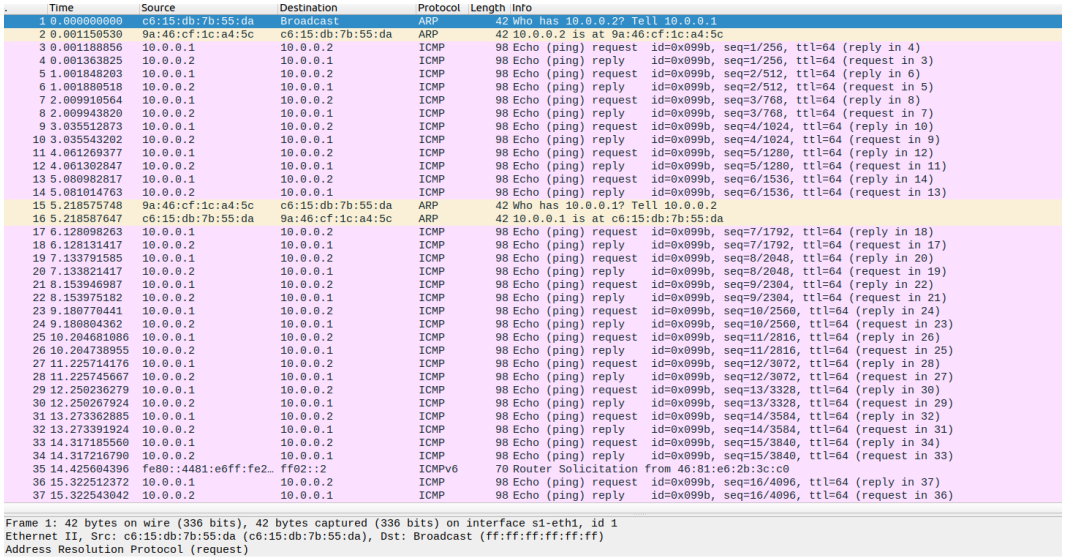
Part1:



	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	c6:15:db:7b:55:da	Broadcast	ARP	42	Who has 10.0.0.2? Tell 10.0.0.1
2	0.001150530	9a:46:cf:1c:a4:5c	c6:15:db:7b:55:da	ARP	42	10.0.0.2 is at 9a:46:cf:1c:a4:5c
3	0.001188856	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=1/256, ttl=64 (reply in 4)
4	0.001363825	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=1/256, ttl=64 (request in 3)
5	1.001848203	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=2/512, ttl=64 (reply in 6)
6	1.001880518	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=2/512, ttl=64 (request in 5)
7	2.009910564	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=3/768, ttl=64 (reply in 8)
8	2.009943820	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=3/768, ttl=64 (request in 7)
9	3.035512873	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=4/1024, ttl=64 (reply in 10)
10	3.035543202	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=4/1024, ttl=64 (request in 9)
11	4.061269377	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=5/1280, ttl=64 (reply in 12)
12	4.061302847	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=5/1280, ttl=64 (request in 11)
13	5.080982817	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=6/1536, ttl=64 (reply in 14)
14	5.081014763	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=6/1536, ttl=64 (request in 13)
15	5.218575748	9a:46:cf:1c:a4:5c	c6:15:db:7b:55:da	ARP	42	Who has 10.0.0.1? Tell 10.0.0.2
16	5.218587647	c6:15:db:7b:55:da	9a:46:cf:1c:a4:5c	ARP	42	10.0.0.1 is at c6:15:db:7b:55:da
17	6.128098263	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=7/1792, ttl=64 (reply in 18)
18	6.128131417	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=7/1792, ttl=64 (request in 17)
19	7.133791585	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=8/2048, ttl=64 (reply in 20)
20	7.133821417	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=8/2048, ttl=64 (request in 19)
21	8.153946987	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=9/2304, ttl=64 (reply in 22)
22	8.153975182	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=9/2304, ttl=64 (request in 21)
23	9.180770441	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=10/2560, ttl=64 (reply in 24)
24	9.180804362	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=10/2560, ttl=64 (request in 23)
25	10.204681086	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=11/2816, ttl=64 (reply in 26)
26	10.204738955	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=11/2816, ttl=64 (request in 25)
27	11.225714176	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=12/3072, ttl=64 (reply in 28)
28	11.225745667	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=12/3072, ttl=64 (request in 27)
29	12.250236279	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=13/3328, ttl=64 (reply in 30)
30	12.250267924	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=13/3328, ttl=64 (request in 29)
31	13.273362885	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=14/3584, ttl=64 (reply in 32)
32	13.273391924	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=14/3584, ttl=64 (request in 31)
33	14.317185560	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=15/3840, ttl=64 (reply in 34)
34	14.317216790	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=15/3840, ttl=64 (request in 33)
35	14.425604396	fe80::4481:e6ff:fe2…	ff02::2	ICMPv6	70	Router Solicitation from 46:81:e6:2b:3c:c0
36	15.322512372	10.0.0.1	10.0.0.2	ICMP	98	Echo (ping) request id=0x099b, seq=16/4096, ttl=64 (reply in 37)
37	15.322543042	10.0.0.2	10.0.0.1	ICMP	98	Echo (ping) reply id=0x099b, seq=16/4096, ttl=64 (request in 36)

```
Frame 1: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface s1-eth1, id 1
Ethernet II, Src: c6:15:db:7b:55:da (c6:15:db:7b:55:da), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
Address Resolution Protocol (request)
```

Part2:

1. tshark

sudo tshark -f ‘icmp and src or dst host 8.8.8.8’ -w ‘packet01.pcapng’

```
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ sudo tshark -f 'icmp and src or dst host 8.8.8.8' -w 'packet01.pcapng'
Running as user "root" and group "root". This could be dangerous.
Capturing on 'enp0s3'
 ** (tshark:3660) 14:05:27.141603 [Main MESSAGE] -- Capture started.
 ** (tshark:3660) 14:05:27.141817 [Main MESSAGE] -- File: "packet01.pcapng"
20 ^C
```

ping 8.8.8.8 ping 208.67.220.220

```
cindy@cindy-VirtualBox:~$ ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=115 time=8.19 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=115 time=13.4 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=115 time=8.22 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=115 time=8.39 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=115 time=7.80 ms
64 bytes from 8.8.8.8: icmp_seq=6 ttl=115 time=17.4 ms
64 bytes from 8.8.8.8: icmp_seq=7 ttl=115 time=8.66 ms
64 bytes from 8.8.8.8: icmp_seq=8 ttl=115 time=7.39 ms
64 bytes from 8.8.8.8: icmp_seq=9 ttl=115 time=19.3 ms
64 bytes from 8.8.8.8: icmp_seq=10 ttl=115 time=7.26 ms
^C
--- 8.8.8.8 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9029ms
rtt min/avg/max/mdev = 7.256/10.612/19.346/4.251 ms
cindy@cindy-VirtualBox:~$
PING 208.67.220.220 (208.67.220.220) 56(84) bytes of data.
64 bytes from 208.67.220.220: icmp_seq=1 ttl=47 time=39.2 ms
64 bytes from 208.67.220.220: icmp_seq=2 ttl=47 time=35.0 ms
64 bytes from 208.67.220.220: icmp_seq=3 ttl=47 time=34.7 ms
64 bytes from 208.67.220.220: icmp_seq=4 ttl=47 time=34.9 ms
64 bytes from 208.67.220.220: icmp_seq=5 ttl=47 time=35.8 ms
64 bytes from 208.67.220.220: icmp_seq=6 ttl=47 time=35.6 ms
64 bytes from 208.67.220.220: icmp_seq=7 ttl=47 time=34.8 ms
64 bytes from 208.67.220.220: icmp_seq=8 ttl=47 time=48.4 ms
64 bytes from 208.67.220.220: icmp_seq=9 ttl=47 time=71.0 ms
64 bytes from 208.67.220.220: icmp_seq=10 ttl=47 time=34.8 ms
^C
--- 208.67.220.220 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9038ms
rtt min/avg/max/mdev = 34.726/40.424/71.040/10.972 ms
```

sudo tshark -r packet01.pcapng

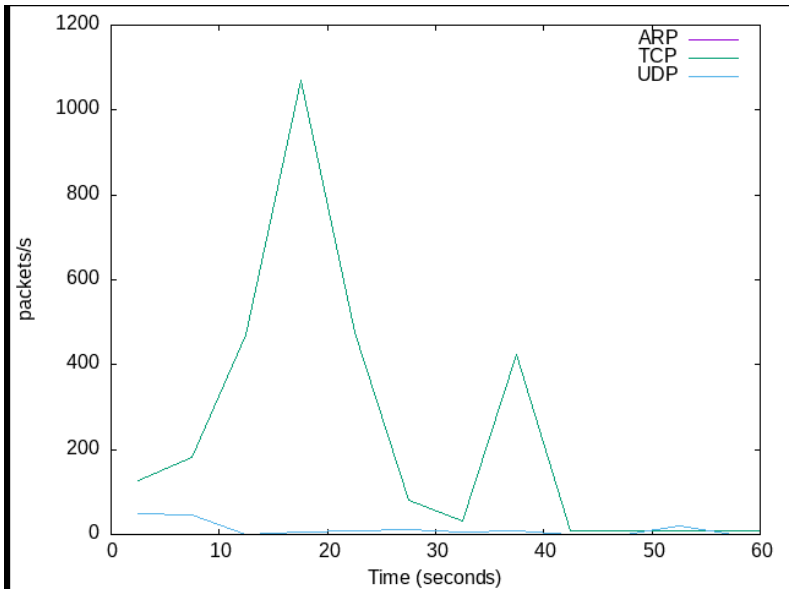
```
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ sudo tshark -r packet01.pcapng
Running as user "root" and group "root". This could be dangerous.
    1 0.000000000    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=1/256, ttl=64
    2 0.008162754     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=1/256, ttl=115 (request in 1)
    3 1.002134536    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=2/512, ttl=64
    4 1.015532145     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=2/512, ttl=115 (request in 3)
    5 2.003291215    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=3/768, ttl=64
    6 2.011486466     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=3/768, ttl=115 (request in 5)
    7 3.010641432    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=4/1024, ttl=64
    8 3.019000053     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=4/1024, ttl=115 (request in 7)
    9 4.011760455    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=5/1280, ttl=64
   10 4.019510740     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=5/1280, ttl=115 (request in 9)
   11 5.018522495    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=6/1536, ttl=64
   12 5.035887481     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=6/1536, ttl=115 (request in 11)
   13 6.020459448    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=7/1792, ttl=64
   14 6.029090358     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=7/1792, ttl=115 (request in 13)
   15 7.028234267    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=8/2048, ttl=64
   16 7.035593157     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=8/2048, ttl=115 (request in 15)
   17 8.030924223    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=9/2304, ttl=64
   18 8.050239606     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=9/2304, ttl=115 (request in 17)
   19 9.033035157    10.0.2.15 → 8.8.8.8      ICMP 98 Echo (ping) request  id=0x0004, seq=10/2560, ttl=64
   20 9.040266698     8.8.8.8 → 10.0.2.15     ICMP 98 Echo (ping) reply    id=0x0004, seq=10/2560, ttl=115 (request in 19)
```

2. tcpstat

sudo tcpstat -f 'icmp'

```
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ sudo tcpstat -f 'icmp'
[sudo] password for cindy:
Listening on enp0s3
Time:1663569361 n=10     avg=84.00        stddev=0.00      bps=1344.00
Time:1663569366 n=10     avg=84.00        stddev=0.00      bps=1344.00
^CTime:1663569371        n=6      avg=84.00       stddev=0.00      bps=806.40
```

3. tcpdump & tcpstat & gnuplot



4. mininet & iperf & gnuplot

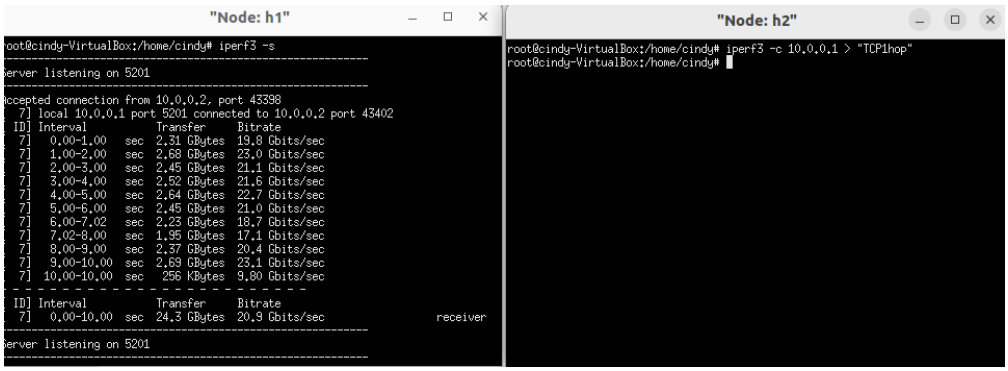
4-1.

Iperf 是網絡性能測試工具，它可以用來測量網絡 **bandwidth**，也可以顯示網絡延遲抖動、丟包率等訊息。當網路出現問題時，可以利用它來測試，來了解問題出在哪裡。

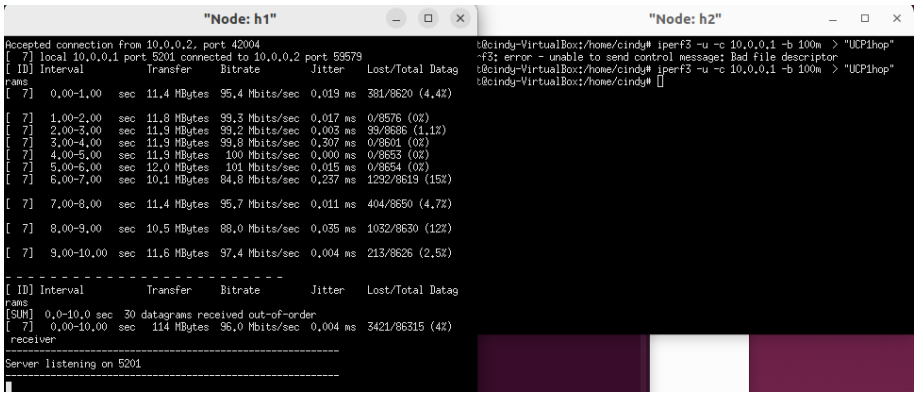
4-2.

sudo mn

TCP(1hop)

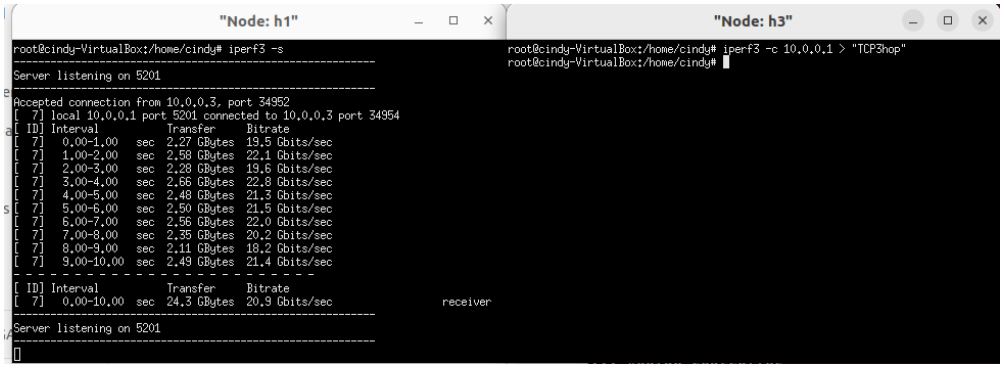


UCP(1hop)

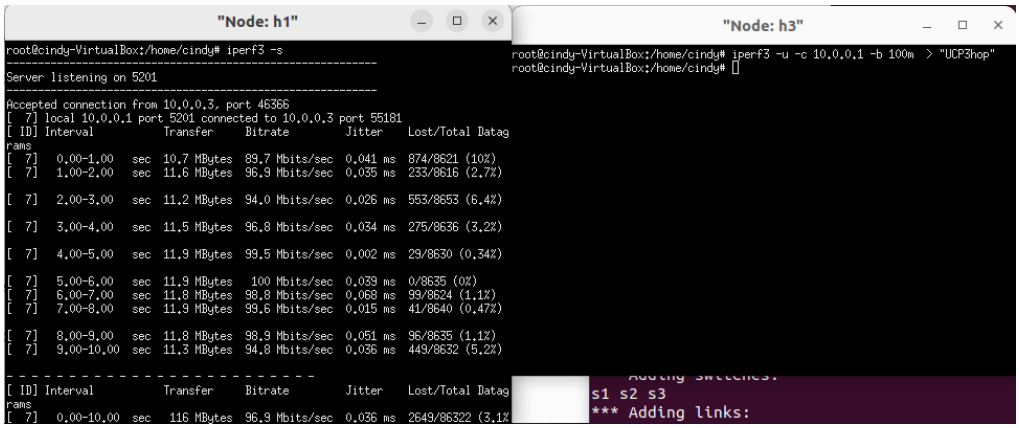


sudo mn –topo=linear,3

TCP(3hop)

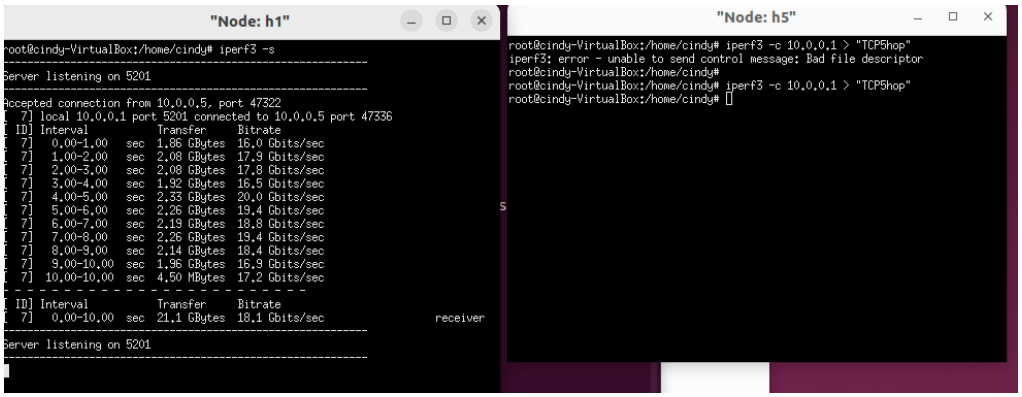


UCP(3hop)

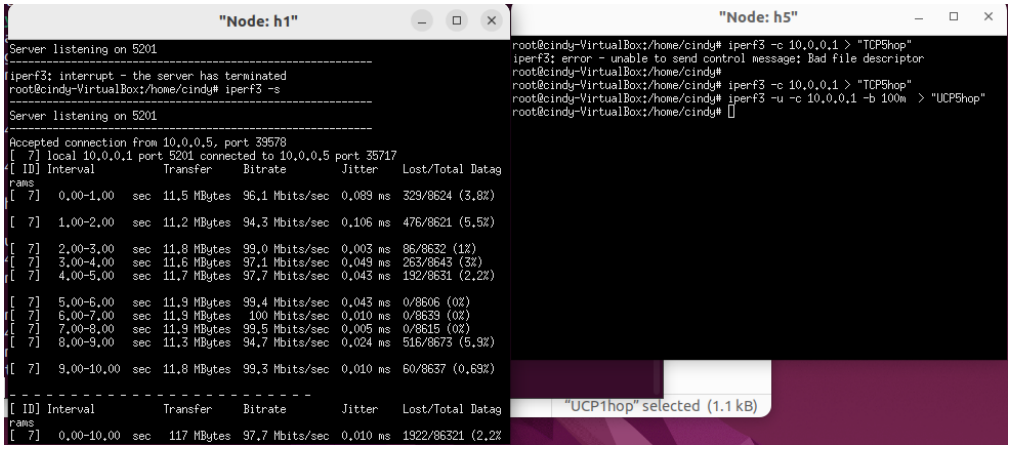


sudo mn –topo=linear,5

TCP(5hop)



UCP(5hop)



4-3.

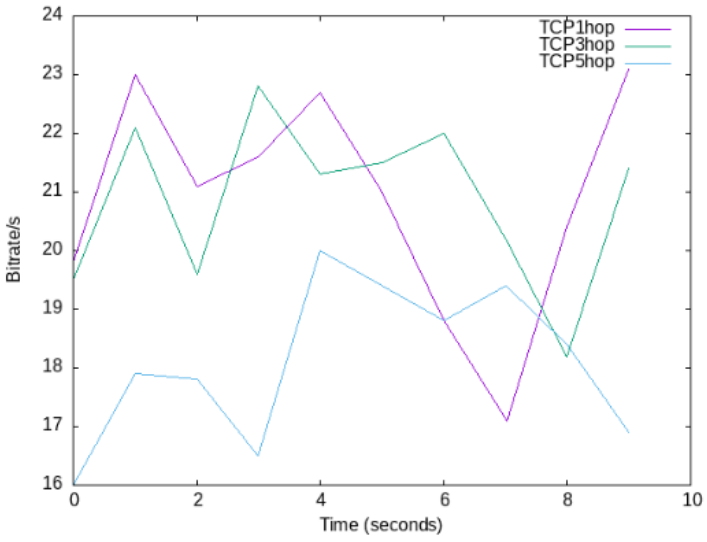
```
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ cat TCP1hop | grep Gbits | tr - " " |h
ead -10 | awk {'print $3,$8'} > TCP1hopf
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ cat TCP3hop | grep Gbits | tr - " " |h
ead -10 | awk {'print $3,$8'} > TCP3hopf
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ cat TCP5hop | grep Gbits | tr - " " |h
ead -10 | awk {'print $3,$8'} > TCP5hopf
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ cat UDP5hop | grep Mbits | tr - " " |h
ead -10 | awk {'print $3,$8'} > UDP5hopf
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ cat UDP3hop | grep Mbits | tr - " " |h
ead -10 | awk {'print $3,$8'} > UDP3hopf
cindy@cindy-VirtualBox:~/TCPIP/TCPIP_HW2$ cat UDP1hop | grep Mbits | tr - " " |h
ead -10 | awk {'print $3,$8'} > UDP1hopf
```

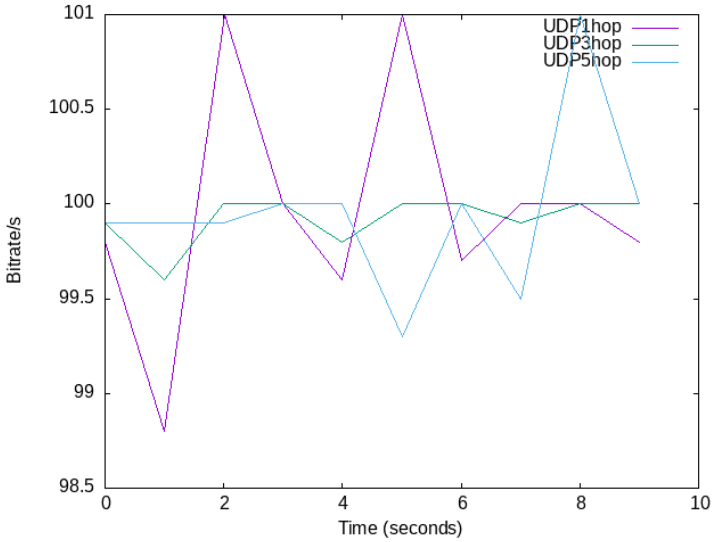
Open | script2 ~/TCPIP/TCPIP_HW2 | Save

```
1 set terminal png
2 set style data lines
3 set xlabel "Time (seconds)"
4 set ylabel "Bitrate/s"
5 plot [00:10] "TCP1hopf" using 1:2 title "TCP1hop", \
6                "TCP3hopf" using 1:2 title "TCP3hop", \
7                "TCP5hopf"using 1:2 title "TCP5hop"
```

Open | script3 ~/TCPIP/TCPIP_HW2 | Save

```
1 set terminal png
2 set style data lines
3 set xlabel "Time (seconds)"
4 set ylabel "Bitrate/s"
5 plot [00:10] "UDP1hopf" using 1:2 title "UDP1hop", \
6                "UDP3hopf" using 1:2 title "UDP3hop", \
7                "UDP5hopf" using 1:2 title "UDP5hop"
```





4-4.

TCP 1、3、5node 的 bitrate 差異很比較大，而 UDP 差異比較小，TCP 要經過三方交握，會有延遲、封包掉了又要重傳，而 UDP 能傳多快就傳多快，不管封包有沒有準確送達，就繼續傳下一個封包，所以差異比較小。

5.

```
root@cindy-VirtualBox:/home/cindy/TCPIP/TCPIP_HW2# netperf -t TCP_STREAM -H 10.
0.0.1 -l 60
MIGRATED TCP STREAM TEST from 0.0.0.0 (0.0.0.0) port 0 AF_INET to 10.0.0.1 () po
rt 0 AF_INET : demo
Recv   Send    Send
Socket Socket  Message  Elapsed
Size   Size    Size     Time     Throughput
bytes  bytes   bytes    secs.    10^6bits/sec

 87380  87380  87380    60.03    14916.69
```

```
root@cindy-VirtualBox:/home/cindy/TCPIP/TCPIP_HW2# netperf -t UDP_STREAM -H 10.
0.0.1 -l 60
MIGRATED UDP STREAM TEST from 0.0.0.0 (0.0.0.0) port 0 AF_INET to 10.0.0.1 () po
rt 0 AF_INET : demo
Socket  Message  Elapsed      Messages
Size    Size     Time         Okay Errors   Throughput
bytes   bytes    secs            #      #   10^6bits/sec

212992   65507   60.01      402616      0    3515.88
212992           60.01      394468           3444.72
```