Computer Networks - Network Simulation Using NS3

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Question 1

Q.1. Run the simulation with the default parameters (provided in the table) and answer the following questions.
a. What is the maximum expected value (theoretical) of throughput (in Mbps)? Why?
The maximum expected value (theoretical) of throughput (in Mbps) is <u>5Mbps</u> because this is the bottleneck bandwidth of our network. The link bandwidth between N0-N1 is 10Mbps and N1-N2 is 5Mbps.

b. How much is Bandwidth-Delay-Product (BDP)? Express your answer in terms of the number of packets.
Bandwidth = 5Mbps
Round Trip Time (RTT) = (delay1 + delay2) x 2
= (10ms + 15ms) x 2
= 50ms

The Bandwidth-Delay-Product = Bandwidth X RTT
= 5Mbps x 50ms
= [5 x 1000000 bits/sec] x [0.05 sec]
= [5000000] x [0.05]
= 250000 bits

Given application payload size is 1460 bytes
In numbers of packet this is = bits/ application payload size
= 250000/[1460 x 8]
= 21.404 packets ~ <u>22 packets</u> [Since we can’t transfer 21.404 packets]

c. What is the average computed throughput of the TCP transfer?

Ethernet | IPv4 · 1 | IPv6 | TCP · 1 | UDP

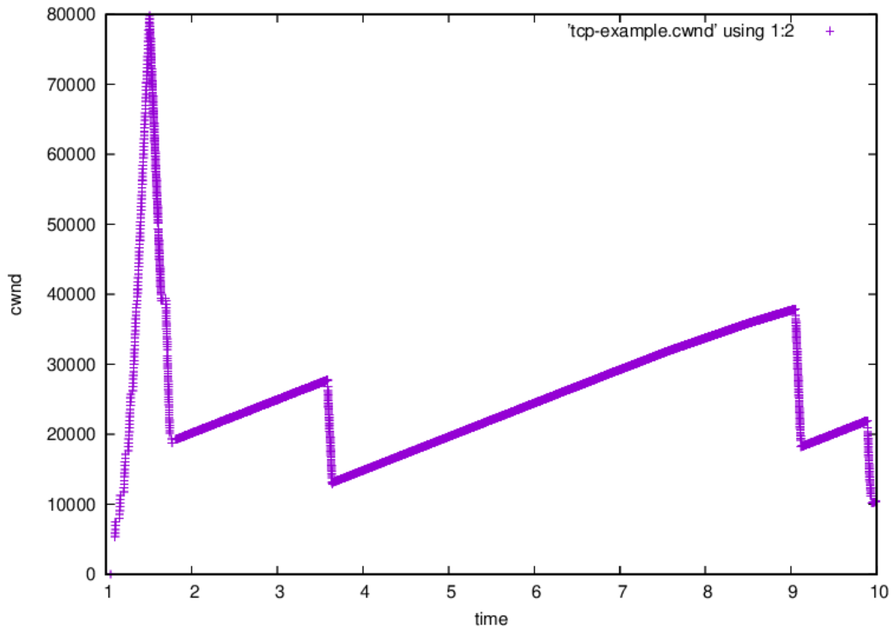
Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
10.1.1.1	49153	10.1.2.2	8080	11,349	4,587 k	7,408	4,369 k	3,941	217 k	0.000000	8.9737	3,895 k	193 k

The average computed throughput of the TCP transfer is 3895k + 193k = 4088k bits/sec

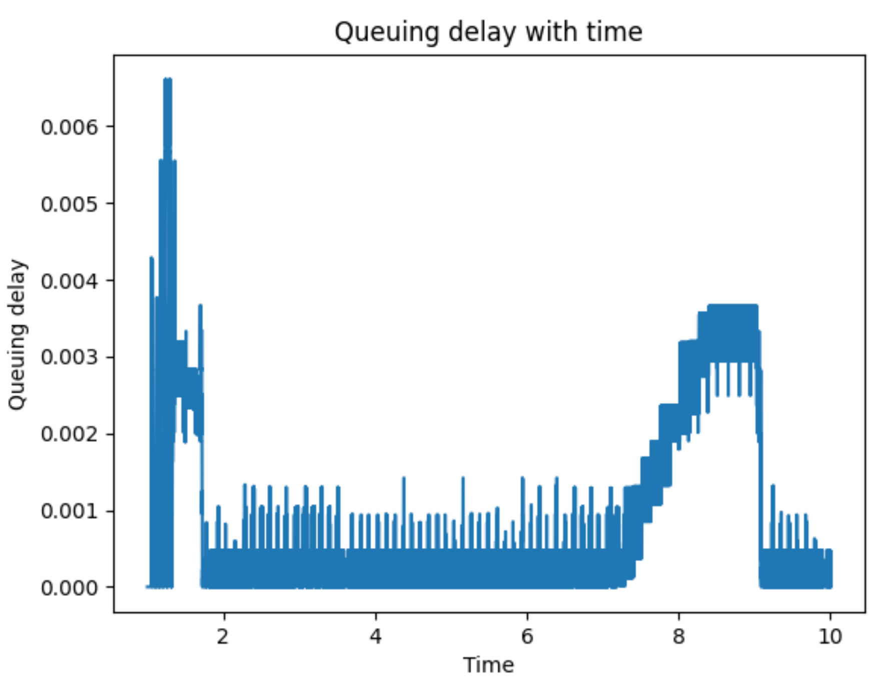
d. Is the achieved throughput approximately equal to the maximum expected value? If it is not, explain the reason for the difference.
No, the achieved throughput is not approximately equal to the maximum expected value. This is because the throughput is also dependent on factors other than bottleneck bandwidth. There could be high queuing at the routers which would lead to queuing delay which would reduce the throughput. The packets can also have some errors or the queue at routers might be full,

because of which they might be dropped causing retransmission of those packets. This retransmission of packets would further decrease throughput. So the achieved throughput is less than the maximum expected value.

e. Plot Congestion Window (CWND) with time



f. Plot queueing delay with time



g. Are the plots in 1(e) and 1(f) related?
Yes, the plots are related. They both follow a similar course. Both the plots rise initially, then fall, then slowly rise again and then fall again. This is because congestion and queuing delay are related. A larger queuing delay is an indicator of more congestion in the network.

Question 2

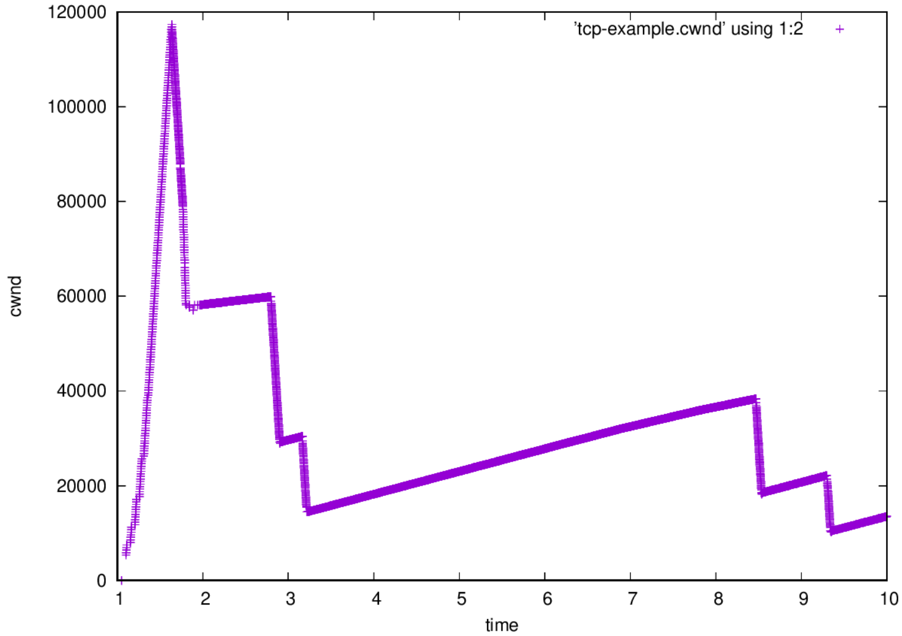
Q.2. Change queue size to 50 (rest of the parameter values are same as default values)
a. What is the average computed throughput of the TCP transfer?

Ethernet | IPv4 · 1 | IPv6 | TCP · 1 | UDP

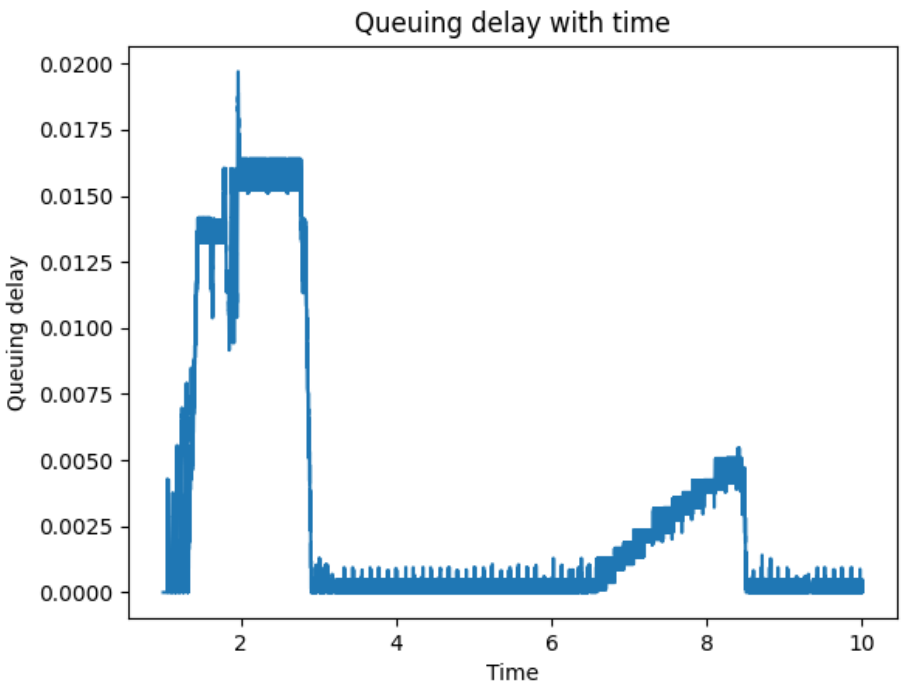
Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
10.1.1.1	49153	10.1.2.2	8080	11,800	4,745 k	7,656	4,514 k	4,144	230 k	0.000000	8.9746	4,024 k	205 k

The average computed throughput of the TCP transfer is 4024k + 205k = 4229k bits/sec

b. Plot CWND with time



c. Plot queueing delay with time



d. Compare CWND plots of Q.1. and Q.2., what insights did you gain?
In Q1 the max congestion window is 80000 and in Q2 it is 120000 (which is more than in Q1). Due to a larger queue size, more packets were able to be queued due to which we were able to increase our congestion window size and see a larger congestion window initially in Q2.

Question 3

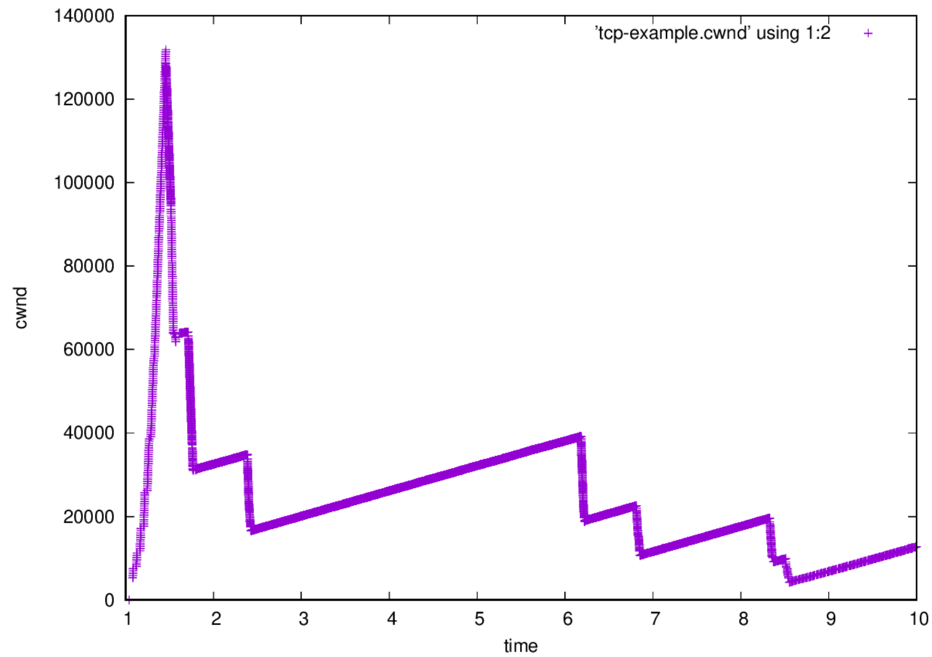
Q.3. Change N1-N2 bandwidth to 10Mbps and N1-N2 delay as 10ms (rest of the parameter values are same as default values)
a. What is the average computed throughput of the TCP transfer?

Ethernet | IPv4 · 1 | IPv6 | TCP · 1 | UDP

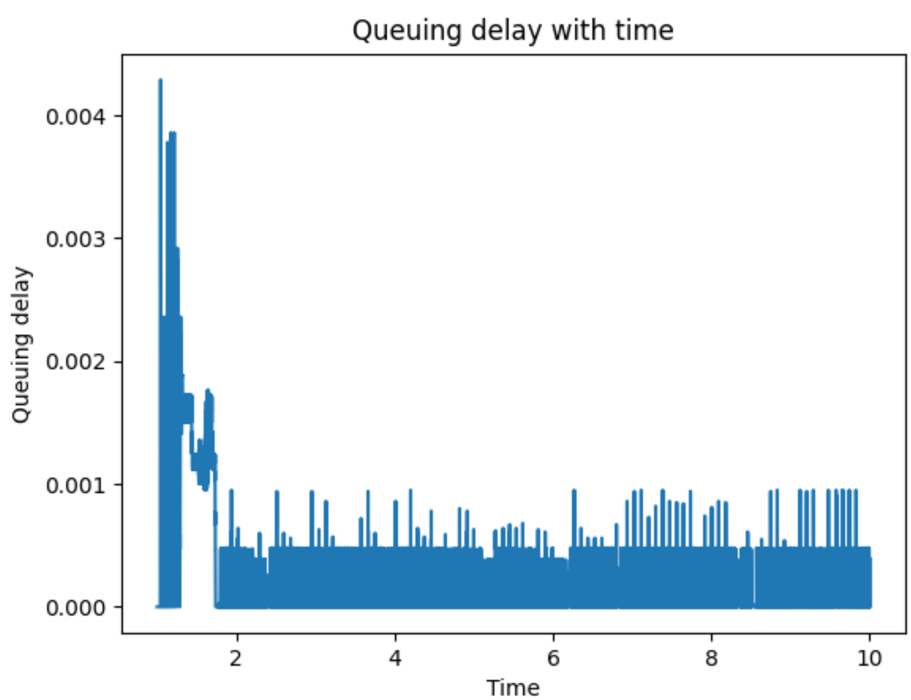
Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
10.1.1.1	49153	10.1.2.2	8080	13,868	5,562 k	8,981	5,292 k	4,887	270 k	0.000000	8.9746	4,717 k	240 k

The average computed throughput of the TCP transfer is 4717k + 240k = 4957k bits/sec

b. Plot CWND with time



c. Plot queueing delay with time



d. Compare queuing delay plots of Q.1. and Q.3., what insights did you gain?

The queuing delay in Q3 is less than the queuing delay in Q1. This is because with an increase in the bandwidth, the numbers of packets waiting in the queue at the router (node1) were decreased, which led to lesser queuing delay.

Question 4

Q.4. Change TCP version to TCP CUBIC (rest of the parameter values are same as default values)

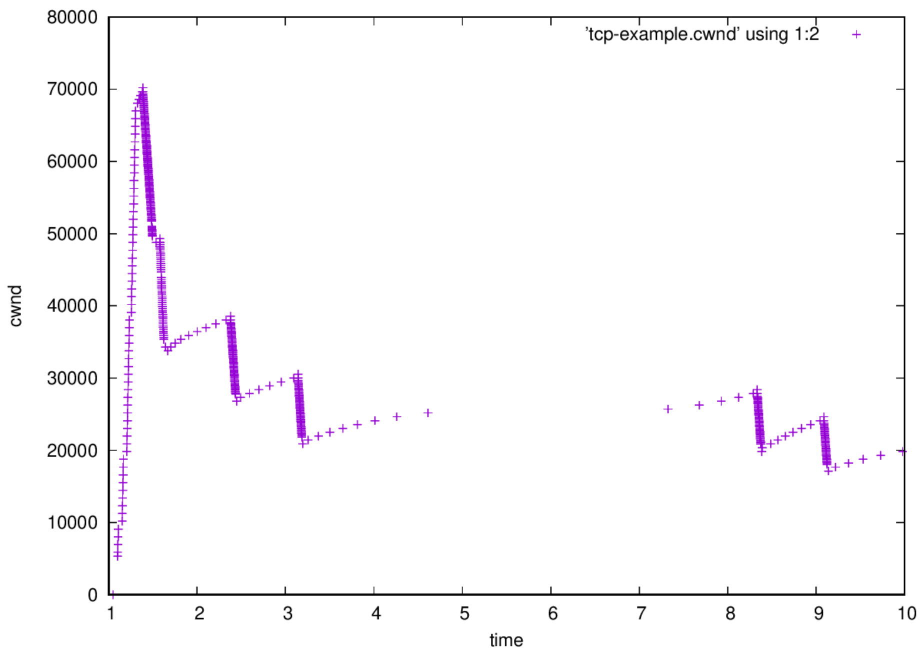
a. What is the average computed throughput of the TCP transfer?

Ethernet | IPv4 · 1 | IPv6 | TCP · 1 | UDP

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
10.1.1.1	49153	10.1.2.2	8080	12,251	4,941 k	7,977	4,705 k	4,274	236 k	0.000000	8.9730	4,195 k	210 k

The average computed throughput of the TCP transfer is 4195k + 210k = 4405k bits/sec

b. Plot CWND with time

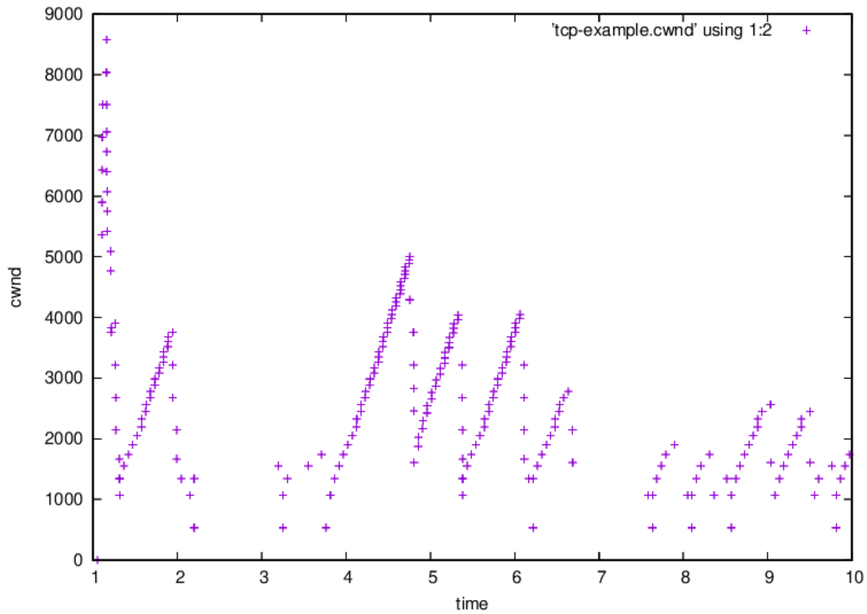


c. Compare the CWND graph obtained here with that of Q.1. Point out the differences during the various stages (slow start, congestion avoidance, and fast recovery phases) for each variant. You can use the loss rate parameter to inject more or less losses as needed, to clearly identify the difference between the variants.

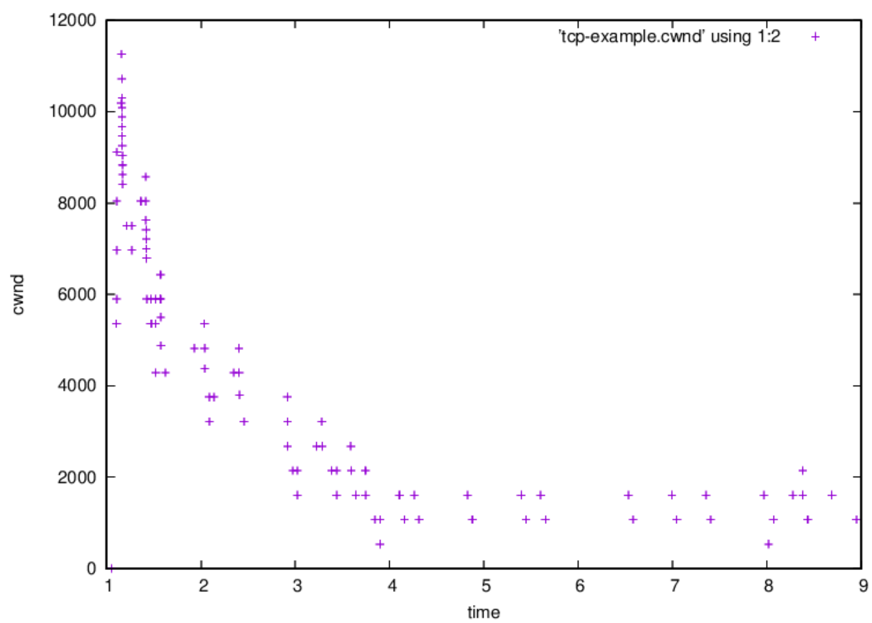
In Q1 we used TcpNewReno while in Q4 we are using TcpCubic. In the slow start phase TcpNewReno is similar to TcpCubic. They both reach a peak (slow start threshold). The two variants also perform similarly in the fast recovery phase. But the two variants differ in the way the congestion window is adjusted. In the congestion avoidance phase, from the graphs we can see that TcpNewReno increases linearly while TcpCubic has a cubic function increase. TcpCubic stays at the plateau for a long time between the concave and convex region, as can be seen in q4b graph between 4s and 8s.

To clearly identify the difference between the variants I plotted the following graphs after changing the loss rate parameter to 0.0001.

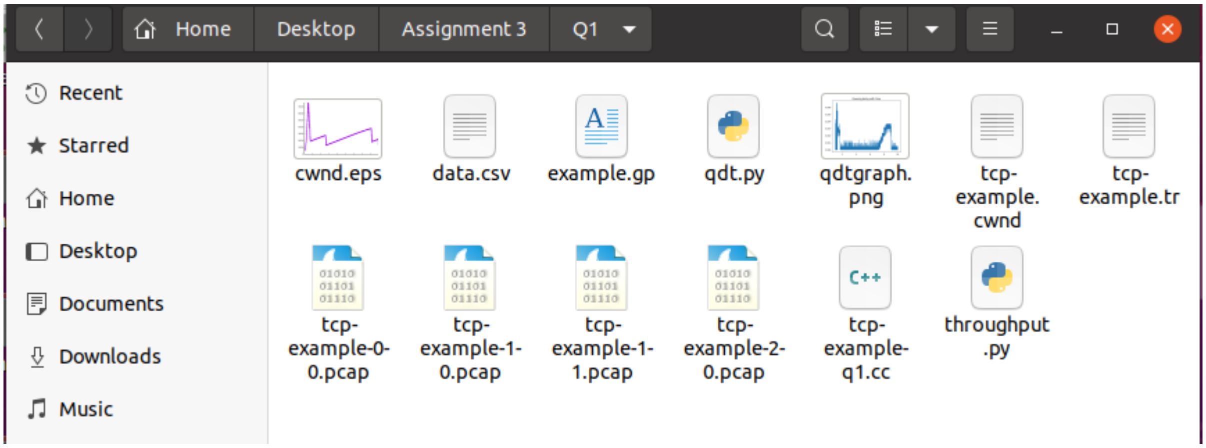
TcpNewReno

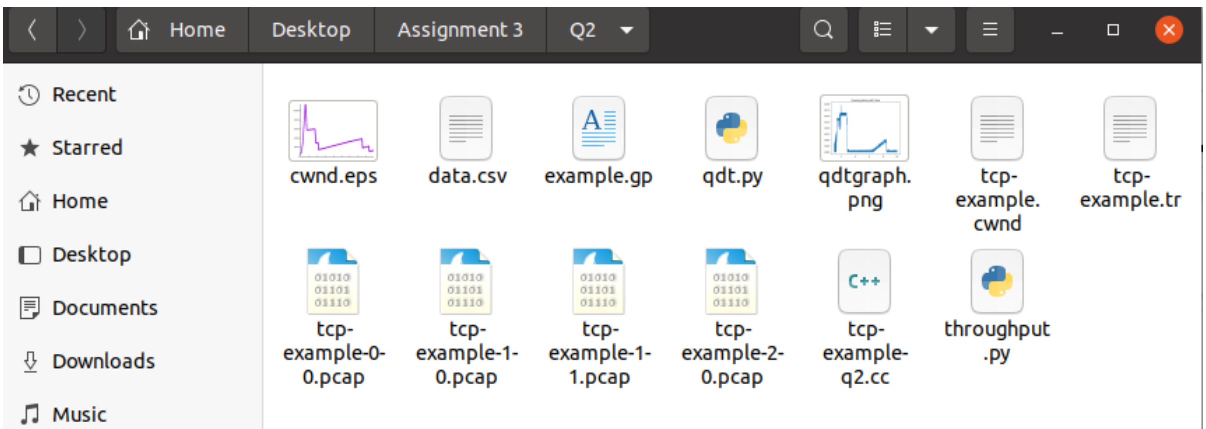


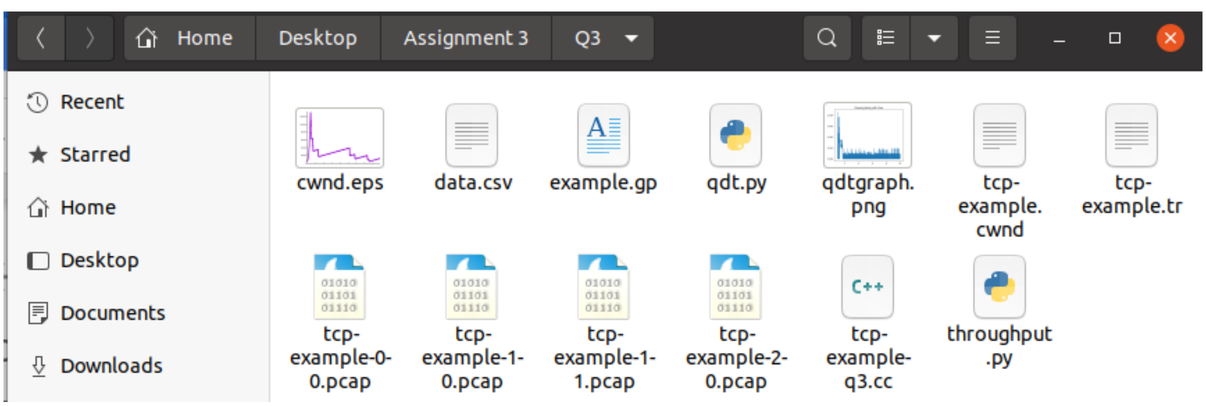
TcpCubic

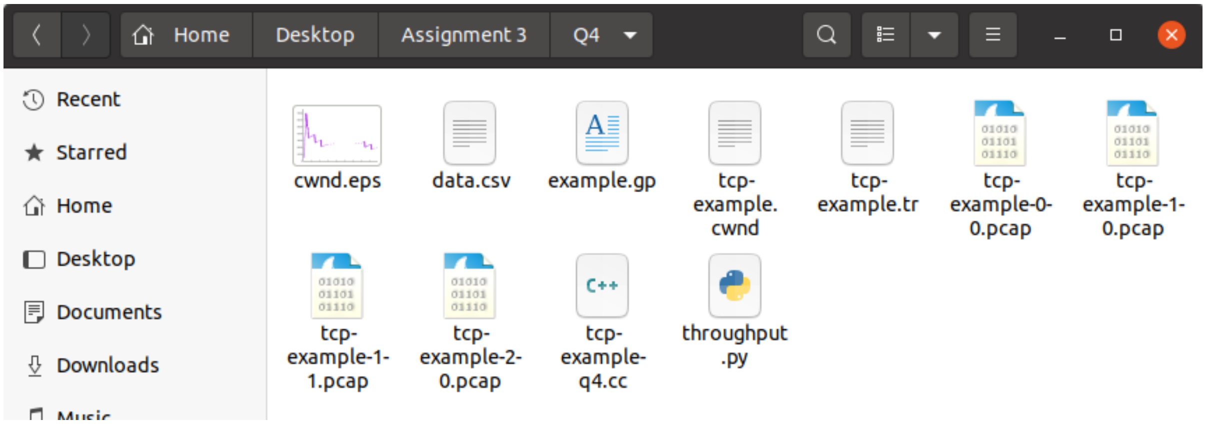


Captured files (Screenshots)








Home
Desktop
Assignment 3
Q4
Recent
Starred
Home
Desktop
Documents
Downloads
cwnd.eps
data.csv
example.gp
tcp-example.cwnd
tcp-example.tr
tcp-example-0-0.pcap
tcp-example-1-0.pcap
tcp-example-1-1.pcap
tcp-example-2-0.pcap
tcp-example-q4.cc
throughput.py