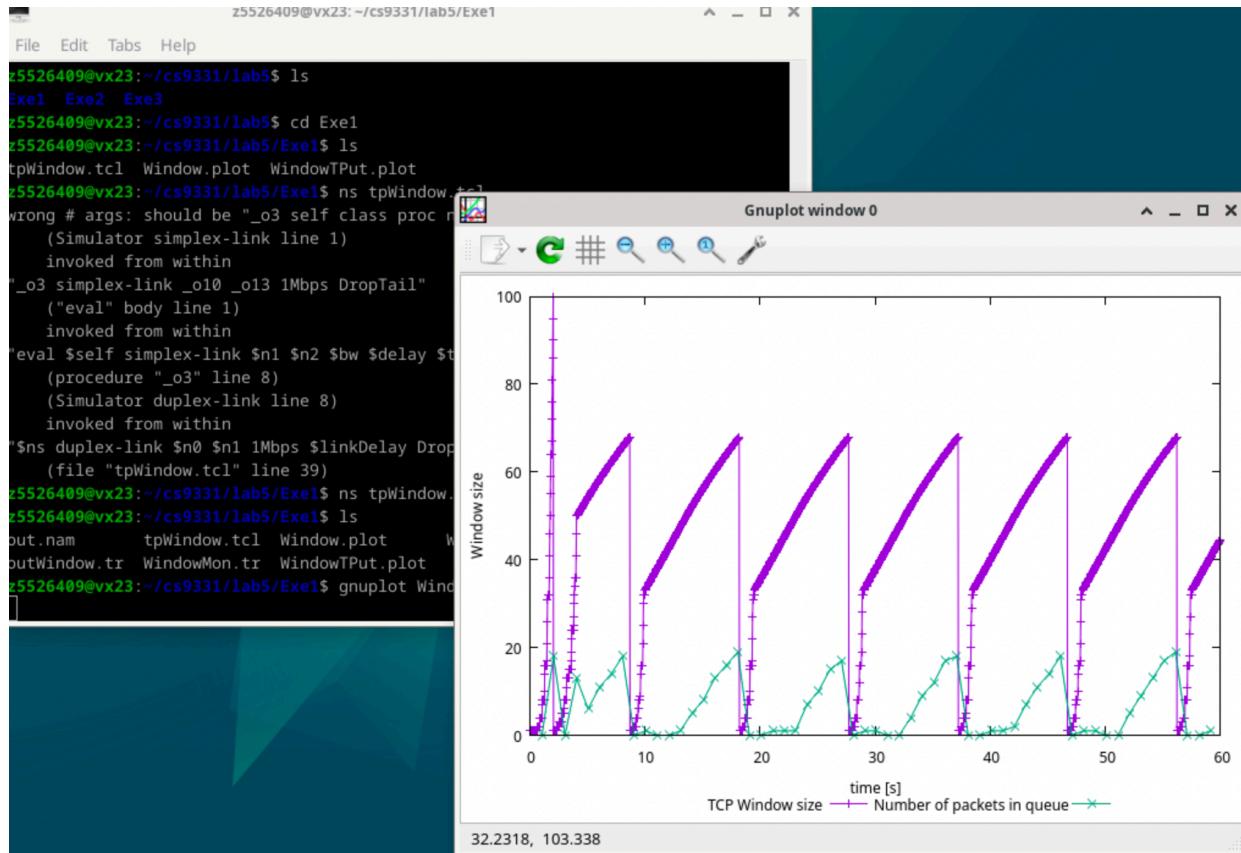


Exercise 1: Understanding TCP Congestion Control using ns-2 (4 Marks)

Question 1: Run the script with the max initial window size set to 150 packets and the delay set to 100ms (be sure to type "ms" after 100).



(a) In this case, what is the maximum size of the congestion window that the TCP flow reaches?

100

(b) What does the TCP flow do when the congestion window reaches this value? Why?

set window size back to 1, 3 ACK or timeout

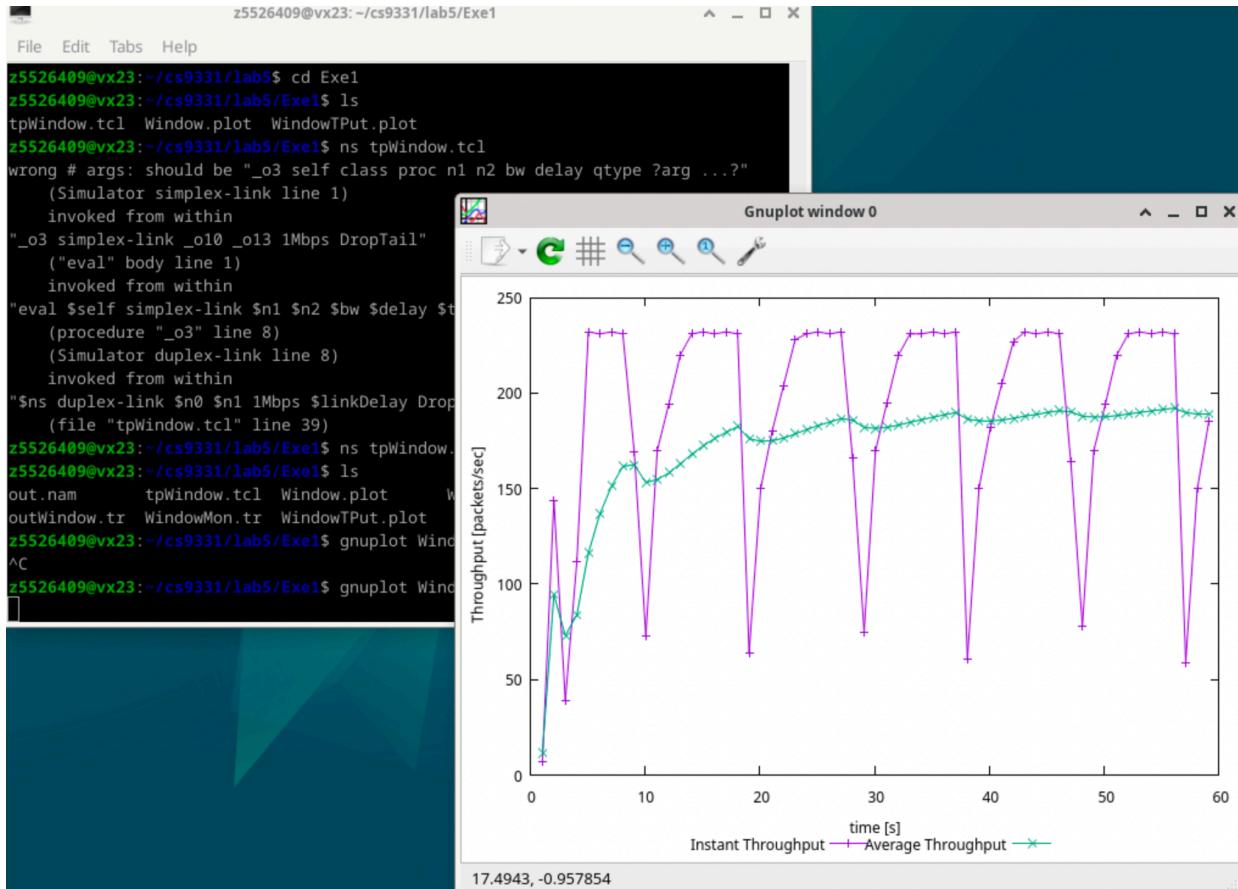
reset threshold

(c) What happens next?

slow start again, AIMD after reaching threshold

when there are 3 duplicate ACK or timeout, set window size to 1, and set the threshold to cwnd/2

Question 2: From the simulation script we used, we know that the packet's payload is 500 Bytes. Keep in mind that the size of the IP and TCP headers is 20 Bytes each. Neglect any other headers. What is the average throughput of TCP in this case? (both in number of packets per second and bps)



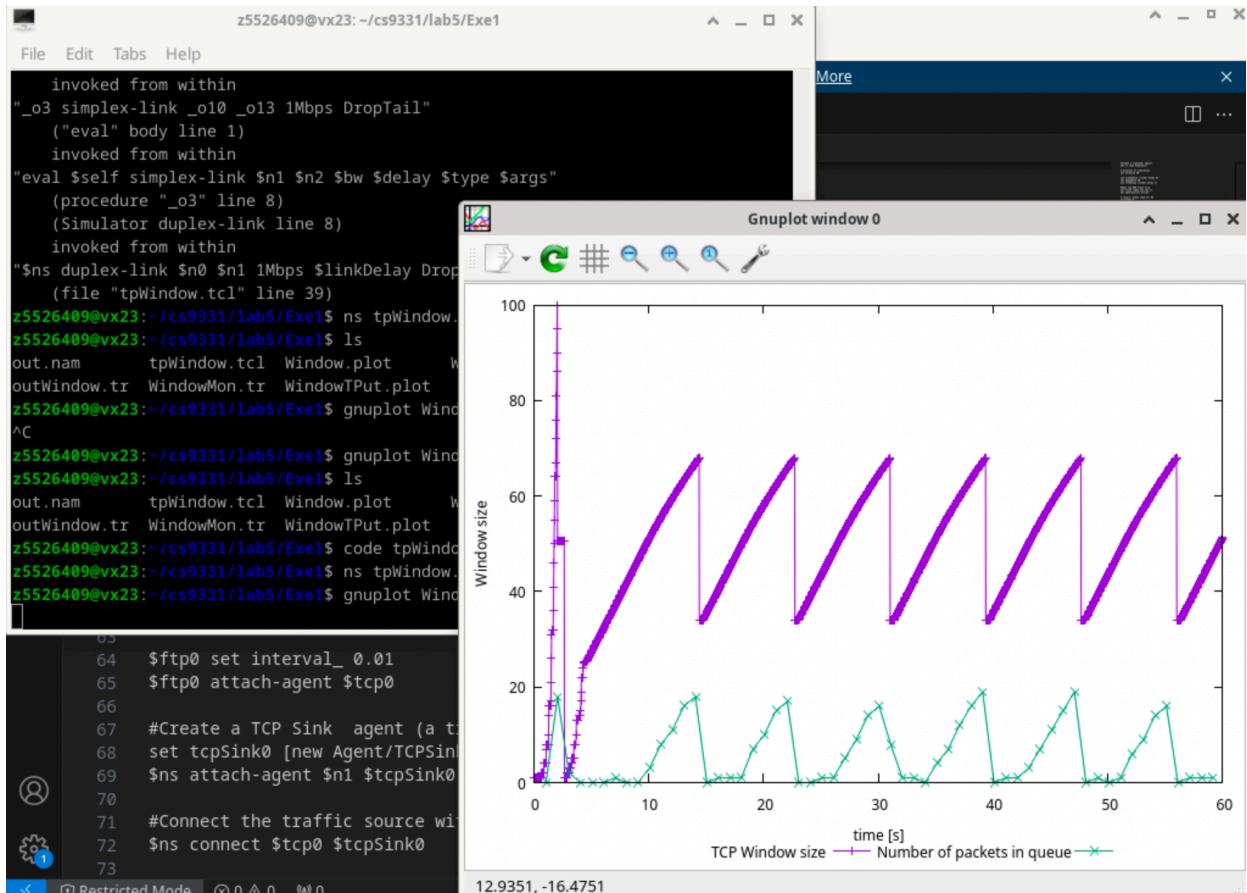
about 190 packets/sec

$$(500 + 20 + 20) * 8 * 190 = 820800 \text{ bps}$$

Question 3: Repeat the steps outlined in Questions 1 and 2 but for TCP Reno. Compare the graphs for the two implementations and explain the differences. (Hint: compare the number of times the congestion window returns to zero in each case). How does the average throughput differ in both implementations?

Q1

(a)

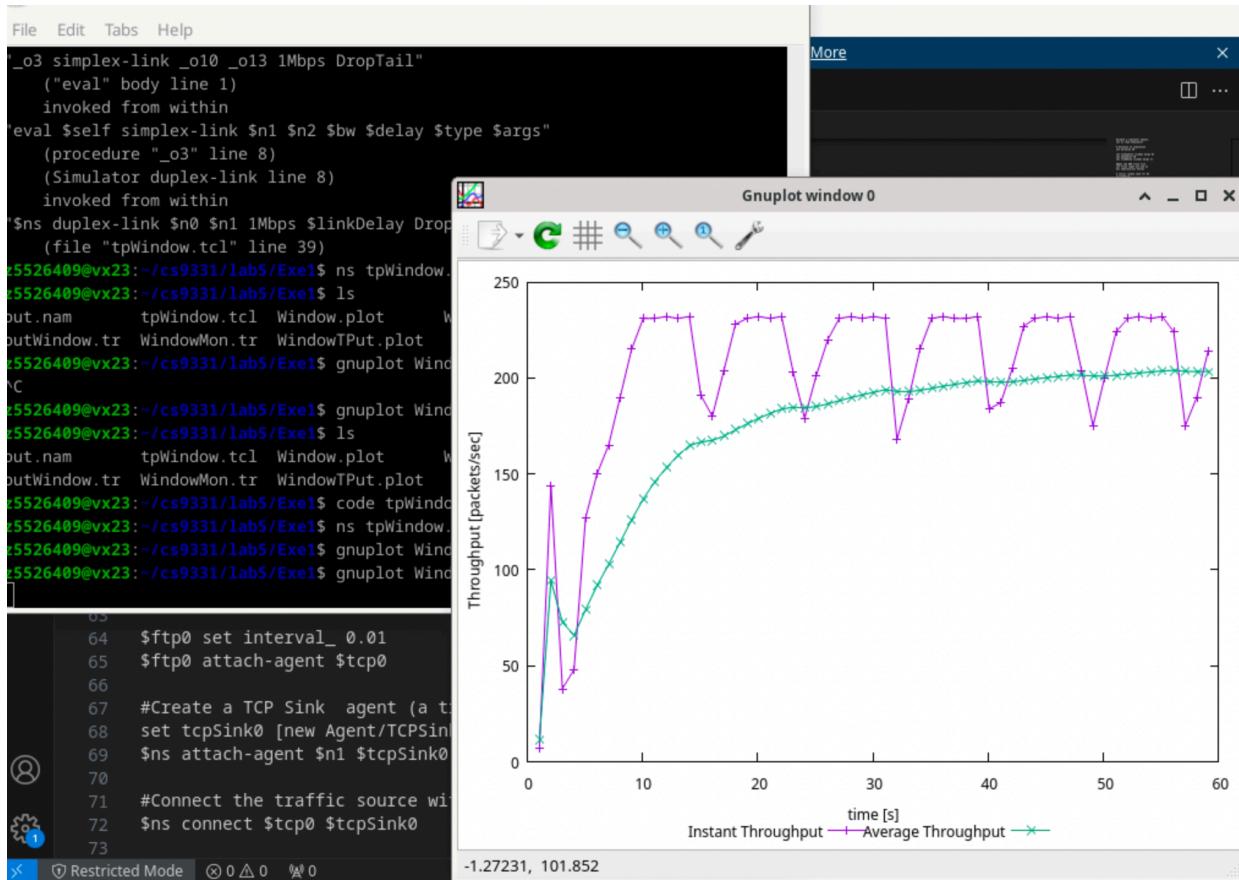


100

(b)

gey 3 ACK, window size/2, threshold = current window size / 2

(c)



the reno threshold is a little higher than Tahoe

Q2

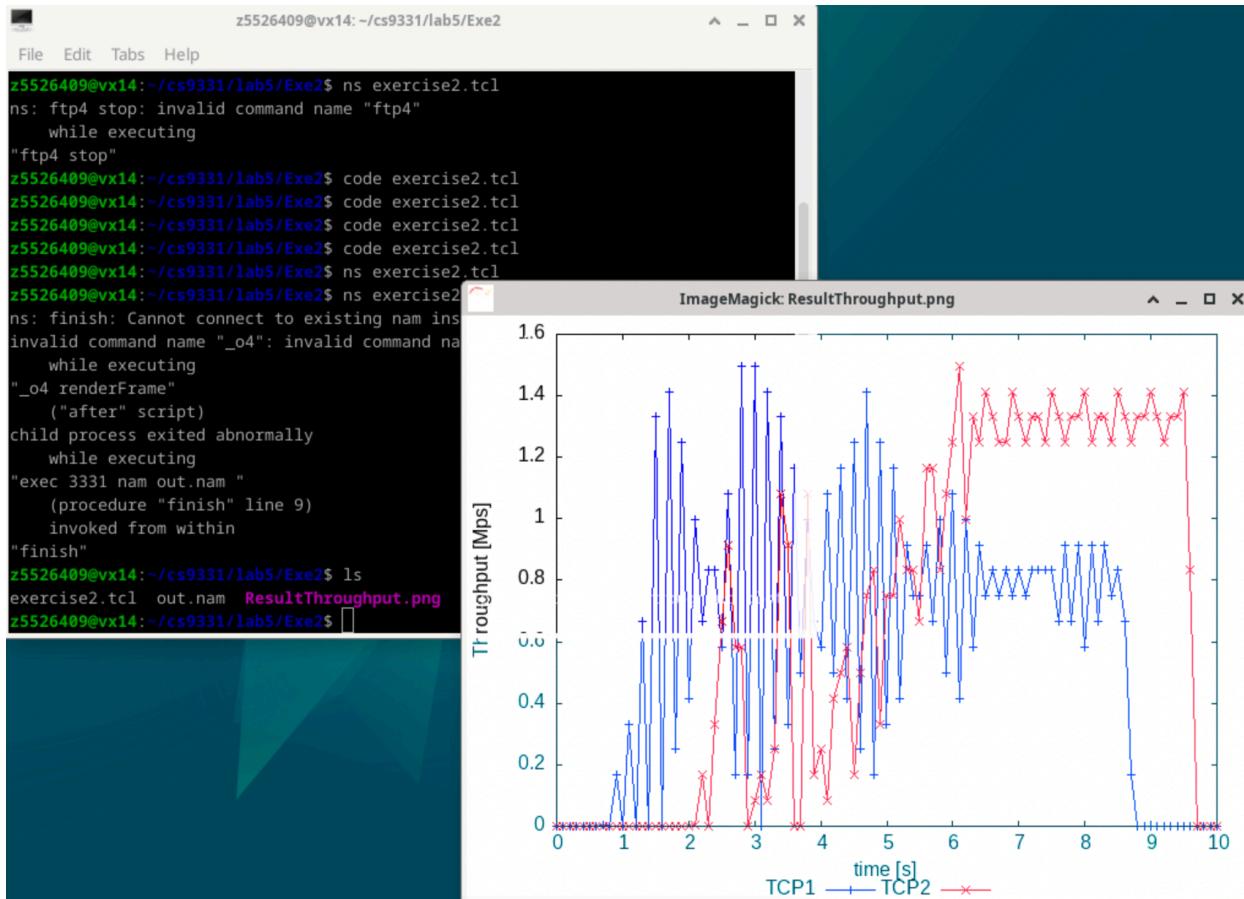
about 200 packets/sec
 $(500 + 20 + 20) * 8 * 200 = 864000 \text{ bps}$

Exercise 2: Setting up NS2 simulation for measuring TCP throughput (3.5 marks)

```
z5526409@vx14:~/cs9331/lab5/Exe2
File Edit Tabs Help
ns: ftp4 stop: invalid command name "ftp4"
      while executing
"ftp4 stop"
z5526409@vx14:~/cs9331/lab5/Exe2$ code exercise2.tcl
z5526409@vx14:~/cs9331/lab5/Exe2$ code exercise2.tcl
z5526409@vx14:~/cs9331/lab5/Exe2$ code exercise2.tcl
z5526409@vx14:~/cs9331/lab5/Exe2$ code exercise2.tcl
z5526409@vx14:~/cs9331/lab5/Exe2$ ns exercise2.tcl
z5526409@vx14:~/cs9331/lab5/Exe2$ ns exercise2.tcl
ns: finish: Cannot connect to existing nam instance. Starting a new one...
invalid command name "_o4": invalid command name "_o4"
      while executing
"_o4 renderFrame"
      ("after" script)
child process exited abnormally
      while executing
"exec 3331 nam out.nam "
      (procedure "finish" line 9)
invoked from within
"finish"
z5526409@vx14:~/cs9331/lab5/Exe2$ ls
exercise2.tcl out.nam ResultThroughput.png tcp1.tr tcp2.tr throughput.plot
z5526409@vx14:~/cs9331/lab5/Exe2$ ns exercise2.tcl
```

The terminal window shows a series of errors and commands related to network simulation. It starts with an 'ftp4 stop' command which fails because 'ftp4' is not a valid command. This is followed by several attempts to run 'code exercise2.tcl' which also fail due to the same reason. Finally, it tries to run 'ns exercise2.tcl' which fails because it cannot connect to an existing 'nam' instance and instead starts a new one. This leads to another error where it tries to execute a command named '_o4' which is not defined. The terminal ends with a successful 'ls' command showing files like 'ResultThroughput.png', 'tcp1.tr', 'tcp2.tr', and 'throughput.plot'.

The 'nam: out.nam' window displays a network topology with 8 nodes labeled 0 through 7. The connections are as follows: node 3 is connected to node 2; node 2 is connected to node 4; node 4 is connected to node 5; node 0 is connected to node 1; node 1 is connected to node 6; and node 6 is connected to node 7. The window also includes a toolbar with various icons for file operations, a status bar showing '0.284000 Step: 2.0ms', and a timeline at the bottom.



Question 1: Why is the throughput achieved by flow TCP2 higher than TCP1 between 6 sec to 8 sec?

TCP2 throughput is higher than TCP1 between 6 sec to 8 sec

TCP2 competes with TCP1

TCP2 has less RTT than TCP1, TCP2 has more round trip than TCP1 in same time

TCP2 shares more bandwidth on n2-n4

Question 2: Why does the throughput for flow tcp1 fluctuate between a time span of 0.5 sec to 2 sec?

slow start probing bandwidth

Exercise 3: Understanding the Impact of Network Dynamics on Routing (2.5 marks)

The screenshot shows the NS-2 simulation environment. On the left, a terminal window displays a series of error messages from a Tcl script. The messages indicate that Nam syntax has changed for link-down and link-up events, specifically for nodes 1, 2, 3, 4, and 5. The script is creating eight nodes and connecting them in a specific topology. On the right, the main NS-2 window shows a network graph with nodes 0 through 5. Node 0 is connected to node 1, which is connected to node 2. Node 4 is connected to both node 0 and node 5. Node 3 is connected to node 5. A 'ZoomIn' button is visible above the graph. Below the graph, a timeline bar shows time steps from 0.0ms to 1.386000ms in 2.0ms increments. A status bar at the bottom indicates 'down down'.

```

File Edit Tabs Help
Please use this format in the future.
v -t <time> -e <tcl expression>

Nam syntax has changed: v -t 1 link-down 1 1 4
Please use this format in the future.
v -t <time> -e <tcl expression>

Nam syntax has changed: v -t 1.2 link-up 1.2 4 1
Please use this format in the future.
v -t <time> -e <tcl expression>

Nam syntax has changed: v -t 1.2 link-up 1.2 4 1
Please use this format in the future.
v -t <time> -e <tcl expression>

Nam syntax has changed: v -t 1.2 link-up 1.2 1 4
Please use this format in the future.
v -t <time> -e <tcl expression>

Nam syntax has changed: v -t 1.2 link-up 1.2 1 4
Please use this format in the future.
v -t <time> -e <tcl expression>

[

34  #create eight nodes
35  set n0 [$ns node]
36  ##>>
37  set n1 [$ns node]
38  set n2 [$ns node]
39  set n3 [$ns node]
40  set n4 [$ns node]
41  set n5 [$ns node]
42  set n6 [$ns node]
43  set n7 [$ns node]
44

```

Question 1: Which nodes communicate with which other nodes? Which route do the packets follow? Does it change over time?

0145

235

Does it change over time? No

Question 2: What happens at time 1.0 and time 1.2? Does the route between the communicating nodes change as a result?

0 1 broke down, but the route doesn't change

2 to 5 unaffected

Question 3: Did you observe additional traffic compared to Step 3 above? How does the network react to the changes that take place at time 1.0 and time 1.2 now?

discover packet can not be transferred from 0 to 1 4 5

reroute existing passway, 0 1 2 3 5

Question 4: How does this change affect the routing? Explain why.

increase 1 to 4 cost to 3

change it way from 0145 to 01235

Question 5: Describe what happens and deduce the effect of the line you just uncommented.

increase 1 to 4 cost to 2

increase 3 to 5 cost to 3

2 to 5 have 2 same cost path, it doesn't change the path

after setting multiPath_ 1

use two paths to transfer