

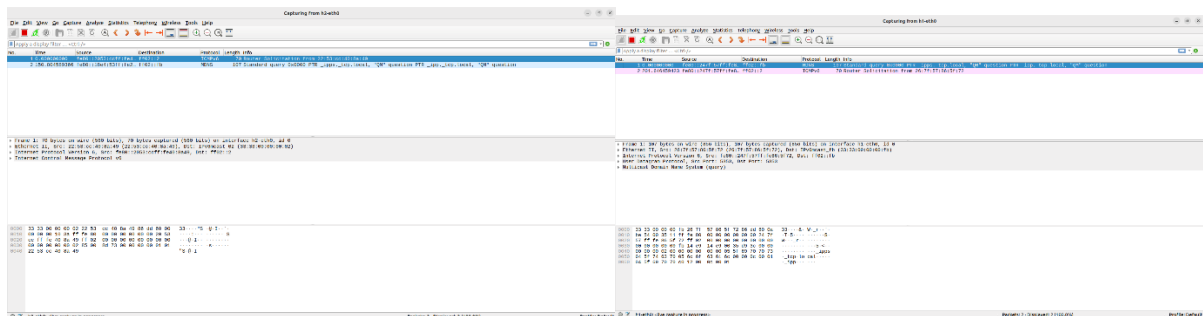
高等電腦網路作業 2

資工碩一 M113040116 蘇柏瑜

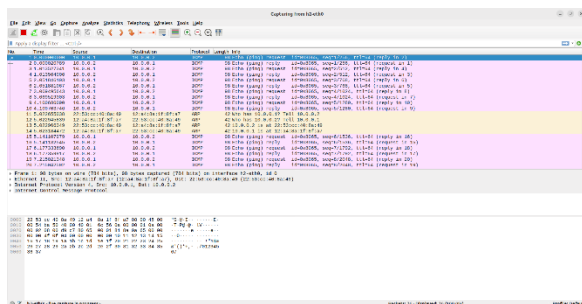
Part1:

Mininet

Host 1, host 2



H1 ping h2



Part2:

1. tshark

a. tshark -f 'icmp' -f "host 8.8.8.8"

```

root@ubuntu:/home/briansu# tshark -i enp0s3 -Y icmp -Y ip.addr==8.8.8.8
Running as user "root" and group "root". This could be dangerous.
Capturing on 'enp0s3'
** (tshark:6721) 20:25:30.383114 [Main MESSAGE] -- Capture started.
** (tshark:6721) 20:25:30.383221 [Main MESSAGE] -- File: "/tmp/wireshark_enp0s30JMQB2.pcapng"
^C0 packets captured

```

b. `tshark -w packet01.pcap -f 'icmp' -f "host 8.8.8.8"`

```

root@ubuntu:/home/briansu# tshark -i enp0s3 -Y icmp -Y ip.addr==8.8.8.8 -w packet01.pcap

```

c.

<pre> ^C root@ubuntu:/home/briansu# 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=116 time=8.50 ms 64 bytes from 8.8.8.8: icmp_seq=2 ttl=116 time=8.69 ms 64 bytes from 8.8.8.8: icmp_seq=3 ttl=115 time=8.31 ms 64 bytes from 8.8.8.8: icmp_seq=4 ttl=116 time=8.64 ms 64 bytes from 8.8.8.8: icmp_seq=5 ttl=116 time=8.22 ms 64 bytes from 8.8.8.8: icmp_seq=6 ttl=115 time=9.28 ms 64 bytes from 8.8.8.8: icmp_seq=7 ttl=116 time=8.00 ms 64 bytes from 8.8.8.8: icmp_seq=8 ttl=115 time=8.51 ms 64 bytes from 8.8.8.8: icmp_seq=9 ttl=116 time=8.59 ms 64 bytes from 8.8.8.8: icmp_seq=10 ttl=116 time=9.34 ms 64 bytes from 8.8.8.8: icmp_seq=11 ttl=115 time=10.4 ms 64 bytes from 8.8.8.8: icmp_seq=12 ttl=115 time=11.3 ms 64 bytes from 8.8.8.8: icmp_seq=13 ttl=115 time=8.23 ms </pre>	<pre> briansu@ubuntu:~\$ ping 208.67.220.220 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=22.2 ms 64 bytes from 208.67.220.220: icmp_seq=2 ttl=47 time=38.3 ms 64 bytes from 208.67.220.220: icmp_seq=3 ttl=47 time=22.6 ms 64 bytes from 208.67.220.220: icmp_seq=4 ttl=47 time=27.0 ms 64 bytes from 208.67.220.220: icmp_seq=5 ttl=47 time=22.2 ms 64 bytes from 208.67.220.220: icmp_seq=6 ttl=47 time=35.7 ms 64 bytes from 208.67.220.220: icmp_seq=7 ttl=47 time=24.2 ms 64 bytes from 208.67.220.220: icmp_seq=8 ttl=47 time=20.8 ms 64 bytes from 208.67.220.220: icmp_seq=9 ttl=47 time=23.1 ms 64 bytes from 208.67.220.220: icmp_seq=10 ttl=47 time=21.9 ms 64 bytes from 208.67.220.220: icmp_seq=11 ttl=47 time=27.6 ms 64 bytes from 208.67.220.220: icmp_seq=12 ttl=47 time=26.7 ms 64 bytes from 208.67.220.220: icmp_seq=13 ttl=47 time=26.6 ms 64 bytes from 208.67.220.220: icmp_seq=14 ttl=47 time=21.5 ms </pre>
---	---

d. `root@ubuntu:/home/briansu# tshark -r packet01.pcap`

e. `tshark -w packet01.pcap -f 'icmp' -f "host 8.8.8.8"`

2. tcpstat

`tcpstat -f 'icmp'`

```
root@ubuntu:/home/briansu# tcpstat -l enp0s3 -f icmp PING 140.117.172.86 (140.117.172.86) 56(84) bytes of data.
Time:1695215459 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215464 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215469 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215474 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215479 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215484 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215489 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215494 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215499 n=4 avg=84.00 stddev=0.00 bps=537.60
Time:1695215504 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215509 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215514 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215519 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215524 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215529 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215534 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215539 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215544 n=4 avg=84.00 stddev=0.00 bps=537.60
Time:1695215549 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215554 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215559 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215564 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215569 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215574 n=5 avg=84.00 stddev=0.00 bps=672.00
Time:1695215579 n=5 avg=84.00 stddev=0.00 bps=672.00
^CTime:1695215584 n=4 avg=84.00 stddev=0.00 bps=537.60
root@ubuntu:/home/briansu#
```

3. tcpdump & tcpstat & gnuplot

如附檔 graph1.png

4. mininet & iperf & gnuplot

4-1

1. 測試網絡頻寬和性能： 兩個主機之間的網路連接的實際頻寬
2. 網路性能調試： 遇到性能問題時，幫助確定位置
3. 測試網路負載： 模擬實際網絡流量
4. 優化網路設置： 測試不同網絡設置的效能，例如調整路由器、防火牆或交換機的參數
5. 監控網絡性能： 定期運行並記錄結果，以監控網絡性能的變化

4-2

(依序為 TCP 1hop, 3hops, 5hops)

```
iperf -s -p 5566 -i 1
```

```
iperf -c 10.0.0.2 -p 5566 -t 20 > tcp_1
```

```
cat tcp | grep sec | head -n 20 | tr - " " | awk '{print $4,$6}' > tcp_res
```

```
root@ubuntu: /home/briansu

*** No default OpenFlow controller found for default switch!
*** Falling back to OVS Bridge
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller

*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> links
h1-eth0<->s1-eth1 (OK OK)
h2-eth0<->s1-eth2 (OK OK)
mininet> xterm h1,h2
node 'h1,h2' not in network
mininet> xterm h1 h2

"Node: h1"
root@ubuntu:/home/briansu# iperf -c 10.0.0.2 -p 5566 -t 15 > tcp_hop
root@ubuntu:/home/briansu# iperf -c 10.0.0.2 -p 5566 -t 20 > tcp_hop
root@ubuntu:/home/briansu# iperf -c 10.0.0.2 -p 5566 -t 20

Client connecting to 10.0.0.2, TCP port 5566
TCP window size: 65.3 KByte (default)
[ 1] local 10.0.0.1 port 33600 connected with 10.0.0.2 port 5566
[ ID] Interval      Transfer    Bandwidth
[ 1] 0.000-20.012 sec  51.4 GBytes 25.4 Gbits/sec
root@ubuntu:/home/briansu#

"Node: h2"
root@ubuntu:/home/briansu# iperf -s -p 5566 -i 1 > tcp_1
Server listening on TCP port 5566
TCP window size: 65.3 KByte (default)
[ ID] Interval      Transfer    Bandwidth
[ 1] local 10.0.0.2 port 5566 connected with 10.0.0.1 port 33600
[ ID] Interval      Transfer    Bandwidth
[ 1] 0.000-1.000 sec  2.07 GBytes 17.8 Gbits/sec
[ 2] 1.000-2.000 sec  3.19 GBytes 26.8 Gbits/sec
[ 3] 2.000-3.000 sec  2.42 GBytes 20.8 Gbits/sec
[ 4] 3.000-4.000 sec  3.38 GBytes 28.6 Gbits/sec
[ 5] 4.000-5.000 sec  3.31 GBytes 28.4 Gbits/sec
[ 6] 5.000-6.000 sec  2.33 GBytes 25.2 Gbits/sec
[ 7] 6.000-7.000 sec  3.39 GBytes 29.1 Gbits/sec
[ 8] 7.000-8.000 sec  3.44 GBytes 29.5 Gbits/sec
[ 9] 8.000-9.000 sec  3.39 GBytes 29.2 Gbits/sec
[10] 9.000-10.000 sec  3.35 GBytes 28.9 Gbits/sec
[11] 10.000-11.000 sec  3.38 GBytes 29.0 Gbits/sec
[12] 11.000-12.000 sec  3.47 GBytes 29.8 Gbits/sec
[13] 12.000-13.000 sec  3.50 GBytes 30.0 Gbits/sec
[14] 13.000-14.000 sec  3.23 GBytes 27.8 Gbits/sec
[15] 14.000-15.000 sec  3.49 GBytes 29.2 Gbits/sec
[16] 15.000-16.000 sec  3.45 GBytes 29.5 Gbits/sec
[17] 16.000-17.000 sec  3.27 GBytes 28.1 Gbits/sec
[18] 17.000-18.000 sec  3.32 GBytes 28.0 Gbits/sec
[19] 18.000-19.000 sec  3.33 GBytes 29.1 Gbits/sec
[20] 19.000-20.000 sec  3.25 GBytes 27.9 Gbits/sec
[ 1] 0.000-20.003 sec  51.5 GBytes 27.3 Gbits/sec
root@ubuntu:/home/briansu# iperf -s -p 5566 -i 1 > tcp_1
```

```
root@ubuntu: /home/briansu

h1 h2 h3
*** Done
completed in 183.955 seconds
root@ubuntu:/home/briansu# mn --topo linear,5
*** No default OpenFlow controller found for default switch!
*** Falling back to OVS Bridge
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2 s3 s4 s5
*** Adding links:
(h1, s1) (h2, s2) (h3, s3) (h4, s4) (h5, s5) (s2, s1) (s3, s2) (s4, s3) (s5, s4)

*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller

*** Starting 5 switches
s1 s2 s3 s4 s5 ...
*** Starting CLI:
mininet> xterm h1 h2

"Node: h1"
root@ubuntu:/home/briansu# iperf -c 10.0.0.2 -p 5566 -t 20
Client connecting to 10.0.0.2, TCP port 5566
TCP window size: 340 KByte (default)
[ ID] Interval      Transfer    Bandwidth
[ 1] local 10.0.0.1 port 37090 connected with 10.0.0.2 port 5566
[ ID] Interval      Transfer    Bandwidth
[ 1] 0.000-20.0421 sec  57.8 GBytes 24.8 Gbits/sec
root@ubuntu:/home/briansu#

"Node: h2"
root@ubuntu:/home/briansu# iperf -s -p 5566 -i 1 > top_5
```

```
root@ubuntu: /home/briansu

*** Stopping 2 hosts
h1 h2
*** Done
completed in 653.116 seconds
root@ubuntu:/home/briansu# mn --topo linear,5
*** No default OpenFlow controller found for default switch!
*** Falling back to OVS Bridge
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1 s2 s3
*** Adding links:
(h1, s1) (h2, s2) (h3, s3) (s2, s1) (s3, s2)
*** Configuring hosts
h1 h2 h3
*** Starting controller

*** Starting 3 switches
s1 s2 s3 ...
*** Starting CLI:
mininet> xterm h1 h2

"Node: h1"
root@ubuntu:/home/briansu# iperf -c 10.0.0.2 -p 5566 -t 20
Client connecting to 10.0.0.2, TCP port 5566
TCP window size: 65.3 KByte (default)
[ ID] Interval      Transfer    Bandwidth
[ 1] local 10.0.0.1 port 36240 connected with 10.0.0.2 port 5566
[ ID] Interval      Transfer    Bandwidth
[ 1] 0.000-20.0122 sec  58.5 GBytes 25.1 Gbits/sec
root@ubuntu:/home/briansu#

"Node: h2"
root@ubuntu:/home/briansu# iperf -s -p 5566 -i 1 > tcp_3
```

(依序為 UDP 1hop, 3hops, 5shops)

```
iperf -s -u -p 5566 -i 1
```

```
iperf -u -c 10.0.0.2 -b 10G -t 20 -p 5566 > udp_1
```

```
cat udp | grep MBytes | head -n 20 | tr - " " | awk '{print $4,$8}' > udp_res
```

```
root@ubuntu: /home/briansu

*** No default OpenFlow controller found for default switch!
*** Falling back to OVS Bridge
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2
*** Adding switches:
s1
*** Adding links:
(h1, s1) (h2, s1)
*** Configuring hosts
h1 h2
*** Starting controller
*** Starting 1 switches
s1 ...
*** Starting CLI:
mininet> link
invalid number of args: link
mininet> links
mininet> xterm h1 h2

"Node: h1"
root@ubuntu:/home/briansu# iperf -u -c 10.0.0.2 -b 10G -t 20 > udp_1
read failed: Connection refused
read failed: Connection refused
[ 5] WARNING: did not receive ack of last datagram after 10 tries.
root@ubuntu:/home/briansu# iperf3 -u -c 10.0.0.2 -b 10G -t 20 > udp_1
iperf3: error - unable to send control message: Bad file descriptor
root@ubuntu:/home/briansu# iperf -u -c 10.0.0.2 -b 10G -t 20 > udp_1
read failed: Connection refused
read failed: Connection refused
[ 5] WARNING: did not receive ack of last datagram after 10 tries.
root@ubuntu:/home/briansu# iperf -u -c 10.0.0.2 -b 10G -t 20 -p 5566 > udp_1
root@ubuntu:/home/briansu# iperf -u -c 10.0.0.2 -b 10G -t 20 -p 5566

Client connecting to 10.0.0.2, UDP port 5566
Sending 1470 byte datagrams, IPG target: 1.10 us (kalanen adjust)
UDP buffer size: 208 KByte (default)

[ 1] local 10.0.0.1 port 33161 connected with 10.0.0.2 port 5566
[ ID] Interval      Transfer    Bandwidth
[ 1] 0.0000-20.0000 sec  5.14 GBytes  2.21 Gbits/sec
[ 1] Sent 3751013 datagrams
[ 1] Server Report:
[ ID] Interval      Transfer    Bandwidth      Jitter    Lost/Total Datagrams
[ 1] 0.0000-19.9993 sec  5.09 GBytes  2.19 Gbits/sec  0.002 ms 32739/3751012 (0.87%)
[ 1] 0.0000-19.9993 sec  95 datagrams received out-of-order
root@ubuntu:/home/briansu#

"Node: h2"
Server listening on UDP port 5566
UDP buffer size: 208 KByte (default)

[ 1] local 10.0.0.2 port 5566 connected with 10.0.0.1 port 45266
[ ID] Interval      Transfer    Bandwidth      Jitter    Lost/Total Datagrams
[ 1] 0.0000-1.0000 sec  233 KBytes  1.59 Gbits/sec  0.001 ms 514/186373 (0.31%)
[ 1] 0.0000-1.0000 sec  92 datagrams received out-of-order
[ 1] 1.0000-2.0000 sec  251 KBytes  2.11 Gbits/sec  0.000 ms 141/173394 (0.078%)
[ 1] 2.0000-3.0000 sec  242 KBytes  2.03 Gbits/sec  0.000 ms 6765/178431 (3.82%)
[ 1] 3.0000-4.0000 sec  240 KBytes  2.01 Gbits/sec  0.001 ms 430/171455 (0.252%)
[ 1] 4.0000-5.0000 sec  242 KBytes  2.03 Gbits/sec  0.000 ms 1562/173840 (0.9%)
[ 1] 5.0000-6.0000 sec  270 KBytes  2.26 Gbits/sec  0.000 ms 1106/133840 (0.571%)
[ 1] 6.0000-7.0000 sec  267 KBytes  2.24 Gbits/sec  0.000 ms 2397/133337 (1.52%)
[ 1] 7.0000-8.0000 sec  263 KBytes  2.20 Gbits/sec  0.001 ms 335/187737 (0.182%)
[ 1] 8.0000-9.0000 sec  266 KBytes  2.23 Gbits/sec  0.001 ms 239/189935 (0.132%)
[ 1] 9.0000-10.0000 sec  244 KBytes  2.04 Gbits/sec  0.001 ms 3423/177278 (1.92%)
[ 1] 10.0000-11.0000 sec  245 KBytes  2.06 Gbits/sec  0.001 ms 1360/176142 (0.774%)
[ 1] 11.0000-12.0000 sec  259 KBytes  2.08 Gbits/sec  0.001 ms 4243/183228 (2.33%)
[ 1] 12.0000-13.0000 sec  210 KBytes  1.76 Gbits/sec  0.001 ms 4338/154770 (3.22%)
[ 1] 13.0000-14.0000 sec  203 KBytes  1.71 Gbits/sec  0.001 ms 9438/154501 (6.12%)
[ 1] 14.0000-15.0000 sec  226 KBytes  1.90 Gbits/sec  0.001 ms 337/151695 (0.211%)
[ 1] 15.0000-16.0000 sec  260 KBytes  2.18 Gbits/sec  0.001 ms 4062/189841 (2.15%)
[ 1] 16.0000-17.0000 sec  269 KBytes  2.26 Gbits/sec  0.001 ms 405/192251 (0.211%)
[ 1] 17.0000-18.0000 sec  217 KBytes  1.82 Gbits/sec  0.001 ms 885/163490 (5.4%)
[ 1] 18.0000-19.0000 sec  239 KBytes  2.01 Gbits/sec  0.001 ms 10885/181275 (5.98%)
[ 1] 19.0000-19.9992 sec  244 KBytes  2.05 Gbits/sec  0.000 ms 327/14664 (0.192%)
[ 1] 0.0000-19.9992 sec  4.77 GBytes  2.05 Gbits/sec  0.000 ms 62073/3543602 (1.8%)
[ 1] 0.0000-19.9992 sec  30 datagrams received out-of-order
root@ubuntu:/home/briansu# iperf -s -u -p 5566 -i 1 > udp_1
```

```
root@ubuntu: /home/briansu

h1 h2 h3
*** Done
completed in 235.180 seconds
root@ubuntu:/home/briansu# mn --topo linear,5
*** No default OpenFlow controller found for default switch!
*** Falling back to OVS Bridge
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2 s3 s4 s5
*** Adding links:
(h1, s1) (h2, s2) (h3, s3) (h4, s4) (h5, s5) (s2, s1) (s3, s2) (s4, s3) (s5, s4)

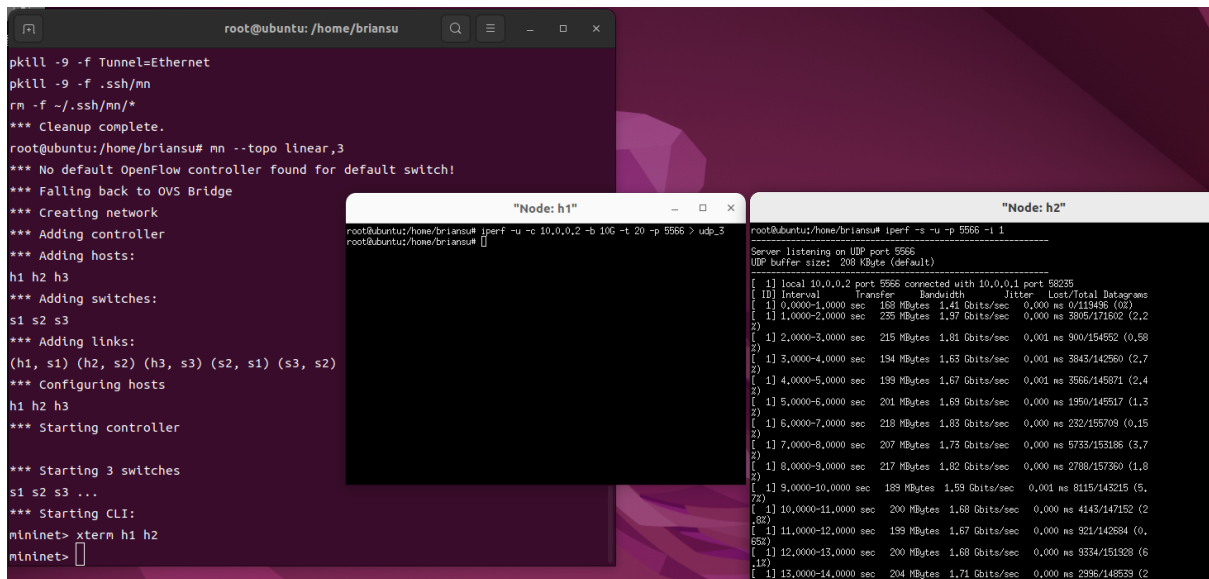
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
*** Starting 5 switches
s1 s2 s3 s4 s5 ...
*** Starting CLI:
mininet> xterm h1 h2
mininet>

"Node: h1"
root@ubuntu:/home/briansu# iperf -u -c 10.0.0.2 -b 10G -t 20 -p 5566

Client connecting to 10.0.0.2, UDP port 5566
Sending 1470 byte datagrams, IPG target: 1.10 us (kalanen adjust)
UDP buffer size: 208 KByte (default)

[ 1] local 10.0.0.1 port 45927 connected with 10.0.0.2 port 5566
[ ID] Interval      Transfer    Bandwidth
[ 1] 0.0000-20.0000 sec  4.10 GBytes  1.76 Gbits/sec
[ 1] Sent 2995376 datagrams
[ 1] Server Report:
[ ID] Interval      Transfer    Bandwidth      Jitter    Lost/Total Datagrams
[ 1] 0.0000-19.9967 sec  4.02 GBytes  1.72 Gbits/sec  0.000 ms 62513/2995376 (2.12%)
[ 1] 0.0000-19.9967 sec  142 datagrams received out-of-order
root@ubuntu:/home/briansu#

"Node: h2"
root@ubuntu:/home/briansu# iperf -s -u -p 5566 -i 1 > udp_5
```



```
root@ubuntu: /home/briansu
pkill -9 -f Tunnel=Ethernet
pkill -9 -f .ssh/mn
rm -f ~/.ssh/mn/*
*** Cleanup complete.
root@ubuntu:/home/briansu# mn --topo linear,3
*** No default OpenFlow controller found for default switch!
*** Falling back to OVS Bridge
*** Creating network
*** Adding controller
*** Adding hosts:
h1 h2 h3
*** Adding switches:
s1 s2 s3
*** Adding links:
(h1, s1) (h2, s2) (h3, s3) (s2, s1) (s3, s2)
*** Configuring hosts
h1 h2 h3
*** Starting controller
*** Starting 3 switches
s1 s2 s3 ...
*** Starting CLI:
mininet> xterm h1 h2
mininet>

"Node: h1"
root@ubuntu:/home/briansu# iperf -u -c 10.0.0.2 -b 10G -t 20 -p 5556 > udp_3
root@ubuntu:/home/briansu#

"Node: h2"
root@ubuntu:/home/briansu# iperf -s -u -p 5556 -i 1
Server listening on UDP port 5556
UDP buffer size: 200 MByte (default)
[ 1] local 10.0.0.2 port 5556 connected with 10.0.0.1 port 58235
[ 0] interval      Transfer      Bandwidth      Itter  Lost/Total Datagrams
[ 1] 0.000-1.000 sec  168 MBytes  1.41 Gbits/sec  0.000 ns 0/119496 (0%)
[ 1] 1.000-2.000 sec  235 MBytes  1.97 Gbits/sec  0.000 ns 3805/171602 (2.2%)
[ 1] 2.000-3.000 sec  215 MBytes  1.81 Gbits/sec  0.001 ns 900/154552 (0.58%)
[ 1] 3.000-4.000 sec  194 MBytes  1.63 Gbits/sec  0.001 ns 3843/142560 (2.7%)
[ 1] 4.000-5.000 sec  193 MBytes  1.67 Gbits/sec  0.001 ns 3566/145871 (2.4%)
[ 1] 5.000-6.000 sec  201 MBytes  1.69 Gbits/sec  0.000 ns 1950/145517 (1.3%)
[ 1] 6.000-7.000 sec  218 MBytes  1.83 Gbits/sec  0.000 ns 232/155709 (0.15%)
[ 1] 7.000-8.000 sec  207 MBytes  1.73 Gbits/sec  0.000 ns 5733/153186 (3.7%)
[ 1] 8.000-9.000 sec  217 MBytes  1.82 Gbits/sec  0.000 ns 2788/157360 (1.8%)
[ 1] 9.000-10.000 sec  189 MBytes  1.59 Gbits/sec  0.001 ns 8115/143215 (5.72%)
[ 1] 10.000-11.000 sec  200 MBytes  1.68 Gbits/sec  0.000 ns 4143/147152 (2.82%)
[ 1] 11.000-12.000 sec  193 MBytes  1.67 Gbits/sec  0.000 ns 921/142684 (0.652%)
[ 1] 12.000-13.000 sec  200 MBytes  1.68 Gbits/sec  0.000 ns 9334/151328 (6.15%)
[ 1] 13.000-14.000 sec  204 MBytes  1.71 Gbits/sec  0.000 ns 2396/148539 (2.2%)
```

4-3

如附檔 **tcp.png**, **udp.png**

4-4

可靠性：

TCP 是一種可靠的協議，它確保資料依序到達目的地，如果資料包遺失或損壞，它會重新傳輸。這確保了資料的完整性和可靠性，但也導致了較高的延遲。

UDP 是一種不可靠的協議，它沒有資料包重新傳輸機制。如果資料包遺失或損壞，不會進行任何修復。使得傳輸更快，但資料完整性不如 TCP 可靠。

連接性：

TCP 是面向連線的協議，建立連線需要三次握手，確保通訊的兩端都已經準備好發送和接收資料。這種連接性適用於許多應用，如網頁瀏覽和文件傳輸。

UDP 是面向無連線的協議，它不需要建立連線。這使得 UDP 適用於需要快速傳輸資料的應用，例如即時音視訊串流。

流量控制：

TCP 具有流量控制機制，可根據目標主機的處理能力和網路擁塞情況來控制資料的發送速率。

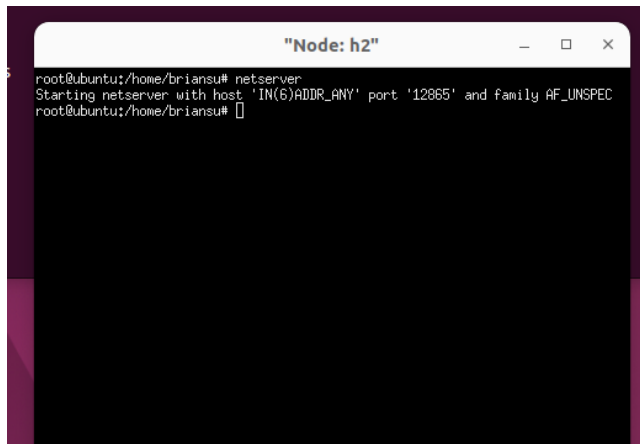
UDP 不提供流量控制，發送端會以最大速率發送數據，這可能導致網路擁塞。

5. netperf

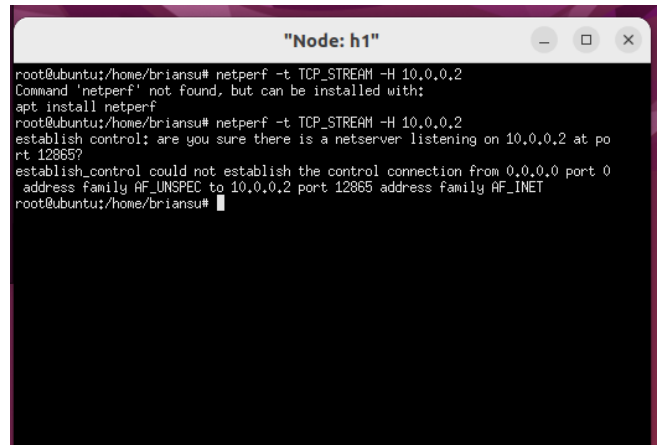
a.

```
netperf -t TCP_STREAM -H 10.0.0.2
```

```
netserver
```



```
"Node: h2"
root@ubuntu:/home/briansu# netserver
Starting netserver with host 'IN(6)ADDR_ANY' port '12865' and family AF_UNSPEC
root@ubuntu:/home/briansu#
```

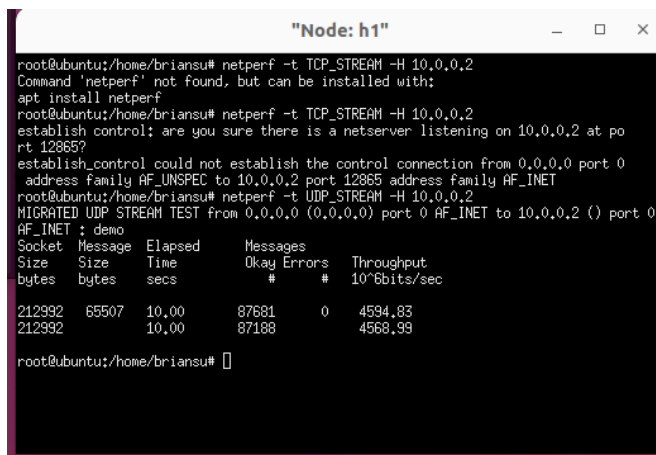


```
"Node: h1"
root@ubuntu:/home/briansu# netperf -t TCP_STREAM -H 10.0.0.2
Command 'netperf' not found, but can be installed with:
apt install netperf
root@ubuntu:/home/briansu# netperf -t TCP_STREAM -H 10.0.0.2
establish control: are you sure there is a netserver listening on 10.0.0.2 at po
rt 12865?
establish_control could not establish the control connection from 0.0.0.0 port 0
address family AF_UNSPEC to 10.0.0.2 port 12865 address family AF_INET
root@ubuntu:/home/briansu#
```

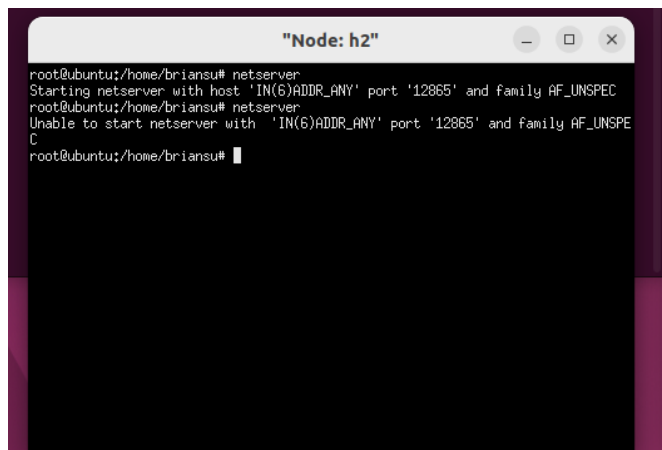
b.

```
netperf -t UDP_STREAM -H 10.0.0.2
```

```
netserver
```



```
"Node: h1"
root@ubuntu:/home/briansu# netperf -t TCP_STREAM -H 10.0.0.2
Command 'netperf' not found, but can be installed with:
apt install netperf
root@ubuntu:/home/briansu# netperf -t TCP_STREAM -H 10.0.0.2
establish control: are you sure there is a netserver listening on 10.0.0.2 at po
rt 12865?
establish_control could not establish the control connection from 0.0.0.0 port 0
address family AF_UNSPEC to 10.0.0.2 port 12865 address family AF_INET
root@ubuntu:/home/briansu# netperf -t UDP_STREAM -H 10.0.0.2
MIGRATED UDP STREAM TEST from 0.0.0.0 (0.0.0.0) port 0 AF_INET to 10.0.0.2 () port 0
AF_INET : demo
Socket Message Elapsed Messages
Size Size Time Okay Errors Throughput
bytes bytes secs # # 10^6bits/sec
212992 65507 10.00 87681 0 4594.83
212992 10.00 87188 4568.99
root@ubuntu:/home/briansu#
```



```
"Node: h2"
root@ubuntu:/home/briansu# netserver
Starting netserver with host 'IN(6)ADDR_ANY' port '12865' and family AF_UNSPEC
root@ubuntu:/home/briansu# netserver
Unable to start netserver with 'IN(6)ADDR_ANY' port '12865' and family AF_UNSPE
C
root@ubuntu:/home/briansu#
```