NS Lab3 Report

Part 1:

1.

Before:

```
[+] Run DHCP server
mininet> r1 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r1-eth0
192.168.1.0     0.0.0.0         255.255.255.192 U     0      0        0 r1-eth1
192.168.1.64    0.0.0.0         255.255.255.192 U     0      0        0 r1-eth2
mininet> r2 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth0
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth1
mininet> r3 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth0
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth1
mininet> r4 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r4-eth0
140.114.0.0     0.0.0.0         255.255.255.0   U     0      0        0 r4-eth1
mininet>
```

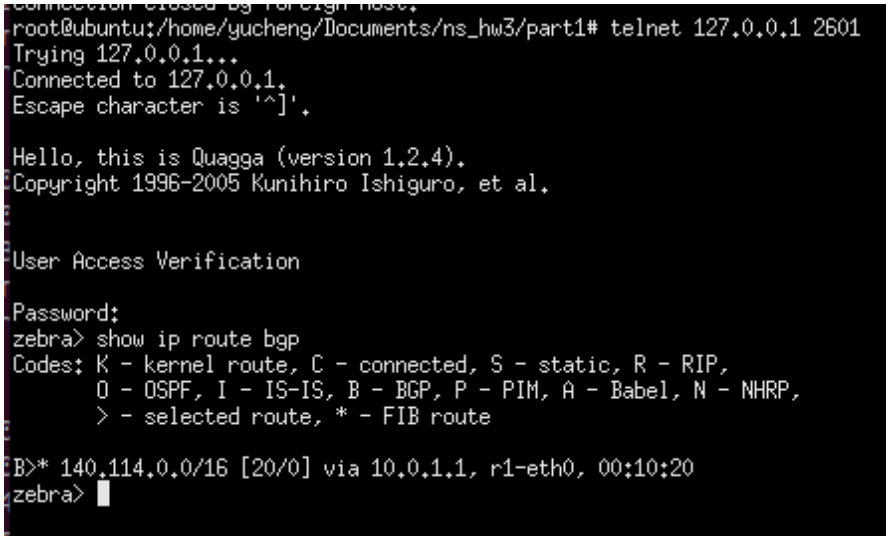
After:

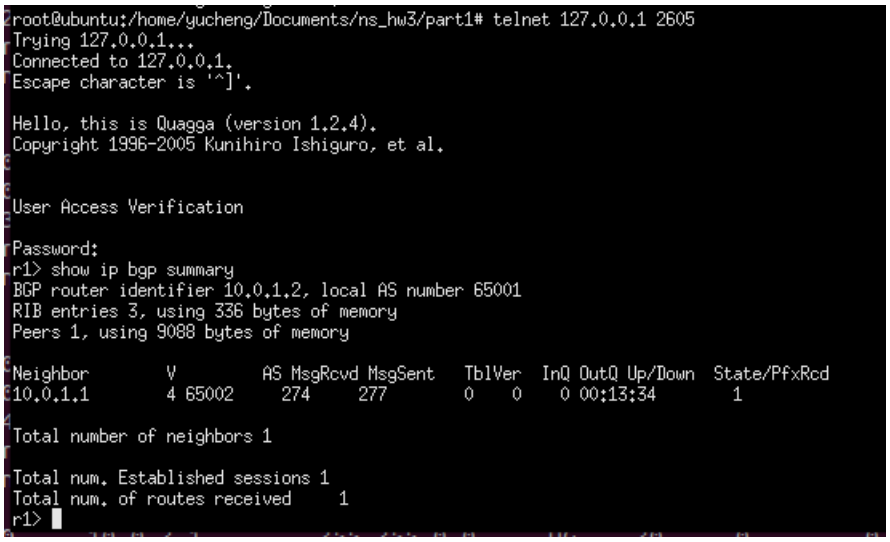
```
mininet> r1 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r1-eth0
140.114.0.0     10.0.1.1        255.255.0.0     UG    20     0        0 r1-eth0
192.168.1.0     0.0.0.0         255.255.255.192 U     0      0        0 r1-eth1
192.168.1.64    0.0.0.0         255.255.255.192 U     0      0        0 r1-eth2
mininet> r2 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth0
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth1
140.113.0.0     10.0.1.2        255.255.0.0     UG    20     0        0 r2-eth1
140.114.0.0     10.0.0.2        255.255.0.0     UG    20     0        0 r2-eth0
mininet> r3 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth0
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth1
140.113.0.0     10.0.0.1        255.255.0.0     UG    20     0        0 r3-eth0
140.114.0.0     10.0.2.3        255.255.0.0     UG    20     0        0 r3-eth1
mininet> r4 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r4-eth0
140.113.0.0     10.0.2.1        255.255.0.0     UG    20     0        0 r4-eth0
140.114.0.0     0.0.0.0         255.255.255.0   U     0      0        0 r4-eth1
mininet>
```

2. For Zebra: telnet 127.0.0.1 2601 / show ip route bgp
   For BGPD: telnet 127.0.0.1 2605 / show ip bgp summary

   下列圖片在上方為 zebra，下方為 bgpd。

   r1:





   r2:

```
root@ubuntu:/home/yucheng/Documents/ns_hw3/part1# telnet 127.0.0.1 2601
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
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User Access Verification

Password:
zebra> show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, A - Babel, N - NHRP,
       > - selected route, * - FIB route

B>* 140.113.0.0/16 [20/0] via 10.0.1.2, r2-eth1, 00:21:44
B>* 140.114.0.0/16 [20/0] via 10.0.0.2, r2-eth0, 00:21:39
zebra>
```

```
root@ubuntu:/home/yucheng/Documents/ns_hw3/part1# telnet 127.0.0.1 2605
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
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User Access Verification

Password:
r2> show ip route summary
% [BGP] Unknown command: show ip route summary
r2> show ip bgp summary
BGP router identifier 10.0.0.1, local AS number 65002
RIB entries 3, using 336 bytes of memory
Peers 2, using 18 KiB of memory

Neighbor        V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.0.2        4 65003     470     473        0    0    0 00:23:24        1
10.0.1.2        4 65001     471     472        0    0    0 00:23:24        1

Total number of neighbors 2

Total num. Established sessions 2
Total num. of routes received    2
r2>
et> r4 route
```

r3:

```
Connection closed by foreign host.
root@ubuntu:/home/yucheng/Documents/ns_hw3/part1# telnet 127.0.0.1 2601
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
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User Access Verification

Password:
zebra> show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, A - Babel, N - NHRP,
       > - selected route, * - FIB route

B>* 140.113.0.0/16 [20/0] via 10.0.0.1, r3-eth0, 00:25:07
B>* 140.114.0.0/16 [20/0] via 10.0.2.3, r3-eth1, 00:25:12
zebra>
```

```
root@ubuntu:/home/yucheng/Documents/ns_hw3/part1# telnet 127.0.0.1 2605
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
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User Access Verification

Password:
r3> show ip bgp summary
BGP router identifier 10.0.0.2, local AS number 65003
RIB entries 3, using 336 bytes of memory
Peers 2, using 18 KiB of memory

Neighbor        V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.0.1        4 65002     495     496        0    0    0 00:24:36        1
10.0.2.3        4 65004     494     497        0    0    0 00:24:36        1

Total number of neighbors 2

Total num. Established sessions 2
Total num. of routes received     2
r3>
```

r4:

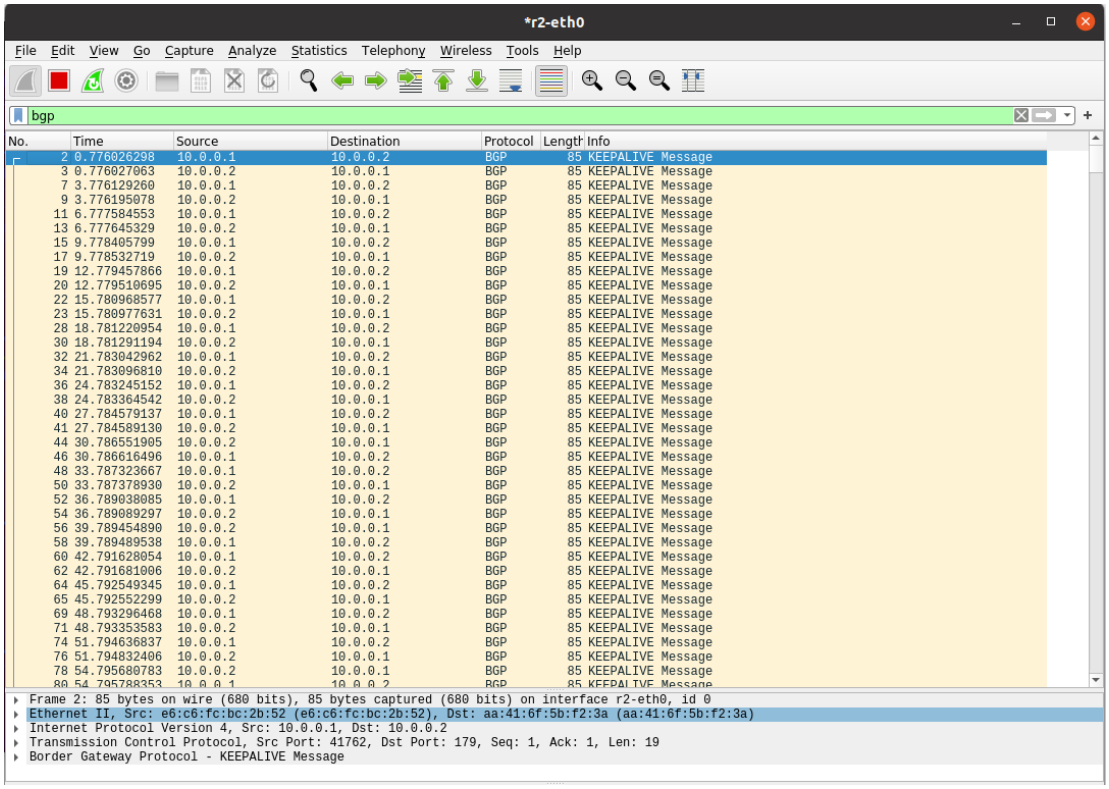
```
root@ubuntu:/home/yucheng/Documents/ns_hw3/part1# telnet 127.0.0.1 2601
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
zebra> show ip route bgp
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, A - Babel, N - NHRP,
       > - selected route, * - FIB route

B>* 140.113.0.0/16 [20/0] via 10.0.2.1, r4-eth0, 00:26:22
zebra>
```

```
root@ubuntu:/home/yucheng/Documents/ns_hw3/part1# telnet 127.0.0.1 2605
Trying 127.0.0.1...
Connected to 127.0.0.1.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
r4> show ip bgp summary
BGP router identifier 10.0.2.3, local AS number 65004
RIB entries 3, using 336 bytes of memory
Peers 1, using 9088 bytes of memory

Neighbor        V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.2.1        4 65003     545     546        0    0    0 00:27:06        1

Total number of neighbors 1

Total num. Established sessions 1
Total num. of routes received     1
r4>
```

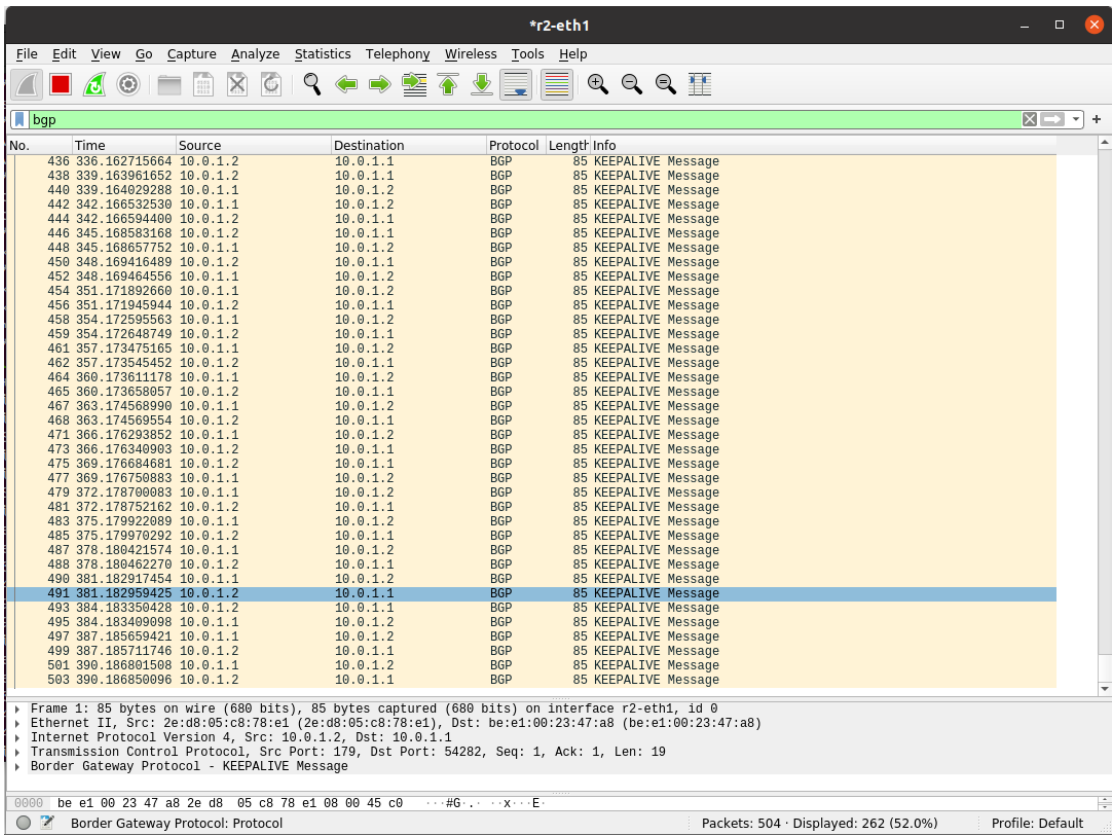
3.

3-1: BGP packets exchanged by r2 and r3:

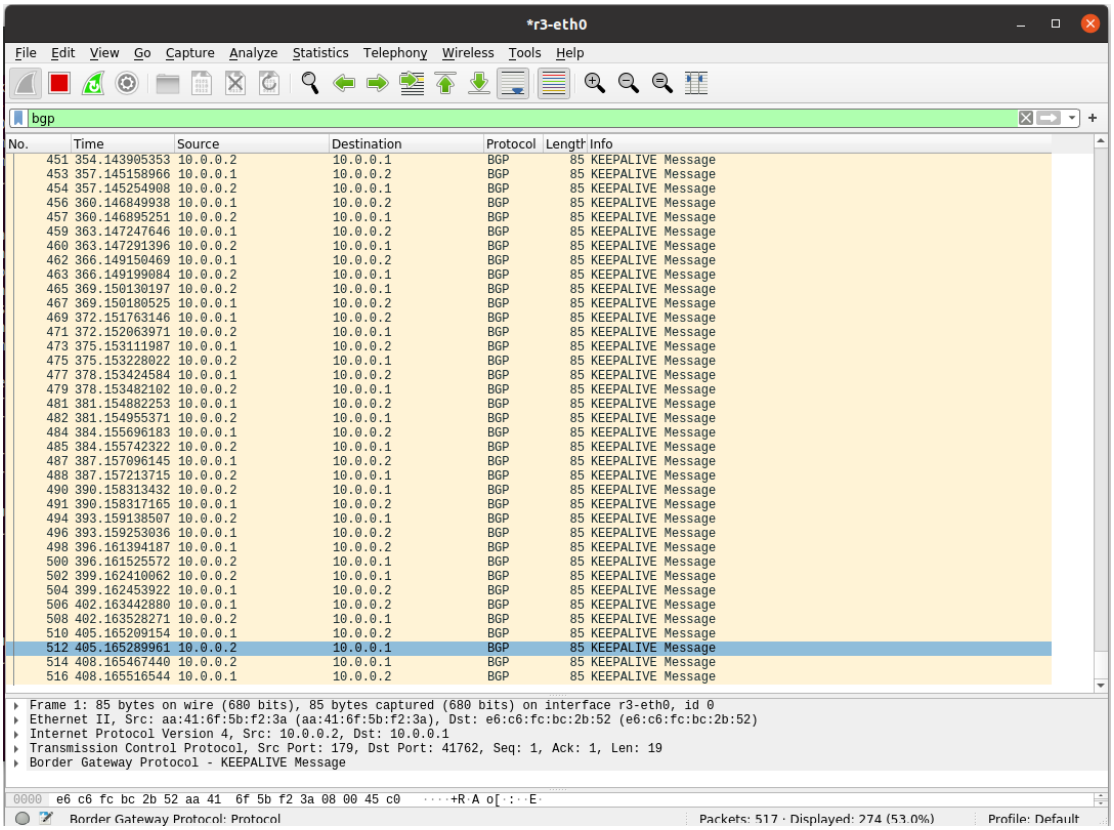
r2-eth0:



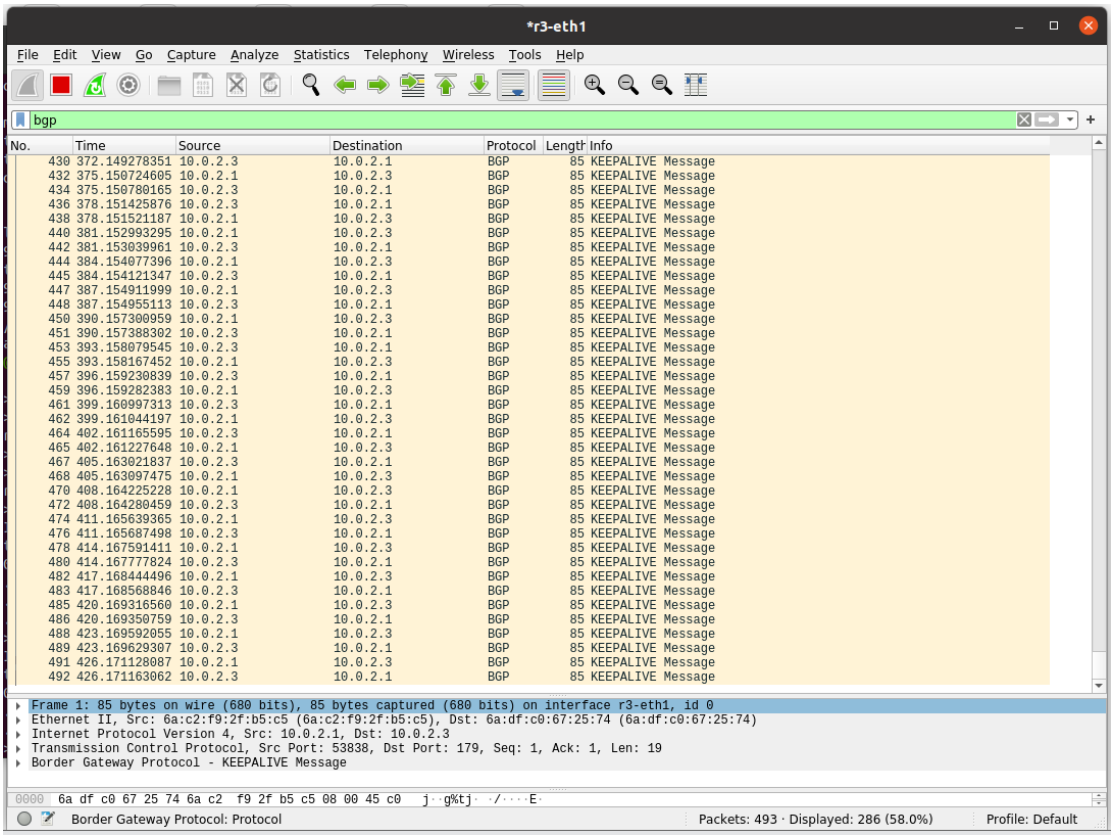
r2-eth1:



r3-eth0:



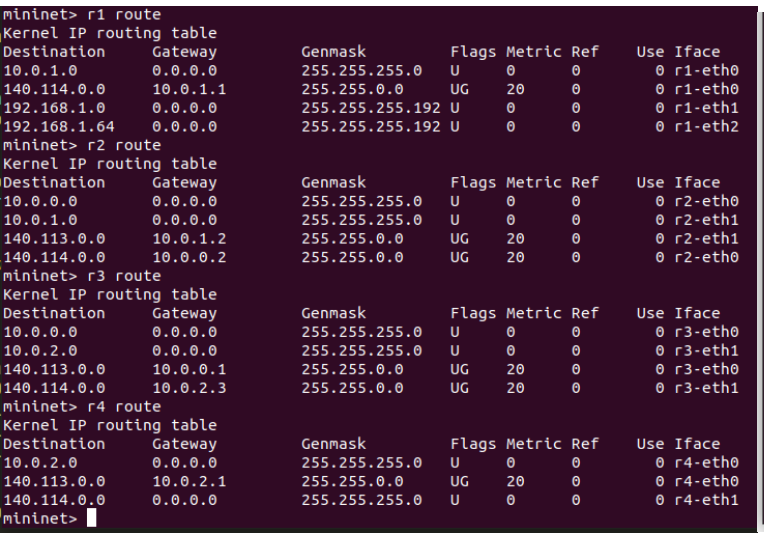
r3-eth1:



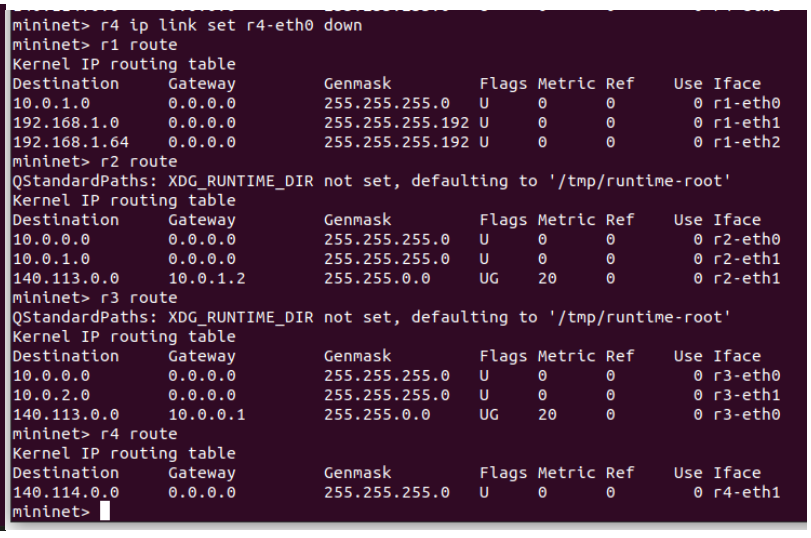
3-2: Set r4-eth0 down:

```
mininet> r4 ip link set r4-eth0 down
mininet> r1 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r1-eth0
192.168.1.0     0.0.0.0         255.255.255.192 U     0      0        0 r1-eth1
192.168.1.64    0.0.0.0         255.255.255.192 U     0      0        0 r1-eth2
mininet> r2 route
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth0
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth1
140.113.0.0     10.0.1.2        255.255.0.0     UG    20     0        0 r2-eth1
mininet> r3 route
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth0
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth1
140.113.0.0     10.0.0.1        255.255.0.0     UG    20     0        0 r3-eth0
mininet> r4 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
140.114.0.0     0.0.0.0         255.255.255.0   U     0      0        0 r4-eth1
mininet>
```

在輸入 r4 ip link set r4-eth0 down 之後，各路由器的 routing table 都有所改變，直接拿原本的 table 做比較:



```
mininet> r1 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r1-eth0
140.114.0.0     10.0.1.1        255.255.0.0     UG    20     0        0 r1-eth0
192.168.1.0     0.0.0.0         255.255.255.192 U     0      0        0 r1-eth1
192.168.1.64    0.0.0.0         255.255.255.192 U     0      0        0 r1-eth2
mininet> r2 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth0
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth1
140.113.0.0     10.0.1.2        255.255.0.0     UG    20     0        0 r2-eth1
140.114.0.0     10.0.0.2        255.255.0.0     UG    20     0        0 r2-eth0
mininet> r3 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth0
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth1
140.113.0.0     10.0.0.1        255.255.0.0     UG    20     0        0 r3-eth0
140.114.0.0     10.0.2.3        255.255.0.0     UG    20     0        0 r3-eth1
mininet> r4 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r4-eth0
140.113.0.0     10.0.2.1        255.255.0.0     UG    20     0        0 r4-eth0
140.114.0.0     0.0.0.0         255.255.255.0   U     0      0        0 r4-eth1
mininet>
```

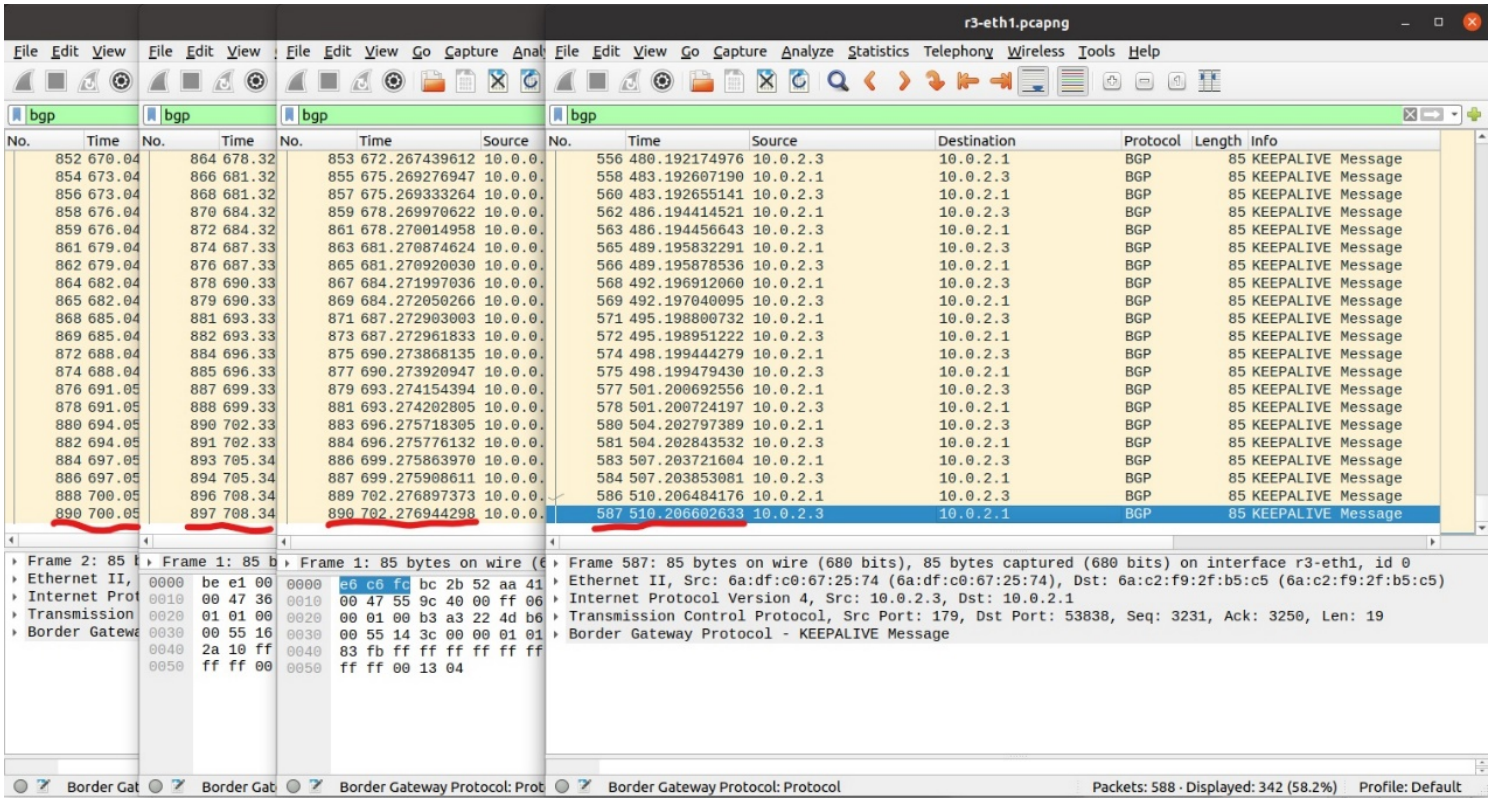


```
mininet> r4 ip link set r4-eth0 down
mininet> r1 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r1-eth0
192.168.1.0     0.0.0.0         255.255.255.192 U     0      0        0 r1-eth1
192.168.1.64    0.0.0.0         255.255.255.192 U     0      0        0 r1-eth2
mininet> r2 route
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth0
10.0.1.0        0.0.0.0         255.255.255.0   U     0      0        0 r2-eth1
140.113.0.0     10.0.1.2        255.255.0.0     UG    20     0        0 r2-eth1
mininet> r3 route
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
10.0.0.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth0
10.0.2.0        0.0.0.0         255.255.255.0   U     0      0        0 r3-eth1
140.113.0.0     10.0.0.1        255.255.0.0     UG    20     0        0 r3-eth0
mininet> r4 route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
140.114.0.0     0.0.0.0         255.255.255.0   U     0      0        0 r4-eth1
mininet>
```

左邊是原本都連得上的情況，右邊是將 r4-eth0 disable 掉的情況。我們可以發現，r1、r2、r3 中，140.114.0.0 的這條路由全都不見了；而對 r4 來說，則只剩下 140.114.0.0 這條路由。這代表 r1、r2、r3 都可以正常傳送封包，就只傳不到 r4；而 r4 就只

能傳到 H4，剩下的 host、router 都無法傳到。

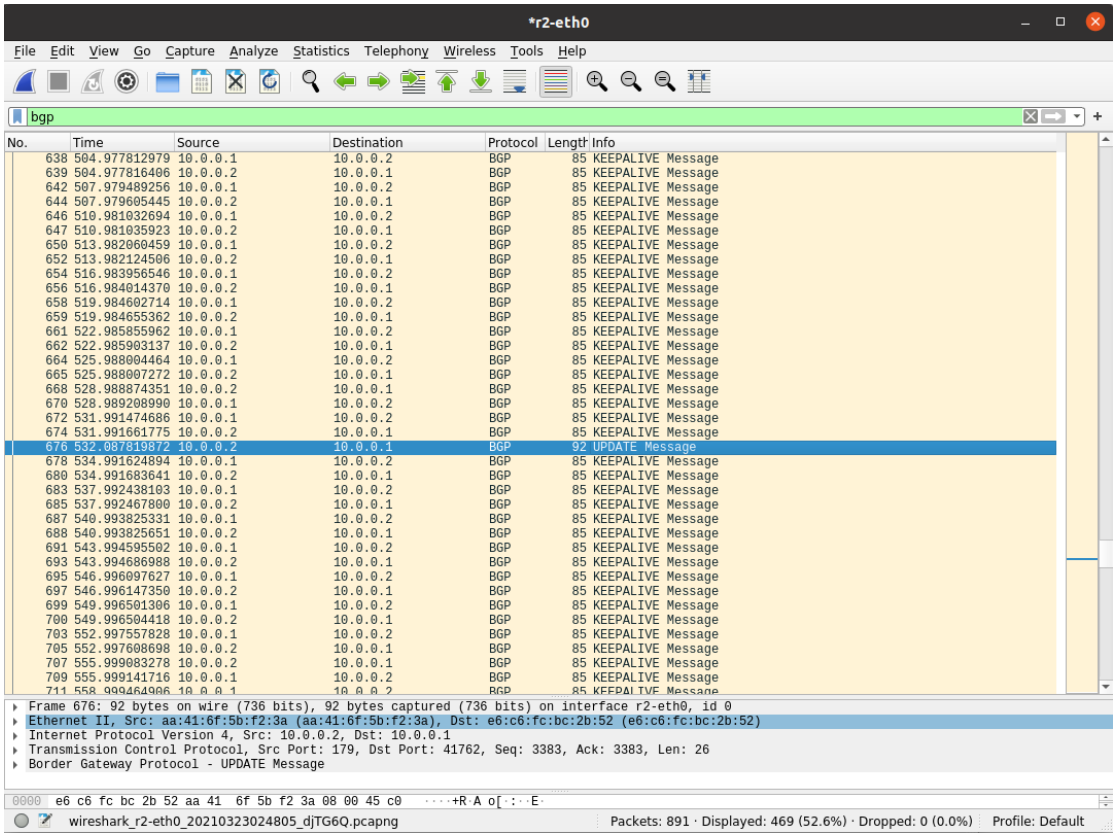
3-3: How does r3 know r4 is unreachable?

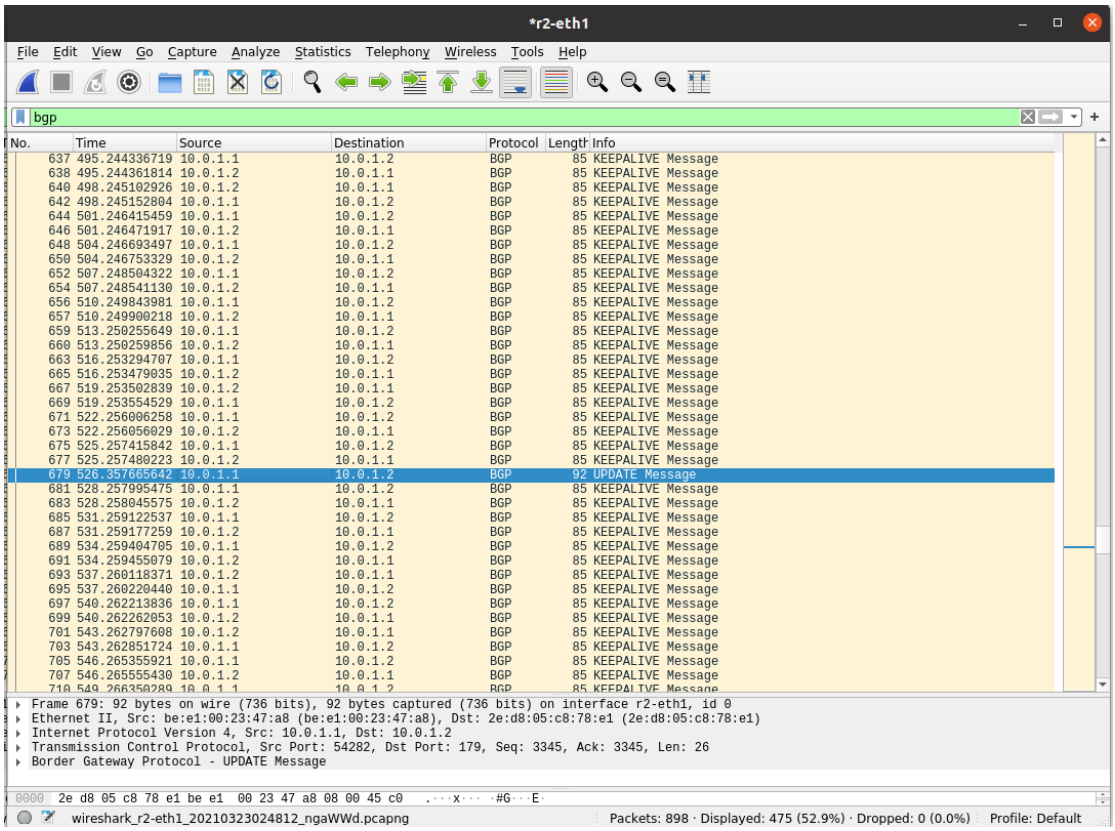


上圖由左至右分別是 r2-eth0、r2-eth1、r3-eth0、r3-eth1 的 wireshark 截圖。這四個 interface 都由我大致在同一時間開始及停止 listen。可以發現，BGP 大概每隔 3 秒就會用一個 KEEPALIVE message 和自己的 neighbor 互傳。而 r3-eth1 在 disable r4-eth0 之後就沒有再傳送、接收到封包了，最後一個封包是在時間 510.2 秒收到來自 r4-eth0 的 KEEPALIVE。而其他 interface 的最後一個封包都在大約 700 秒左右。由此可以推斷，510 秒時大約就是下達 disable r4-eth0 指令的時候。而下達之後，r3 由於 r3-eth1 沒有收到該有的 KEEPALIVE message，而

知道 r4 變成 unreachable 了。

3-4: How does r2 know r4 is unreachable?





上兩圖分別是 r2-eth0、r2-eth1 的 wireshark 截圖。可以發現在 530 秒左右時，兩個 interface 都收到了一個 UPDATE message。而承上題，下達 disable 指令時大約是 510 秒。由此可以推斷，在 r3 得知 r4 unreachable 之後，便發送 UPDATE message 給其他的 router，告知他們更新 routing table，將 r4 移除。而 r2 收到了這個 message，因此得知了 r4 unreachable。

Part 2:

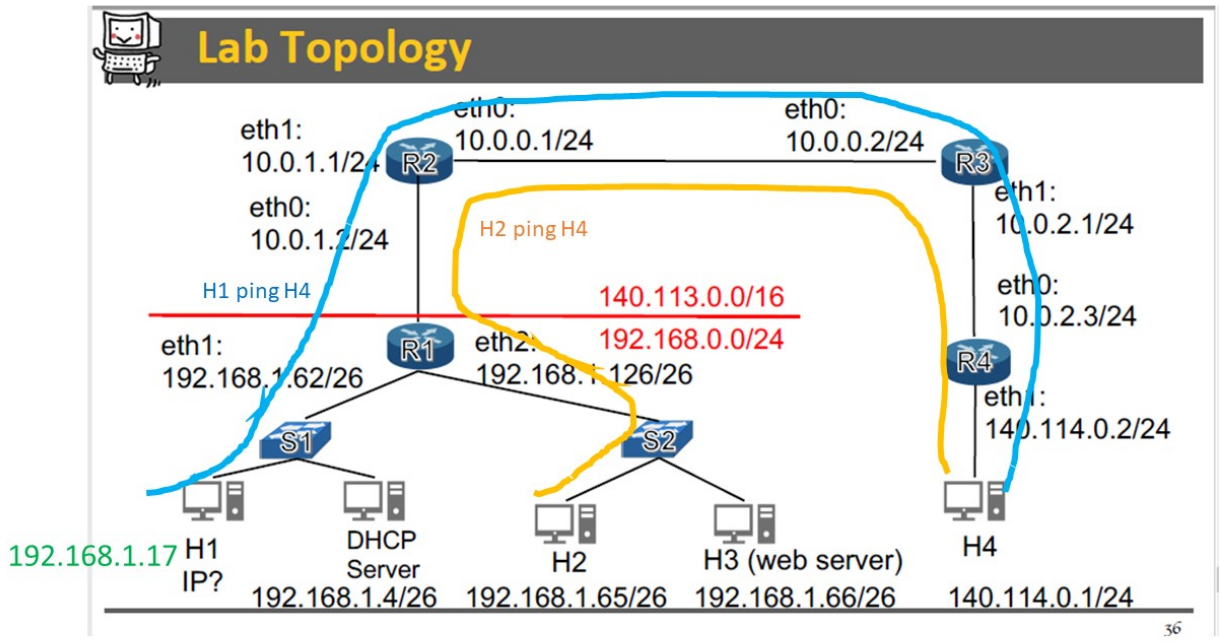
1. Curl:

```
mininet> h3 python2 -m SimpleHTTPServer &
mininet> h4 curl 140.113.0.40:80
bash: curl: command not found
mininet> h4 curl 140.113.0.40:80
<!DOCTYPE html PUBLIC "-//W3C//DTD HTML 3.2 Final//EN"><html>
<title>Directory listing for /</title>
<body>
<h2>Directory listing for /</h2>
<hr>
<ul>
<li><a href="bgp_r1.conf">bgp_r1.conf</a>
<li><a href="bgp_r2.conf">bgp_r2.conf</a>
<li><a href="bgp_r3.conf">bgp_r3.conf</a>
<li><a href="bgp_r4.conf">bgp_r4.conf</a>
<li><a href="dhcpd.conf">dhcpd.conf</a>
<li><a href="topology.py">topology.py</a>
<li><a href="zebra.conf">zebra.conf</a>
</ul>
<hr>
</body>
</html>
mininet>
```

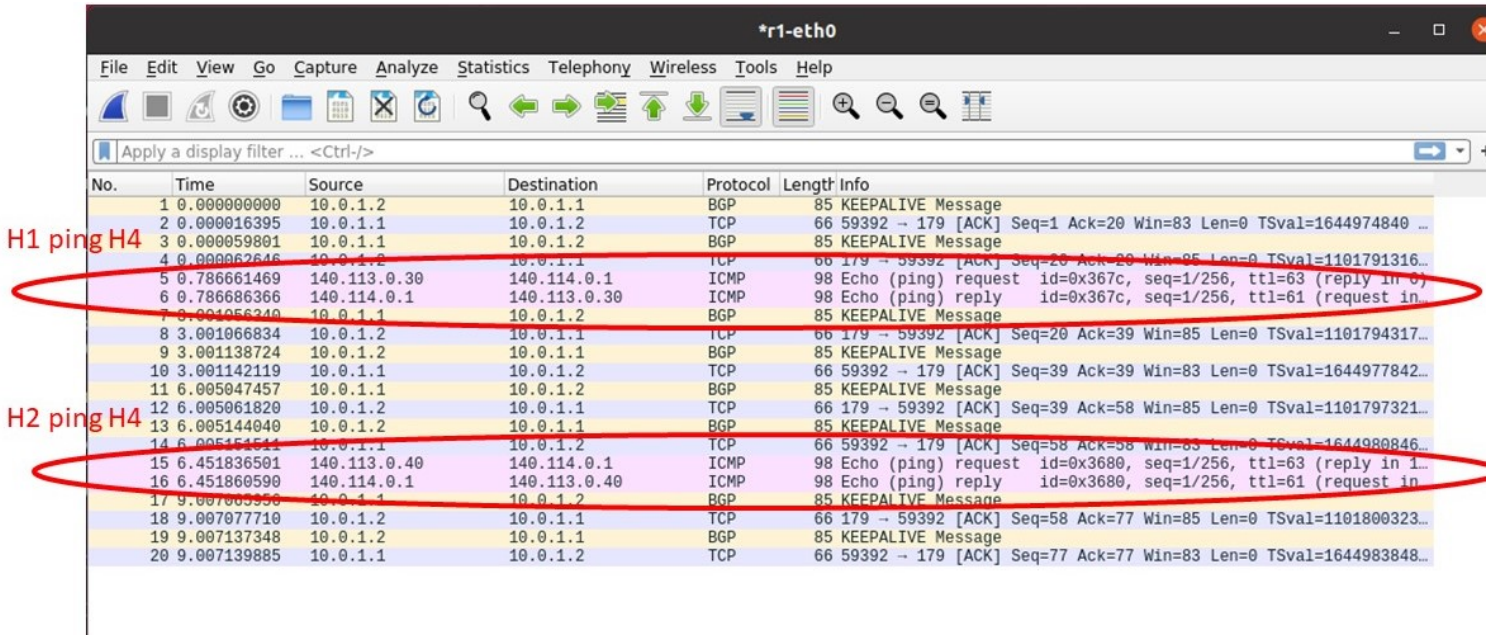
2. Ping:

```
mininet> h1 ping h4 -c 1
PING 140.114.0.1 (140.114.0.1) 56(84) bytes of data.
64 bytes from 140.114.0.1: icmp_seq=1 ttl=60 time=0.322 ms

--- 140.114.0.1 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.322/0.322/0.322/0.000 ms
mininet> h2 ping h4 -c 1
PING 140.114.0.1 (140.114.0.1) 56(84) bytes of data.
64 bytes from 140.114.0.1: icmp_seq=1 ttl=60 time=0.305 ms

--- 140.114.0.1 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.305/0.305/0.305/0.000 ms
mininet> h3 ping h4 -c 1
Serving HTTP on 0.0.0.0 port 8000 ...
140.114.0.1 - - [23/Mar/2021 08:38:39] "GET / HTTP/1.1" 200 -
PING 140.114.0.1 (140.114.0.1) 56(84) bytes of data.
64 bytes from 140.114.0.1: icmp_seq=1 ttl=60 time=0.261 ms

--- 140.114.0.1 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.261/0.261/0.261/0.000 ms
mininet>
```

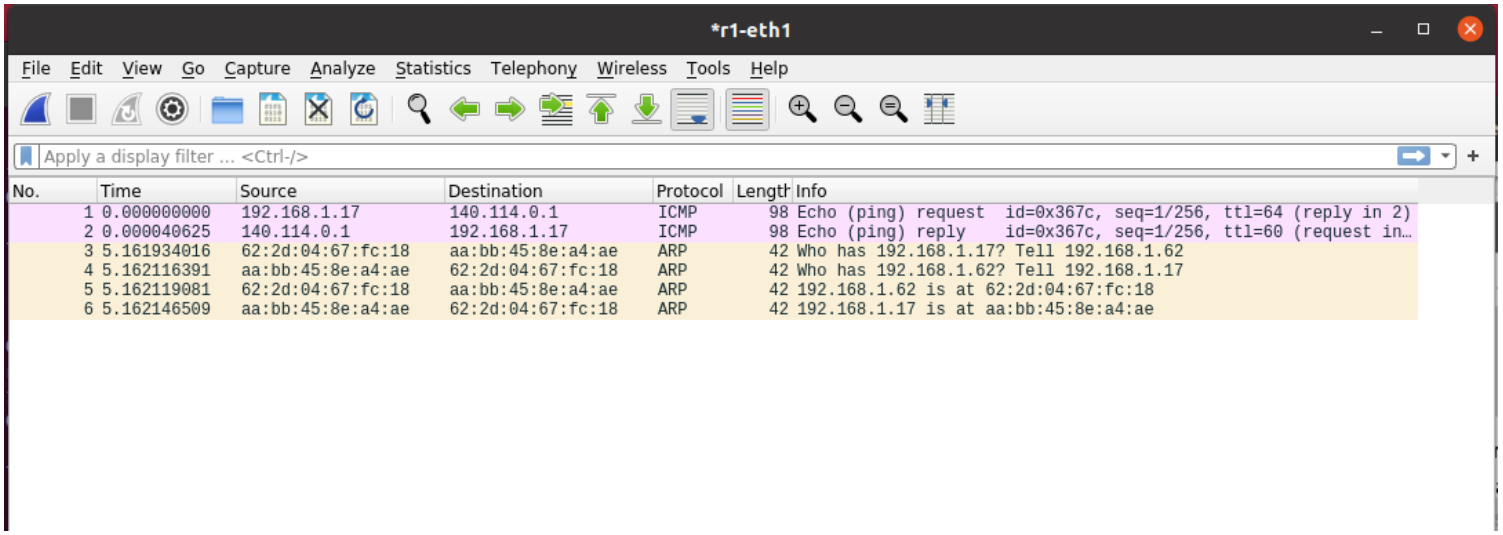
3. r1 wireshark:



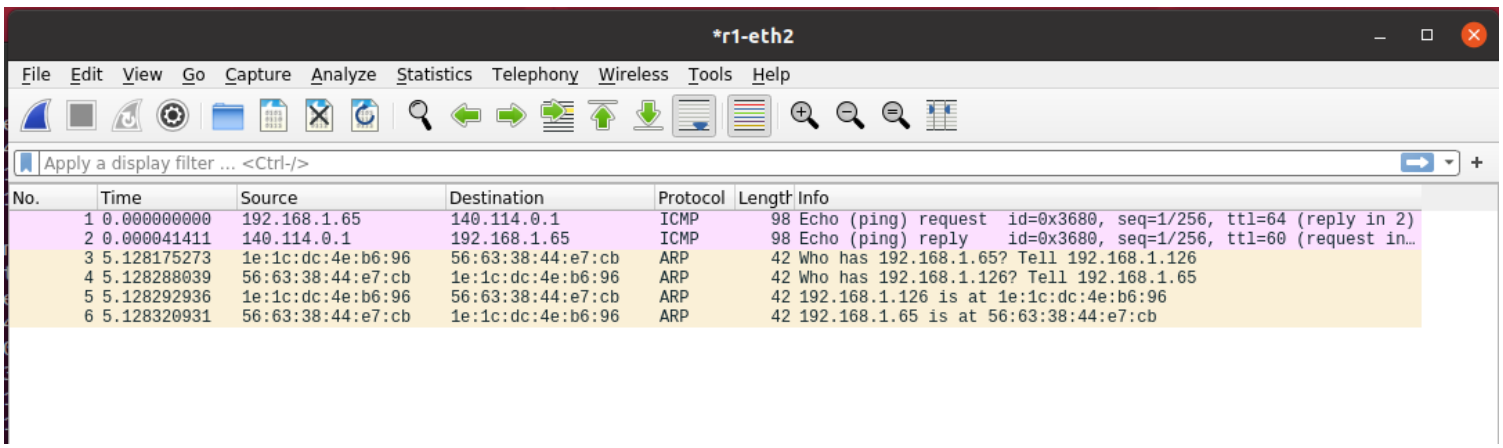
r1-eth0:



r1-eth1: (h1 ping h4)



r1-eth2: (h2 ping h4)



結合以上拓樸結構和 wireshark 截圖，我們可以得出以下結論:

I. h1 (192.168.1.17) 發出 ping request，首先到 r1-eth1，經由 r1 轉傳，從 r1-eth0 出來。由於經過 NAT，source ip 變為 140.113.0.30。到 h4 (140.114.0.1) 後，h4 收到並送出 ping reply，經由原路徑返回。相反的，過 r1 一樣會將 destination ip 從 140.113.0.30 轉成 192.168.1.17，並由 h1 接收。

II. h2 (192.168.1.65) 同理，經過設有 NAT 的 r1 會將 source ip 從原本的 192.168.1.65 轉成 140.113.0.40；回來時也將 destination ip 從 140.113.0.40 轉成 192.168.1.65。