



LAB WEEK 2:
NAT, Port Forwarding & Routing

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Week 2: Nắm vững kỹ thuật NAT, Port Forwarding & Routing.

Phần 1: NAT.

Mỗi bạn tạo 2 VM:

VM1: 1/1/20/vmbr0/vmbr1

- IP WAN: liên hệ leader để được cấp IP
- IP LAN: 10.0.0.1/24

VM2: 1/1/20/vmbr1

- IP LAN: 10.0.0.2/24 - GW: 10.0.0.1

Yêu cầu:

- Sử dụng iptables cấu hình VM1 NAT masquerade để VM2 có thể đi ra internet được thông qua VM1.
- Reboot VM1 và sau khi boot vào OS thì VM2 vẫn có thể đi ra internet được thông qua VM1.

1. Sử dụng iptables cấu hình VM1 NAT masquerade để VM2 có thể đi ra internet được thông qua VM1.

Cấu hình card mạng của VM1

```
# This is the network config written by 'subiquity'
network:
  version: 2
  renderer: networkd
  ethernets:
    ens18:
      dhcp4: no
      addresses:
        - 192.168.1.121/24
      nameservers:
        addresses:
          - 8.8.8.8
          - 8.8.4.4
      routes:
        - to: default
          via: 192.168.1.1
    ens19:
      dhcp4: no
      addresses:
        - 10.0.25.1/24
```

Cấu hình card mạng của VM2

```
GNU nano 6.2 /etc/netplan/00-installer-config.yaml
# This is the network config written by 'subiquity'
network:
  version: 2
  renderer: networkd
  ethernets:
    ens18:
      dhcp4: no
      addresses:
        - 10.0.25.2/24
      nameservers:
        addresses:
          - 8.8.8.8
          - 8.8.4.4
      routes:
        - to: default
          via: 10.0.25.1
```

2. Lưu iptables để sau reboot vẫn còn

sudo apt install iptables-persistent -y

sudo netfilter-persistent save

```
tduy@ubuntu-server:~$ sudo netfilter-persistent save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/15-ip4tables save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/25-ip6tables save
```

NAT Masquerade (ens18 là interface WAN, ens19 là interface LAN)

sudo iptables -t nat -A POSTROUTING -o ens18 -j MASQUERADE

```
tduy@ubuntu-server:~$ sudo iptables -t nat -A POSTROUTING -o ens18 -j MASQUERADE
tduy@ubuntu-server:~$ sudo iptables -A FORWARD -i ens19 -o ens18 -j ACCEPT
tduy@ubuntu-server:~$ sudo iptables -A FORWARD -i ens18 -o ens19 -m state --state RELATED,ESTABLISHED -j ACCEPT
tduy@ubuntu-server:~$ sudo netfilter-persistent save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/15-ip4tables save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/25-ip6tables save
```

3. Reboot VM1 và sau khi boot vào OS thì VM2 vẫn có thể đi ra internet được thông qua VM1

```
QEMU (ns15-w02-duydn2-vm1-vmb10-v) QEMU (ns15-w02-duydn2-vm2-vmb11) - noVNC - Google Chrome
intern.vhost.vn8006/?console=ls intern.vhost.vn8006/?console=kvm&noVnc=1&vmid=3200&vmname=ns15-w02-duydn2-vm2-vmb11&node=intern&resize=off&cmd=

Starting Rule-based M
[OK] Finished Load Kernel
[OK] Started Device Mapper
[OK] Finished Load/Save Ra
[OK] Started Journal Servi
[OK] Starting Flush Journa
[OK] Finished Set the cons
[OK] Reached target Prepan
Mounting Mount unit f
Mounting Mount unit f
Mounting Mount unit f
Mounting Mount unit f
Mounting Mount unit f
Failed to connect to https://changelogs.ubuntu.com/meta-release-lts. Check your Internet connection or proxy settings
[OK] Mounted Mount unit fo
[OK] Mounted Mount unit fo
[OK] Mounted Mount unit fo
[OK] Mounted Mount unit fo
[OK] Mounted Mount unit fo
[OK] Reached target Mounte
[OK] Reached target Local
[OK] Starting Load Appere
[OK] Starting Set console
[OK] Starting Create final
[OK] Starting netfilter pe
[OK] Starting Tell Plymouth
[OK] Starting Set Up Addit
[OK] Starting Uncompilate
[OK] Finished Set console
[OK] Mounting Arbitrary Ex
[OK] Finished Create final
[OK] Finished Uncompilate
[OK] Mounted Arbitrary Exe
[OK] Finished Tell Plymouth
[OK] Starting Create Volat
[OK] Finished Coldplug Alltduy@ubuntu-server:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:58:21:da brd ff:ff:ff:ff:ff:ff
    altname enp0s18
    inet 192.168.1.121/24 brd 192.168.1.255 scope global ens18
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe58:21da/64 scope link
        valid_lft forever preferred_lft forever
3: ens19: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:3d:08:36 brd ff:ff:ff:ff:ff:ff
    altname enp0s19
    inet 10.0.25.1/24 brd 10.0.25.255 scope global ens19
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe3d:836/64 scope link
        valid_lft forever preferred_lft forever
tduy@ubuntu-server:~$ ping -c 4 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=117 time=39.2 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=117 time=38.2 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=117 time=38.4 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=117 time=38.4 ms

--- 8.8.8.8 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 38.137/39.468/41.593/1.288 ms
tduy@ubuntu-server:~$ ping -c 4 10.0.25.2
PING 10.0.25.2 (10.0.25.2) 56(84) bytes of data.
64 bytes from 10.0.25.2: icmp_seq=1 ttl=64 time=0.648 ms
64 bytes from 10.0.25.2: icmp_seq=2 ttl=64 time=0.445 ms
64 bytes from 10.0.25.2: icmp_seq=3 ttl=64 time=0.617 ms
64 bytes from 10.0.25.2: icmp_seq=4 ttl=64 time=0.782 ms

--- 10.0.25.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 0.445/0.623/0.782/0.120 ms
```

4. Cho phép forward từ LAN sang WAN

sudo iptables -A FORWARD -i ens19 -o ens18 -j ACCEPT

sudo iptables -A FORWARD -i ens18 -o \$ens19 -m state --state ESTABLISHED,RELATED -j ACCEPT

Lấy VM1 ping ra internet và ping được VM2

```
tduy@ubuntu-server:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:58:21:da brd ff:ff:ff:ff:ff:ff
    altname enp0s18
    inet 192.168.1.121/24 brd 192.168.1.255 scope global ens18
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe58:21da/64 scope link
        valid_lft forever preferred_lft forever
3: ens19: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:3d:08:36 brd ff:ff:ff:ff:ff:ff
    altname enp0s19
    inet 10.0.25.1/24 brd 10.0.25.255 scope global ens19
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe3d:836/64 scope link
        valid_lft forever preferred_lft forever
tduy@ubuntu-server:~$ ping -c 4 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=118 time=38.9 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=118 time=39.2 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=118 time=38.1 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=118 time=41.6 ms

--- 8.8.8.8 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 38.137/39.468/41.593/1.288 ms
tduy@ubuntu-server:~$ ping -c 4 10.0.25.2
PING 10.0.25.2 (10.0.25.2) 56(84) bytes of data.
64 bytes from 10.0.25.2: icmp_seq=1 ttl=64 time=0.648 ms
64 bytes from 10.0.25.2: icmp_seq=2 ttl=64 time=0.445 ms
64 bytes from 10.0.25.2: icmp_seq=3 ttl=64 time=0.617 ms
64 bytes from 10.0.25.2: icmp_seq=4 ttl=64 time=0.782 ms

--- 10.0.25.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 0.445/0.623/0.782/0.120 ms
```

Từ VM2 thì có thể ping được VM1 và internet

```
tduy@ubuntu-server:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:4c:f4:88 brd ff:ff:ff:ff:ff:ff
    altname enp0s18
    inet 10.0.25.2/24 brd 10.0.25.255 scope global ens18
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe4c:f488/64 scope link
        valid_lft forever preferred_lft forever
3: ens19: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN group default qlen 1000
    link/ether bc:24:11:51:73:6c brd ff:ff:ff:ff:ff:ff
    altname enp0s19
tduy@ubuntu-server:~$ ping -c 4 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=117 time=38.8 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=117 time=38.5 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=117 time=38.7 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=117 time=46.0 ms

--- 8.8.8.8 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 38.454/40.493/46.034/3.201 ms
tduy@ubuntu-server:~$ ping -c 4 10.0.25.1
PING 10.0.25.1 (10.0.25.1) 56(84) bytes of data.
64 bytes from 10.0.25.1: icmp_seq=1 ttl=64 time=0.461 ms
64 bytes from 10.0.25.1: icmp_seq=2 ttl=64 time=0.495 ms
64 bytes from 10.0.25.1: icmp_seq=3 ttl=64 time=0.722 ms
64 bytes from 10.0.25.1: icmp_seq=4 ttl=64 time=0.434 ms

--- 10.0.25.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 0.434/0.528/0.722/0.114 ms
```

Phần 2: Port Forwarding.

Yêu cầu:

- Cấu hình port forwarding trên VM1 để khi SSH vào IP WAN của VM1(192.168.1.121) port 2222 thì có thể truy cập được SSH được thẳng vào VM2.

1. Cấu hình port forwarding trên VM1

```
tduy@ubuntu-server:~$ sudo iptables -t nat -A PREROUTING -i ens18 -p tcp --dport 2222 -j DNAT --to-destination 10.0.25.2:22
tduy@ubuntu-server:~$ !150
sudo iptables -A FORWARD -p tcp -d 10.0.25.2 --dport 22 -m state --state NEW,ESTABLISHED,RELATED -j ACCEPT
tduy@ubuntu-server:~$ sudo netfilter-persistent save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/15-ip4tables save
run-parts: executing /usr/share/netfilter-persistent/plugins.d/25-ip6tables save
```

2. Dò thử trên VM1 cổng 2222 IP WAN đã có packet chưa

```
tduy@ubuntu-server:~$ sudo tcpdump -i ens18 port 2222
[sudo] password for tduy:
tcpdump: verbose output suppressed, use -v[v]... for full protocol decode
listening on ens18, link-type EN10MB (Ethernet), snapshot length 262144 bytes
12:30:10.994980 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [R.], seq 0, ack 1518647606, win 0, length 0
12:30:11.997271 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [R.], seq 0, ack 1, win 0, length 0
12:30:14.013265 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [R.], seq 0, ack 1, win 0, length 0
12:30:18.141170 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [S], seq 1518647605, win 64240, options [mss 1460,sackOK,TS val 1197451714 ecr 0,nop,wscale 7], length 0
12:30:18.142644 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [S.], seq 1459841459, ack 1518647606, win 65160, options [mss 1460,sackOK,TS val 716757158 ecr 1197451714,nop,wscale 7], length 0
12:30:18.143310 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [L.], ack 1, win 502, options [nop,nop,TS val 1197451716 ecr 716757158], length 0
12:30:18.146035 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [P.], seq 1:33, ack 1, win 502, options [nop,nop,TS val 1197451719 ecr 716757158], length 32
12:30:18.146431 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [L.], ack 33, win 509, options [nop,nop,TS val 716757162 ecr 1197451719], length 0
12:30:18.198958 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [P.], seq 1:33, ack 33, win 509, options [nop,nop,TS val 716757214 ecr 1197451719], length 32
12:30:18.199517 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [L.], ack 33, win 502, options [nop,nop,TS val 1197451773 ecr 716757214], length 0
12:30:18.204083 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [P.], seq 33:1537, ack 33, win 502, options [nop,nop,TS val 1197451777 ecr 716757214], length 1504
12:30:18.204718 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [L.], ack 1537, win 500, options [nop,nop,TS val 716757220 ecr 1197451777], length 0
12:30:18.207090 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [P.], seq 33:1113, ack 1537, win 500, options [nop,nop,TS val 716757223 ecr 1197451777], length 1080
12:30:18.207505 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [L.], ack 1113, win 501, options [nop,nop,TS val 1197451781 ecr 716757223], length 0
12:30:18.217548 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [P.], seq 1537:1585, ack 1113, win 501, options [nop,nop,TS val 1197451791 ecr 716757223], length 48
12:30:18.218132 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [L.], ack 1585, win 501, options [nop,nop,TS val 716757234 ecr 1197451791], length 0
12:30:18.239260 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [P.], seq 1113:1637, ack 1585, win 501, options [nop,nop,TS val 716757255 ecr 1197451791], length 524
12:30:18.239879 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [L.], ack 1637, win 501, options [nop,nop,TS val 1197451813 ecr 716757255], length 0
12:30:18.265242 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [P.], seq 1585:1601, ack 1637, win 501, options [nop,nop,TS val 1197451838 ecr 716757255], length 16
12:30:18.265909 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [L.], ack 1601, win 501, options [nop,nop,TS val 716757282 ecr 1197451838], length 0
12:30:18.266365 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [P.], seq 1601:1645, ack 1637, win 501, options [nop,nop,TS val 1197451839 ecr 716757282], length 44
12:30:18.266880 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [L.], ack 1645, win 501, options [nop,nop,TS val 716757283 ecr 1197451839], length 0
12:30:18.267513 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [P.], seq 1637:1681, ack 1645, win 501, options [nop,nop,TS val 716757283 ecr 1197451839], length 44
12:30:18.268035 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [P.], seq 1645:1705, ack 1681, win 501, options [nop,nop,TS val 1197451841 ecr 716757283], length 60
12:30:18.275014 IP ubuntu-server.2222 > 192.168.1.123.53864: Flags [P.], seq 1681:1733, ack 1705, win 501, options [nop,nop,TS val 716757291 ecr 1197451841], length 52
12:30:18.317080 IP 192.168.1.123.53864 > ubuntu-server.2222: Flags [L.], ack 1733, win 501, options [nop,nop,TS val 1197451890 ecr 716757291], length 0
```

3. Máy VM2 cũng đang lắng nghe trên port 22 mà port forwarding đã ánh xạ từ port 2222

```
tduy@ubuntu-server:~$ sudo ss -tln | grep :22
[sudo] password for tduy:
tcp        LISTEN 0      128          0.0.0.0:*        0.0.0.0:*
tcp        LISTEN 0      128          ::::22          ::::*
```

4. Kết quả đã thành công ssh từ máy client có IP là 192.168.1.123 sang máy 192.168.1.123

```
tduy@ubuntu-server:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:99:d7:8c brd ff:ff:ff:ff:ff:ff
    altname enp0s18
    inet 192.168.1.123/24 brd 192.168.1.255 scope global ens18
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe99:d78c/64 scope link
        valid_lft forever preferred_lft forever
tduy@ubuntu-server:~$ ssh -p 2222 tduy@192.168.1.121
tduy@192.168.1.121's password:
Welcome to Ubuntu 22.04 LTS (GNU/Linux 5.15.0-25-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

System information as of Fri Apr 18 12:51:03 AM UTC 2025

System load:  0.14013671875   Processes:            95
Usage of /:   15.4% of 31.32GB Users logged in:             1
Memory usage: 10%            IPv4 address for ens18: 10.0.25.2
Swap usage:   0%

0 updates can be applied immediately.

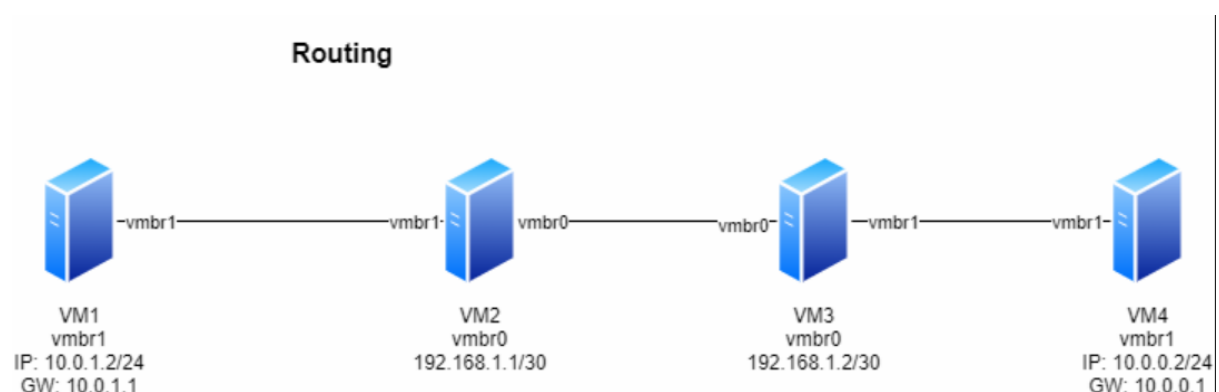
Failed to connect to https://changelogs.ubuntu.com/meta-release-lts. Check your Internet connection or proxy settings

Last login: Fri Apr 18 00:49:18 2025
tduy@ubuntu-server:~$
```

Phần 3: Routing.

Môi trường: đề tài yêu cầu 2 bạn làm chung 1 bài lab. Mỗi bạn được cấp 2 VM và cấu hình mạng như hình sau:

- Bạn 1: VM2 (có vmbr0 và vmbr1) và VM1 (only vmbr1)
- Bạn 2: VM3 (có vmbr0 và vmbr1) và VM4 (only vmbr1)



Yêu cầu:

- Cấu hình VM2 và VM3 để cho network của VM4 và VM1 có thể ping thấy nhau.
- Reboot lại VM2 và VM3 thì hệ thống vẫn hoạt động bình thường (sau khi vào OS).

Cấu hình các máy VM

VM1

- IP: 10.0.25.2
- GW: 10.0.25.1

VM2

- IP WAN: 192.168.1.121
- IP LAN: 10.0.25.1

VM3

- IP WAN: 192.168.1.81
- IP LAN: 10.0.0.1

VM4

- IP: 10.0.0.2
- GW: 10.0.0.1

1. Bật IP Forwarding trên máy VM2

```
167 sudo sysctl -w net.ipv4.ip_forward=1
```

Ghi vào file hệ thống

```
169 sudo echo "net.ipv4.ip_forward=1" >> sudo /etc/sysctl.conf
```

2. Cấu hình route đặt đường mặc định để thêm vào bảng định tuyến để máy tính có thể gửi gói tin đến địa chỉ IP 10.0.0.2 thông qua cổng (gateway) 192.168.1.81

```
170 sudo ip route add 10.0.0.2/24 via 192.168.1.81
171 sudo ip route add 10.0.0.2 via 192.168.1.81
```

3. Để route tồn tại sau khi reboot, thêm vào crontab dùng sudo crontab -e
@reboot ip route add 10.0.0.2 via 192.168.1.81

```
GNU nano 6.2 /tmp/crontab.3gH1R/crontab
# Edit this file to introduce tasks to be run by cron.
#
# Each task to run has to be defined through a single line
# indicating with different fields when the task will be run
# and what command to run for the task
#
# To define the time you can provide concrete values for
# minute (m), hour (h), day of month (dom), month (mon),
# and day of week (dow) or use '*' in these fields (for 'any').
#
# Notice that tasks will be started based on the cron's system
# daemon's notion of time and timezones.
#
# Output of the crontab jobs (including errors) is sent through
# email to the user the crontab file belongs to (unless redirected).
#
# For example, you can run a backup of all your user accounts
# at 5 a.m every week with:
# 0 5 * * 1 tar -zcf /var/backups/home.tgz /home/
#
# For more information see the manual pages of crontab(5) and cron(8)
#
# e.g. h. doc. org. day. command
@reboot ip route add 10.0.0.2 via 192.168.1.81
```

4. Sau khi cấu hình thì được kết quả

```
tduy@ubuntu-server:~$ ip route
default via 192.168.1.1 dev ens18 proto static
10.0.0.2 via 192.168.1.81 dev ens18
10.0.25.0/24 dev ens19 proto kernel scope link src 10.0.25.1
192.168.1.0/24 dev ens18 proto kernel scope link src 192.168.1.121
```

5. Kết quả dùng VM2(IP: 192.168.1.121) ping cho VM4 (IP: 10.0.0.2) thành công

```
2: ens18: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:58:21:da brd ff:ff:ff:ff:ff:ff
    altname enp0s18
    inet 192.168.1.121/24 brd 192.168.1.255 scope global ens18
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe58:21da/64 scope link
        valid_lft forever preferred_lft forever
3: ens19: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether bc:24:11:3d:08:36 brd ff:ff:ff:ff:ff:ff
    altname enp0s19
    inet 10.0.25.1/24 brd 10.0.25.255 scope global ens19
        valid_lft forever preferred_lft forever
    inet6 fe80::be24:11ff:fe3d:836/64 scope link
        valid_lft forever preferred_lft forever
tduy@ubuntu-server:~$ sudo sysctl -w net.ipv4.ip_forward=1
[sudo] password for tduy:
net.ipv4.ip_forward = 1
tduy@ubuntu-server:~$ sudo echo "net.ipv4.ip_forward=1" >> /etc/sysctl.conf
-bash: /etc/sysctl.conf: Permission denied
tduy@ubuntu-server:~$ sudo echo "net.ipv4.ip_forward=1" >> sudo /etc/sysctl.conf
tduy@ubuntu-server:~$ sudo ip route add 10.0.0.2/24 via 192.168.1.81
Error: Invalid prefix for given prefix length.
tduy@ubuntu-server:~$ sudo ip route add 10.0.0.2 via 192.168.1.81
tduy@ubuntu-server:~$ ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data:
64 bytes from 10.0.0.2: icmp_seq=1 ttl=63 time=2.14 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=63 time=1.37 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=63 time=1.29 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=63 time=1.39 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=63 time=1.37 ms
64 bytes from 10.0.0.2: icmp_seq=6 ttl=63 time=1.28 ms
^C
--- 10.0.0.2 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 5009ms
rtt min/avg/max/mdev = 1.284/1.474/2.140/0.300 ms
tduy@ubuntu-server:~$
```

6. Kết quả VM1 ping được tới VM3 và VM4 thành công

```
tduy@ubuntu-server:~$ ping -c 4 192.168.1.81
PING 192.168.1.81 (192.168.1.81) 56(84) bytes of data.
64 bytes from 192.168.1.81: icmp_seq=1 ttl=63 time=6.34 ms
64 bytes from 192.168.1.81: icmp_seq=2 ttl=63 time=1.42 ms
64 bytes from 192.168.1.81: icmp_seq=3 ttl=63 time=1.43 ms
64 bytes from 192.168.1.81: icmp_seq=4 ttl=63 time=1.46 ms

--- 192.168.1.81 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 1.424/2.662/6.336/2.121 ms
tduy@ubuntu-server:~$ ping -c 4 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=62 time=2.34 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=62 time=1.65 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=62 time=1.94 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=62 time=1.76 ms

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 1.650/1.923/2.344/0.263 ms
```

7. Kết quả VM2 ping tới VM3 và VM4 thành công

```
tduy@ubuntu-server:~$ ping 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=63 time=1.98 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=63 time=1.38 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=63 time=1.43 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=63 time=1.40 ms
64 bytes from 10.0.0.2: icmp_seq=5 ttl=63 time=1.39 ms
^C
--- 10.0.0.2 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4005ms
rtt min/avg/max/mdev = 1.381/1.515/1.975/0.230 ms
tduy@ubuntu-server:~$ ping -c 4 192.168.1.81
PING 192.168.1.81 (192.168.1.81) 56(84) bytes of data.
64 bytes from 192.168.1.81: icmp_seq=1 ttl=64 time=0.872 ms
64 bytes from 192.168.1.81: icmp_seq=2 ttl=64 time=0.839 ms
64 bytes from 192.168.1.81: icmp_seq=3 ttl=64 time=0.709 ms
64 bytes from 192.168.1.81: icmp_seq=4 ttl=64 time=0.951 ms

--- 192.168.1.81 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
```

8. Reboot lại VM2 thì hệ thống vẫn hoạt động bình thường (sau khi vào OS) do có cấu hình trong crontab

```
tduy@ubuntu-server:~$ ping -c 4 10.0.0.2
PING 10.0.0.2 (10.0.0.2) 56(84) bytes of data.
64 bytes from 10.0.0.2: icmp_seq=1 ttl=62 time=2.89 ms
64 bytes from 10.0.0.2: icmp_seq=2 ttl=62 time=1.44 ms
64 bytes from 10.0.0.2: icmp_seq=3 ttl=62 time=2.02 ms
64 bytes from 10.0.0.2: icmp_seq=4 ttl=62 time=2.20 ms

--- 10.0.0.2 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 1.443/2.137/2.887/0.515 ms
tduy@ubuntu-server:~$ ping -c 4 192.168.1.81
PING 192.168.1.81 (192.168.1.81) 56(84) bytes of data.
64 bytes from 192.168.1.81: icmp_seq=1 ttl=63 time=1.21 ms
64 bytes from 192.168.1.81: icmp_seq=2 ttl=63 time=0.877 ms
64 bytes from 192.168.1.81: icmp_seq=3 ttl=63 time=0.813 ms
64 bytes from 192.168.1.81: icmp_seq=4 ttl=63 time=1.06 ms

--- 192.168.1.81 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
```