HIGH SPEED NETWORKS

BUFFERBLOAT

LAB-#3

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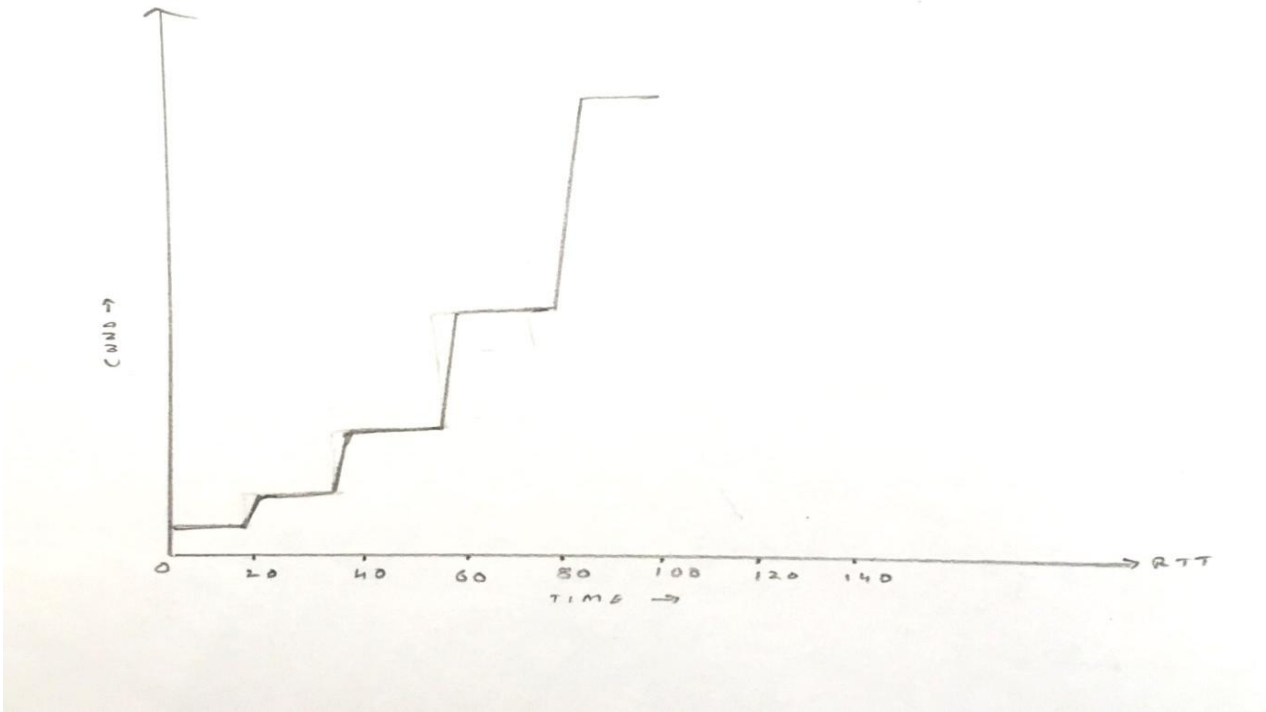
1. **Answer: 1.0 second**

```
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=21.3 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=21.2 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=20.4 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=25.4 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=20.4 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 20.419/22.384/25.455/1.900 ms
mininet> h2 wget http://10.0.0.1
--2016-04-13 10:22:31--  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%  171K 0s
   150K .......... .......... ...                              100%  184K=1.0s

2016-04-13 10:22:32 (178 KB/s) - 'index.html' saved [177669/177669]

mininet>
```

2. **Sketch how you think cwnd evolves over time at H1. Mark multiples of RTT on the x-axis**

```
64 bytes from 10.0.0.2: icmp_seq=1 ttl=64 time=22.1 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=20.4 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 20.454/21.286/22.119/0.845 ms
Initially, the delay between two hosts is around 20ms
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=23.6 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=21.5 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=25.1 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=20.4 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=24.0 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=21.3 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=21.2 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=20.4 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=25.4 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=20.4 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9013ms
rtt min/avg/max/mdev = 20.419/22.384/25.455/1.900 ms
mininet>
```

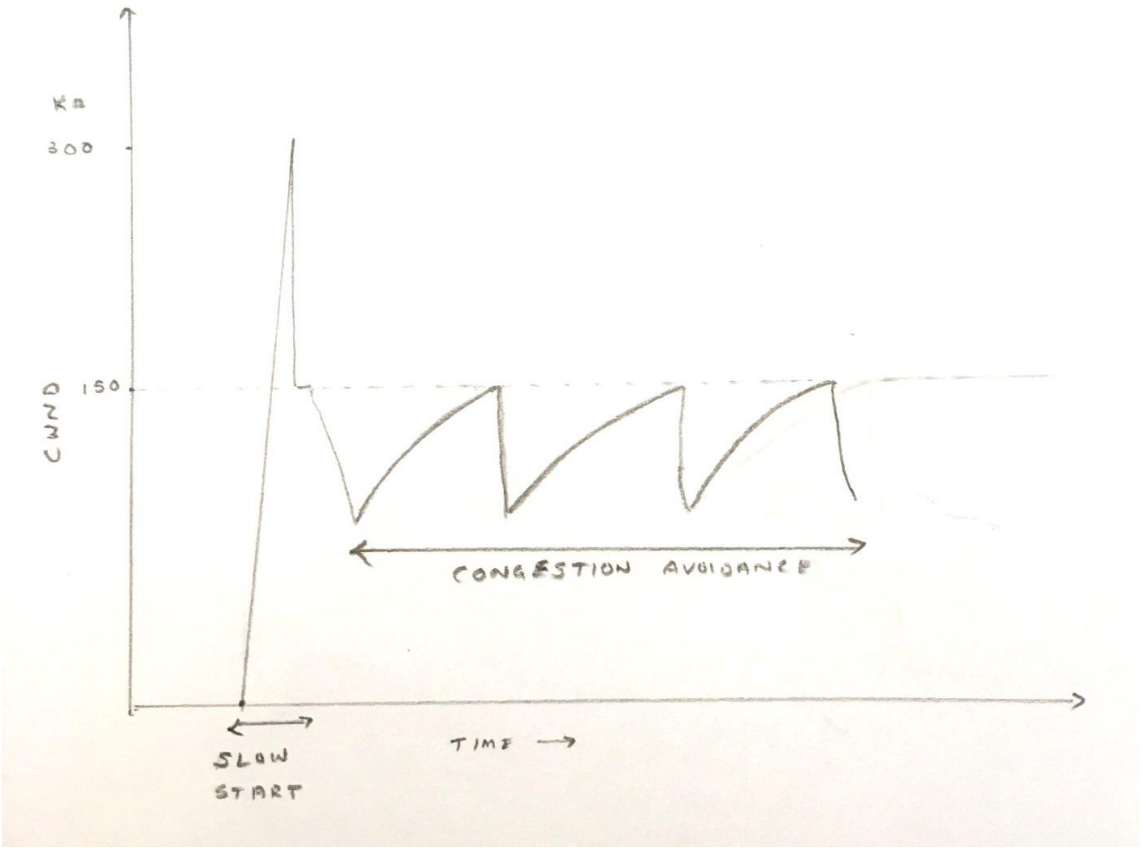
Cwnd increases exponentially every RTT which is around 20ms.Short flows stay in slow start phase.



3. **Sketch how you think cwnd evolves over time at H1. You might find it useful to use ping to measure how the delay evolves over time, after the iperf has started**

```
2016-04-13 10:22:32 (178 KB/s) - 'index.html' saved [177669/177669]

mininet> h1 ./iperf.sh
10.0.0.2 - - [13/Apr/2016 10:22:31] "GET / HTTP/1.1" 200 -
started iperf
mininet> h2 tail -f ./iperf-recv.txt
[  4] 16.0-17.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 17.0-18.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 18.0-19.0 sec   174 KBytes  1.42 Mbits/sec
[  4] 19.0-20.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 20.0-21.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 21.0-22.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 22.0-23.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 23.0-24.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 24.0-25.0 sec   174 KBytes  1.42 Mbits/sec
[  4] 25.0-26.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 26.0-27.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 27.0-28.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 28.0-29.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 29.0-30.0 sec   175 KBytes  1.44 Mbits/sec
[  4] 30.0-31.0 sec   174 KBytes  1.42 Mbits/sec
[  4] 31.0-32.0 sec   175 KBytes  1.44 Mbits/sec
^Cmininet>
```

Cwnd increases exponentially during slow-start phase, but it later increases linearly during congestion avoidance phase. Initially it tries to achieve 300KB of congestion window, but experience congestion-window reduces to half (150 KB=1.5KB*100) .After this it enters congestion avoidance phase with cwnd increases by 1 every RTT



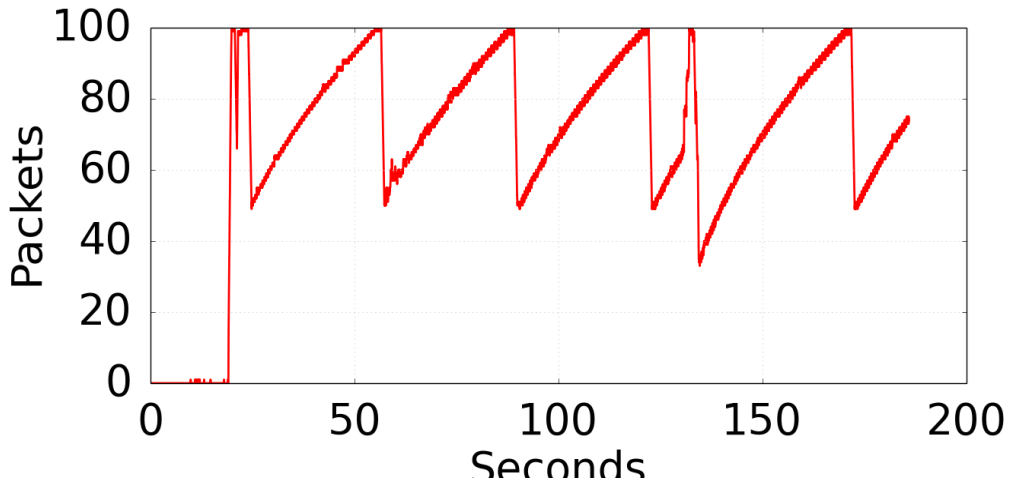
4. **Answer: 4.3 seconds**

```
64 bytes from 10.0.0.2: icmp_seq=59 ttl=64 time=704 ms
64 bytes from 10.0.0.2: icmp_seq=60 ttl=64 time=723 ms
64 bytes from 10.0.0.2: icmp_seq=61 ttl=64 time=732 ms
64 bytes from 10.0.0.2: icmp_seq=62 ttl=64 time=743 ms
64 bytes from 10.0.0.2: icmp_seq=63 ttl=64 time=745 ms
64 bytes from 10.0.0.2: icmp_seq=64 ttl=64 time=756 ms
64 bytes from 10.0.0.2: icmp_seq=65 ttl=64 time=764 ms
64 bytes from 10.0.0.2: icmp_seq=66 ttl=64 time=782 ms
64 bytes from 10.0.0.2: icmp_seq=67 ttl=64 time=789 ms
64 bytes from 10.0.0.2: icmp_seq=68 ttl=64 time=798 ms
64 bytes from 10.0.0.2: icmp_seq=69 ttl=64 time=808 ms
64 bytes from 10.0.0.2: icmp_seq=70 ttl=64 time=744 ms
64 bytes from 10.0.0.2: icmp_seq=71 ttl=64 time=414 ms
64 bytes from 10.0.0.2: icmp_seq=72 ttl=64 time=431 ms
64 bytes from 10.0.0.2: icmp_seq=73 ttl=64 time=456 ms
64 bytes from 10.0.0.2: icmp_seq=74 ttl=64 time=473 ms
64 bytes from 10.0.0.2: icmp_seq=75 ttl=64 time=491 ms
64 bytes from 10.0.0.2: icmp_seq=76 ttl=64 time=492 ms
64 bytes from 10.0.0.2: icmp_seq=77 ttl=64 time=509 ms
64 bytes from 10.0.0.2: icmp_seq=78 ttl=64 time=526 ms
64 bytes from 10.0.0.2: icmp_seq=79 ttl=64 time=544 ms
64 bytes from 10.0.0.2: icmp_seq=80 ttl=64 time=553 ms
64 bytes from 10.0.0.2: icmp_seq=81 ttl=64 time=571 ms
64 bytes from 10.0.0.2: icmp_seq=82 ttl=64 time=589 ms
64 bytes from 10.0.0.2: icmp_seq=83 ttl=64 time=607 ms
64 bytes from 10.0.0.2: icmp_seq=84 ttl=64 time=617 ms
64 bytes from 10.0.0.2: icmp_seq=85 ttl=64 time=634 ms
64 bytes from 10.0.0.2: icmp_seq=86 ttl=64 time=643 ms
64 bytes from 10.0.0.2: icmp_seq=87 ttl=64 time=659 ms
```

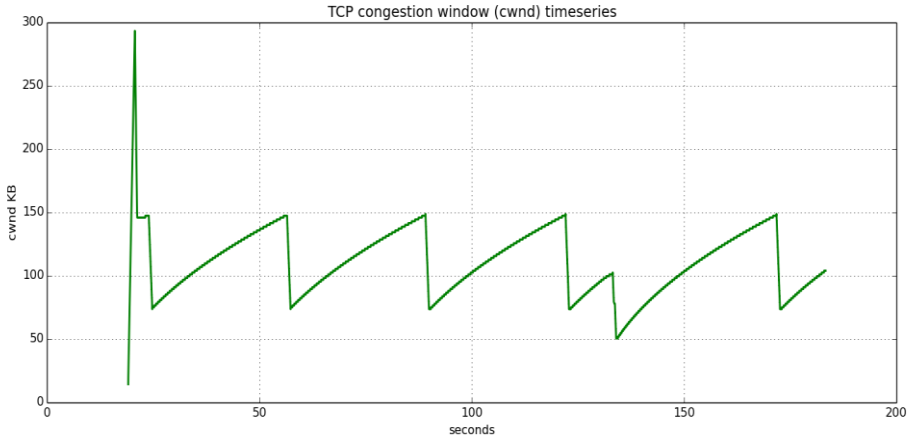
```
mininet> h1 ./iperf.sh
started iperf
mininet> h2 wget http://10.0.0.1
--2016-04-13 10:59:18--  http://10.0.0.1/
Connecting to 10.0.0.1:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 177669 (174K) [text/html]
Saving to: 'index.html'

     0K .......... .......... .......... .......... .......... 28% 41.5K 3s
    50K .......... .......... .......... .......... .......... 57% 66.7K 1s
   100K .......... .......... .......... .......... .......... 86% 60.6K 0s
   150K .......... .......... ...                              100% 15.3K=4.3s

2016-04-13 10:59:23 (40.2 KB/s) - 'index.html' saved [177669/177669]

mininet>
```

5. **Why does the web page take so much longer to download? Please write your explanation below**
   Web page takes around 4.3 sec to download. It is a short flow as compared to iperf (long flow). All the long flows use the available bandwidth. Here the buffer size is more (100 pkts), all this is occupied by large iperf flows hence short http flows takes lot of time (delays) as compared to the previous one (1 sec)
6. **Measuring real cwnd and buffer occupancy values:**

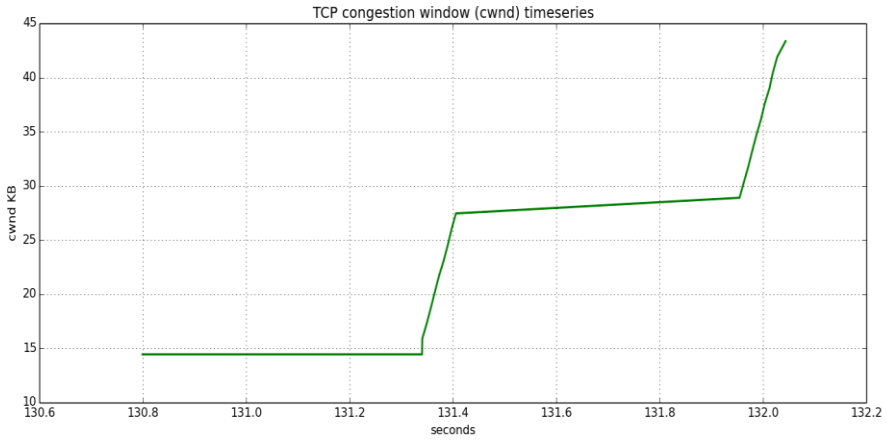
a) **Queue**



b) cwnd- iperf:

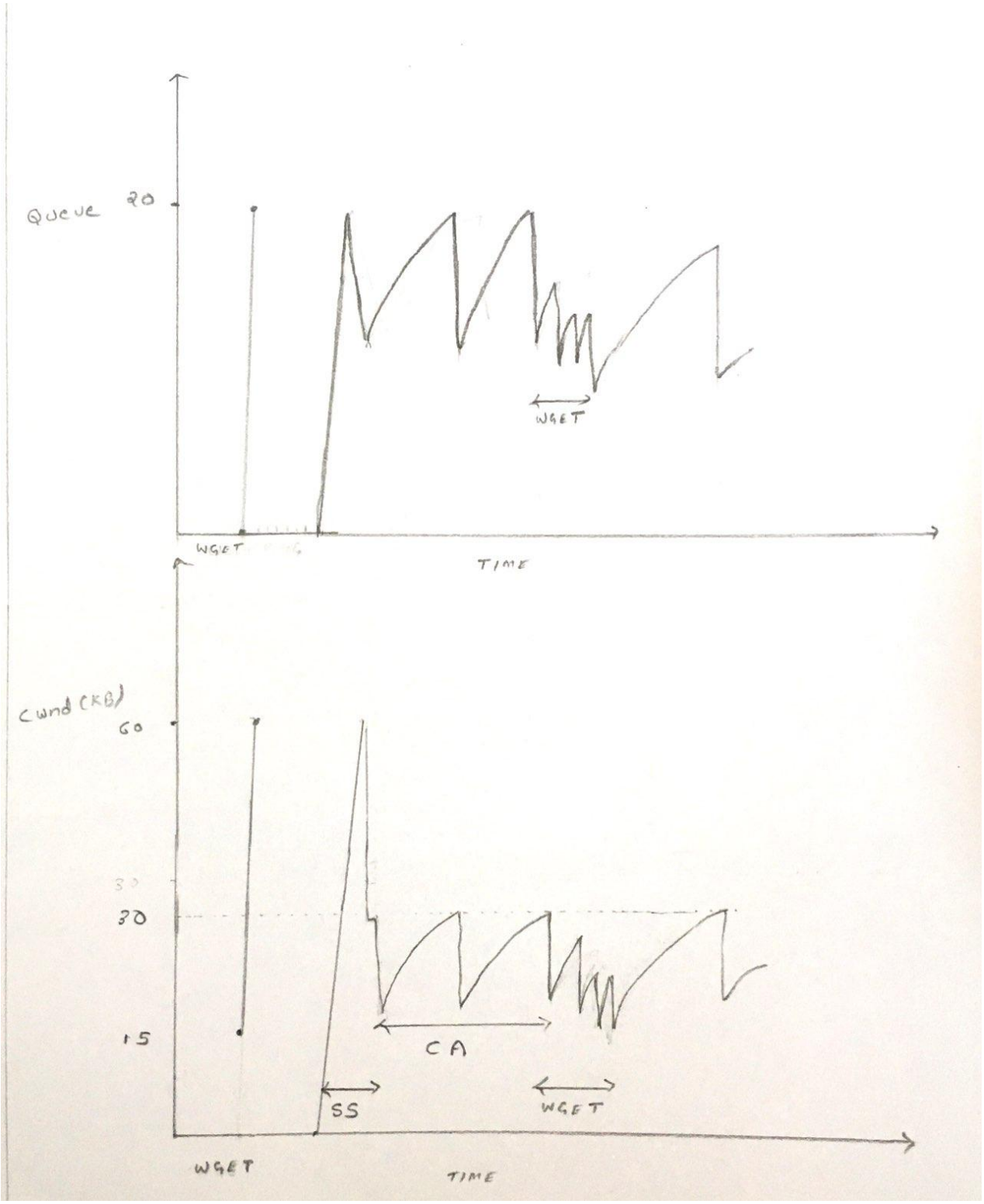


c) cwnd-wget:



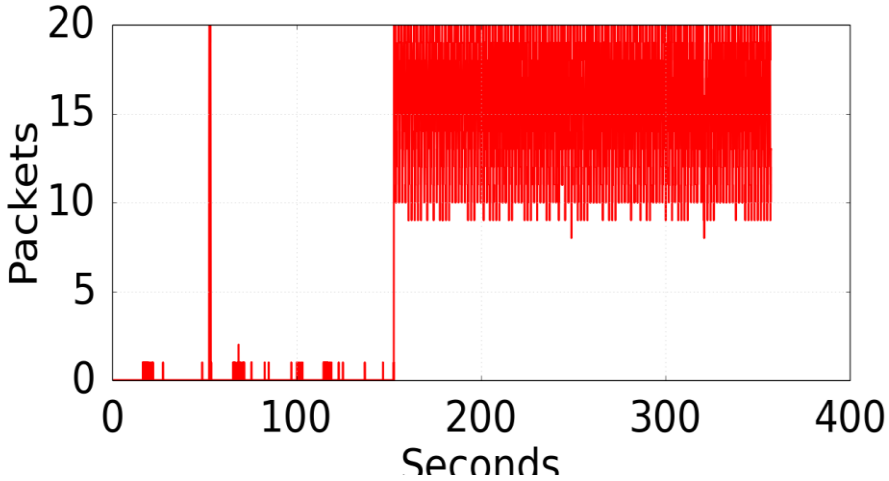
7. What do you think the cwnd and queue occupancy will be like in this case?

Here we see that initial rise in cwnd is caused by first wget with cwnd= 60KB (1.5KB*20*2). It's a short flow and it finishes in slow start phase and does not enter congestion avoidance phase, also queue occupancy is full- 20 packets . Next when we start iperf, we again see a peak with 60KB and then it enters congestion avoidance phase. Here queue is full and then there is a drop of packet, queue occupancy decreases and then increases. Next wget comes, there is a interference between iperf and wget , hence there is packet drop and the cwnd and buffer size reduces. When the wget process is done the cwnd and buffer adjusts for iperf state (as previous values)

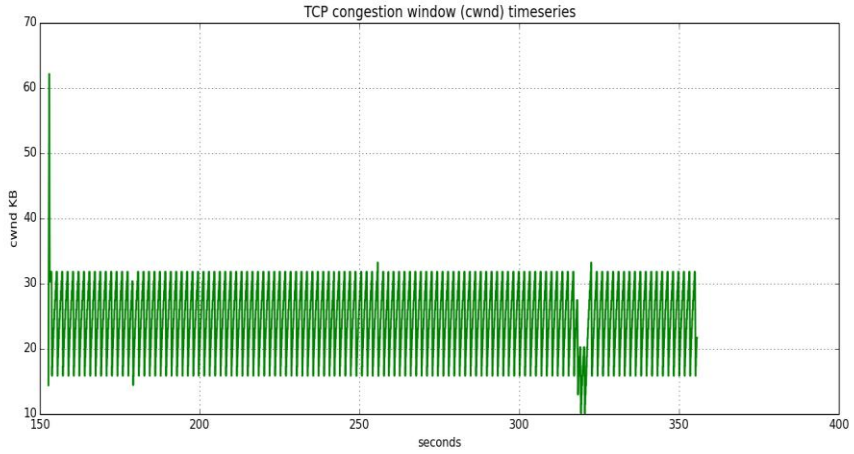

Queue
20
WGET
TIME
cwnd (KB)
60
30
15
CA
SS
WGET
WGET
TIME

8. **Plot the figure for cwnd and queue occupancy, this time using the script "./plot_figures_minq.sh"**

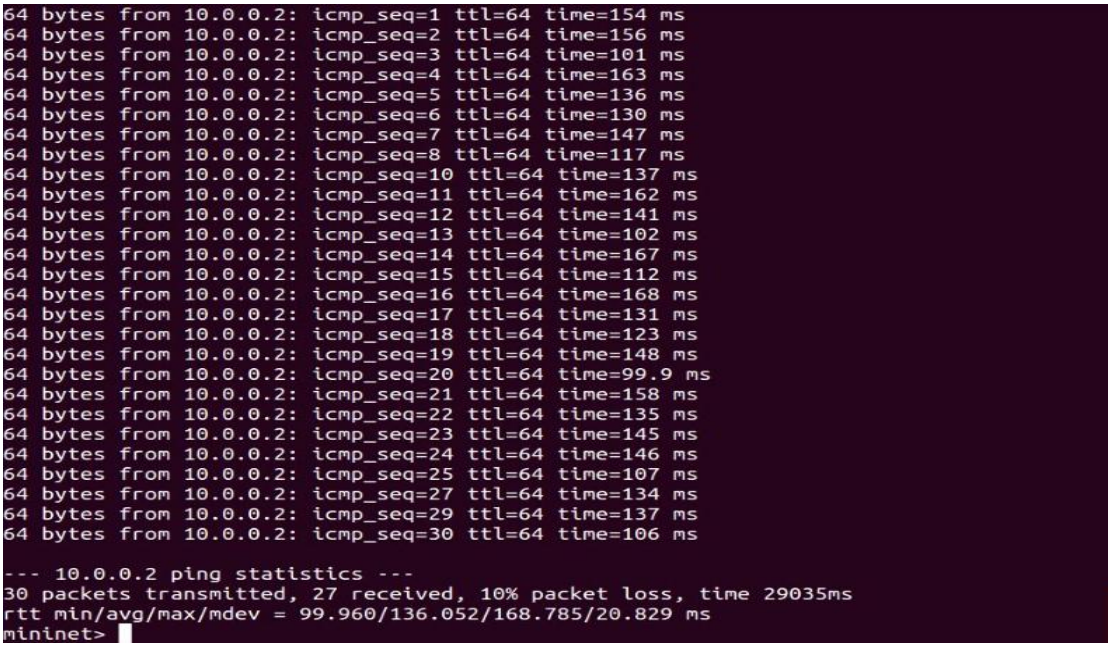
a) **Queue:**

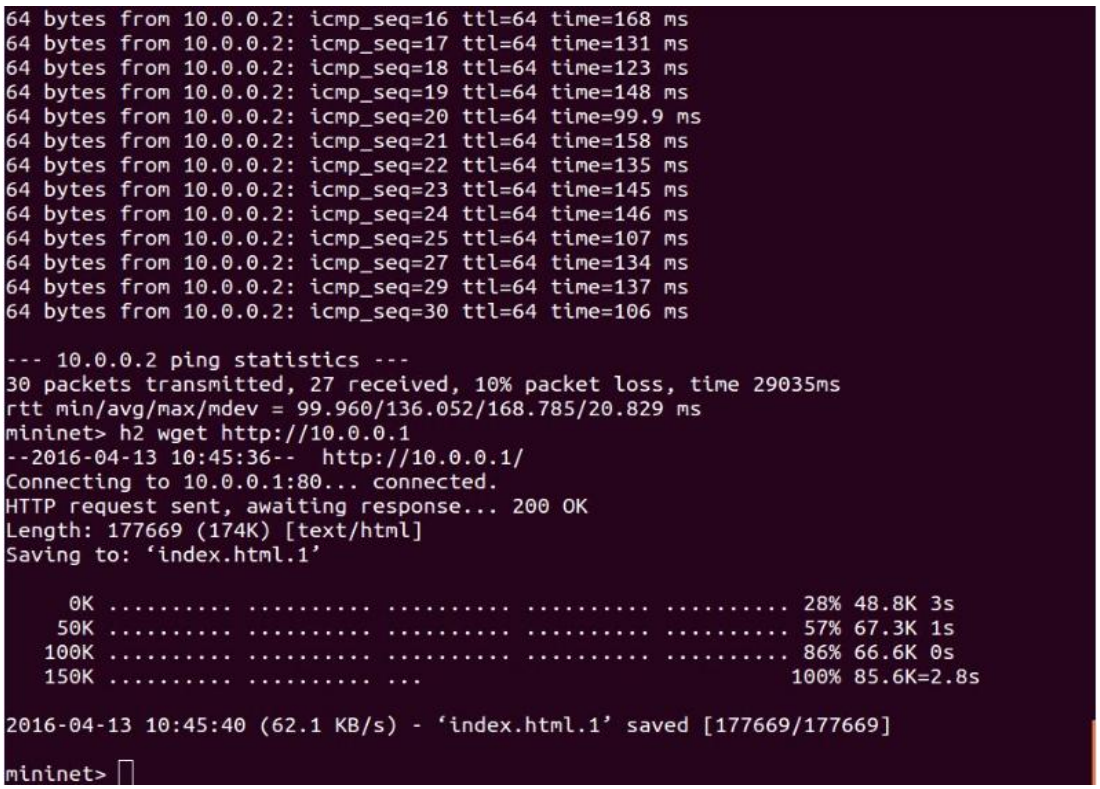


b) **Cwnd- iperf:**



c) **Cwnd-wget:**





9. **Why does reducing the queue size reduce the download time for wget? Please put your explanation below**

The buffer size is less around 20 packets as compared to 100 packets, small flows (wget) get a chance to send their packet early, without waiting for the large flows in the buffer to finish off. Since the waiting time (queuing time) is less compared to the previous one, the time taken by wget is also less.

10. **Different Queue:**

Both the large and small flows are given equal priority. Hence, time for wget is same with and without iperf.

```
qdisc removed
qdisc added
classes created
filters added
qdisc removed
qdisc added
classes created
filters added
Ping result:
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=21.1 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=20.5 ms

--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 20.547/20.872/21.198/0.356 ms
Initially, the delay between two hosts is around 20ms
mininet> h2 wget http://10.0.0.1
--2016-04-13 10:49:59--  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%  182K=1.0s

2016-04-13 10:50:00 (178 KB/s) - 'index.html' saved [177669/177669]

mininet>
```

```
mininet> h2 wget http://10.0.0.1
--2016-04-13 10:49:59--  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%  182K=1.0s

2016-04-13 10:50:00 (178 KB/s) - 'index.html' saved [177669/177669]

mininet> h1 ping -c 10 h2
10.0.0.2 - - [13/Apr/2016 10:49:59] "GET / HTTP/1.1" 200 -
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=23.0 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=21.3 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=22.8 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=20.9 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=21.7 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=20.3 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=20.4 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=22.5 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=21.3 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=20.6 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9016ms
rtt min/avg/max/mdev = 20.312/21.534/23.065/0.950 ms
mininet>
```

After iperf started

```
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=20.6 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=20.5 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=21.0 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=21.1 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=21.8 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=20.5 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=21.4 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=26.1 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=20.5 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=20.7 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=23.3 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=23.2 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=22.2 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=22.7 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=21.0 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=21.6 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=20.3 ms
64 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=20.9 ms
64 bytes from 10.0.0.2: icmp_seq=22 ttl=64 time=22.3 ms
64 bytes from 10.0.0.2: icmp_seq=23 ttl=64 time=21.0 ms
64 bytes from 10.0.0.2: icmp_seq=24 ttl=64 time=22.5 ms
64 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=21.2 ms
64 bytes from 10.0.0.2: icmp_seq=26 ttl=64 time=22.1 ms
64 bytes from 10.0.0.2: icmp_seq=27 ttl=64 time=21.6 ms
64 bytes from 10.0.0.2: icmp_seq=28 ttl=64 time=22.1 ms
64 bytes from 10.0.0.2: icmp_seq=29 ttl=64 time=23.3 ms
64 bytes from 10.0.0.2: icmp_seq=30 ttl=64 time=23.1 ms

--- 10.0.0.2 ping statistics ---
30 packets transmitted, 30 received, 0% packet loss, time 29050ms
rtt min/avg/max/mdev = 20.341/21.926/26.138/1.242 ms
mininet>
```

```
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=21.0 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=21.6 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=20.3 ms
64 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=20.9 ms
64 bytes from 10.0.0.2: icmp_seq=22 ttl=64 time=22.3 ms
64 bytes from 10.0.0.2: icmp_seq=23 ttl=64 time=21.0 ms
64 bytes from 10.0.0.2: icmp_seq=24 ttl=64 time=22.5 ms
64 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=21.2 ms
64 bytes from 10.0.0.2: icmp_seq=26 ttl=64 time=22.1 ms
64 bytes from 10.0.0.2: icmp_seq=27 ttl=64 time=21.6 ms
64 bytes from 10.0.0.2: icmp_seq=28 ttl=64 time=22.1 ms
64 bytes from 10.0.0.2: icmp_seq=29 ttl=64 time=23.3 ms
64 bytes from 10.0.0.2: icmp_seq=30 ttl=64 time=23.1 ms

--- 10.0.0.2 ping statistics ---
30 packets transmitted, 30 received, 0% packet loss, time 29050ms
rtt min/avg/max/mdev = 20.341/21.926/26.138/1.242 ms
mininet> h2 wget http://10.0.0.1
--2016-04-13 10:55:30--  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.1’

     0K .......... .......... .......... .......... .......... 28%  182K 1s
    50K .......... .......... .......... .......... .......... 57%  177K 0s
   100K .......... .......... .......... .......... .......... 86%  171K 0s
   150K .......... .......... ...                              100%  182K=1.0s

2016-04-13 10:55:31 (177 KB/s) - ‘index.html.1’ saved [177669/177669]

mininet>
```