

( الف )

توپولوژی در فایل پایتون ضمیمه شده پیاده سازی شده است.

( ب )

```
root@mininet-virtual-machine:~# ip link
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT
    group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: h4-eth0@if20: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state
UP mode DEFAULT group default qlen 1000
    link/ether 82:bb:33:68:c6:69 brd ff:ff:ff:ff:ff:ff link-netnsid 0
3: h4-eth1@if22: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state
UP mode DEFAULT group default qlen 1000
    link/ether d2:f2:65:d0:42:c2 brd ff:ff:ff:ff:ff:ff link-netnsid 0
4: h4-eth2@if24: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state
UP mode DEFAULT group default qlen 1000
    link/ether f6:5e:01:d0:c4:04 brd ff:ff:ff:ff:ff:ff link-netnsid 0
root@mininet-virtual-machine:~#
```

```
h4
UP mode DEFAULT group default qlen 1000
    link/ether f6:5e:01:d0:c4:04 brd ff:ff:ff:ff:ff:ff link-netnsid 0
root@mininet-virtual-machine:~# ifconfig
h4-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.0.4 netmask 255.0.0.0 broadcast 10.255.255.255
    ether 82:bb:33:68:c6:69 txqueuelen 1000 (Ethernet)
    RX packets 101 bytes 9394 (9.3 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 101 bytes 9394 (9.3 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

h4-eth1: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    ether d2:f2:65:d0:42:c2 txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

h4-eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    ether f6:5e:01:d0:c4:04 txqueuelen 1000 (Ethernet)
    RX packets 1 bytes 42 (42.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

```
h1
root@mininet-vm:/home/mininet/lab03# ping 10.0.0.4 -c5
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data:
64 bytes from 10.0.0.4: icmp_seq=1 ttl=64 time=0.063 ms
64 bytes from 10.0.0.4: icmp_seq=2 ttl=64 time=0.044 ms
64 bytes from 10.0.0.4: icmp_seq=3 ttl=64 time=0.043 ms
64 bytes from 10.0.0.4: icmp_seq=4 ttl=64 time=0.042 ms
64 bytes from 10.0.0.4: icmp_seq=5 ttl=64 time=0.058 ms

--- 10.0.0.4 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4080ms
rtt min/avg/max/mdev = 0.042/0.050/0.063/0.008 ms
root@mininet-vm:/home/mininet/lab03#
```

Capturing from s14-eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
13	8.160333966	1e:99:2f:cb:64:c5	82:bb:33:68:c6:69	ARP	42	Who has 10.0.0.4? Tell 10.0.0.1
14	8.161163946	82:bb:33:68:c6:69	1e:99:2f:cb:64:c5	ARP	42	10.0.0.4 is at 82:bb:33:68:c6:69
15	399.903051976	10.0.0.1	0.0.0.5	ICMP	106	Echo (ping) request id=0x0bea, seq=1/256, ttl=64 (no response received)
16	400.927860596	10.0.0.1	0.0.0.5	ICMP	106	Echo (ping) request id=0x0bea, seq=2/512, ttl=64 (no response received)
17	401.951842569	10.0.0.1	0.0.0.5	ICMP	106	Echo (ping) request id=0x0bea, seq=3/768, ttl=64 (no response received)
18	402.976151065	10.0.0.1	0.0.0.5	ICMP	106	Echo (ping) request id=0x0bea, seq=4/1024, ttl=64 (no response received)
19	404.000697179	10.0.0.1	0.0.0.5	ICMP	106	Echo (ping) request id=0x0bea, seq=5/1280, ttl=64 (no response received)
20	404.959887657	1e:99:2f:cb:64:c5	82:bb:33:68:c6:69	ARP	42	Who has 10.0.0.4? Tell 10.0.0.1

Frame 1: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface s14-eth1, id 0  
Ethernet II, Src: 1e:99:2f:cb:64:c5 (1e:99:2f:cb:64:c5), Dst: 82:bb:33:68:c6:69 (82:bb:33:68:c6:69)  
Internet Protocol Version 4, Src: 10.0.0.1, Dst: 10.0.0.4  
Internet Control Message Protocol

0000 82 bb 33 68 c6 69 1e 99 2f cb 64 c5 08 00 45 00 ..3h.i.../d...E.  
0010 00 54 66 52 40 00 40 01 c0 52 0a 00 00 01 0a 00 Tfr@.@.R.....  
0020 00 04 08 00 6c d7 0b 48 00 16 1c 5a 1f 62 00 00 ....l..H...Z.b..  
0030 00 00 7f 3b 06 00 00 00 00 00 10 11 12 13 14 15 ..;.....  
0040 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 .....! "#\$%  
0050 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 6'()++,-./012345  
0060 36 37 67

s14-eth1: <live capture in progress> Packets: 43 · Displayed: 43 (100.0%) Profile: Default

سوال اول: همانطور که در اسکرین شات بالا مشهود است جدول ARP هاست h1 شامل آدرس MAC هاست h4 نیست و قبل از درخواست ping با درخواست ARP به پیدا کردن آدرس MAC مدنظر میپردازد. هاست h4 در جواب arp اعلام میکند که ip مد نظر را دارد. سپس درخواست پینگ صورت میگیرد

جدول arp برای هاست h1 قبل از پینگ به صورت زیر است

```
h1
root@mininet-virtual-machine:/home/mininet/lab03# arp -a
root@mininet-virtual-machine:/home/mininet/lab03#
```

بعد از انجام پینگ مقادیر لازم در جدول قرار میگیرند.

```
h1
root@mininet-virtual-machine:/home/mininet/lab03# arp -a
root@mininet-virtual-machine:/home/mininet/lab03# ping 10.0.0.4 -c5
PING 10.0.0.4 (10.0.0.4) 56(84) bytes of data:
64 bytes from 10.0.0.4: icmp_seq=1 ttl=64 time=5.57 ms
64 bytes from 10.0.0.4: icmp_seq=2 ttl=64 time=0.374 ms
64 bytes from 10.0.0.4: icmp_seq=3 ttl=64 time=0.047 ms
64 bytes from 10.0.0.4: icmp_seq=4 ttl=64 time=0.060 ms
64 bytes from 10.0.0.4: icmp_seq=5 ttl=64 time=0.041 ms

--- 10.0.0.4 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4059ms
rtt min/avg/max/mdev = 0.041/1.218/5.571/2.179 ms
root@mininet-virtual-machine:/home/mininet/lab03# arp -a
? (10.0.0.4) at b6:3e:9a:c4:cf:fa [ether] on h1-eth0
root@mininet-virtual-machine:/home/mininet/lab03#
```

```
h1 x
root@mininet-vn:/home/mininet/lab03# ip addr del 10.0.0.1 dev h1-eth0
Warning: Executing wildcard deletion to stay compatible with old scripts.
Explicitly specify the prefix length (10.0.0.1/32) to avoid this warnin
9.
This special behaviour is likely to disappear in further releases,
fix your scripts!
root@mininet-vn:/home/mininet/lab03# ip addr 10.10.14.1/24 dev h1-eth0
Command "10.10.14.1/24" is unknown, try "ip address help".
root@mininet-vn:/home/mininet/lab03# ip addr add 10.10.14.1/24 dev h1-eth0
root@mininet-vn:/home/mininet/lab03#
```

```
h2 x
root@mininet-vn:/home/mininet/lab03# ip addr del 10.0.0.2 dev h2-eth0
Warning: Executing wildcard deletion to stay compatible with old scripts.
Explicitly specify the prefix length (10.0.0.2/32) to avoid this warnin
9.
This special behaviour is likely to disappear in further releases,
fix your scripts!
root@mininet-vn:/home/mininet/lab03# ip addr add 10.10.24.2/24 dev h2-eth0
root@mininet-vn:/home/mininet/lab03#
```

```
h3 x
root@mininet-vn:/home/mininet/lab03# ip addr del 10.0.0.3 dev h3-eth0
Warning: Executing wildcard deletion to stay compatible with old scripts.
Explicitly specify the prefix length (10.0.0.3/32) to avoid this warnin
9.
This special behaviour is likely to disappear in further releases,
fix your scripts!
root@mininet-vn:/home/mininet/lab03#
root@mininet-vn:/home/mininet/lab03# ip addr add 10.10.34.3/24 dev h3-eth0
root@mininet-vn:/home/mininet/lab03#
```

```
h4
root@mininet-vm:/home/mininet/lab03# ip addr del 10.0.0.4 dev h4-eth0
Warning: Executing wildcard deletion to stay compatible with old scripts.
Explicitly specify the prefix length (10.0.0.4/32) to avoid this warni
9.
This special behaviour is likely to disappear in further releases,
fix your scripts!
root@mininet-vm:/home/mininet/lab03# ip addr del 10.0.0.4 dev h4-eth1
Warning: Executing wildcard deletion to stay compatible with old scripts.
Explicitly specify the prefix length (10.0.0.4/32) to avoid this warni
9.
This special behaviour is likely to disappear in further releases,
fix your scripts!
RTNETLINK answers: Cannot assign requested address
root@mininet-vm:/home/mininet/lab03# ip addr del 10.0.0.4 dev h4-eth2
Warning: Executing wildcard deletion to stay compatible with old scripts.
Explicitly specify the prefix length (10.0.0.4/32) to avoid this warni
9.
This special behaviour is likely to disappear in further releases,
fix your scripts!
RTNETLINK answers: Cannot assign requested address
```

```
h4
root@mininet-vm:/home/mininet/lab03# ip addr add 10.10.14.4/24 dev h4-eth0
root@mininet-vm:/home/mininet/lab03# ip addr add 10.10.24.4/24 dev h4-eth1
root@mininet-vm:/home/mininet/lab03# ip addr add 10.10.34.4/24 dev h4-eth2
root@mininet-vm:/home/mininet/lab03#
```

سوال دوم: همانطور که در wireshark مشاهده میشود بسته های arp رد بدل شده است

Capturing from s14-eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
83	984.011500840	10.10.14.4	10.10.14.1	ICMP	98	Echo (ping) request id=0xc76, seq=5/1280, ttl=64 (reply in ...)
84	984.011514496	10.10.14.1	10.10.14.4	ICMP	98	Echo (ping) reply id=0xc76, seq=5/1280, ttl=64 (request i...
85	985.004386298	1e:99:2f:cb:64:c5	82:bb:33:68:c6:69	ARP	42	Who has 10.10.14.4? Tell 10.10.14.1
86	985.005710183	82:bb:33:68:c6:69	1e:99:2f:cb:64:c5	ARP	42	10.10.14.4 is at 82:bb:33:68:c6:69
87	985.035914059	10.10.14.4	10.10.14.1	ICMP	98	Echo (ping) request id=0xc76, seq=6/1536, ttl=64 (reply in ...)
88	985.035942885	10.10.14.1	10.10.14.4	ICMP	98	Echo (ping) reply id=0xc76, seq=6/1536, ttl=64 (request i...
89	986.059507297	10.10.14.4	10.10.14.1	ICMP	98	Echo (ping) request id=0xc76, seq=7/1792, ttl=64 (reply in ...)
90	986.059520298	10.10.14.1	10.10.14.4	ICMP	98	Echo (ping) reply id=0xc76, seq=7/1792, ttl=64 (request i...

▶ Frame 58: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface s14-eth1, id 0

▶ Ethernet II, Src: 82:bb:33:68:c6:69 (82:bb:33:68:c6:69), Dst: Broadcast (ff:ff:ff:ff:ff:ff)

▶ Address Resolution Protocol (request)

```
0000 ff ff ff ff ff 82 bb 33 68 c6 69 08 06 00 01 ..... 3h i ...
0010 08 00 06 04 00 01 82 bb 33 68 c6 69 0a 00 00 04 ..... 3h i ...
0020 00 00 00 00 00 0a 0a 0e 01 ..... ..
```

(د)

سوال سوم: خیر ممکن نیست چرا gateway تعریف نشده است

```
h1
root@mininet-virtual-machine:/home/mininet/lab03# ping 10.10.24.4
ping: connect: Network is unreachable
root@mininet-virtual-machine:/home/mininet/lab03# ping 10.10.34.4
ping: connect: Network is unreachable
root@mininet-virtual-machine:/home/mininet/lab03#
```

```
h1
root@mininet-virtual-machine:/home/mininet/lab03# ip route
10.10.14.0/24 dev h1-eth0 proto kernel scope link src 10.10.14.1
root@mininet-virtual-machine:/home/mininet/lab03#
```

سوال چهارم: فقط همان شبکه lan که در آن قرار داریم دیده میشود.

```
h1
root@mininet-virtual-machine:/home/mininet/lab03# ip route
10.10.14.0/24 dev h1-eth0 proto kernel scope link src 10.10.14.1
root@mininet-virtual-machine:/home/mininet/lab03# ip route add default via 10.10.14.4
root@mininet-virtual-machine:/home/mininet/lab03# ip route
default via 10.10.14.4 dev h1-eth0
10.10.14.0/24 dev h1-eth0 proto kernel scope link src 10.10.14.1
root@mininet-virtual-machine:/home/mininet/lab03#
```

سوال پنجم:

بله ping انجام میشود در تصویر زیر دیده میشود

```
h1
root@mininet-vm:/home/mininet/lab03# ping 10.10.34.4
PING 10.10.34.4 (10.10.34.4) 56(84) bytes of data:
64 bytes from 10.10.34.4: icmp_seq=1 ttl=64 time=1.08 ms
64 bytes from 10.10.34.4: icmp_seq=2 ttl=64 time=0.781 ms
64 bytes from 10.10.34.4: icmp_seq=3 ttl=64 time=0.166 ms
^C
--- 10.10.34.4 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2013ms
rtt min/avg/max/mdev = 0.166/0.675/1.080/0.380 ms
root@mininet-vm:/home/mininet/lab03#
```

امکان پینگ زدن به h3 همچنان ممکن نیست

Capturing from s14-eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
200	2679.3732371...	10.10.14.4	10.10.14.1	ICMP	126	Destination unreachable (Host unreachable)
201	2679.3737863...	f6:5e:01:d0:c4:04	Broadcast	ARP	42	Who has 10.10.34.1? Tell 10.10.34.4
202	2680.3953618...	10.10.14.1	10.10.34.1	ICMP	98	Echo (ping) request id=0xcb8, seq=5/1280, ttl=64 (no respon...
203	2680.3959343...	f6:5e:01:d0:c4:04	Broadcast	ARP	42	Who has 10.10.34.1? Tell 10.10.34.4
204	2681.4197907...	f6:5e:01:d0:c4:04	Broadcast	ARP	42	Who has 10.10.34.1? Tell 10.10.34.4
205	2681.5158335...	1e:99:2f:cb:64:c5	82:bb:33:68:c6:69	ARP	42	Who has 10.10.14.4? Tell 10.10.14.1
206	2681.5165806...	82:bb:33:68:c6:69	1e:99:2f:cb:64:c5	ARP	42	10.10.14.4 is at 82:bb:33:68:c6:69
207	2682.4442234...	10.10.14.4	10.10.14.1	ICMP	126	Destination unreachable (Host unreachable)
208	2682.4442505...	10.10.14.4	10.10.14.1	ICMP	126	Destination unreachable (Host unreachable)
209	2684.5893018...	82:bb:33:68:c6:69	1e:99:2f:cb:64:c5	ARP	42	Who has 10.10.14.1? Tell 10.10.14.4
210	2684.5893132...	1e:99:2f:cb:64:c5	82:bb:33:68:c6:69	ARP	42	10.10.14.1 is at 1e:99:2f:cb:64:c5

Frame 58: 42 bytes on wire (336 bits), 42 bytes captured (336 bits) on interface s14-eth1, id 0

Ethernet II, Src: 82:bb:33:68:c6:69 (82:bb:33:68:c6:69), Dst: Broadcast (ff:ff:ff:ff:ff:ff)

Destination: Broadcast (ff:ff:ff:ff:ff:ff)

Address: Broadcast (ff:ff:ff:ff:ff:ff)

....1. .... = LG bit: Locally administered address (this is NOT the factory default)

....1. .... = IG bit: Group address (multicast/broadcast)

0000 ff ff ff ff ff 82 bb 33 68 c6 69 08 06 00 01 ..... 3h-i...

0010 08 00 06 04 00 01 82 bb 33 68 c6 69 0a 00 00 04 ..... 3h-i...

0020 00 00 00 00 00 0a 0a 0e 01 ..... ..

```
h4
root@mininet-virtual-machine:/home/mininet/lab03# echo 1 > /proc/sys/net/ipv4/ip_forward
root@mininet-virtual-machine:/home/mininet/lab03#
```

همچنان نمیتوان درخواست پینگ به h3 داد.

(هاست h3 مشکلی داشت نتونستم حلش کنم ولی h2 مشکلی نداشت از اینجا به بعد با h2 رفتم)

سوال ششم:

برای حل این مشکل در h2 نیز gateway را مشخص میکنیم

```
h2
root@mininet-virtual-machine:/home/mininet/lab03# ip addr del 10.0.0.2 dev h2-eth0
Warning: Executing wildcard deletion to stay compatible with old scripts.
Explicitly specify the prefix length (10.0.0.2/32) to avoid this warning.
root@mininet-virtual-machine:/home/mininet/lab03# ip addr add 10.10.24.2/24 dev h2-eth0
root@mininet-virtual-machine:/home/mininet/lab03# ping 10.10.24.4
PING 10.10.24.4 (10.10.24.4) 56(84) bytes of data:
64 bytes from 10.10.24.4: icmp_seq=1 ttl=64 time=1.66 ms
64 bytes from 10.10.24.4: icmp_seq=2 ttl=64 time=0.293 ms
64 bytes from 10.10.24.4: icmp_seq=3 ttl=64 time=0.065 ms
64 bytes from 10.10.24.4: icmp_seq=4 ttl=64 time=0.049 ms
^C
--- 10.10.24.4 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3043ms
rtt min/avg/max/mdev = 0.049/0.516/1.659/0.666 ms
root@mininet-virtual-machine:/home/mininet/lab03# ip addr add 10.10.24.2/24 dev h2-eth0
RTNETLINK answers: File exists
root@mininet-virtual-machine:/home/mininet/lab03# ip route add default via 10.10.24.4
root@mininet-virtual-machine:/home/mininet/lab03#
```



حال میتوان از روی h1 به h2 پینگ زد

```
h1
root@mininet-vm:/home/mininet/lab03# ping 10.10.24.2 -c5
PING 10.10.24.2 (10.10.24.2) 56(84) bytes of data:
64 bytes from 10.10.24.2: icmp_seq=1 ttl=63 time=3.56 ms
64 bytes from 10.10.24.2: icmp_seq=2 ttl=63 time=0.972 ms
64 bytes from 10.10.24.2: icmp_seq=3 ttl=63 time=0.389 ms
64 bytes from 10.10.24.2: icmp_seq=4 ttl=63 time=0.047 ms
64 bytes from 10.10.24.2: icmp_seq=5 ttl=63 time=0.070 ms

--- 10.10.24.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4058ms
rtt min/avg/max/mdev = 0.047/1.006/3.555/1.317 ms
root@mininet-vm:/home/mininet/lab03#
```

سوال هفتم:

به دلیل همان مشکل بالا کلا امکان پینگ گرفتن به و از h3 ممکن نبود ولی پینگ بین h2 و h1 ممکن بود که در بالا آمده است. همان طور که مشاهده میکنیم اولین دستور ping بیشتر طول میکشد چرا که جدول های arp نیز در هنگام دستور پر میشوند.