

Lab 4

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2.2

h1 ip: 10.0.0.1

h2 ip: 10.0.0.2

3.1

1 sec

start of tcp transfer, cwnd should be in slow start phase, increasing from 1, 2, 4..., exponentially

3.2

iperf

```
bowen@bowen-VirtualBox: ~/lab4/lab4
--- 10.0.0.2 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1003ms
rtt min/avg/max/mdev = 31.469/31.491/31.514/0.178 ms
Initially, the delay between two hosts is around 20ms
mininet> h1 ./iperf.sh
started iperf
mininet> h2 tail -f ./iperf-recv.txt
[ 4] local 10.0.0.2 port 5001 connected with 10.0.0.1 port 56451
[ ID] Interval      Transfer      Bandwidth
[ 4] 0.0- 1.0 sec    177 KBytes    1.45 Mbits/sec
[ 4] 1.0- 2.0 sec   94.7 KBytes    776 Kbits/sec
[ 4] 2.0- 3.0 sec   222 KBytes    1.82 Mbits/sec
[ 4] 3.0- 4.0 sec   209 KBytes    1.71 Mbits/sec
[ 4] 4.0- 5.0 sec   175 KBytes    1.44 Mbits/sec
[ 4] 5.0- 6.0 sec   116 KBytes    950 Kbits/sec
[ 4] 6.0- 7.0 sec   233 KBytes    1.91 Mbits/sec
[ 4] 7.0- 8.0 sec   175 KBytes    1.44 Mbits/sec
[ 4] 8.0- 9.0 sec   175 KBytes    1.44 Mbits/sec
[ 4] 9.0-10.0 sec   175 KBytes    1.44 Mbits/sec
[ 4] 10.0-11.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 11.0-12.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 12.0-13.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 13.0-14.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 14.0-15.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 15.0-16.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 16.0-17.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 17.0-18.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 18.0-19.0 sec  175 KBytes    1.44 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  174 KBytes    1.42 Mbits/sec
[ 4] 23.0-24.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 24.0-25.0 sec  175 KBytes    1.44 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  174 KBytes    1.42 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  175 KBytes    1.44 Mbits/sec
[ 4] 31.0-32.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 32.0-33.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 33.0-34.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 34.0-35.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 35.0-36.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 36.0-37.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 37.0-38.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 38.0-39.0 sec  43.8 KBytes    359 Kbits/sec
[ 4] 39.0-40.0 sec  304 KBytes    2.49 Mbits/sec
[ 4] 40.0-41.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 41.0-42.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 42.0-43.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 43.0-44.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 44.0-45.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 45.0-46.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 46.0-47.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 47.0-48.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 48.0-49.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 49.0-50.0 sec  174 KBytes    1.42 Mbits/sec
[ 4] 50.0-51.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 51.0-52.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 52.0-53.0 sec  175 KBytes    1.44 Mbits/sec
[ 4] 53.0-54.0 sec  175 KBytes    1.44 Mbits/sec
```

```

mininet> h1 ping -c 100 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=35.6 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=40.4 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=31.2 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=30.8 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=31.0 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=35.5 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=31.2 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=42.7 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=31.1 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=48.1 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=32.1 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=30.6 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=33.5 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=45.9 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=33.9 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=48.3 ms
64 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=47.0 ms
64 bytes from 10.0.0.2: icmp_seq=22 ttl=64 time=55.6 ms
64 bytes from 10.0.0.2: icmp_seq=23 ttl=64 time=49.6 ms
64 bytes from 10.0.0.2: icmp_seq=24 ttl=64 time=30.6 ms
64 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=32.0 ms
64 bytes from 10.0.0.2: icmp_seq=26 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=27 ttl=64 time=30.8 ms
64 bytes from 10.0.0.2: icmp_seq=28 ttl=64 time=35.3 ms
64 bytes from 10.0.0.2: icmp_seq=29 ttl=64 time=41.2 ms
64 bytes from 10.0.0.2: icmp_seq=30 ttl=64 time=46.1 ms
64 bytes from 10.0.0.2: icmp_seq=31 ttl=64 time=37.4 ms
^C
--- 10.0.0.2 ping statistics ---
31 packets transmitted, 31 received, 0% packet loss, time 30171ms
rtt min/avg/max/mdev = 30.608/36.854/55.613/7.286 ms

```

ping = 36 ms

with iperf running

```

mininet> h1 ping -c 100 h2
10.0.0.2 - - [29/Oct/2020 00:48:16] "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=698 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=706 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=711 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=721 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=723 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=732 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=742 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=729 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=739 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=748 ms
64 bytes from 10.0.0.2: icmp_seq=11 ttl=64 time=749 ms
^C
--- 10.0.0.2 ping statistics ---
11 packets transmitted, 11 received, 0% packet loss, time 10004ms
rtt min/avg/max/mdev = 698.394/727.506/749.043/16.303 ms

```

ping = 727 ms

with iperf running

wget

```
mininet> h1 ./iperf.sh
started iperf
mininet> h2 wget h1
--2020-10-29 00:48:16-- 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% 38.1K 3s
50K ..... 57% 35.6K 2s
100K ..... 86% 344K 0s
150K ..... 100% 14.9K=4.4s

2020-10-29 00:48:21 (39.1 KB/s) - 'index.html' saved [177669/177669]
```

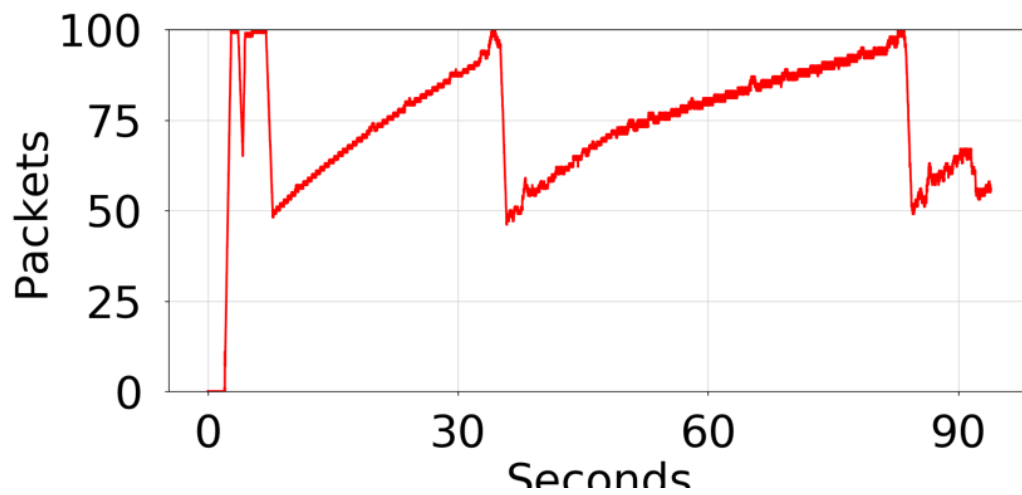
took 5 secs

the bandwidth is shared with iperf, causing the effective bandwidth available to download the file to be smaller, resulting in longer time.

3.3

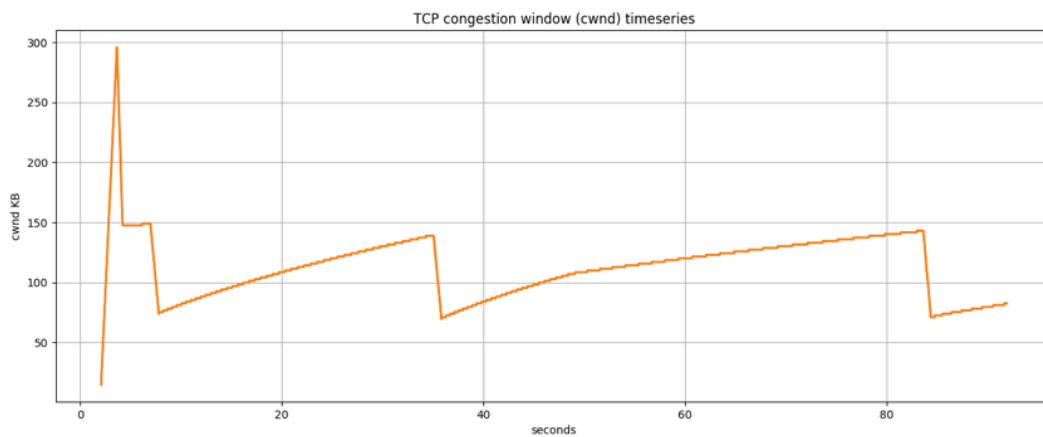
100 packets

exp_3.3_queue.png

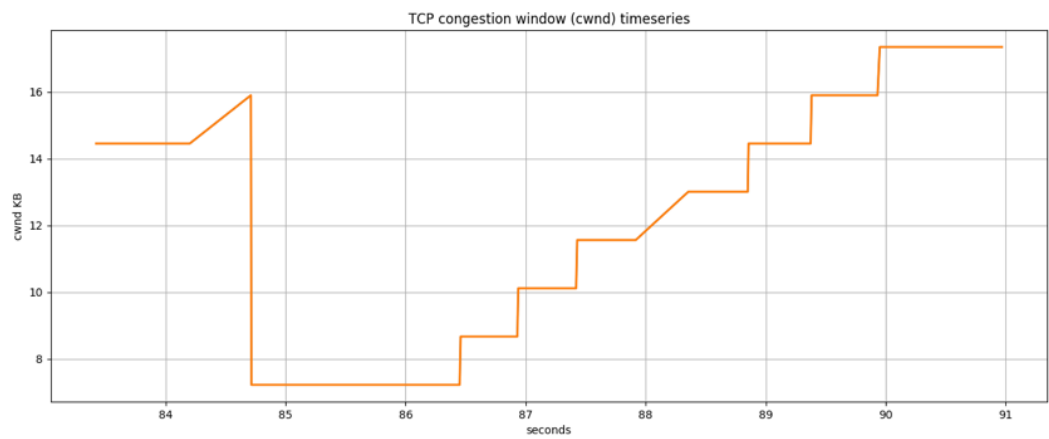


takes a long time to fill up the buffer

exp_3.3_tcp_cwnd_iperf.png



exp_3.3_tcp_cwnd_wget.png



3.4

minq

20 packets

```
mininet> h2 wget h1
--2020-10-29 00:59:22-- 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% 106K 1s
 50K ..... 57% 344K 0s
100K ..... 86% 199K 0s
150K ..... 100% 44.2K=1.4s

2020-10-29 00:59:23 (124 KB/s) - 'index.html' saved [177669/177669]
```

time: 1 sec

no change

```
mininet> h1 ping -c 10 h2
10.0.0.2 - - [29/Oct/2020 00:59:22] "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=30.7 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=40.4 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=42.2 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=30.7 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=31.3 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=47.2 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=49.2 ms
64 bytes from 10.0.0.2: icmp_seq=9 ttl=64 time=31.6 ms
64 bytes from 10.0.0.2: icmp_seq=10 ttl=64 time=31.6 ms

--- 10.0.0.2 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9021ms
rtt min/avg/max/mdev = 30.485/36.596/49.289/7.092 ms
```

ping: 36.596 ms

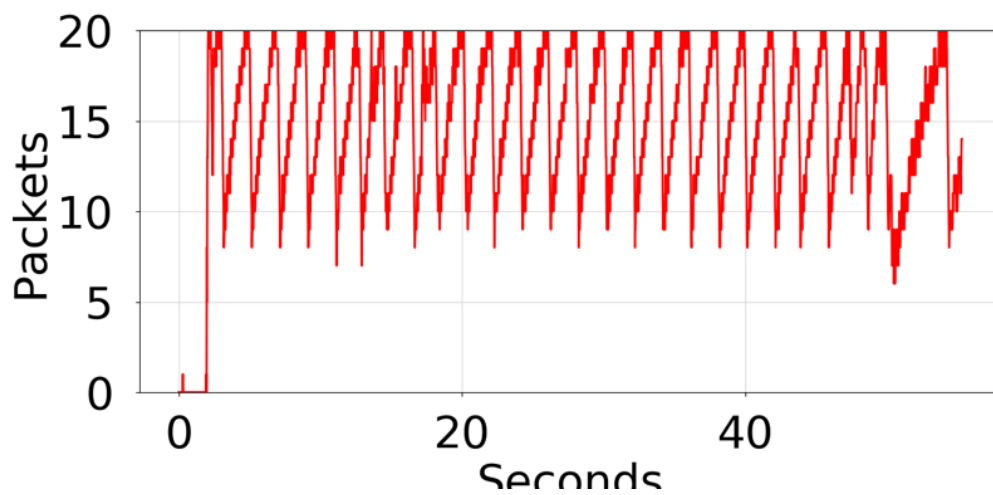
no change between experiment with 100 and 20 packets

restart

capture exp_3.4

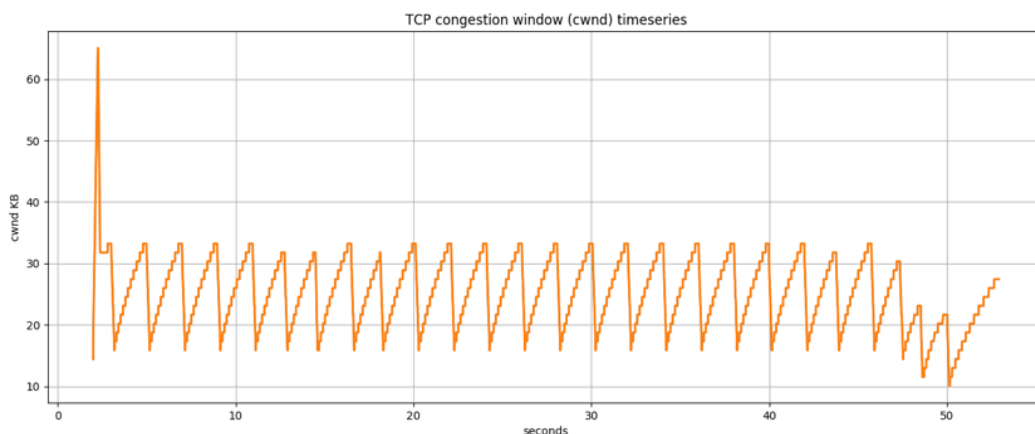
h1 ./iperf.sh

exp_3.4_queue.png



takes a faster time to fill up the buffer, compared to previous

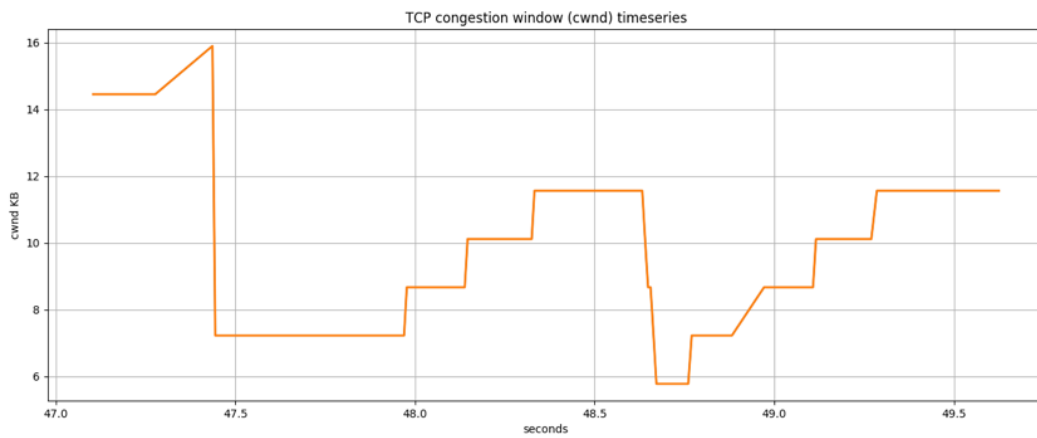
exp_3.4_tcp_cwnd_iperf.png



very frequent multiplicative decrease

cwnd = ssthresh is much lower than previous (32 KB vs 148 KB)

exp_3.4_tcp_cwnd_wget.png



queue: very fast fill up, then gets cut into half

cwnd: very fast reach the limit of ssthresh, then gets cut into half

```
h1 ping -c 30 h2
```

```
h2 wget h1
```

```

mininet> h1 ./iperf.sh
started iperf
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=110 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=64 time=166 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=64 time=110 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=64 time=167 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=64 time=111 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=64 time=160 ms
64 bytes from 10.0.0.2: icmp_seq=7 ttl=64 time=121 ms
64 bytes from 10.0.0.2: icmp_seq=8 ttl=64 time=172 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=11 ttl=64 time=143 ms
64 bytes from 10.0.0.2: icmp_seq=12 ttl=64 time=95.2 ms
64 bytes from 10.0.0.2: icmp_seq=13 ttl=64 time=154 ms
64 bytes from 10.0.0.2: icmp_seq=14 ttl=64 time=100 ms
64 bytes from 10.0.0.2: icmp_seq=15 ttl=64 time=151 ms
64 bytes from 10.0.0.2: icmp_seq=16 ttl=64 time=103 ms
64 bytes from 10.0.0.2: icmp_seq=17 ttl=64 time=161 ms
64 bytes from 10.0.0.2: icmp_seq=18 ttl=64 time=105 ms
64 bytes from 10.0.0.2: icmp_seq=19 ttl=64 time=153 ms
64 bytes from 10.0.0.2: icmp_seq=20 ttl=64 time=104 ms
64 bytes from 10.0.0.2: icmp_seq=21 ttl=64 time=154 ms
64 bytes from 10.0.0.2: icmp_seq=22 ttl=64 time=100 ms
64 bytes from 10.0.0.2: icmp_seq=23 ttl=64 time=156 ms
64 bytes from 10.0.0.2: icmp_seq=24 ttl=64 time=101 ms
64 bytes from 10.0.0.2: icmp_seq=25 ttl=64 time=169 ms
64 bytes from 10.0.0.2: icmp_seq=26 ttl=64 time=105 ms
64 bytes from 10.0.0.2: icmp_seq=27 ttl=64 time=163 ms
64 bytes from 10.0.0.2: icmp_seq=28 ttl=64 time=107 ms
64 bytes from 10.0.0.2: icmp_seq=29 ttl=64 time=164 ms
64 bytes from 10.0.0.2: icmp_seq=30 ttl=64 time=108 ms

--- 10.0.0.2 ping statistics ---
30 packets transmitted, 29 received, 3% packet loss, time 29050ms
rtt min/avg/max/mdev = 95.242/133.509/172.746/27.462 ms
mininet> h2 wget h1
--2020-10-29 01:03:59-- 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% 55.2K 2s
 50K ..... 57% 62.6K 1s
100K ..... 86% 60.7K 0s
150K ..... 100% 70.9K=2.9s

2020-10-29 01:04:02 (60.7 KB/s) - 'index.html' saved [177669/177669]

```

time: 3 sec

when the queue size is smaller, iperf experiences multiplicative decrease more often. this results in more opportunities to achieve TCP fairness, allowing wget connection to get its share of bandwidth.