

Congestion control

Transport layer protocols

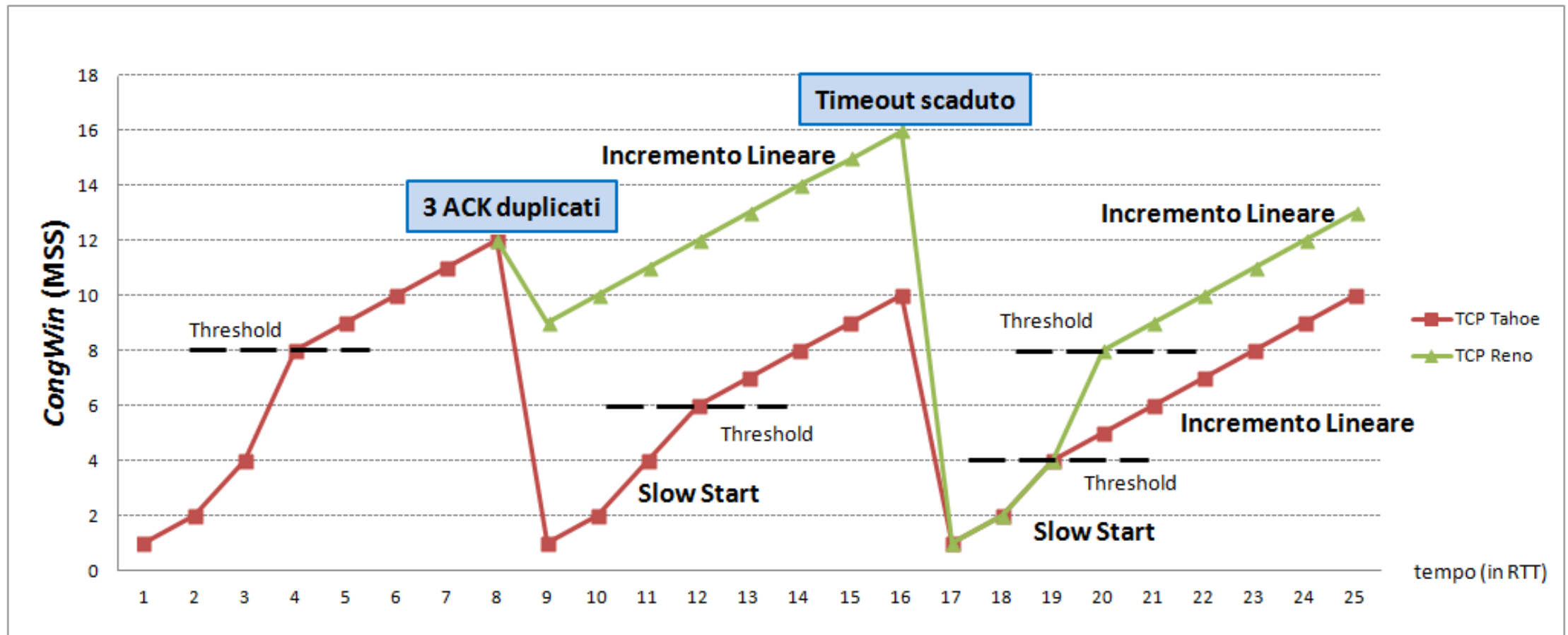
- Transmission Control Protocol (TCP)

- Connection-oriented
- Three-way handshake
- Congestion control
- Flow control
- Acknowledgement mechanism
- Slow

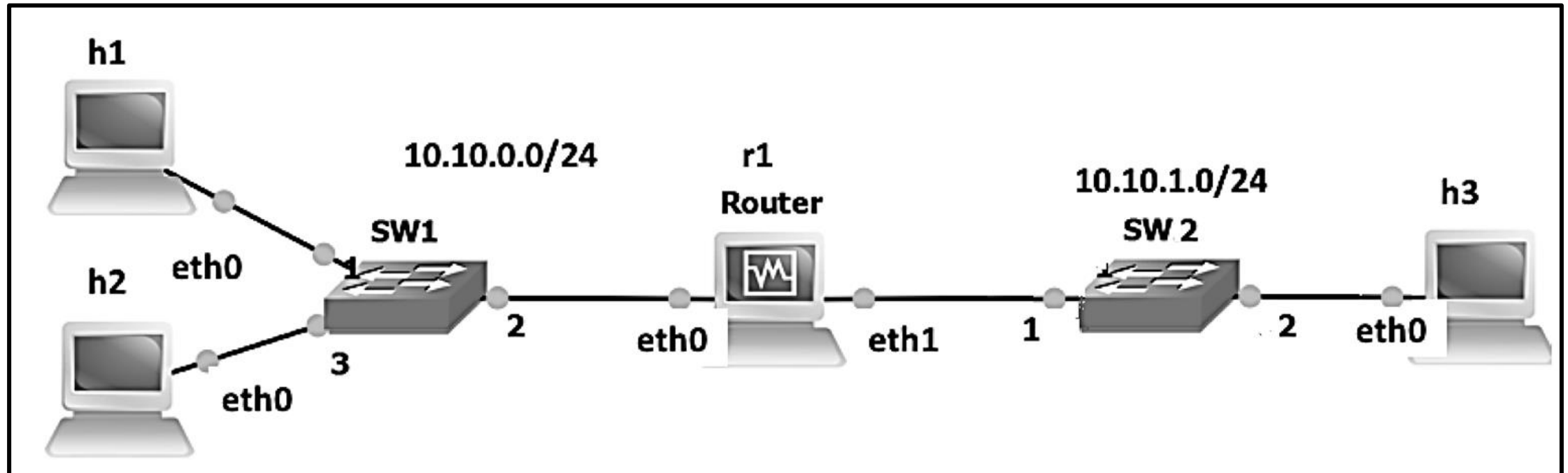
- User Datagram Protocol (UDP)

- Connection-less
- No handshake mechanism
- No congestion control
- No flow control
- No acknowledgement
- Fast

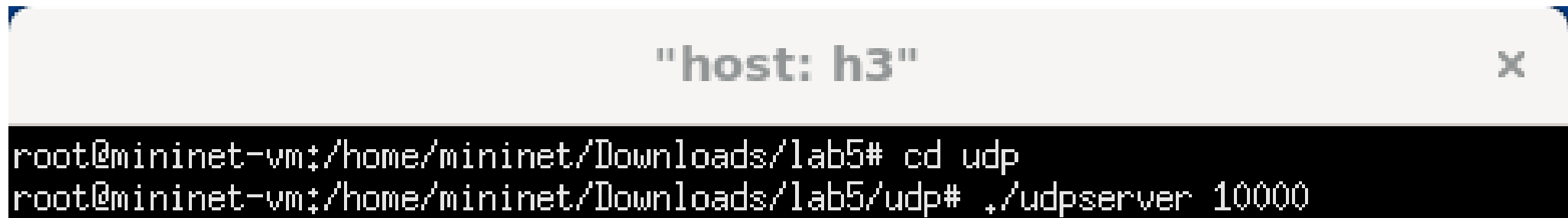
TCP congestion control



lab5_network.py



UDP connection



```
root@mininet-vm:/home/mininet/Downloads/lab5# cd udp
root@mininet-vm:/home/mininet/Downloads/lab5/udp# ./udpserver 10000
```

A terminal window titled "host: h3" with a close button (x) in the top right corner. The terminal shows two lines of text: the first line is the command `cd udp` and the second line is the command `./udpserver 10000`. The prompt for the first line is `root@mininet-vm:/home/mininet/Downloads/lab5#` and for the second line is `root@mininet-vm:/home/mininet/Downloads/lab5/udp#`.

"host: h1"

x

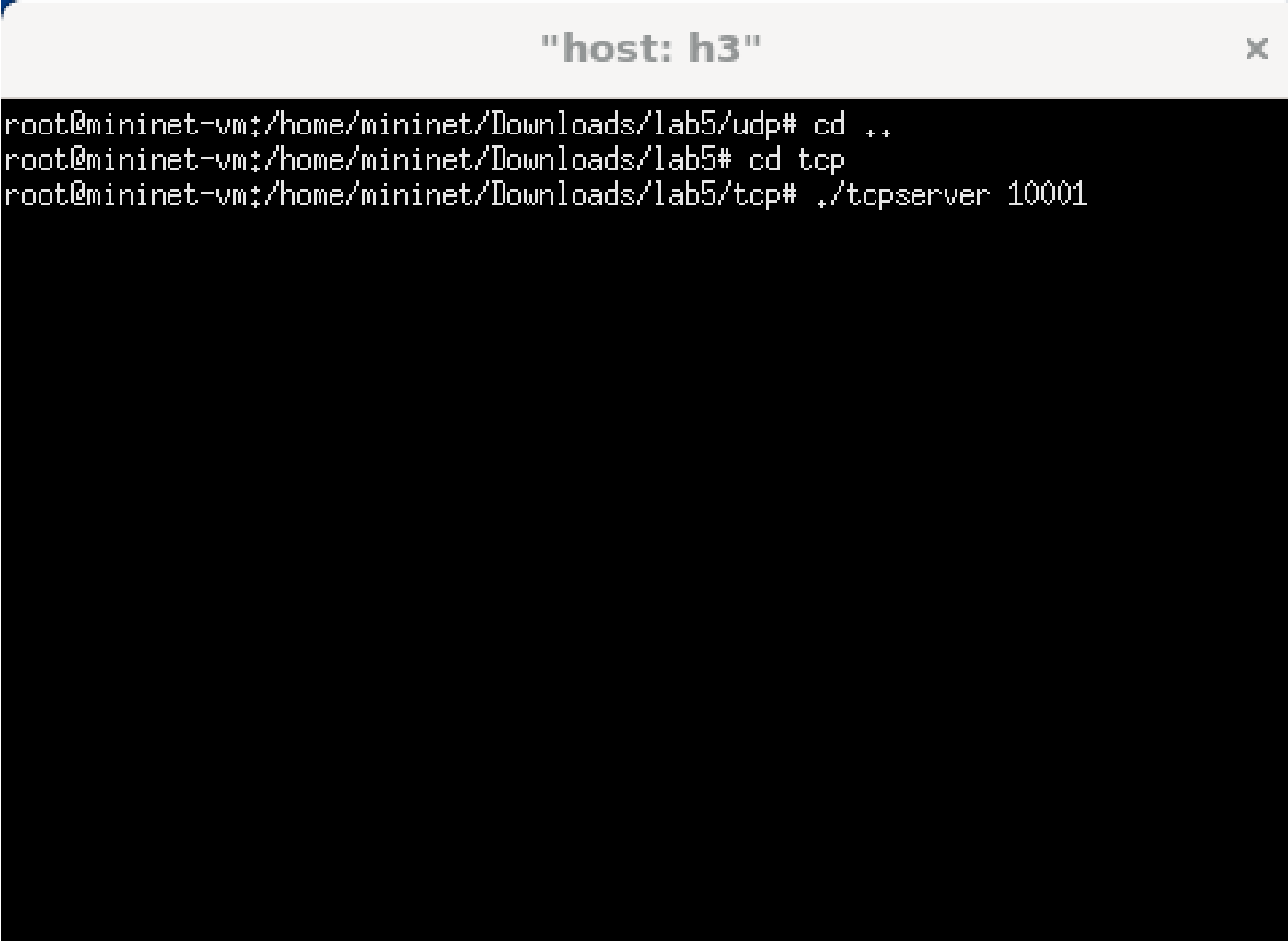
```
root@mininet-vm:/home/mininet/Downloads/lab5# cd udp
root@mininet-vm:/home/mininet/Downloads/lab5/udp# ./udpclient 10.10.1.3 10000 100
1.0s - sent: 14 pkts, 107.6 kbits/s
2.1s - sent: 27 pkts, 100.0 kbits/s
3.1s - sent: 40 pkts, 99.8 kbits/s
4.2s - sent: 53 pkts, 102.6 kbits/s
5.2s - sent: 66 pkts, 100.0 kbits/s
6.2s - sent: 79 pkts, 100.1 kbits/s
7.3s - sent: 92 pkts, 100.3 kbits/s
8.3s - sent: 105 pkts, 100.1 kbits/s
9.4s - sent: 118 pkts, 100.2 kbits/s
10.4s - sent: 131 pkts, 100.1 kbits/s
11.4s - sent: 144 pkts, 100.1 kbits/s
12.5s - sent: 157 pkts, 100.2 kbits/s
13.5s - sent: 170 pkts, 100.2 kbits/s
14.6s - sent: 183 pkts, 100.1 kbits/s
15.6s - sent: 196 pkts, 100.1 kbits/s
16.6s - sent: 209 pkts, 100.2 kbits/s
17.7s - sent: 222 pkts, 100.3 kbits/s
18.7s - sent: 235 pkts, 99.9 kbits/s
19.8s - sent: 248 pkts, 100.1 kbits/s
20.8s - sent: 261 pkts, 100.1 kbits/s
21.8s - sent: 274 pkts, 100.3 kbits/s
```

"host: h3"

x

```
root@mininet-vm:/home/mininet/Downloads/lab5# cd udp
root@mininet-vm:/home/mininet/Downloads/lab5/udp# ./udpserver 10000
0.0s - received: 1/ sent: 1 pkts (loss 0.000%), 0.2 kbit/s
47.0s - received: 14/ sent: 14 pkts (loss 0.000%), 100.3 kbit/s
48.0s - received: 27/ sent: 27 pkts (loss 0.000%), 100.0 kbit/s
49.0s - received: 40/ sent: 40 pkts (loss 0.000%), 100.0 kbit/s
50.1s - received: 53/ sent: 53 pkts (loss 0.000%), 100.0 kbit/s
51.1s - received: 66/ sent: 66 pkts (loss 0.000%), 100.0 kbit/s
52.2s - received: 79/ sent: 79 pkts (loss 0.000%), 100.0 kbit/s
53.2s - received: 92/ sent: 92 pkts (loss 0.000%), 99.9 kbit/s
54.2s - received: 105/ sent: 105 pkts (loss 0.000%), 100.1 kbit/s
55.3s - received: 118/ sent: 118 pkts (loss 0.000%), 100.0 kbit/s
56.3s - received: 131/ sent: 131 pkts (loss 0.000%), 100.0 kbit/s
57.4s - received: 144/ sent: 144 pkts (loss 0.000%), 100.0 kbit/s
58.4s - received: 157/ sent: 157 pkts (loss 0.000%), 100.0 kbit/s
59.4s - received: 170/ sent: 170 pkts (loss 0.000%), 100.0 kbit/s
60.5s - received: 183/ sent: 183 pkts (loss 0.000%), 100.0 kbit/s
61.5s - received: 196/ sent: 196 pkts (loss 0.000%), 100.0 kbit/s
62.6s - received: 209/ sent: 209 pkts (loss 0.000%), 100.0 kbit/s
63.6s - received: 222/ sent: 222 pkts (loss 0.000%), 99.8 kbit/s
64.6s - received: 235/ sent: 235 pkts (loss 0.000%), 100.2 kbit/s
65.7s - received: 248/ sent: 248 pkts (loss 0.000%), 100.0 kbit/s
66.7s - received: 261/ sent: 261 pkts (loss 0.000%), 100.0 kbit/s
67.8s - received: 274/ sent: 274 pkts (loss 0.000%), 100.0 kbit/s
```

TCP connection

A terminal window titled "host: h3" with a close button (X) in the top right corner. The terminal shows a sequence of commands and directory changes. The prompt is root@mininet-vm. The user navigates from /home/mininet/Downloads/lab5/udp to /home/mininet/Downloads/lab5/tcp and then runs the tcpserver command to listen on port 10001.

```
root@mininet-vm:/home/mininet/Downloads/lab5/udp# cd ../  
root@mininet-vm:/home/mininet/Downloads/lab5# cd tcp  
root@mininet-vm:/home/mininet/Downloads/lab5/tcp# ./tcpserver 10001
```


"host: h1"



```
root@mininet-vm:/home/mininet/Downloads/lab5/udp# cd ..
root@mininet-vm:/home/mininet/Downloads/lab5# cd tcp
root@mininet-vm:/home/mininet/Downloads/lab5/tcp# ./tcpclient 10.10.1.3 10001
0.0:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 10 rtt  1.9ms
0.0:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 18 rtt  8.8ms
0.0:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 30 rtt 11.5ms
0.0:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 44 rtt 17.0ms
0.2:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 13 rtt 22.1ms
0.3:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 19 rtt 20.1ms
0.4:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 23 rtt 25.1ms
0.5:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 15 rtt 16.1ms
0.6:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 20 rtt 21.5ms
0.7:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 24 rtt 26.3ms
0.8:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 16 rtt 16.7ms
1.0:      0.0kbps avg (    0.0[inst],    0.0[mov.avg]) cwnd 21 rtt 22.6ms
1.1: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 12 rtt 26.6ms
1.2: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 20 rtt 21.7ms
1.3: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 12 rtt 25.8ms
1.5: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 19 rtt 20.2ms
1.6: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 24 rtt 25.9ms
1.7: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 16 rtt 16.7ms
1.8: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 21 rtt 22.6ms
1.9: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 12 rtt 25.3ms
2.0: 9195.5kbps avg ( 9195.5[inst], 9195.5[mov.avg]) cwnd 18 rtt 18.9ms
```