

## Lab 2: IP Assignment and Hop-by-hop Forwarding

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### Part 1

1. After you complete Steps 1-1

**a. Can h3 ping h4? Briefly explain why or why not.(5%)**

- 可以，h3 和 h4 在同一個 LAN 內

**b. Can h3 ping h5? Briefly explain why or why not.(5%)**

- 可以，h3 ping h5 會經過的 router 皆有經過設定，使得 h3 和 h5 間是暢通的。

2. Take screenshot to show that your topology configuration is correct. (10%)

```
mininet> net
h1 h1-eth0:s1-eth2
h2 h2-eth0:s1-eth3
h3 h3-eth0:s2-eth2
h4 h4-eth0:s2-eth3
h5 h5-eth0:s3-eth2
h6 h6-eth0:s3-eth3
DHCPServer DHCPServer-eth0:s1-eth4
r1 r1-eth0:r2-eth1 r1-eth1:s1-eth1 r1-eth2:s2-eth1
r2 r2-eth0:r3-eth0 r2-eth1:r1-eth0
r3 r3-eth0:r2-eth0 r3-eth1:r4-eth0
r4 r4-eth0:r3-eth1 r4-eth1:s3-eth1
s1 lo: s1-eth1:r1-eth1 s1-eth2:h1-eth0 s1-eth3:h2-eth0 s1-eth4:DHCPServer-eth0
s2 lo: s2-eth1:r1-eth2 s2-eth2:h3-eth0 s2-eth3:h4-eth0
s3 lo: s3-eth1:r4-eth1 s3-eth2:h5-eth0 s3-eth3:h6-eth0
mininet> █
```

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### Part 2

3. Run dhcp on h1 and capture DHCP messages. Take screenshot to show the IPs and MACs. (10%)

```

mininet> h1 wireshark &
mininet> h1 dhclient h1-eth0
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
mininet> h1 ifconfig
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.1.1 netmask 255.255.255.128 broadcast 192.168.1.127
    inet6 fe80::200:ff:fe00:1 prefixlen 64 scopeid 0x20<link>
    ether 00:00:00:00:00:01 txqueuelen 1000 (Ethernet)
    RX packets 60 bytes 5953 (5.9 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 14 bytes 1408 (1.4 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>

```

4. Can hosts other than h1 and h2 acquire IP addresses from DHCP server? Briefly explain your answer. (5%)

- 不行，因為和 DHCP Server 不在同一個 LAN 內

5. Run dhcp on h2 and take screenshot to show IP of h2. (5%)

```

soulr@ubuntu:~/Desktop/lab2$ sudo python topology.py
[+] Run DHCP server
h1 doesn't have connectivity to 192.168.1.129
h1 doesn't have connectivity to 192.168.1.130
h1 doesn't have connectivity to 192.168.3.2
h1 doesn't have connectivity to 192.168.3.3
h2 doesn't have connectivity to 192.168.1.129
h2 doesn't have connectivity to 192.168.1.130
h2 doesn't have connectivity to 192.168.3.2
h2 doesn't have connectivity to 192.168.3.3
WRONG ANSWER
mininet> h1 dhclient h1-eth0
mininet> h2 dhclient h2-eth0
mininet> h2 ifconfig h2-eth0
h2-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.1.34 netmask 255.255.255.128 broadcast 192.168.1.127
    inet6 fe80::200:ff:fe00:2 prefixlen 64 scopeid 0x20<link>
    ether 00:00:00:00:00:02 txqueuelen 1000 (Ethernet)
    RX packets 42 bytes 4853 (4.8 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 10 bytes 1128 (1.1 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

mininet>

```

## 6. Explain how you make dhcp server assigned fixed address to h2. (5%)

- I bind the specific IP with the MAC address of h2 in `dhcpd.conf`.

```
host fixed-ip {
    hardware ethernet 00:00:00:00:00:02;
    fixed-address 192.168.1.34;
}
```

## Part 3

## 7. What does r1 do on the packets from h1 to h5, and h5 to h1, respectively? Capture packets and show screenshot to explain your answers. (5%)

- h1 -> h5: r1 received the packet from h1 by eth1, send it to h5 by eth0.
- h5 -> h1: r1 received the packet from h5 by eth0, send it to h1 by eth1.

**Capturing from r1-eth0**

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::e0d0:93ff:fe00::2	ff02::2	ICMPv6	70	Router Solicitation from e2:d0:93:fc:64:6f
2	5.547219785	192.168.1.1	192.168.3.2	ICMP	98	Echo (ping) request id=0x22ab, seq=1/256, ttl=63 (reply in 3)
3	5.548283163	192.168.3.2	192.168.1.1	ICMP	98	Echo (ping) reply id=0x22ab, seq=1/256, ttl=61 (request in 2)
4	10.752772082	ba:2a:7f:32:c2:47	e2:d0:93:fc:64:6f	ARP	42	Who has 10.0.1.1? Tell 10.0.1.2
5	10.752665111	e2:d0:93:fc:64:6f	ba:2a:7f:32:c2:47	ARP	42	Who has 10.0.1.2? Tell 10.0.1.1
6	10.753505671	ba:2a:7f:32:c2:47	e2:d0:93:fc:64:6f	ARP	42	10.0.1.2 is at ba:2a:7f:32:c2:47
7	10.753621869	e2:d0:93:fc:64:6f	ba:2a:7f:32:c2:47	ARP	42	10.0.1.1 is at e2:d0:93:fc:64:6f

**Capturing from r1-eth1**

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::f0ce:29ff:fe00::1	ff02::2	ICMPv6	70	Router Solicitation from f2:ce:29:0f:d9:66
2	5.546171430	00:00:00:00:00:01	Broadcast	ARP	42	Who has 192.168.1.126? Tell 192.168.1.1
3	5.546196650	f2:ce:29:0f:d9:66	00:00:00:00:00:01	ARP	42	192.168.1.126 is at f2:ce:29:0f:d9:66
4	5.547258537	192.168.1.1	192.168.3.2	ICMP	98	Echo (ping) request id=0x22ab, seq=1/256, ttl=64 (reply in 5)
5	5.548349021	192.168.3.2	192.168.1.1	ICMP	98	Echo (ping) reply id=0x22ab, seq=1/256, ttl=60 (request in 4)
6	10.752690254	f2:ce:29:0f:d9:66	00:00:00:00:00:01	ARP	42	Who has 192.168.1.1? Tell 192.168.1.126
7	10.754083920	00:00:00:00:00:01	f2:ce:29:0f:d9:66	ARP	42	192.168.1.1 is at 00:00:00:00:00:01
8	32.768632127	fe80::d470:b2ff:fe30::3	ff02::2	ICMPv6	70	Router Solicitation from d6:70:b2:3a:55:4f

## 8. Capture packets and take screenshot to answer the following two questions

### a. Show the first six ICMP Unreachable messages. Ultimately, h1 will send traceroute packets to h5 successfully. (5%)

Capturing from r1-eth0						
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
20	29.136593188	192.168.1.1	192.168.3.2	UDP	74	56944 → 33446 Len=32
21	29.136622989	192.168.1.1	192.168.3.2	UDP	74	46861 → 33447 Len=32
22	29.136637866	192.168.1.1	192.168.3.2	UDP	74	57140 → 33448 Len=32
23	29.136647002	192.168.1.1	192.168.3.2	UDP	74	59761 → 33449 Len=32
24	29.136861187	192.168.3.2	192.168.1.1	ICMP	102	Destination unreachable (Port unreachable)
25	29.136869161	192.168.3.2	192.168.1.1	ICMP	102	Destination unreachable (Port unreachable)
26	29.136875475	192.168.3.2	192.168.1.1	ICMP	102	Destination unreachable (Port unreachable)
27	29.136881534	192.168.3.2	192.168.1.1	ICMP	102	Destination unreachable (Port unreachable)
28	29.137702278	192.168.1.1	192.168.3.2	UDP	74	50162 → 33450 Len=32
29	29.137721800	192.168.3.2	192.168.1.1	ICMP	102	Destination unreachable (Port unreachable)
30	29.137735312	192.168.1.1	192.168.3.2	UDP	74	59577 → 33451 Len=32
31	29.137745700	192.168.3.2	192.168.1.1	ICMP	102	Destination unreachable (Port unreachable)
32	29.137756882	192.168.1.1	192.168.3.2	UDP	74	48347 → 33452 Len=32
33	29.137770533	192.168.1.1	192.168.3.2	UDP	74	37016 → 33453 Len=32
34	29.137783291	192.168.1.1	192.168.3.2	UDP	74	58893 → 33454 Len=32
35	34.304903296	b2:83:cf:70:86:ca	da:83:f2:67:b7:ba	ARP	42	Who has 10.0.1.1? Tell 10.0.1.2
36	34.304909097	da:83:f2:67:b7:ba	b2:83:cf:70:86:ca	ARP	42	Who has 10.0.1.2? Tell 10.0.1.1
37	34.305028944	b2:83:cf:70:86:ca	da:83:f2:67:b7:ba	ARP	42	10.0.1.2 is at b2:83:cf:70:86:ca
38	34.305031844	da:83:f2:67:b7:ba	b2:83:cf:70:86:ca	ARP	42	10.0.1.1 is at da:83:f2:67:b7:ba
39	42.240194240	fe80::d883:f2ff:fe6...	ff02::2	ICMPv6	70	Router Solicitation from da:83:f2:67:b7:ba
40	46.336124426	fe80::b083:cfff:fe7...	ff02::2	ICMPv6	70	Router Solicitation from b2:83:cf:70:86:ca

b. Show the ICMP packets forwarded by each router, which constitute the first successful delivery of a traceroute packet from h1 to h5. (5%)

Capturing from r1-eth0						
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::b083:cfff:fe7...	ff02::2	ICMPv6	70	Router Solicitation from b2:83:cf:70:86:ca
2	0.512502087	fe80::d883:f2ff:fe6...	ff02::2	ICMPv6	70	Router Solicitation from da:83:f2:67:b7:ba
3	14.848414750	fe80::d883:f2ff:fe6...	ff02::2	ICMPv6	70	Router Solicitation from da:83:f2:67:b7:ba
4	15.871664176	fe80::b083:cfff:fe7...	ff02::2	ICMPv6	70	Router Solicitation from b2:83:cf:70:86:ca
5	29.136432607	192.168.1.1	192.168.3.2	UDP	74	49758 → 33437 Len=32
6	29.136440733	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
7	29.136448042	192.168.1.1	192.168.3.2	UDP	74	46616 → 33438 Len=32
8	29.136450536	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
9	29.136456240	192.168.1.1	192.168.3.2	UDP	74	33548 → 33439 Len=32
10	29.136475950	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
11	29.136481852	192.168.1.1	192.168.3.2	UDP	74	56026 → 33440 Len=32
12	29.136524921	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	29.136540970	192.168.1.1	192.168.3.2	UDP	74	42609 → 33441 Len=32
14	29.136545235	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
15	29.136549665	192.168.1.1	192.168.3.2	UDP	74	48680 → 33442 Len=32
16	29.136553837	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
17	29.136557598	192.168.1.1	192.168.3.2	UDP	74	48364 → 33443 Len=32
18	29.136574580	192.168.1.1	192.168.3.2	UDP	74	55665 → 33444 Len=32

Capturing from r2-eth0						
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::cce3:49ff:fe0...	ff02::2	ICMPv6	70	Router Solicitation from ce:e3:49:00:a0:c8
2	4.092547881	fe80::54e1:32ff:fef...	ff02::2	ICMPv6	70	Router Solicitation from 56:e1:32:f1:d7:7c
3	11.468450917	192.168.1.1	192.168.3.2	UDP	74	56026 → 33440 Len=32
4	11.468476093	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
5	11.468508573	192.168.1.1	192.168.3.2	UDP	74	42609 → 33441 Len=32
6	11.468511288	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
7	11.468517923	192.168.1.1	192.168.3.2	UDP	74	48680 → 33442 Len=32
8	11.468520012	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
9	11.468525941	192.168.1.1	192.168.3.2	UDP	74	48364 → 33443 Len=32
10	11.468537474	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
11	11.468542848	192.168.1.1	192.168.3.2	UDP	74	55665 → 33444 Len=32
12	11.468547465	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	11.468552513	192.168.1.1	192.168.3.2	UDP	74	41889 → 33445 Len=32
14	11.468556603	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
15	11.468561411	192.168.1.1	192.168.3.2	UDP	74	56944 → 33446 Len=32



Capturing from r3-eth0						
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	fe80::cce3:49ff:fe0...	ff02::2	ICMPv6	70	Router Solicitation from ce:e3:49:00:a0:c8
2	4.092571496	fe80::54e1:32ff:fe...	ff02::2	ICMPv6	70	Router Solicitation from 56:e1:32:f1:d7:7c
3	11.468467356	192.168.1.1	192.168.3.2	UDP	74	56026 → 33440 Len=32
4	11.468490293	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
5	11.468523526	192.168.1.1	192.168.3.2	UDP	74	42609 → 33441 Len=32
6	11.468525794	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
7	11.468532843	192.168.1.1	192.168.3.2	UDP	74	48680 → 33442 Len=32
8	11.468534545	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
9	11.468540857	192.168.1.1	192.168.3.2	UDP	74	48364 → 33443 Len=32
10	11.468551992	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
11	11.468557769	192.168.1.1	192.168.3.2	UDP	74	55665 → 33444 Len=32
12	11.468561997	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	11.468567429	192.168.1.1	192.168.3.2	UDP	74	41889 → 33445 Len=32
14	11.468571144	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
15	11.468576332	192.168.1.1	192.168.3.2	UDP	74	56944 → 33446 Len=32

  

Capturing from r4-eth0						
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.1.1	192.168.3.2	UDP	74	48364 → 33443 Len=32
2	0.000007116	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
3	0.000016410	192.168.1.1	192.168.3.2	UDP	74	55665 → 33444 Len=32
4	0.000018337	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
5	0.000025796	192.168.1.1	192.168.3.2	UDP	74	41889 → 33445 Len=32
6	0.000027567	10.0.2.3	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
7	0.000030730	192.168.1.1	192.168.3.2	UDP	74	56944 → 33446 Len=32

9. Briefly explain why sometimes we may have hop details with "\*\*\*." Take Wireshark screenshots to justify your answer. (5%)

- router 會擋由外網送到內網地址的封包，以 r1 為例，它不會轉傳從 r3 來的封包。

Capturing from r1-eth0						
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
4	0.000100300	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
5	0.000144400	192.168.1.1	192.168.3.2	UDP	74	35529 → 33439 Len=32
6	0.000163800	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
7	0.000207400	192.168.1.1	192.168.3.2	UDP	74	45758 → 33440 Len=32
8	0.000253201	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
9	0.000286201	192.168.1.1	192.168.3.2	UDP	74	36674 → 33441 Len=32
10	0.000325501	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
11	0.000350700	192.168.1.1	192.168.3.2	UDP	74	52198 → 33442 Len=32
12	0.000390301	10.0.0.2	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	0.000415101	192.168.1.1	192.168.3.2	UDP	74	34564 → 33443 Len=32
14	0.000531301	192.168.1.1	192.168.3.2	UDP	74	48181 → 33444 Len=32

  

Capturing from r1-eth1						
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Apply a display filter ... <Ctrl-/>						
No.	Time	Source	Destination	Protocol	Length	Info
10	0.002048704	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
11	0.002081204	192.168.1.1	192.168.3.2	UDP	74	40584 → 33438 Len=32
12	0.002122504	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	0.002145404	192.168.1.1	192.168.3.2	UDP	74	35529 → 33439 Len=32
14	0.002186004	10.0.1.1	192.168.1.1	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
15	0.002208604	192.168.1.1	192.168.3.2	UDP	74	45758 → 33440 Len=32
16	0.002287004	192.168.1.1	192.168.3.2	UDP	74	36674 → 33441 Len=32
17	0.002351805	192.168.1.1	192.168.3.2	UDP	74	52198 → 33442 Len=32

- 根據上圖所示，r1-eth0 可以收到 r3 (10.0.0.2) 傳來的封包，但 r1 不會轉傳給 h1 (r1-eth1)。