Lab 3: Dynamic Routing and Network Address Translation

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Part 1: Setup Environment

Topology setup

```
soulr@ubuntu:~$ sudo docker exec h1 ip r
default via 192.168.1.2 dev h1R1veth
172.17.0.0/16 dev eth0  proto kernel  scope link  src 172.17.0.2
192.168.1.0/24 dev h1R1veth  proto kernel  scope link  src 192.168.1.3
soulr@ubuntu:~$ sudo docker exec h2 ip r
default via 192.168.2.2 dev h2R1veth
172.17.0.0/16 dev eth0  proto kernel  scope link  src 172.17.0.3
192.168.2.0/24 dev h2R1veth  proto kernel  scope link  src 192.168.2.3
soulr@ubuntu:~$ sudo docker exec R1 ip r
default via 172.17.0.1 dev eth0
140.113.1.0/24 via 140.113.2.3 dev R1R2veth  proto zebra
140.113.2.0/24 dev R1R2veth  proto kernel  scope link  src 140.113.2.2
172.17.0.0/16 dev eth0  proto kernel  scope link  src 172.17.0.4
192.168.1.0/24 dev R1h1veth  proto kernel  scope link  src 192.168.1.2
192.168.2.0/24 dev R1h2veth  proto kernel  scope link  src 192.168.2.2
soulr@ubuntu:~$ sudo docker exec R2 ip r
default via 172.17.0.1 dev eth0
140.113.1.0/24 dev R2hRveth  proto kernel  scope link  src 140.113.1.2
140.113.2.0/24 dev R2R1veth  proto kernel  scope link  src 140.113.2.3
172.17.0.0/16 dev eth0  proto kernel  scope link  src 172.17.0.5
192.168.1.0/24 via 140.113.2.2 dev R2R1veth  proto zebra
192.168.2.0/24 via 140.113.2.2 dev R2R1veth  proto zebra
soulr@ubuntu:~$ sudo docker exec hR ip r
default via 140.113.1.2 dev hRR2veth
140.113.1.0/24 dev hRR2veth  proto kernel  scope link  src 140.113.1.3
172.17.0.0/16 dev eth0  proto kernel  scope link  src 172.17.0.6
soulr@ubuntu:~$
```

Quagga info

Bgp summary

- R1

```
R1bgp> show ip bgp summary
BGP router identifier 140.113.2.2, local AS number 65000
RIB entries 5, using 560 bytes of memory
Peers 1, using 4568 bytes of memory

Neighbor        V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
140.113.2.3     4 65001     307     308        0    0    0 00:15:10        1
```

- R2

```
R2bgp> show ip bgp summary
BGP router identifier 140.113.2.3, local AS number 65001
RIB entries 5, using 560 bytes of memory
Peers 1, using 4568 bytes of memory

Neighbor        V         AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
140.113.2.2     4 65000     350     353        0    0    0 00:16:43        2

Total number of neighbors 1
```

bgpd.conf

- R1

```
soulr@ubuntu:~$ sudo docker exec R1 cat /etc/quagga/bgpd.conf
! BGP configuration for R1
!
hostname R1bgp
password vRouter
!
router bgp 65000
        bgp router-id 140.113.2.2
        timers bgp 3 9
        neighbor 140.113.2.3 remote-as 65001
        neighbor 140.113.2.3 ebgp-multihop
        neighbor 140.113.2.3 timers connect 5
        neighbor 140.113.2.3 advertisement-interval 5
        network 192.168.1.0/24
        network 192.168.2.0/24
!
log stdout
```

- R2

```
soulr@ubuntu:~$ sudo docker exec R2 cat /etc/quagga/bgpd.conf
! BGP configuration for R2
!
hostname R2bgp
password vRouter
!
router bgp 65001
        bgp router-id 140.113.2.3
        timers bgp 3 9
        neighbor 140.113.2.2 remote-as 65000
        neighbor 140.113.2.2 ebgp-multihop
        neighbor 140.113.2.2 timers connect 5
        neighbor 140.113.2.2 advertisement-interval 5
        network 140.113.1.0/24
!
log stdout
```

Part 2: Source NAT

Reachability

h1 and h2 can ping hR or not

可以，來自 h1 和 h2 的封包透過內網傳至 R1， R1 透過 bgp 看到 hR，將封包傳到 hR。反向 hR 將封包傳至 R2, R2 透過 bgp 看到 h1, h2，將封包傳回 h1, h2。

```
soulr@ubuntu:~$ sudo docker exec -it h1 ping 140.113.1.3
PING 140.113.1.3 (140.113.1.3) 56(84) bytes of data.
64 bytes from 140.113.1.3: icmp_seq=1 ttl=62 time=0.313 ms
64 bytes from 140.113.1.3: icmp_seq=2 ttl=62 time=0.989 ms
64 bytes from 140.113.1.3: icmp_seq=3 ttl=62 time=0.264 ms
^C
--- 140.113.1.3 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 0.264/0.522/0.989/0.330 ms
soulr@ubuntu:~$ sudo docker exec -it h2 ping 140.113.1.3
PING 140.113.1.3 (140.113.1.3) 56(84) bytes of data.
64 bytes from 140.113.1.3: icmp_seq=1 ttl=62 time=0.284 ms
64 bytes from 140.113.1.3: icmp_seq=2 ttl=62 time=0.237 ms
64 bytes from 140.113.1.3: icmp_seq=3 ttl=62 time=0.250 ms
^C
--- 140.113.1.3 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2031ms
rtt min/avg/max/mdev = 0.237/0.257/0.284/0.019 ms
soulr@ubuntu:~$
```

Source NAT rules

Before SNAT rules

- R1h1veth

```
root@413b3d1351e6:/# ping 140.113.1.3
PING 140.113.1.3 (140.113.1.3) 56(84) bytes of data.
64 bytes from 140.113.1.3: icmp_seq=1 ttl=62 time=0.151 ms
64 bytes from 140.113.1.3: icmp_seq=2 ttl=62 time=0.252 ms
64 bytes from 140.113.1.3: icmp_seq=3 ttl=62 time=0.349 ms
^C
--- 140.113.1.3 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2024ms
rtt min/avg/max/mdev = 0.151/0.250/0.349/0.082 ms
root@413b3d1351e6:/#
```

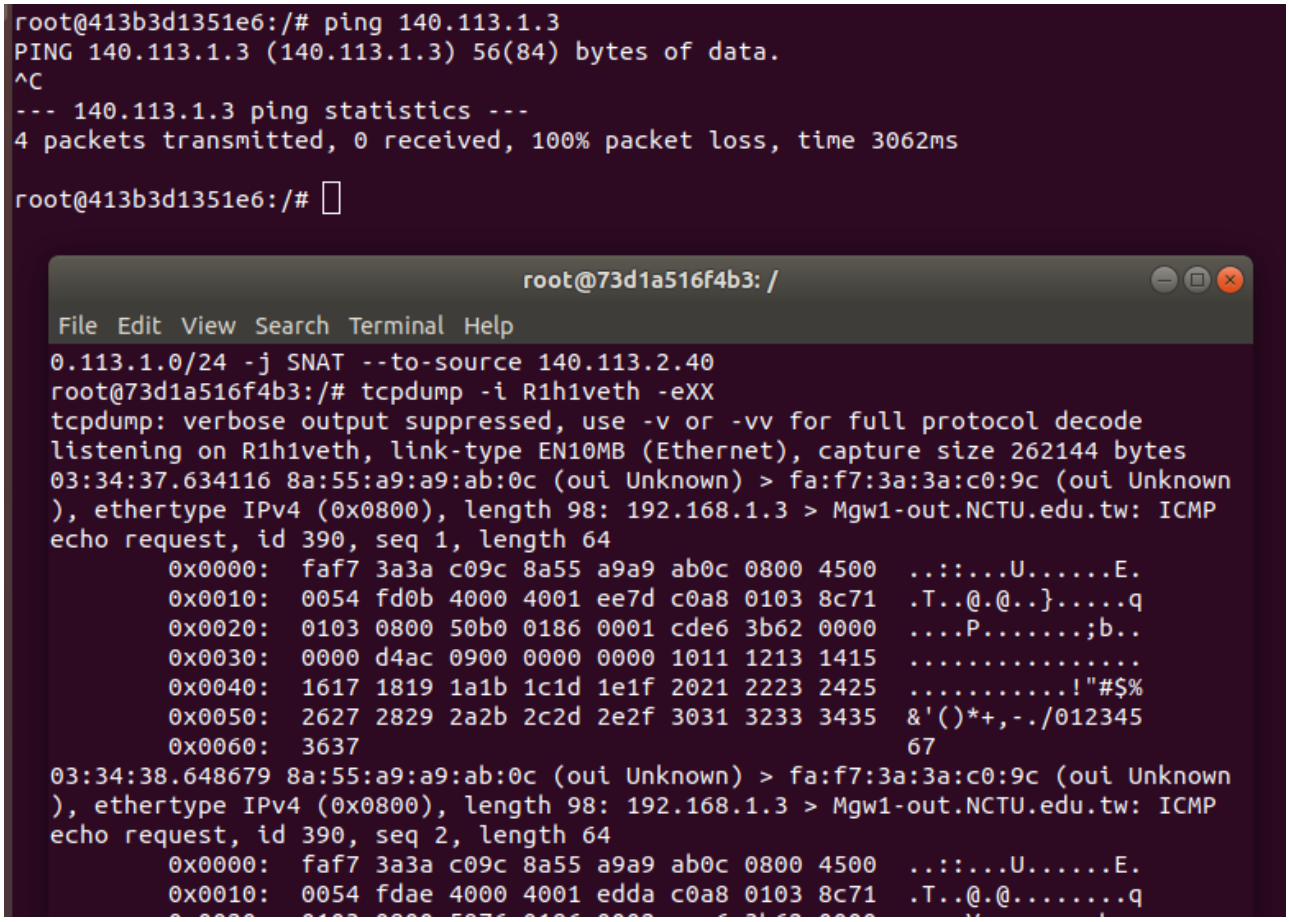
```
root@73d1a516f4b3: /
File  Edit  View  Search  Terminal  Help
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on R1h1veth, link-type EN10MB (Ethernet), capture size 262144 bytes
03:24:57.103707 8a:55:a9:a9:ab:0c (oui Unknown) > fa:f7:3a:3a:c0:9c (oui Unknown
), ethertype IPv4 (0x0800), length 98: 192.168.1.3 > Mgw1-out.NCTU.edu.tw: ICMP
echo request, id 365, seq 1, length 64
        0x0000:  faf7 3a3a c09c 8a55 a9a9 ab0c 0800 4500  ..::...U......E.
        0x0010:  0054 391c 4000 4001 b26d c0a8 0103 8c71  .T9.@.@..m.....q
        0x0020:  0103 0800 72e3 016d 0001 89e4 3b62 0000  ....r..m....;b..
        0x0030:  0000 fe94 0100 0000 0000 1011 1213 1415  ................
        0x0040:  1617 1819 1a1b 1c1d 1e1f 2021 2223 2425  ...........!"#$%
        0x0050:  2627 2829 2a2b 2c2d 2e2f 3031 3233 3435  &'()*+,-./012345
        0x0060:  3637                                     67
03:24:57.103812 fa:f7:3a:3a:c0:9c (oui Unknown) > 8a:55:a9:a9:ab:0c (oui Unknown
), ethertype IPv4 (0x0800), length 98: Mgw1-out.NCTU.edu.tw > 192.168.1.3: ICMP
echo reply, id 365, seq 1, length 64
        0x0000:  8a55 a9a9 ab0c faf7 3a3a c09c 0800 4500  .U......::....E.
        0x0010:  0054 8566 0000 3e01 a823 8c71 0103 c0a8  .T.f..>..#.q....
        0x0020:  0103 0000 7ae3 016d 0001 89e4 3b62 0000  ....z..m....;b..
```

- R1R2veth

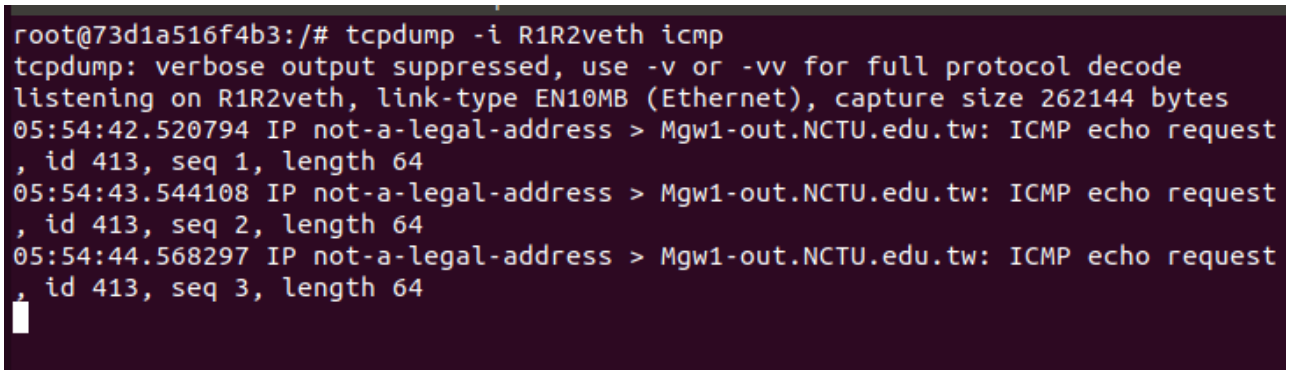
```
root@73d1a516f4b3:/# tcpdump -i R1R2veth icmp
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on R1R2veth, link-type EN10MB (Ethernet), capture size 262144 bytes
05:53:14.802214 IP 192.168.1.3 > fpop3.nctu.edu.tw: ICMP echo request, id 410, s
eq 1, length 64
05:53:14.802590 IP fpop3.nctu.edu.tw > 192.168.1.3: ICMP echo reply, id 410, seq
 1, length 64
05:53:15.808299 IP 192.168.1.3 > fpop3.nctu.edu.tw: ICMP echo request, id 410, s
eq 2, length 64
05:53:15.808437 IP fpop3.nctu.edu.tw > 192.168.1.3: ICMP echo reply, id 410, seq
 2, length 64
05:53:16.824879 IP 192.168.1.3 > fpop3.nctu.edu.tw: ICMP echo request, id 410, s
eq 3, length 64
```

After SNAT rules

- R1h1veth



- R1R2veth

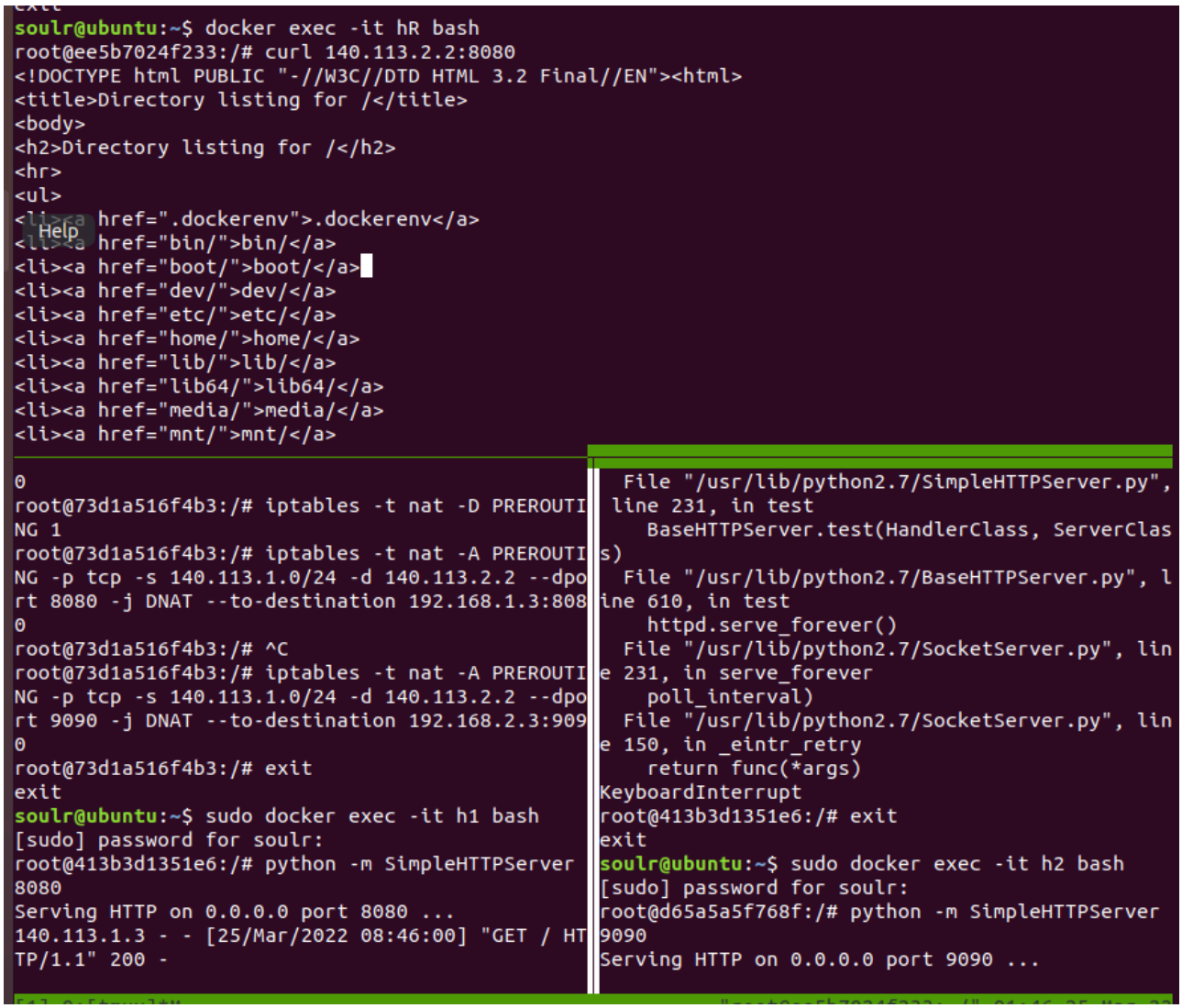


Part 3: Destination NAT

Results of hR curl h1, h2

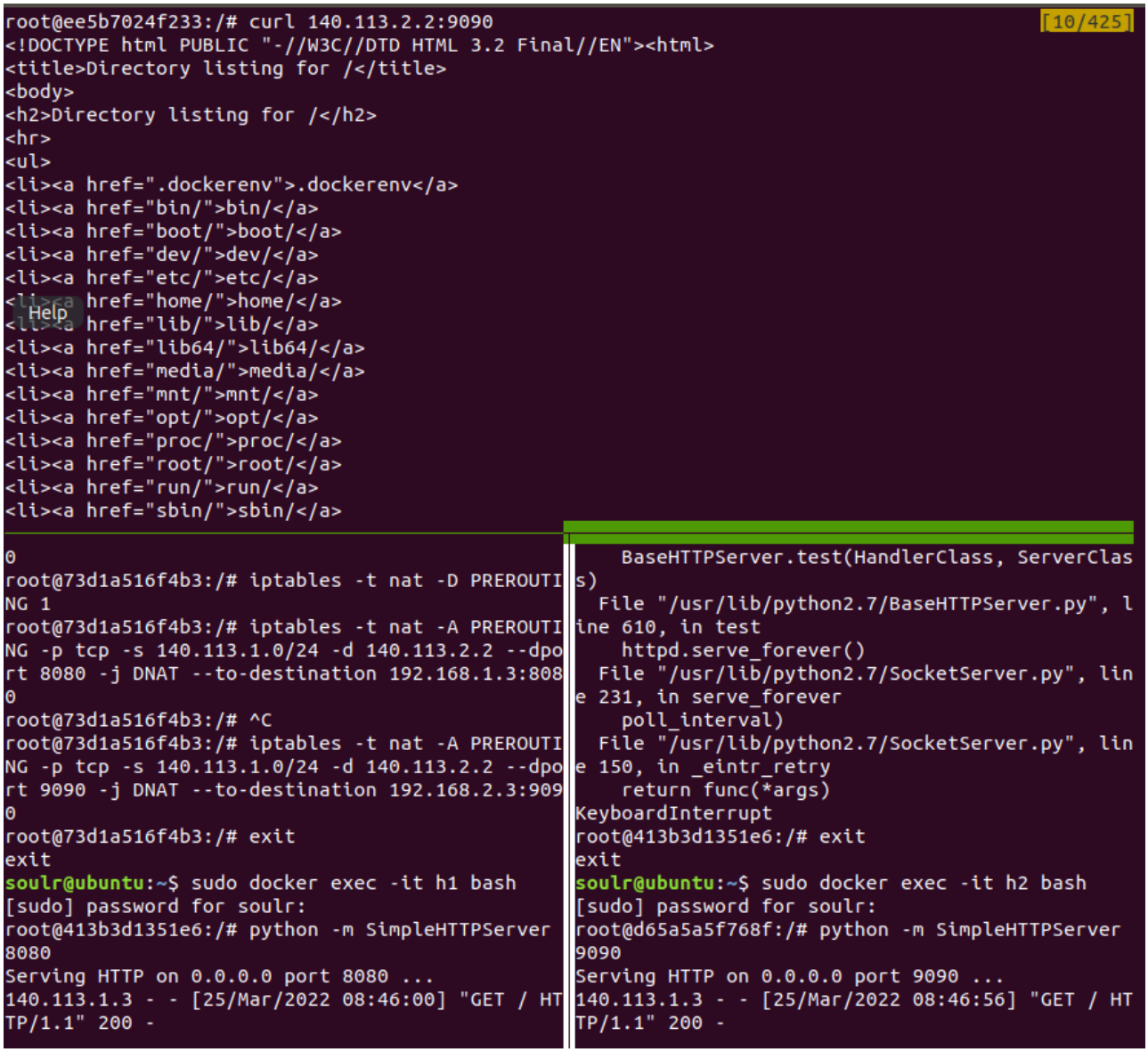
Since my R1's IP is 140.113.2.2, I should run `curl 140.113.2.2:<port>` rather than `curl 140.113.2.1:<port>`.

- h1


soulr@ubuntu:~$ docker exec -it hR bash
root@ee5b7024f233:/# curl 140.113.2.2:8080
<!DOCTYPE html PUBLIC "-//W3C//DTD HTML 3.2 Final//EN"><html>
<title>Directory listing for /</title>
<body>
<h2>Directory listing for /</h2>
<hr>

.dockerenv
bin/
boot/
dev/
etc/
home/
lib/
lib64/
media/
mnt/
Help
0
root@73d1a516f4b3:/# iptables -t nat -D PREROUTING 1
root@73d1a516f4b3:/# iptables -t nat -A PREROUTING -p tcp -s 140.113.1.0/24 -d 140.113.2.2 --dport 8080 -j DNAT --to-destination 192.168.1.3:8080
root@73d1a516f4b3:/# ^C
root@73d1a516f4b3:/# iptables -t nat -A PREROUTING -p tcp -s 140.113.1.0/24 -d 140.113.2.2 --dport 9090 -j DNAT --to-destination 192.168.2.3:9090
root@73d1a516f4b3:/# exit
exit
soulr@ubuntu:~$ sudo docker exec -it h1 bash
[sudo] password for soulr:
root@413b3d1351e6:/# python -m SimpleHTTPServer 8080
Serving HTTP on 0.0.0.0 port 8080 ...
140.113.1.3 - - [25/Mar/2022 08:46:00] "GET / HTTP/1.1" 200 -
File "/usr/lib/python2.7/SimpleHTTPServer.py", line 231, in test
BaseHTTPServer.test(HandlerClass, ServerClass)
File "/usr/lib/python2.7/BaseHTTPServer.py", line 610, in test
httpd.serve_forever()
File "/usr/lib/python2.7/SocketServer.py", line 231, in serve_forever
poll_interval)
File "/usr/lib/python2.7/SocketServer.py", line 150, in _eintr_retry
return func(*args)
KeyboardInterrupt
root@413b3d1351e6:/# exit
exit
soulr@ubuntu:~$ sudo docker exec -it h2 bash
[sudo] password for soulr:
root@d65a5a5f768f:/# python -m SimpleHTTPServer 9090
Serving HTTP on 0.0.0.0 port 9090 ...

- h2



Destination NAT rules

Before NAT rules

```
soulr@ubuntu:~$ docker exec -it hR bash
root@ee5b7024f233:/# curl 140.113.2.2:8080
curl: (7) Failed to connect to 140.113.2.2 port 8080: Connection refused
root@ee5b7024f233:/# curl 140.113.2.2:9090
curl: (7) Failed to connect to 140.113.2.2 port 9090: Connection refused
root@ee5b7024f233:/#
```

```
 line 231, in test
    BaseHTTPServer.test(HandlerClass, ServerClas
s)
  File "/usr/lib/python2.7/BaseHTTPServer.py", l
ine 610, in test
    httpd.serve_forever()
  File "/usr/lib/python2.7/SocketServer.py", lin
e 231, in serve_forever
    poll_interval)
  File "/usr/lib/python2.7/SocketServer.py", lin
e 150, in _eintr_retry
    return func(*args)
KeyboardInterrupt
root@413b3d1351e6:/# exit
exit
soulr@ubuntu:~$
soulr@ubuntu:~$ sudo docker exec -it h1 bash
[sudo] password for soulr:
root@413b3d1351e6:/# python -m SimpleHTTPServer
8080
Serving HTTP on 0.0.0.0 port 8080 ...
```

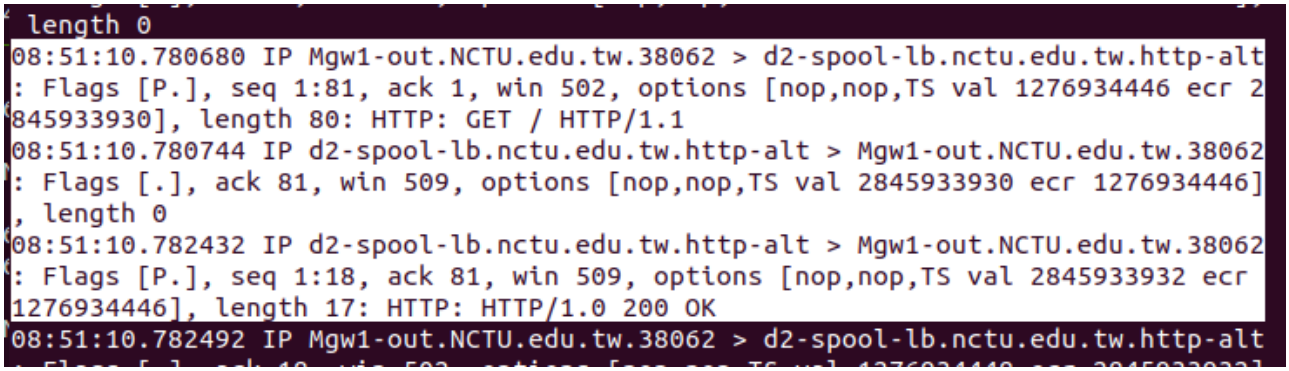
```
    BaseHTTPServer.test(HandlerClass, ServerClas
s)
  File "/usr/lib/python2.7/BaseHTTPServer.py", l
ine 610, in test
    httpd.serve_forever()
  File "/usr/lib/python2.7/SocketServer.py", lin
e 231, in serve_forever
    poll_interval)
  File "/usr/lib/python2.7/SocketServer.py", lin
e 150, in _eintr_retry
    return func(*args)
KeyboardInterrupt
root@d65a5a5f768f:/# exit
exit
soulr@ubuntu:~$
soulr@ubuntu:~$
soulr@ubuntu:~$ sudo docker exec -it h2 bash
[sudo] password for soulr:
root@d65a5a5f768f:/# python -m SimpleHTTPServer
9090
Serving HTTP on 0.0.0.0 port 9090 ...
```

After DNAT rules

- R1h1veth

```
root@73d1a516f4b3:/# tcpdump -i R1h1veth
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on R1h1veth, link-type EN10MB (Ethernet), capture size 262144 bytes
08:58:10.133920 IP Mgw1-out.NCTU.edu.tw.38066 > 192.168.1.3.http-alt: Flags [S],
 seq 99490542, win 64240, options [mss 1460,sackOK,TS val 1277352252 ecr 0,nop,w
scale 7], length 0
08:58:10.134135 IP 192.168.1.3.http-alt > Mgw1-out.NCTU.edu.tw.38066: Flags [S.]
, seq 1085997623, ack 99490543, win 65160, options [mss 1460,sackOK,TS val 28463
51737 ecr 1277352252,nop,wscale 7], length 0
08:58:10.134366 IP Mgw1-out.NCTU.edu.tw.38066 > 192.168.1.3.http-alt: Flags [.],
 ack 1, win 502, options [nop,nop,TS val 1277352253 ecr 2846351737], length 0
08:58:10.165256 IP Mgw1-out.NCTU.edu.tw.38066 > 192.168.1.3.http-alt: Flags [P.]
, seq 1:81, ack 1, win 502, options [nop,nop,TS val 1277352284 ecr 2846351737],
length 80: HTTP: GET / HTTP/1.1
08:58:10.165462 IP 192.168.1.3.http-alt > Mgw1-out.NCTU.edu.tw.38066: Flags [.],
 ack 81, win 509, options [nop,nop,TS val 2846351768 ecr 1277352284], length 0
08:58:10.174222 IP 192.168.1.3.http-alt > Mgw1-out.NCTU.edu.tw.38066: Flags [P.]
, seq 1:18, ack 81, win 509, options [nop,nop,TS val 2846351777 ecr 1277352284],
 length 17: HTTP: HTTP/1.0 200 OK
08:58:10.174915 IP 192.168.1.3.http-alt > Mgw1-out.NCTU.edu.tw.38066: Flags [FP.
], seq 18:933, ack 81, win 509, options [nop,nop,TS val 2846351778 ecr 127735228
4], length 915: HTTP
^C
7 packets captured
```

- R1R2veth


length 0
08:51:10.780680 IP Mgw1-out.NCTU.edu.tw.38062 > d2-spool-lb.nctu.edu.tw.http-alt
: Flags [P.], seq 1:81, ack 1, win 502, options [nop,nop,TS val 1276934446 ecr 2
845933930], length 80: HTTP: GET / HTTP/1.1
08:51:10.780744 IP d2-spool-lb.nctu.edu.tw.http-alt > Mgw1-out.NCTU.edu.tw.38062
: Flags [.], ack 81, win 509, options [nop,nop,TS val 2845933930 ecr 1276934446]
, length 0
08:51:10.782432 IP d2-spool-lb.nctu.edu.tw.http-alt > Mgw1-out.NCTU.edu.tw.38062
: Flags [P.], seq 1:18, ack 81, win 509, options [nop,nop,TS val 2845933932 ecr
1276934446], length 17: HTTP: HTTP/1.0 200 OK
08:51:10.782492 IP Mgw1-out.NCTU.edu.tw.38062 > d2-spool-lb.nctu.edu.tw.http-alt