- ## What is the normal time required to download the webpage on h1 from h2?

```
mininet> h2 wget h1
--2023-03-01 16:36:06--  http://10.0.0.1/
Connecting to 10.0.0.1:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 177669 (174K) [text/html]
Saving to: ‘index.html’

     0K .......... .......... .......... .......... .......... 28%  182K 1s
    50K .......... .......... .......... .......... .......... 57%  177K 0s
   100K .......... .......... .......... .......... .......... 86%  172K 0s
   150K .......... .......... ...                              100%  179K=1.0s

2023-03-01 16:36:07 (177 KB/s) - ‘index.html’ saved [177669/177669]
```

> 1s

- ## What was your initial expectation for the congestion window size over time?

> The congestion window size is expected to increase gradually as the sender receives acknowledgments from the receiver, indicating that the data is being successfully transmitted without congestion. If congestion occurs, the congestion window size is expected to decrease to avoid further congestion.

- ## After starting iperf on h1, did you observe something interesting in the ping RTT?

For 100 buffer before starting iperf on h1

```
mininet> h1 ping -c 10 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=31.1 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=38.7 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=35.8 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=30.4 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=30.3 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=30.3 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=35.2 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=35.6 ms
--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9025ms
rtt min/avg/max/mdev = 30.318/32.928/38.797/2.958 ms
```

For 100 buffer after starting iperf on h1

```
mininet> h1 ping -c 10 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=561 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=819 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=833 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=695 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=424 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=451 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=461 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=487 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=494 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=520 ms
--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9007ms
rtt min/avg/max/mdev = 424.100/574.959/833.158/144.652 ms
```

For 20 buffer before starting iperf on h1

```
mininet> h1 ping -c 10 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=32.2 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=30.4 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=36.4 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=30.3 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=35.2 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=40.5 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=30.2 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=48.0 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=30.7 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9026ms
rtt min/avg/max/mdev = 30.284/34.505/48.012/5.548 ms
```

For 20 buffer after starting iperf on h1

```
mininet> h1 ping -c 30 h2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=137 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=163 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=107 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=136 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=162 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=179 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=119 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=144 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=186 ms
```

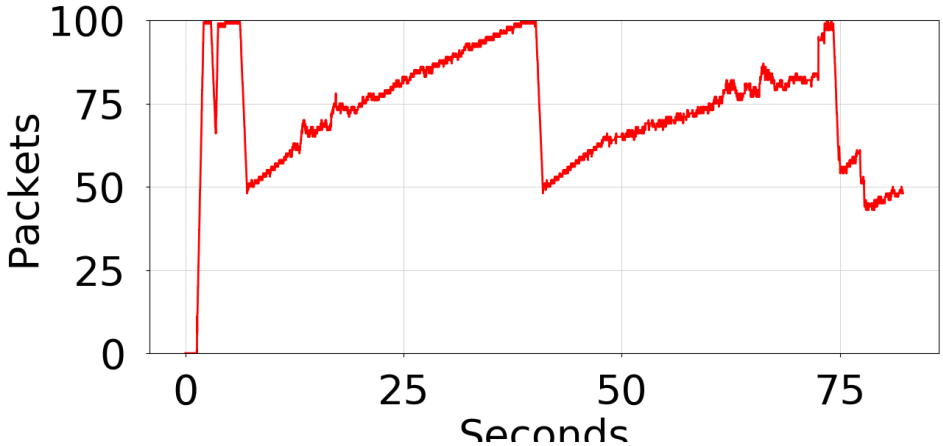
```
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=122 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=145 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=160 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=102 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=122 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=162 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=168 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=111 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=133 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=172 ms
64 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=99.3 ms
64 bytes from 10.0.0.2: icmp_seq=22 ttl=64 time=122 ms
64 bytes from 10.0.0.2: icmp_seq=23 ttl=64 time=155 ms
64 bytes from 10.0.0.2: icmp_seq=24 ttl=64 time=174 ms
64 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=129 ms
64 bytes from 10.0.0.2: icmp_seq=26 ttl=64 time=151 ms
64 bytes from 10.0.0.2: icmp_seq=27 ttl=64 time=176 ms
64 bytes from 10.0.0.2: icmp_seq=28 ttl=64 time=122 ms
64 bytes from 10.0.0.2: icmp_seq=29 ttl=64 time=146 ms
64 bytes from 10.0.0.2: icmp_seq=30 ttl=64 time=168 ms
--- 10.0.0.2 ping statistics ---
30 packets transmitted, 29 received, 3% packet loss, time 29089ms
rtt min/avg/max/mdev = 99.324/144.425/186.589/24.628 ms
```

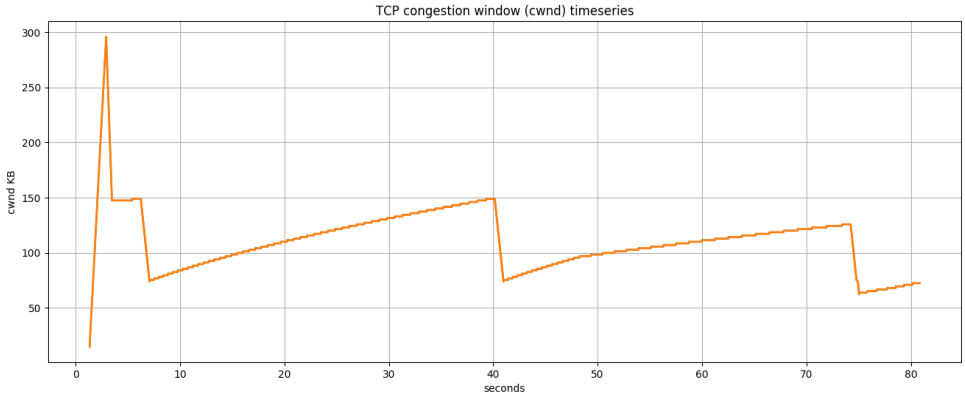
> Before starting iperf on h1, for both 100 packets buffer and 20 packets buffer RTT are very similar which around 30ms.
>
> After starting iperf on h1, for 100 packets buffer, the RTT are vary from 400ms - 800 ms, for 20 packets buffer, the RTT are vary from 100ms - 200ms.

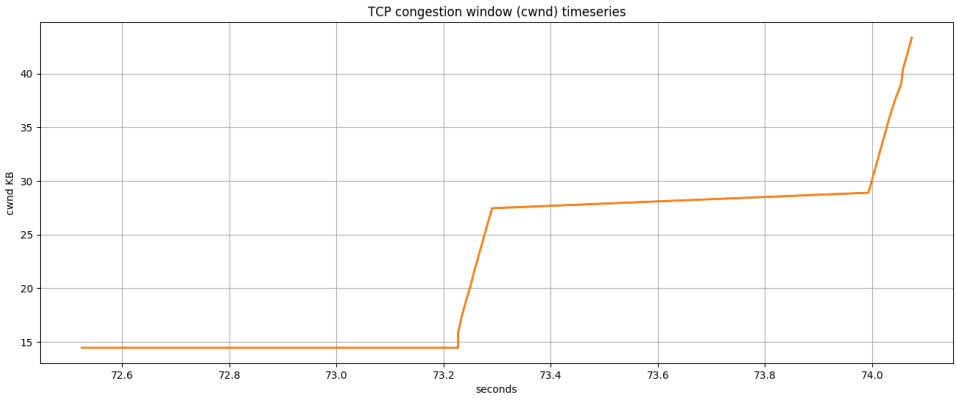
- ## After starting iperf on h1, why does the web page take so much longer to download?

> Because the iperf likes another source keep sending data through the network. Before starting iperf on h1, download is the only thing runs on the network. But after starting iperf on h1, two sources share the network which result in TCP congestion control.

- ## Please provide the figures for the first experiment (with qlen 100).





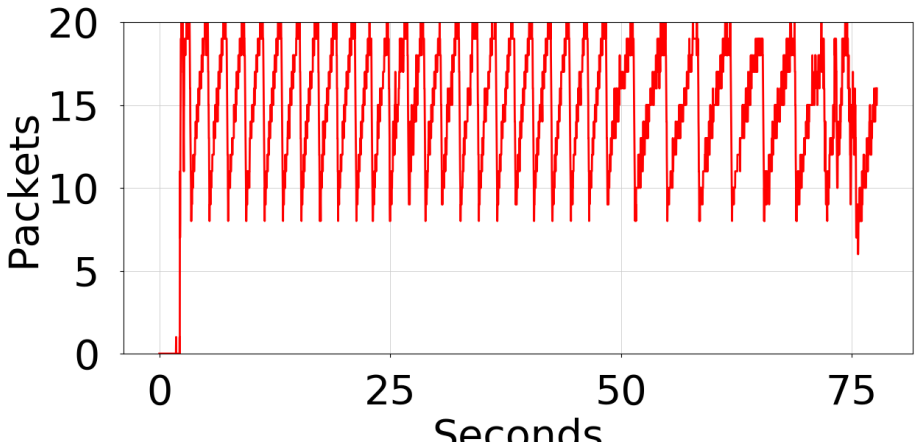


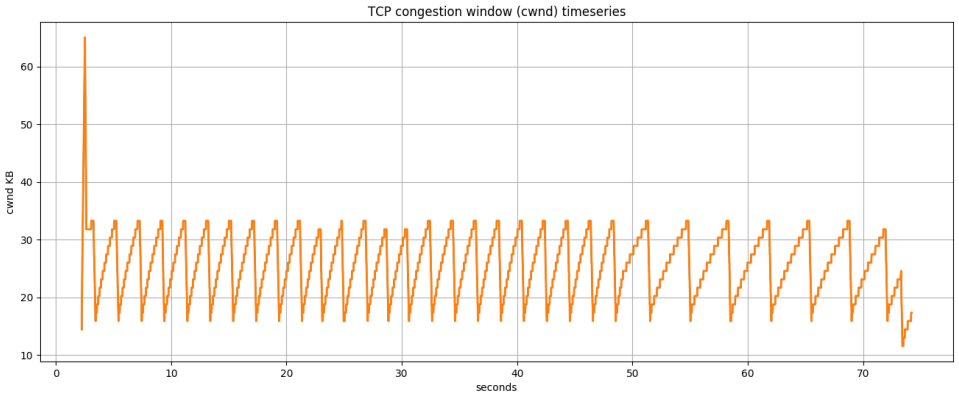
- **Please comment on what you can see in the figures.**

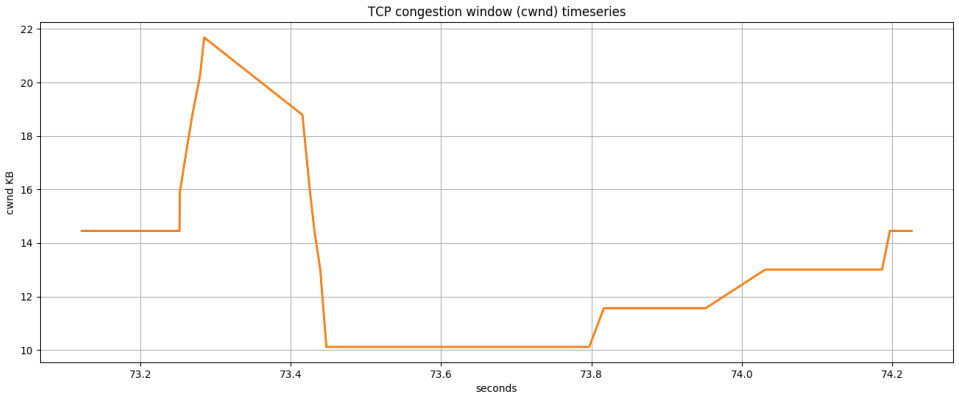
> For figure 1: The Buffer at router is 100 so we can see that when the packets at buffer reaches 100, it will cut down half. We also can see that before 75 second, the increase speed (the slope of the picture) become larger. It is because we run the web page download at that time. Two resources use the same network make the buffer reach to 100 packets more quickly. After 75, it increase first then decrease, i guess
>
> For figure 2 : It is cwnd for iperf, we can see that around 10 - 40 seconds, the cwnd keep increasing, then cut down half at 40s, then keep increasing again. The trick part not sure is at 50s the slope decrease a little bit. At 75s it decrease again. This peak it did not reach as same height as first time. it is because the web page download also begins, which result in the buffer at router reach 100 earlier.

> For figure 3 : It is cwnd for web page download, picture is only one of the sections of this period. We can find that it increase like staircase.

- **Please provide the figures for the second experiment (with qlen 20).**







- **Please comment on what you can see in the figures and what is different from the previous experiment. Explain the reason behind the difference.**

> For figure 1: The Buffer at router is 20 so we can see that when the packets at buffer reaches 20, it will cut down half. We also can see that before 75 second, the increase speed (the slope of the picture) become larger. It is because we run the web page download at that time. Two resources use the same network make the buffer reach to 20 packets more quickly. After 75, it increase first then decrease, i guess
>
> For figure 2 : It is cwnd for iperf, we can see that before 70 seconds, the cwnd keep increasing, then cut down half, then keep increasing again. The trick part not sure is at 50s the increasing slope decrease a little bit. At around 75s, this peak it did not reach as same height as previous. it is because the web page download also begins, which result in the buffer at router reach 20 earlier.
>
> For figure 3 : It is cwnd for web page download, picture is only one of the sections of this period. At 73.3s, it reach the peak and then cut down half from around 22 - around 10. Then it increase like staircases again.