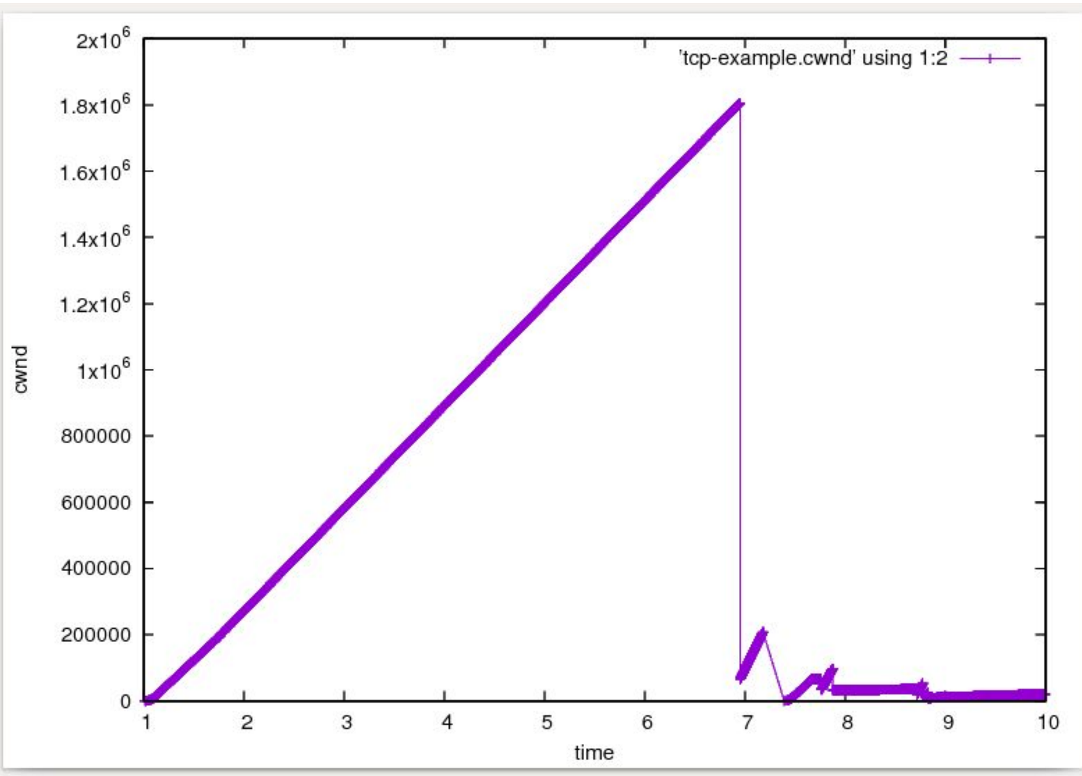
- **Changing parameters:**
  - **Queue Length :**
    - Queuesize=20 Avg = 0.752098671947 Mbps
    - Queuesize=100 Avg = 3.3212426109 Mbps
  - **Error Rate :** Avg increase with decrease in error rate
    - Error rate =0.00000001 Avg = 0.712296776279 Mbps

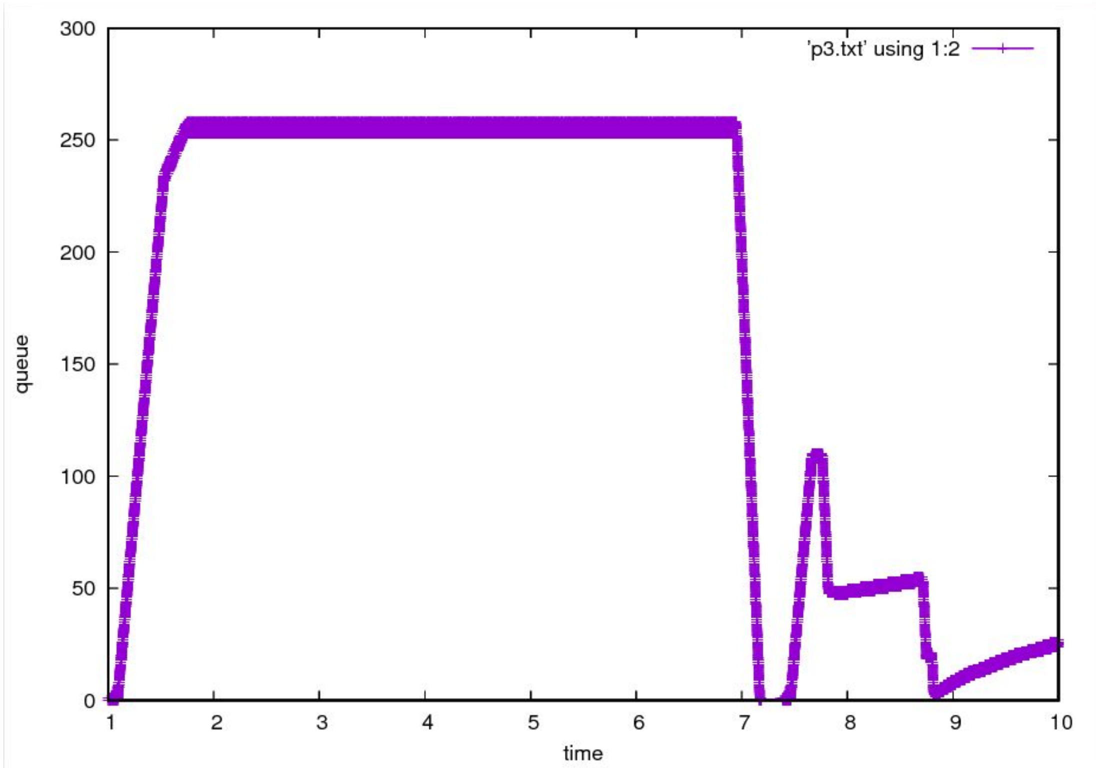
Therefore increase queue size and decrease error rate to increase average throughput.

4.

Queue size	**10**
Average Throughput	**4.43953883332 Mbps**
Queueing delay	

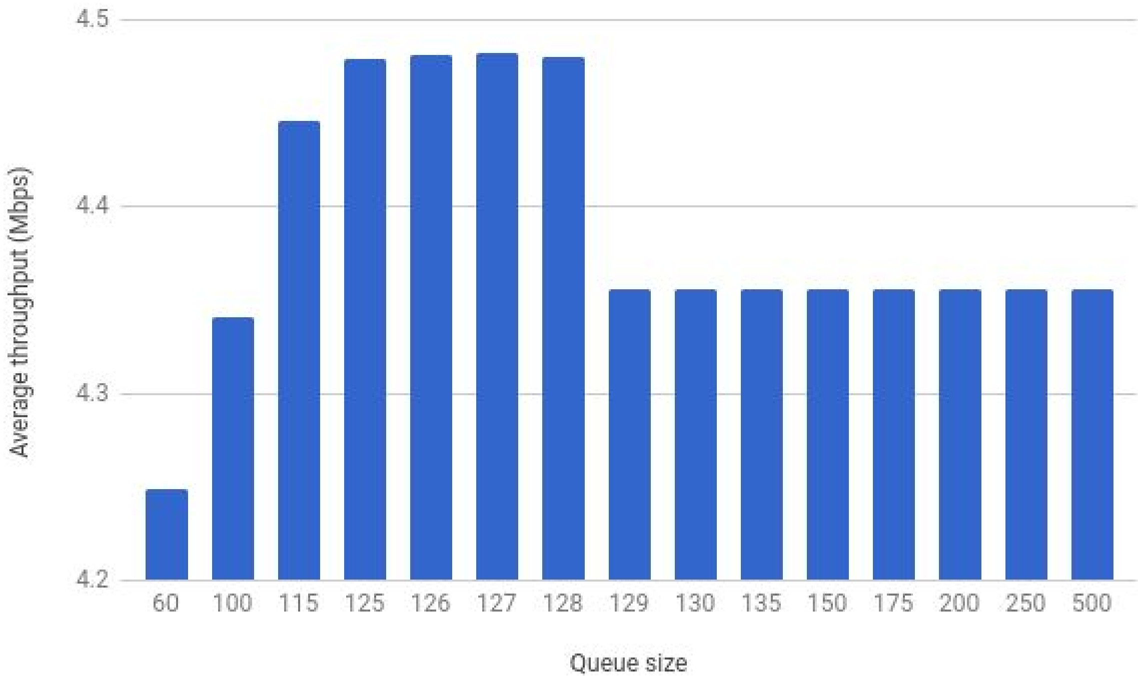
cwnd	
Queue occupancy	

Queue size	**1000**
Average Throughput	**4.3561882419 Mbps**
Queueing delay	
cwnd	

Queue occupancy	

Cwnd: In both cases initially slow start increases cwnd linearly but then enters congestion avoidance state and saw tooth pattern is observed, in second case since queue size is large , the change to congestion avoidance occurs at a later point.

Queue occupancy and delay: As the rate of sending packets is larger , therefore queue fills up but when queue is full , it drops the package and tcp enters fast recovery therefore for some time queue occupancy is constant and then decrease and this cycle repeats.
Since queueing delay is directly proportional to queue occupancy , therefore it has a similar graph.



Most appropriate queue size is 127 at which the average throughput is 4.48217403 Mbps .

This graph can be easily justified.

Initially packets are dropped due to complete usage of queue size by increasing queue size , packet dropping is reduced hence avg throughput increases.