

0716306 NSC lab2 report

Part 1 question

1.

- (a) h2 可以 ping h3，因為 h2 和 h3 之間利用 switch 相連並在同一個網域中，不需要用到 routing

```
demo@SDN-NFV:~/Desktop/NSC_lab2$ sudo python topology.py
h1 doesn't have connectivity to 192.168.1.65
h1 doesn't have connectivity to 192.168.1.66
h1 doesn't have connectivity to 192.168.3.1
h1 doesn't have connectivity to 192.168.3.2
h2 doesn't have connectivity to 192.168.3.1
h2 doesn't have connectivity to 192.168.3.2
h3 doesn't have connectivity to 192.168.3.1
h3 doesn't have connectivity to 192.168.3.2
h4 doesn't have connectivity to 192.168.1.65
h4 doesn't have connectivity to 192.168.1.66
h5 doesn't have connectivity to 192.168.1.65
h5 doesn't have connectivity to 192.168.1.66
WRONG ANSWER
mininet> h2 ping h3
PING 192.168.1.66 (192.168.1.66) 56(84) bytes of data.
64 bytes from 192.168.1.66: icmp_seq=1 ttl=64 time=0.351 ms
64 bytes from 192.168.1.66: icmp_seq=2 ttl=64 time=0.115 ms
64 bytes from 192.168.1.66: icmp_seq=3 ttl=64 time=0.099 ms
64 bytes from 192.168.1.66: icmp_seq=4 ttl=64 time=0.111 ms
^C
--- 192.168.1.66 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3238ms
rtt min/avg/max/mdev = 0.099/0.169/0.351/0.105 ms
```

- (b) h2 不能 ping h4，因為 h2 到 h4 的 path 需要經過 router，但此時所有 router 的 routing table 並沒有到其他網域的 routing path，因此無法成功

```
mininet> h2 ping h4
connect: Network is unreachable
mininet>
```

2. 在完成除 h1 以外的 topology 的部分後，執行 topology 的 check()結果如下圖

```
demo@SDN-NFV:~/Desktop/NSC_lab2$ sudo python topology.py
h1 doesn't have connectivity to 192.168.1.65
h1 doesn't have connectivity to 192.168.1.66
h1 doesn't have connectivity to 192.168.3.1
h1 doesn't have connectivity to 192.168.3.2
WRONG ANSWER
```

Part 2 question

3. 執行完 h1 dhclient h1-eth0 後，wireshark 的截圖如下

No.	Time	Source	Destination	Protocol	Length	Info
2	0.000012362	fe80::2054:aefc:fe5...	ff02::2	ICMPv6	70	Router Solicitation from 22:54:ae:50:a3:d3
3	1.022427273	fe80::20da:24ff:fe0...	ff02::2	ICMPv6	70	Router Solicitation from 22:da:24:0a:7d:8c
4	2.613039387	fe80::2054:aefc:fe5...	ff02::2	ICMPv6	107	Standard query 0x0000 PTR _ipps...tcp.local, "QM" question PTR _ipp...tcp.local, "QM" q...
5	11.262034903	fe80::8bad:3aff:fe6...	ff02::2	ICMPv6	70	Router Solicitation from 8a:ad:3a:6e:57:3b
6	11.339398973	0.0.0.0	255.255.255.255	DHCP	342	DHCP Request - Transaction ID 0x4cb0216d
7	11.348453353	192.168.1.4	255.255.255.255	DHCP	342	DHCP NAK - Transaction ID 0x4cb0216d
8	11.961254420	fe:58:ed:c4:2d:a2	Broadcast	ARP	42	Who has 169.254.9.93? Tell 0.0.0.0
9	13.257061050	fe:58:ed:c4:2d:a2	Broadcast	ARP	42	Who has 169.254.9.93? Tell 0.0.0.0
10	14.333389522	fe:58:ed:c4:2d:a2	Broadcast	ARP	42	Who has 169.254.9.93? Tell 0.0.0.0
11	15.809044540	fe80::2054:aefc:fe5...	ff02::2	ICMPv6	70	Router Solicitation from 22:54:ae:50:a3:d3
12	16.125081256	fe80::fc58:edff:fec...	ff02::2	ICMPv6	70	Router Solicitation from fe:58:ed:c4:2d:a2
13	16.334811882	fe:58:ed:c4:2d:a2	Broadcast	ARP	42	Gratuitous ARP for 169.254.9.93 (Request)
14	18.334923463	fe:58:ed:c4:2d:a2	Broadcast	ARP	42	Gratuitous ARP for 169.254.9.93 (Request)
15	18.612670957	fe80::2054:aefc:fe5...	ff02::2	ICMPv6	107	Standard query 0x0000 PTR _ipps...tcp.local, "QM" question PTR _ipp...tcp.local, "QM" q...
16	19.906063431	fe80::20da:24ff:fe0...	ff02::2	ICMPv6	70	Router Solicitation from 22:da:24:0a:7d:8c
17	20.450726853	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xf436f75b
18	20.451171490	22:da:24:0a:7d:8c	Broadcast	ARP	42	Who has 192.168.1.11? Tell 192.168.1.4
19	21.454175790	192.168.1.4	192.168.1.11	DHCP	342	DHCP Offer - Transaction ID 0xf436f75b
20	21.454767277	0.0.0.0	255.255.255.255	DHCP	342	DHCP Request - Transaction ID 0xf436f75b
21	21.468292495	192.168.1.4	192.168.1.11	DHCP	342	DHCP ACK - Transaction ID 0xf436f75b
22	21.474288781	22:da:24:0a:7d:8c	Broadcast	ARP	42	Who has 192.168.1.11? Tell 192.168.1.4
23	22.497592169	22:da:24:0a:7d:8c	Broadcast	ARP	42	Who has 192.168.1.11? Tell 192.168.1.4
24	22.497630487	fe:58:ed:c4:2d:a2	22:da:24:0a:7d:8c	ARP	42	192.168.1.11 is at fe:58:ed:c4:2d:a2
25	22.497732995	192.168.1.4	192.168.1.11	ICMP	62	Echo (ping) request id=0x18c3, seq=0/0, ttl=64 (reply in 26)
26	22.497756203	192.168.1.11	192.168.1.4	ICMP	62	Echo (ping) reply id=0x18c3, seq=0/0, ttl=64 (request in 25)
27	27.645099476	fe:58:ed:c4:2d:a2	22:da:24:0a:7d:8c	ARP	42	Who has 192.168.1.4? Tell 192.168.1.11
28	27.645028681	22:da:24:0a:7d:8c	fe:58:ed:c4:2d:a2	ARP	42	192.168.1.4 is at 22:da:24:0a:7d:8c
29	38.308068026	fe80::8bad:3aff:fe6...	ff02::2	ICMPv6	70	Router Solicitation from 8a:ad:3a:6e:57:3b
30	48.637052746	fe80::2054:aefc:fe5...	ff02::2	ICMPv6	70	Router Solicitation from 22:54:ae:50:a3:d3
31	50.020888366	fe80::2054:aefc:fe5...	ff02::2	ICMPv6	107	Standard query 0x0000 PTR _ipps...tcp.local, "QM" question PTR _ipp...tcp.local, "QM" q...
32	50.685008763	fe80::fc58:edff:fec...	ff02::2	ICMPv6	70	Router Solicitation from fe:58:ed:c4:2d:a2

Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
 Ethernet II, Src: fe:58:ed:c4:2d:a2 (fe:58:ed:c4:2d:a2), Dst: IPv6multicast_02 (33:33:00:00:00:02)
 Internet Protocol Version 6, Src: fe80::2054:aefc:fe58:edff:fc4:2da2, Dst: ff02::2
 Internet Control Message Protocol v6

```

0000  33 33 00 00 00 02 fe 58 ed c4 2d a2 86 dd 60 00 33 --- X ---
0010  00 00 00 10 3a ff fe 80 00 00 00 00 00 fc 58 --- : --- X
0020  ed ff fe c4 2d a2 ff 02 00 00 00 00 00 00 00 00 --- : --- K
0030  00 00 00 00 02 85 00 4b ae 00 00 00 00 01 01 --- : ---
0040  fe 58 ed c4 2d a2 --- X ---
  
```

在 cmd 輸入 h1 ifconfig 後如下(原本我將 DHCP 給予的 IP range 設為從 192.168.1.0 開始，但因為分配到的 IP 是代表這個網段的 IP，因此後來設為從 192.168.1.10 開始，到 192.168.1.61 結束)

```

mininet> h1 ifconfig
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
inet 192.168.1.11 netmask 255.255.255.192 broadcast 192.168.1.63
inet6 fe80::fc58:edff:fec4:2da2 prefixlen 64 scopeid 0x20<link>
ether fe:58:ed:c4:2d:a2 txqueuelen 1000 (Ethernet)
RX packets 53 bytes 5816 (5.8 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 22 bytes 2248 (2.2 KB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 20 bytes 1000 (1000.0 B)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 20 bytes 1000 (1000.0 B)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

mininet>
  
```

- 然後開始嘗試讓 DHCP server 將 IP 指派給其他的 host，此處以 h2 為例，結果如下，可以看見 h2 的 eth0 介面並無變化，並且參照 wireshark 的介面，觀察 h2-eth0 收到的封包中也並無變化，而因為 dhcpd.conf 中沒有宣告除 192.168.1.0/26 以外的 subnet，因此 DHCP server 不會知道如何分配 IP 給除 h1 以外的 host

No.	Time	Source	Destination	Protocol	Length	Info
1	0.00000000	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
2	3.383046520	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
3	8.892112329	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
4	21.460199064	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
5	41.561628784	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
6	57.405246372	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
7	77.623311562	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
8	91.228528693	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
9	104.425034512	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
10	126.812336767	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
11	129.090456453	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
12	141.007971859	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
13	153.308615739	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
14	162.124894320	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
15	162.679892514	fe80::78b7:95ff:fe00::2	ff02::2	ICMPv6	70	Router Solicitation from 7a:b7:95:f1:4f:17
16	174.575279399	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
17	179.063624797	fe80::348d:27ff:fe00::2	ff02::2	ICMPv6	70	Router Solicitation from 38:bd:27:88:bd:13
18	186.587717562	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc685f6b
19	195.083924336	fe80::6833:87ff:fe00::f0	ff02::f0	MDNS	197	Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipp._tcp.local, "QM" q...

▶ Frame 321: 342 bytes on wire (2736 bits), 342 bytes captured (2736 bits) on interface 0
 ▶ Ethernet II, Src: c6:3e:b9:dd:cc:b9 (c6:3e:b9:dd:cc:b9), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
 ▶ Internet Protocol Version 4, Src: 0.0.0.0, Dst: 255.255.255.255
 ▶ User Datagram Protocol, Src Port: 68, Dst Port: 67
 ▶ Bootstrap Protocol (Discover)

```

0000  ff ff ff ff ff ff c6 3e b9 dd cc b9 00 00 45 10  ....>....E
0010  01 40 00 00 00 00 00 11 39 06 00 00 00 ff ff  ..H....9...
0020  ff ff 00 44 00 43 01 34 0f 7f 01 01 00 48 24  ..D.C.4....H$
0030  73 5e 00 00 00 00 00 00 00 00 00 00 00 00  ..SA.....
0040  00 00 00 00 00 00 c6 3e b9 dd cc b9 00 00 00  ..>.....
0050  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
0060  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
0070  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
0080  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
0090  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
00a0  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
00b0  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
00c0  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
00d0  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
00e0  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
00f0  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
0100  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
0110  00 00 00 00 00 63 62 53 63 35 01 01 0c 07 53  ..C.Sc5....S
0120  44 4e 24 4e 46 56 37 00 01 1c 02 03 0f 06 77  ..DN-MV?....w
0130  2c 2f 1a 79 2a ff 00 00 00 00 00 00 00 00 00  ..,y*.....
0140  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
0150  00 00 00 00 00 00 00 00 00 00 00 00 00 00  ..>.....
  
```

下圖為 h2 ifconfig 後的畫面，可看見 h2 的 IP 並未被修改

```

mininet> h2 ifconfig
h2-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
    inet 192.168.1.65 netmask 255.255.255.192 broadcast 192.168.1.127
    inet6 fe80::c43e:b9ff:fedd:ccb9 prefixlen 64 scopeid 0x20<link>
    ether c6:3e:b9:dd:cc:b9 txqueuelen 1000 (Ethernet)
    RX packets 65 bytes 6062 (6.0 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 54 bytes 12364 (12.3 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 22 bytes 1168 (1.1 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 22 bytes 1168 (1.1 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

mininet>
  
```


Part 3 question

5. 首先是 h1 ping h5 -c 1 的指令，圖中編號為 20 和 21 的 ICMP 封包為執行後所得(此 interface 為 r1-eth1)

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter... <<Ctrl>> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.0000000	FCM0:1605:31ff:f7	fc02::2	ICMPv6	70	Router Solicitation from MCGS::FCM0:1605:31ff:f7
2	2.04777015	FE80::38e7:5cfc:f7	FE02::1f	ICMPv6	70	Router Solicitation from 62:57:03:77:00:8e
3	6.573999863	FE80::38e7:5cfc:f7	FE02::1f	MDNS	167	Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipps._tcp.local, "QM" que
4	8.191706148	FE80::603d:30ff:fe3	FE02::2	ICMPv6	70	Router Solicitation from 62:57:03:77:00:8e
5	12.286751388	FE80::38e7:5cfc:f7	FE02::12	ICMPv6	70	Router Solicitation from 3a:e7:5c:8a:78:5a
6	22.594999050	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc678336a
7	22.595438488	192.168.1.4	255.255.255.255	DHCP	342	DHCP NAK - Transaction ID 0xc678336a
8	22.595890649	62:57:03:77:00:8e	Broadcast	ARP	42	Who has 169.254.8.201? Tell 0.0.0.0
9	24.356029263	62:57:03:77:00:8e	Broadcast	ARP	42	Who has 169.254.8.201? Tell 0.0.0.0
10	26.327267113	62:57:03:77:00:8e	Broadcast	ARP	42	Who has 169.254.8.201? Tell 0.0.0.0
11	29.331801061	62:57:03:77:00:8e	Broadcast	ARP	42	Gratuitous ARP for 169.254.8.201 (Request)
12	30.331557879	62:57:03:77:00:8e	Broadcast	ARP	42	Gratuitous ARP for 169.254.8.201 (Request)
13	32.460190754	0.0.0.0	255.255.255.255	DHCP	342	DHCP Discover - Transaction ID 0xc678336b
14	32.462580589	62:181:30:3e:21:b	Broadcast	ARP	42	Who has 192.168.1.12? Tell 192.168.1.4
15	33.464330934	0.0.0.0	255.255.255.255	DHCP	342	DHCP Request - Transaction ID 0xc678336b
16	33.470121315	62:181:30:3e:21:b	Broadcast	ARP	42	Who has 192.168.1.12? Tell 192.168.1.4
17	34.460966583	62:181:30:3e:21:b	Broadcast	ARP	42	Who has 192.168.1.12? Tell 192.168.1.4
18	34.5200981480	62:57:03:77:00:8e	Broadcast	ARP	42	Who has 192.168.1.12? Tell 192.168.1.12
19	35.016900191	a6:dc:77:4e:f1:7f	62:57:03:77:00:8e	ARP	42	192.168.1.62 is at a6:dc:77:4e:f1:7f
20	35.01116333	192.168.3.2	192.168.3.2	ICMP	98	Echo (ping) request 1d-30b5bf, seq=1/256, ttl=64 (reply in 21)
21	35.261123662	192.168.3.2	192.168.1.12	ICMP	98	Echo (ping) reply 1d-30b5bf, seq=1/256, ttl=60 (request in 20)
22	35.090327377	62:57:03:77:00:8e	62:57:03:77:00:8e	ARP	42	Who has 192.168.1.12? Tell 192.168.1.62
23	35.091414475	62:57:03:77:00:8e	a6:dc:77:4e:f1:7f	ARP	42	192.168.1.12 is at 62:57:03:77:00:8e
24	35.138262026	FE80::a4dc:77ff:fe4	FE02::2	ICMPv6	70	Router Solicitation from a6:dc:77:4e:f1:7f
25	63.485090625	FE80::603d:30ff:fe3	FE02::2	ICMPv6	70	Router Solicitation from 62:57:03:77:00:8e
26	63.675371995	FE80::38e7:5cfc:f7	FE02::1f	MDNS	167	Standard query 0x0000 PTR _ipps._tcp.local, "QM" question PTR _ipps._tcp.local, "QM" que

▶ Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0
 ▶ Ethernet II, Src: a6:dc:77:4e:f1:7f (a6:dc:77:4e:f1:7f), Dst: IPv6mcast:02:33:33:00:00:00:02:02)
 ▶ Internet Protocol Version 6, Src: FE80::603d:30ff:fe3, Dst: FE02::2
 ▶ Internet Control Message Protocol v6

```

0000  33 33 00 00 00 00 02 a6 dc 77 4e f1 7f 86 dd 60 00  33 ---- wM-----
0010  00 00 00 19 18 f1 7f 00 00 00 00 00 00 00 00 00 00  -N-----
0020  7f ff fe 4e f1 7f ff 02 0f 00 00 00 00 00 00 00 00  w-N-----
0030  00 00 00 00 00 02 85 00 5f 00 00 00 00 00 00 01 01  -N-----
0040  a6 dc 77 4e f1 7f 7f 00 00 00 00 00 00 00 00 00 00  wN-----
  
```

下圖為 h5 ping h1 -c 1 的指令，編號 13 和 14 的 ICMP 封包為執行完指令後所得(此 interface 為 r1-eth0)

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter... <<Ctrl-F>> Expression... +

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	Fe80::a4a:e1ff::fe0	ff02::2	ICMPv6	70	Router Solicitation from a0:4a:e1:0c:73:31
2	0.000020162	Fe80::3105:226f::fe0	ff02::2	ICMPv6	70	Router Solicitation from 8a:67:26:02:e2:1d
3	33.0319106340	Fe80::a4a:e1ff::fe0	ff02::2	ICMPv6	70	Router Solicitation from a0:4a:e1:0c:73:31
4	35.068180021	Fe80::0867:26ff::fe0	ff02::2	ICMPv6	70	Router Solicitation from 8a:67:26:02:e2:1d
5	83.126109035	192.168.1.12	192.168.3.2	ICMP	98	Echo (ping) request id=0x3b5f, seq=1256, ttl=63 (reply in 6)
6	83.126115643	192.168.3.2	192.168.1.12	ICMP	98	Echo (ping) reply id=0x3b5f, seq=1256, ttl=63 (request in 5)
7	88.315499238	8a:67:26:02:e2:1d	a0:4a:e1:0c:73:31	ARP	42	Who has 10.0.1.1? Tell 10.0.1.2
8	88.315442456	a0:4a:e1:0c:73:31	8a:67:26:02:e2:1d	ARP	42	Who has 10.0.1.1? Tell 10.0.1.2
9	88.315478003	8a:67:26:02:e2:1d	a0:4a:e1:0c:73:31	ARP	42	10.0.1.2 is at 8a:67:26:02:e2:1d
10	88.315573074	a0:4a:e1:0c:73:31	8a:67:26:02:e2:1d	ARP	42	10.0.1.1 is at a0:4a:e1:0c:73:31
11	94.459095169	Fe80::a4a:e1ff::fe0	ff02::2	ICMPv6	70	Router Solicitation from a0:4a:e1:0c:73:31
12	102.656709889	Fe80::0867:26ff::fe0	ff02::2	ICMPv6	70	Router Solicitation from 8a:67:26:02:e2:1d
13	145.698349306	192.168.3.2	192.168.1.12	ICMP	98	Echo (ping) request id=0x3b79, seq=1256, ttl=63 (reply in 13)
14	145.699306289	192.168.1.12	192.168.3.2	ICMP	98	Echo (ping) reply id=0x3b79, seq=1256, ttl=63 (request in 13)
15	150.779703458	8a:67:26:02:e2:1d	a0:4a:e1:0c:73:31	ARP	42	Who has 10.0.1.1? Tell 10.0.1.2
16	150.779737733	a0:4a:e1:0c:73:31	8a:67:26:02:e2:1d	ARP	42	Who has 10.0.1.1? Tell 10.0.1.2
17	150.780978161	8a:67:26:02:e2:1d	a0:4a:e1:0c:73:31	ARP	42	10.0.1.2 is at 8a:67:26:02:e2:1d
18	150.7809946758	a0:4a:e1:0c:73:31	8a:67:26:02:e2:1d	ARP	42	10.0.1.1 is at a0:4a:e1:0c:73:31

Frame 1: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface 0

Ethernet II, Src: a0:4a:e1:0c:73:31 (a0:4a:e1:0c:73:31), Dst: IPv6ncast_02 (33:33:00:00:00:00:02)

Internet Protocol Version 6 Src: Fe80::a4a:e1ff::fe0:7331, Dst: ff02::2

Internet Control Message Protocol v6

```

0000 33 33 00 00 00 02 a0 4a e1 0c 73 31 86 dd 00 00 33 ..J..s1...
0010 00 00 00 10 3a ff fe 80 00 00 00 00 00 00 00 44 a ..:.....J
0020 e1 ff fe 0c 73 31 ff 02 00 00 00 00 00 00 00 00 ..s1.....
0030 00 00 00 00 00 02 85 00 8a 1c 00 00 00 00 01 01 ..J..s1
0040 a0 4a e1 0c 73 31

```

No.	Time	Source	Destination	Protocol	Length	Info
14	0.0002699010	192.168.1.12	192.168.3.2	UDP	74	41500 - 33447 Len=32
15	0.000222838	192.168.1.12	192.168.3.2	UDP	74	54222 - 33448 Len=32
16	0.000236545	192.168.1.12	192.168.3.2	UDP	74	58514 - 33449 Len=32
17	0.001046581	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
18	0.001169471	192.168.1.62	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
19	0.001189026	192.168.1.62	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
20	0.001266655	10.0.1.1	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
21	0.001221446	10.0.1.1	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
22	0.001237999	10.0.1.1	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
23	0.001245372	10.0.0.2	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
24	0.001249347	10.0.0.2	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
25	0.001253366	10.0.0.2	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
26	0.001259982	10.0.2.3	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
27	0.001263590	10.0.2.3	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
28	0.001266921	10.0.2.3	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
29	0.001341462	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
30	0.001352192	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
31	0.001360692	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
32	0.001366660	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
33	0.003556245	192.168.1.12	192.168.3.2	UDP	74	34880 - 33450 Len=32
34	0.003559300	192.168.1.12	192.168.3.2	UDP	74	36932 - 33460 Len=32
35	0.004100438	192.168.1.12	192.168.1.12	UDP	74	60673 - 33451 Len=32
36	0.004241527	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
37	0.004225428	192.168.1.12	192.168.3.2	UDP	74	42041 - 33452 Len=32
38	0.004246693	192.168.1.12	192.168.3.2	UDP	74	53732 - 33453 Len=32
39	0.004267854	192.168.1.12	192.168.3.2	UDP	74	40697 - 33454 Len=32
40	0.004286657	192.168.1.12	192.168.3.2	UDP	74	37939 - 33455 Len=32
41	0.004306505	192.168.1.12	192.168.3.2	UDP	74	58692 - 33456 Len=32
42	0.004325559	192.168.1.12	192.168.3.2	UDP	74	48818 - 33457 Len=32
43	0.004348635	192.168.1.12	192.168.3.2	UDP	74	46923 - 33458 Len=32
44	0.004367374	192.168.1.12	192.168.3.2	UDP	74	37454 - 33459 Len=32
45	0.004388993	192.168.1.12	192.168.3.2	UDP	74	36932 - 33460 Len=32
46	0.004406565	192.168.1.12	192.168.3.2	UDP	74	55903 - 33461 Len=32
47	5.225273456	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	Who has 192.168.1.12? Tell 192.168.1.62
48	5.225260883	62:57:03:77:d0:8e	a6:dc:77:4e:f1:7f	ARP	42	192.168.1.12 is at 62:57:03:77:d0:8e
49	5.225270250	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	Who has 192.168.1.12? Tell 192.168.1.62
50	5.225270250	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	192.168.1.12 is at a6:dc:77:4e:f1:7f

▶ Frame 49: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0
 ▶ Ethernet II, Src: 62:57:03:77:d0:8e, Dst: a6:dc:77:4e:f1:7f (a6:dc:77:4e:f1:7f)
 ▶ Address Resolution Protocol (request)

```

0000  a6 dc 77 4e f1 7f 62 57 03 77 d0 8e 08 06 00 01  --wN-bW-w-----
0010  08 00 06 04 00 01 62 57 03 77 d0 8e c0 a8 01 0c  --...bW-w-----
0020  00 00 00 00 00 00 c0 a8 01 3e                    --.....>
  
```

下圖為 h1 traceroute h5 的結果，但據替為甚麼只能看到第一、第二和第五條 hop detail 我不是很清楚，因為我第一次執行就是這樣的結果

```

mininet> h1 traceroute h5
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
traceroute to 192.168.3.2 (192.168.3.2), 30 hops max, 60 byte packets
 1  _gateway (192.168.1.62)  1.068 ms  1.134 ms  1.134 ms
 2  10.0.1.1 (10.0.1.1)  1.139 ms  1.140 ms  1.141 ms
 3  10.0.0.2 (10.0.0.2)  1.135 ms  1.126 ms  1.114 ms
 4  10.0.2.3 (10.0.2.3)  1.107 ms  1.098 ms  1.088 ms
 5  192.168.3.2 (192.168.3.2)  1.149 ms  1.146 ms  1.140 ms
mininet>
  
```

- 使用第 6 題中的圖片做說明，下圖中編號為 17 到 19 的封包是 r1 的 gateway(也就是 192.168.1.62/26，是 r1 對 h1 和 DHCP server 的 gateway) 傳給 h1 的 ICMP，而編號為 20 到 22 的封包是 r2 的 eth1 傳給 h1 的 ICMP，這兩個 sender 送出的 ICMP 可以幫助 h1 找到抵達 h5 的路徑(1st hop 和 2nd hop)

No.	Time	Source	Destination	Protocol	Length	Info
14	0.0002699010	192.168.1.12	192.168.3.2	UDP	74	41500 - 33447 Len=32
15	0.000222838	192.168.1.12	192.168.3.2	UDP	74	54222 - 33448 Len=32
16	0.000236545	192.168.1.12	192.168.3.2	UDP	74	58514 - 33449 Len=32
17	0.001046581	192.168.1.62	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
18	0.001169471	192.168.1.62	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
19	0.001189026	192.168.1.62	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
20	0.001266655	10.0.1.1	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
21	0.001221446	10.0.1.1	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
22	0.001237999	10.0.1.1	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
23	0.001245372	10.0.0.2	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
24	0.001249347	10.0.0.2	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
25	0.001253366	10.0.0.2	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
26	0.001259982	10.0.2.3	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
27	0.001263590	10.0.2.3	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
28	0.001266921	10.0.2.3	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
29	0.001341462	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
30	0.001352192	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
31	0.001360692	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
32	0.001366660	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
33	0.003556245	192.168.1.12	192.168.3.2	UDP	74	34880 - 33450 Len=32
34	0.003559300	192.168.1.12	192.168.3.2	UDP	74	36932 - 33460 Len=32
35	0.004100438	192.168.1.12	192.168.1.12	UDP	74	60673 - 33451 Len=32
36	0.004241527	192.168.3.2	192.168.1.12	ICMP	102	Destination unreachable (Port unreachable)
37	0.004225428	192.168.1.12	192.168.3.2	UDP	74	42041 - 33452 Len=32
38	0.004246693	192.168.1.12	192.168.3.2	UDP	74	53732 - 33453 Len=32
39	0.004267854	192.168.1.12	192.168.3.2	UDP	74	40697 - 33454 Len=32
40	0.004286657	192.168.1.12	192.168.3.2	UDP	74	37939 - 33455 Len=32
41	0.004306505	192.168.1.12	192.168.3.2	UDP	74	58692 - 33456 Len=32
42	0.004325559	192.168.1.12	192.168.3.2	UDP	74	48818 - 33457 Len=32
43	0.004348635	192.168.1.12	192.168.3.2	UDP	74	46923 - 33458 Len=32
44	0.004367374	192.168.1.12	192.168.3.2	UDP	74	37454 - 33459 Len=32
45	0.004388993	192.168.1.12	192.168.3.2	UDP	74	36932 - 33460 Len=32
46	0.004406565	192.168.1.12	192.168.3.2	UDP	74	55903 - 33461 Len=32
47	5.225273456	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	Who has 192.168.1.12? Tell 192.168.1.62
48	5.225260883	62:57:03:77:d0:8e	a6:dc:77:4e:f1:7f	ARP	42	192.168.1.12 is at 62:57:03:77:d0:8e
49	5.225270250	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	Who has 192.168.1.12? Tell 192.168.1.62
50	5.225270250	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	192.168.1.12 is at a6:dc:77:4e:f1:7f

▶ Frame 49: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0
 ▶ Ethernet II, Src: 62:57:03:77:d0:8e, Dst: a6:dc:77:4e:f1:7f (a6:dc:77:4e:f1:7f)
 ▶ Address Resolution Protocol (request)

```

0000  a6 dc 77 4e f1 7f 62 57 03 77 d0 8e 08 06 00 01  --wN-bW-w-----
0010  08 00 06 04 00 01 62 57 03 77 d0 8e c0 a8 01 0c  --...bW-w-----
0020  00 00 00 00 00 00 c0 a8 01 3e                    --.....>
  
```

8. 而關於第五個 hop，則是由編號 29 到 32、34、36 的 ICMP 封包組成，sender 皆為 h5

No.	Time	Source	Destination	Protocol	Length	Info
14	0.000209010	192.168.1.12	192.168.3.2	UDP	74	41150 - 33447 Len=32
15	0.000222838	192.168.1.12	192.168.3.2	UDP	74	54222 - 33448 Len=32
16	0.000226545	192.168.1.12	192.168.3.2	UDP	74	58514 - 33449 Len=32
17	0.001169551	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
18	0.001169471	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
19	0.001189055	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
20	0.001208665	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
21	0.001221448	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
22	0.001237999	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
23	0.001245372	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
24	0.001249347	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
25	0.001253380	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
26	0.001259982	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
27	0.001263599	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
28	0.001266921	192.168.1.12	192.168.1.12	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
29	0.001341462	192.168.1.12	192.168.3.2	ICMP	102	Destination unreachable (Port unreachable)
30	0.001352192	192.168.1.12	192.168.3.2	ICMP	102	Destination unreachable (Port unreachable)
31	0.001368682	192.168.1.12	192.168.3.2	ICMP	102	Destination unreachable (Port unreachable)
32	0.001368686	192.168.1.12	192.168.3.2	ICMP	102	Destination unreachable (Port unreachable)
33	0.001368686	192.168.1.12	192.168.3.2	UDP	74	34889 - 33450 Len=32
34	0.001368686	192.168.1.12	192.168.3.2	UDP	74	34889 - 33450 Len=32
35	0.001368686	192.168.1.12	192.168.3.2	UDP	74	34889 - 33450 Len=32
36	0.001368686	192.168.1.12	192.168.3.2	UDP	74	34889 - 33450 Len=32
37	0.001368686	192.168.1.12	192.168.3.2	UDP	74	34889 - 33450 Len=32
38	0.004246603	192.168.1.12	192.168.3.2	UDP	74	53732 - 33453 Len=32
39	0.004267854	192.168.1.12	192.168.3.2	UDP	74	40897 - 33454 Len=32
40	0.004286657	192.168.1.12	192.168.3.2	UDP	74	37939 - 33455 Len=32
41	0.004305655	192.168.1.12	192.168.3.2	UDP	74	58802 - 33456 Len=32
42	0.004325559	192.168.1.12	192.168.3.2	UDP	74	48818 - 33457 Len=32
43	0.004340635	192.168.1.12	192.168.3.2	UDP	74	46923 - 33458 Len=32
44	0.004367374	192.168.1.12	192.168.3.2	UDP	74	37454 - 33459 Len=32
45	0.004388993	192.168.1.12	192.168.3.2	UDP	74	36932 - 33460 Len=32
46	0.004406585	192.168.1.12	192.168.3.2	UDP	74	55903 - 33461 Len=32
47	5.225273456	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	Who has 192.168.1.12? Tell 192.168.1.12
48	5.225280883	62:57:03:77:d0:8e	a6:dc:77:4e:f1:7f	ARP	42	192.168.1.12 is at 62:57:03:77:d0:8e
49	5.225290502	a6:dc:77:4e:f1:7f	62:57:03:77:d0:8e	ARP	42	Who has 192.168.1.12? Tell 192.168.1.12

Frame 49: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface 0
Ethernet II, Src: 62:57:03:77:d0:8e (62:57:03:77:d0:8e), Dst: a6:dc:77:4e:f1:7f (a6:dc:77:4e:f1:7f)
Address Resolution Protocol (request)

0000 a6 dc 77 4e f1 7f 62 57 03 77 d0 8e 06 06 00 01 -- Wi-Fi --
0010 08 00 06 04 00 01 62 57 03 77 d0 8e c0 a8 01 0c -- Wi-Fi --
0020 00 00 00 00 00 00 c0 a8 01 3e -- Wi-Fi --