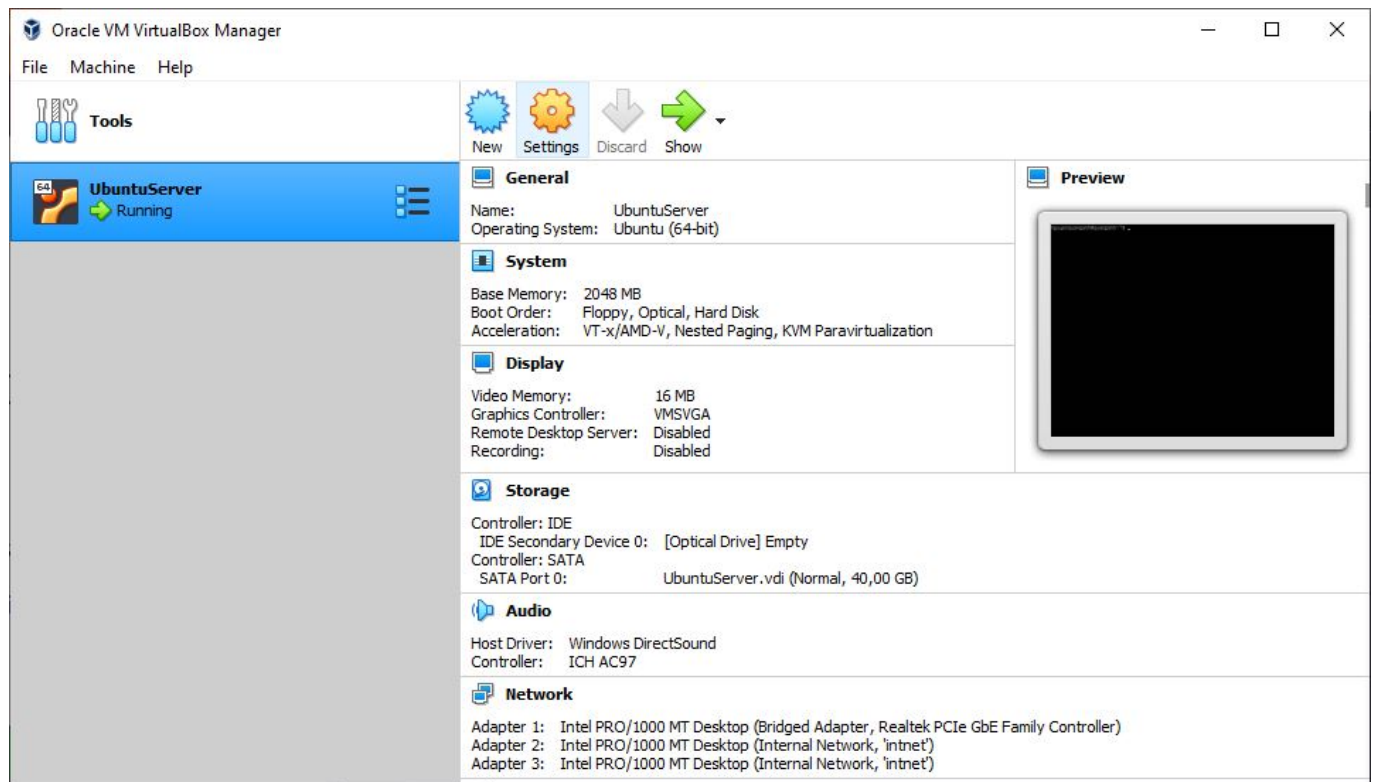
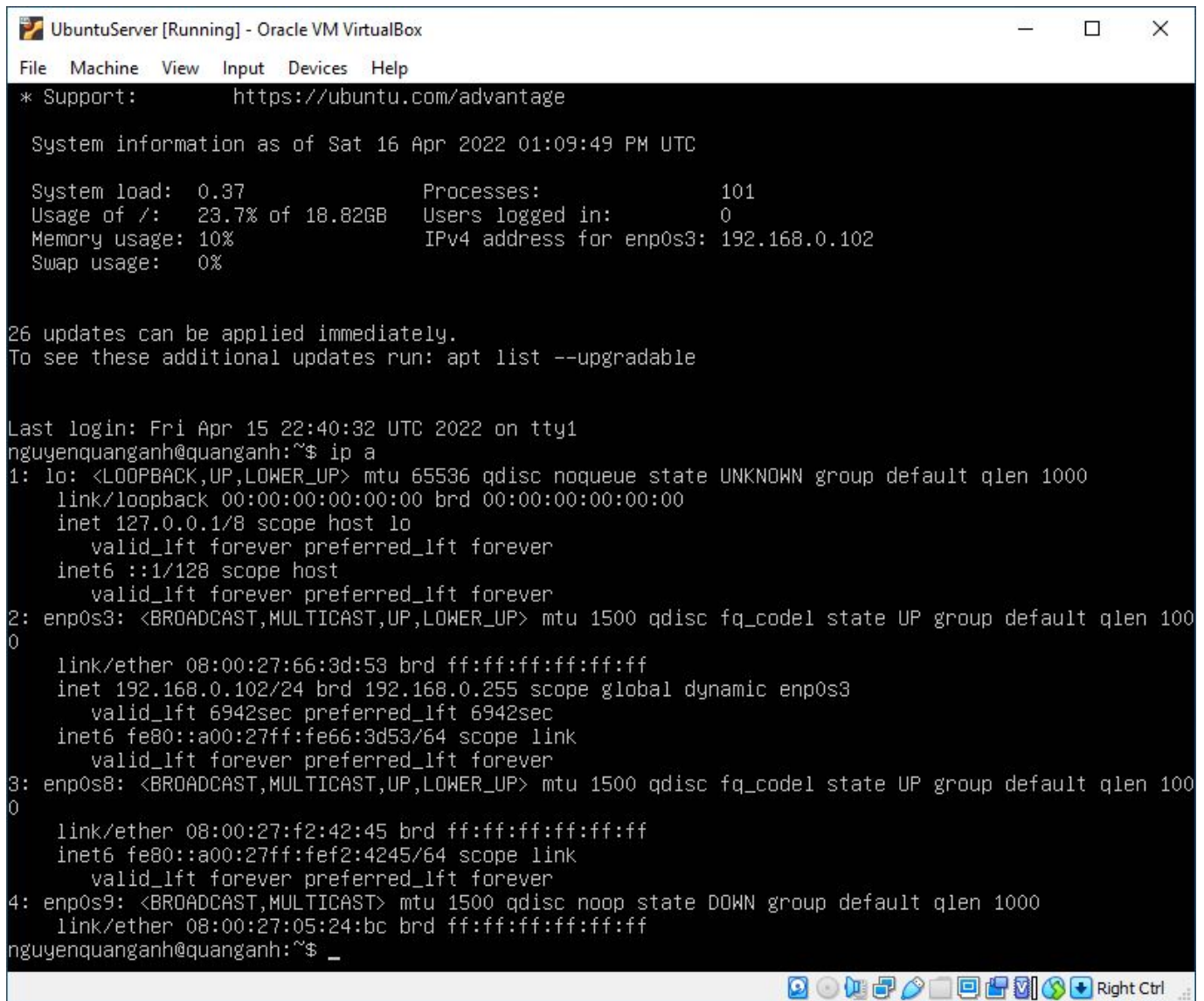


Setup

- Download VirtualBox
- Download Ubuntu Server: <https://ubuntu.com/download/server>
- Setup initial virtual machine



- To change network name to "eth0" for convenience, first to get the interface's information, use `ip a`



```
UbuntuServer [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
* Support: https://ubuntu.com/advantage

System information as of Sat 16 Apr 2022 01:09:49 PM UTC

System load: 0.87          Processes:           101
Usage of /: 23.7% of 18.82GB Users logged in:      0
Memory usage: 10%          IPv4 address for enp0s3: 192.168.0.102
Swap usage: 0%

26 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Last login: Fri Apr 15 22:40:32 UTC 2022 on tty1
nguyenquanganh@quanganh:~$ 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: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:66:3d:53 brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.102/24 brd 192.168.0.255 scope global dynamic enp0s3
        valid_lft 6942sec preferred_lft 6942sec
    inet6 fe80::a00:27ff:fe66:3d53/64 scope link
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:f2:42:45 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::a00:27ff:fef2:4245/64 scope link
        valid_lft forever preferred_lft forever
4: enp0s9: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN group default qlen 1000
    link/ether 08:00:27:05:24:bc brd ff:ff:ff:ff:ff:ff
nguyenquanganh@quanganh:~$ _
```

- From the `dmesg` command, you can see that the device got renamed during the system boot

```
dmesg | grep -i eth
```

```

UbuntuServer [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
26 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Last login: Sat Apr 16 13:09:49 UTC 2022 on tty1
nguyenquanganh@quanganh:~$ 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: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:66:3d:53 brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.102/24 brd 192.168.0.255 scope global dynamic enp0s3
        valid_lft 7060sec preferred_lft 7060sec
    inet6 fe80::a00:27ff:fe66:3d53/64 scope link
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:f2:42:45 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::a00:27ff:fef2:4245/64 scope link
        valid_lft forever preferred_lft forever
4: enp0s9: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN group default qlen 1000
    link/ether 08:00:27:05:24:bc brd ff:ff:ff:ff:ff:ff
nguyenquanganh@quanganh:~$ dmesg | grep -i eth
[ 1.933808] e1000 0000:00:03.0 eth0: (PCI:33MHz:32-bit) 08:00:27:66:3d:53
[ 1.934456] e1000 0000:00:03.0 eth0: Intel(R) PRO/1000 Network Connection
[ 2.333848] e1000 0000:00:08.0 eth1: (PCI:33MHz:32-bit) 08:00:27:f2:42:45
[ 2.334479] e1000 0000:00:08.0 eth1: Intel(R) PRO/1000 Network Connection
[ 2.733965] e1000 0000:00:09.0 eth2: (PCI:33MHz:32-bit) 08:00:27:05:24:bc
[ 2.734625] e1000 0000:00:09.0 eth2: Intel(R) PRO/1000 Network Connection
[ 2.737359] e1000 0000:00:08.0 enp0s8: renamed from eth1
[ 2.738743] e1000 0000:00:09.0 enp0s9: renamed from eth2
[ 2.743935] e1000 0000:00:03.0 enp0s3: renamed from eth0
nguyenquanganh@quanganh:~$

```

- To get an ethX back, edit the grub file:

```
sudo nano /etc/default/grub
```

Enter your password, look for "GRUB_CMDLINE_LINUX" then change

From:

```
GRUB_CMDLINE_LINUX=""
```

Change to:

```
GRUB_CMDLINE_LINUX="net.ifnames=0 biosdevname=0"
```

```

GNU nano 4.8 /etc/default/grub
# If you change this file, run 'update-grub' afterwards to update
# /boot/grub/grub.cfg.
# For full documentation of the options in this file, see:
# info -f grub -n 'Simple configuration'

GRUB_DEFAULT=0
GRUB_TIMEOUT_STYLE=hidden
GRUB_TIMEOUT=0
GRUB_DISTRIBUTOR=`lsb_release -i -s 2> /dev/null || echo Debian`
GRUB_CMDLINE_LINUX_DEFAULT="maybe-ubiquity"
GRUB_CMDLINE_LINUX="net.ifnames=0 biosdevname=0"

# Uncomment to enable BadRAM filtering, modify to suit your needs
# This works with Linux (no patch required) and with any kernel that obtains
# the memory map information from GRUB (GNU Mach, kernel of FreeBSD ...)
#GRUB_BADRAM="0x01234567,0xfefefefe,0x89abcdef,0xefefefef"

# Uncomment to disable graphical terminal (grub-pc only)
#GRUB_TERMINAL=console

# The resolution used on graphical terminal
# note that you can use only modes which your graphic card supports via VBE
# you can see them in real GRUB with the command `vbeinfo'
#GRUB_GFXMODE=640x480

# Uncomment if you don't want GRUB to pass "root=UUID=xxx" parameter to Linux
#GRUB_DISABLE_LINUX_UUID=true

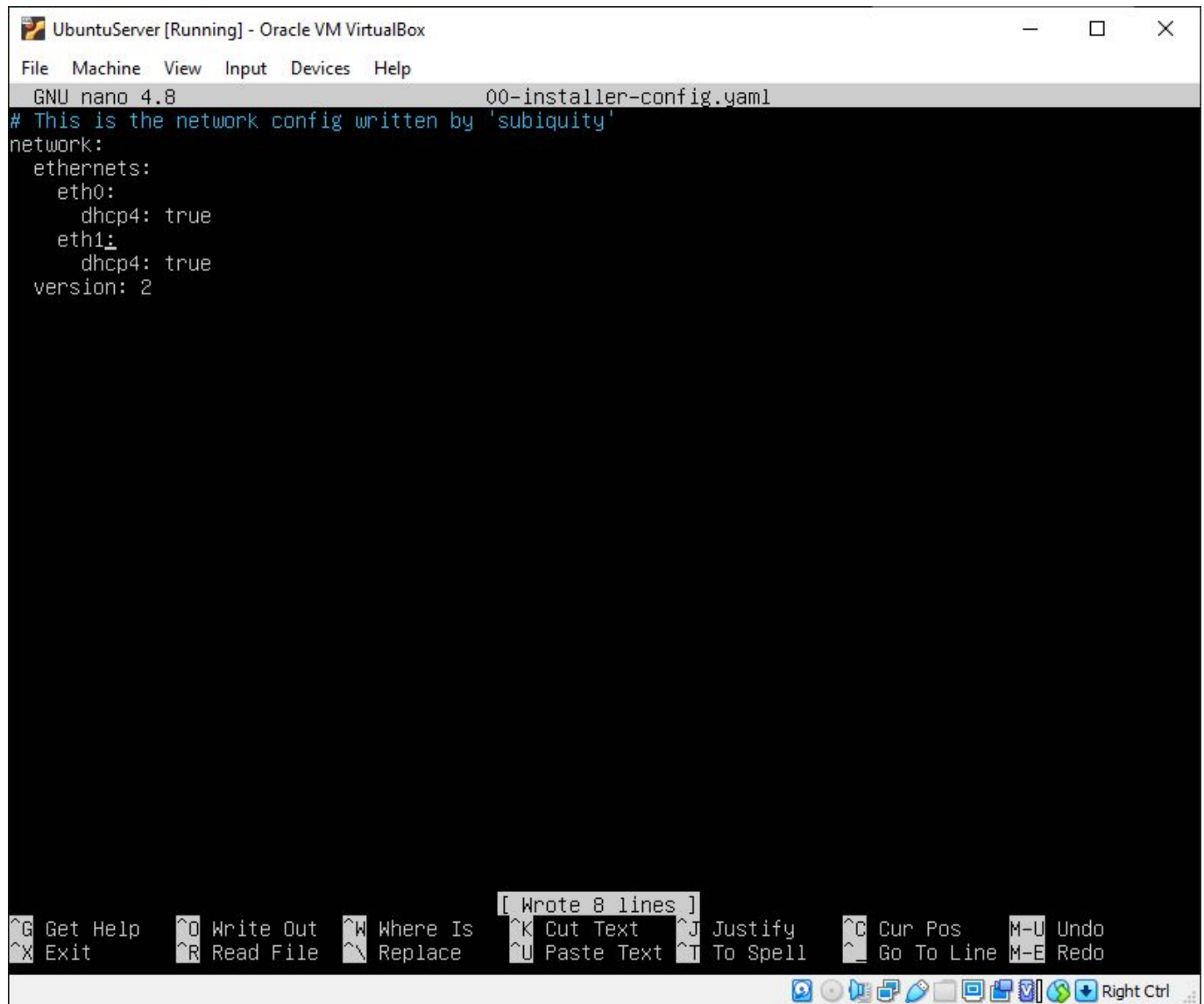
# Uncomment to disable generation of recovery mode menu entries
#GRUB_DISABLE_RECOVERY="true"

# Uncomment to get a beep at grub start
#GRUB_INIT_TUNE="480 440 1"

```

Note: save file

- Finally, edit the interface file in /etc/netplan (using `cd /`, then `cd etc/netplan/` and `ls` to get filename `00-network-manager-all.yaml`) and change the network device name so that you will have a DHCP or static IP address for eth0, eth1 and eth2 (using `sudo nano 00-network-manager-all.yaml`)



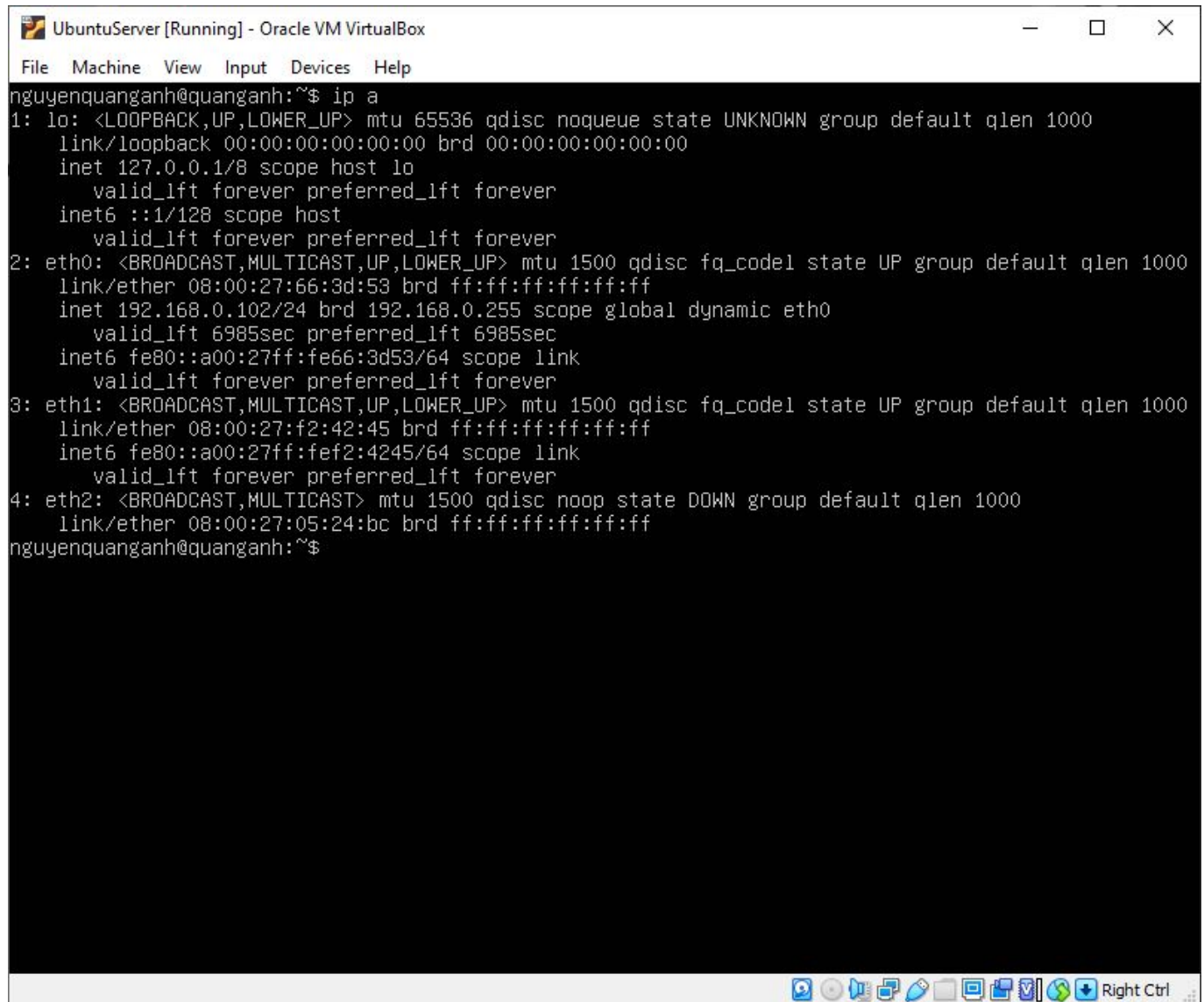
The screenshot shows a VirtualBox window titled "UbuntuServer [Running] - Oracle VM VirtualBox". Inside the window, the GNU nano 4.8 text editor is open, editing a file named "00-installer-config.yaml". The editor's menu bar includes "File", "Machine", "View", "Input", "Devices", and "Help". The content of the file is a network configuration in YAML format:

```
# This is the network config written by 'subiquity'
network:
  ethernets:
    eth0:
      dhcp4: true
    eth1:
      dhcp4: true
  version: 2
```

The nano editor's status bar at the bottom displays various keyboard shortcuts for navigation and editing, such as ^G for Get Help, ^O for Write Out, ^W for Where Is, ^K for Cut Text, ^J for Justify, ^C for Cur Pos, M-U for Undo, ^X for Exit, ^R for Read File, ^_ for Replace, ^U for Paste Text, ^T for To Spell, ^_ for Go To Line, and M-E for Redo. A message "[Wrote 8 lines]" is also visible in the status bar. The bottom of the window features a standard Linux desktop taskbar with icons for applications and system utilities, including a "Right Ctrl" button.

Reboot device after changing

The result is:



```
nguyenquanganh@quanganh:~$ 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: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:66:3d:53 brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.102/24 brd 192.168.0.255 scope global dynamic eth0
        valid_lft 6985sec preferred_lft 6985sec
    inet6 fe80::a00:27ff:fe66:3d53/64 scope link
        valid_lft forever preferred_lft forever
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:f2:42:45 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::a00:27ff:fe66:3d53/64 scope link
        valid_lft forever preferred_lft forever
4: eth2: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN group default qlen 1000
    link/ether 08:00:27:05:24:bc brd ff:ff:ff:ff:ff:ff
nguyenquanganh@quanganh:~$
```

Configure 6 interfaces by the command

- Flush the device before bringing it up

```
sudo ip addr flush dev eth0
```

- You should clone virtual machine to 4 VMs, choose Generate new MAC addresses for all network adapters
- Configure 6 interfaces by the command:

```
PCA: sudo ip -6 addr add 2001:2::10/64 dev eth1
PCB: sudo ip -6 addr add 2001:3::10/64 dev eth1
Router1: sudo ip -4 addr add 129.175.1.1 dev eth2
          sudo ip -6 addr add 2001:2::1/64 dev eth1
Router2: sudo ip -4 addr add 129.175.1.2 dev eth2
          sudo ip -6 addr add 2001:3::1/64 dev eth1
```

where -6 represents the ipv6 network, eth0 is the device's name and **2001:2::/64** is the inet6 prefix.

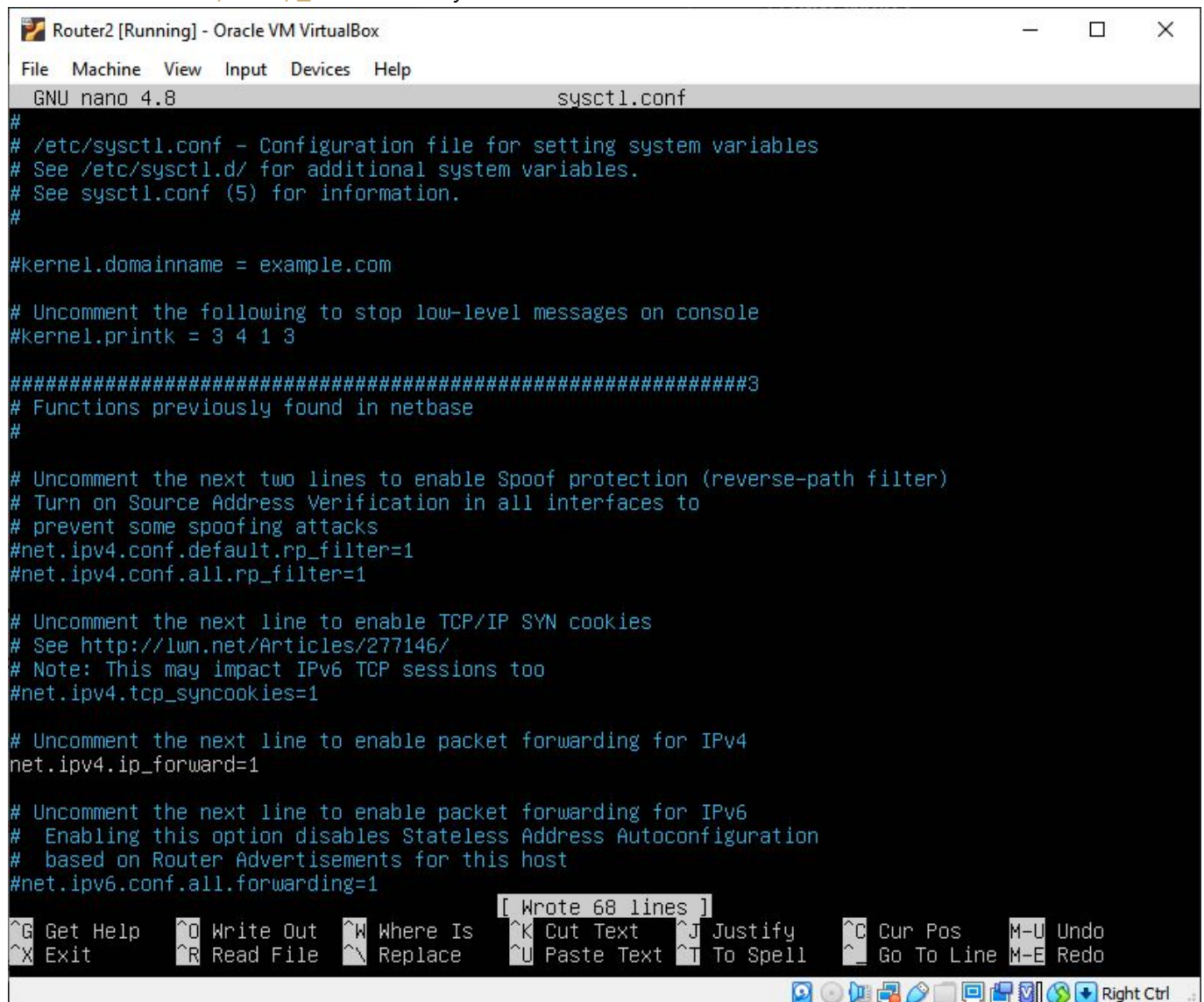
Activate devices (both Router1 and Router2)

```
sudo ip link set eth1 up
sudo ip link set eth2 up
```

Enable forwarding:

```
cd /
cd etc/
sudo nano sysctl.conf
```

Uncomment **net.ipv4.ip_forward=1** by delete # before that line



```
Router2 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
GNU nano 4.8 sysctl.conf
#
# /etc/sysctl.conf - Configuration file for setting system variables
# See /etc/sysctl.d/ for additional system variables.
# See sysctl.conf (5) for information.
#
#kernel.domainname = example.com
# Uncomment the following to stop low-level messages on console
#kernel.printk = 3 4 1 3
#####3
# Functions previously found in netbase
#
# Uncomment the next two lines to enable Spoof protection (reverse-path filter)
# Turn on Source Address Verification in all interfaces to
# prevent some spoofing attacks
#net.ipv4.conf.default.rp_filter=1
#net.ipv4.conf.all.rp_filter=1
#
# Uncomment the next line to enable TCP/IP SYN cookies
# See http://lwn.net/Articles/277146/
# Note: This may impact IPv6 TCP sessions too
#net.ipv4.tcp_syncookies=1
#
# Uncomment the next line to enable packet forwarding for IPv4
net.ipv4.ip_forward=1
#
# Uncomment the next line to enable packet forwarding for IPv6
# Enabling this option disables Stateless Address Autoconfiguration
# based on Router Advertisements for this host
#net.ipv6.conf.all.forwarding=1
[Wrote 68 lines]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos M-U Undo
^X Exit ^R Read File ^\ Replace ^U Paste Text ^T To Spell ^_ Go To Line M-E Redo
Right Ctrl
```

Configure the tunnel between the two border routers

Write the command line to add the remote of IPv4 address to the tunnel in order to create a IPv6-in-IPv4 tunnel

- Router1: `$ sudo ip tunnel add tunnell mode sit remote 129.175.1.2 local 129.175.1.1 ttl 255`
- Router2: `$ sudo ip tunnel add tunnell mode sit remote 129.175.1.1 local 129.175.1.2 ttl 255`

To activate the tunnel, we use the command:

```
ip link set tunnell up
```

When finish, the tunnel will be show as an interface in ifconfig

- To add ipv6 address to the tunnel, use `sudo ip addr add 2001:2::/64 dev tunnell`

Configure routing tables on all PCs

To flush all routes on the routing tables, the ip command options route flush table main are used. The full commands to run are:

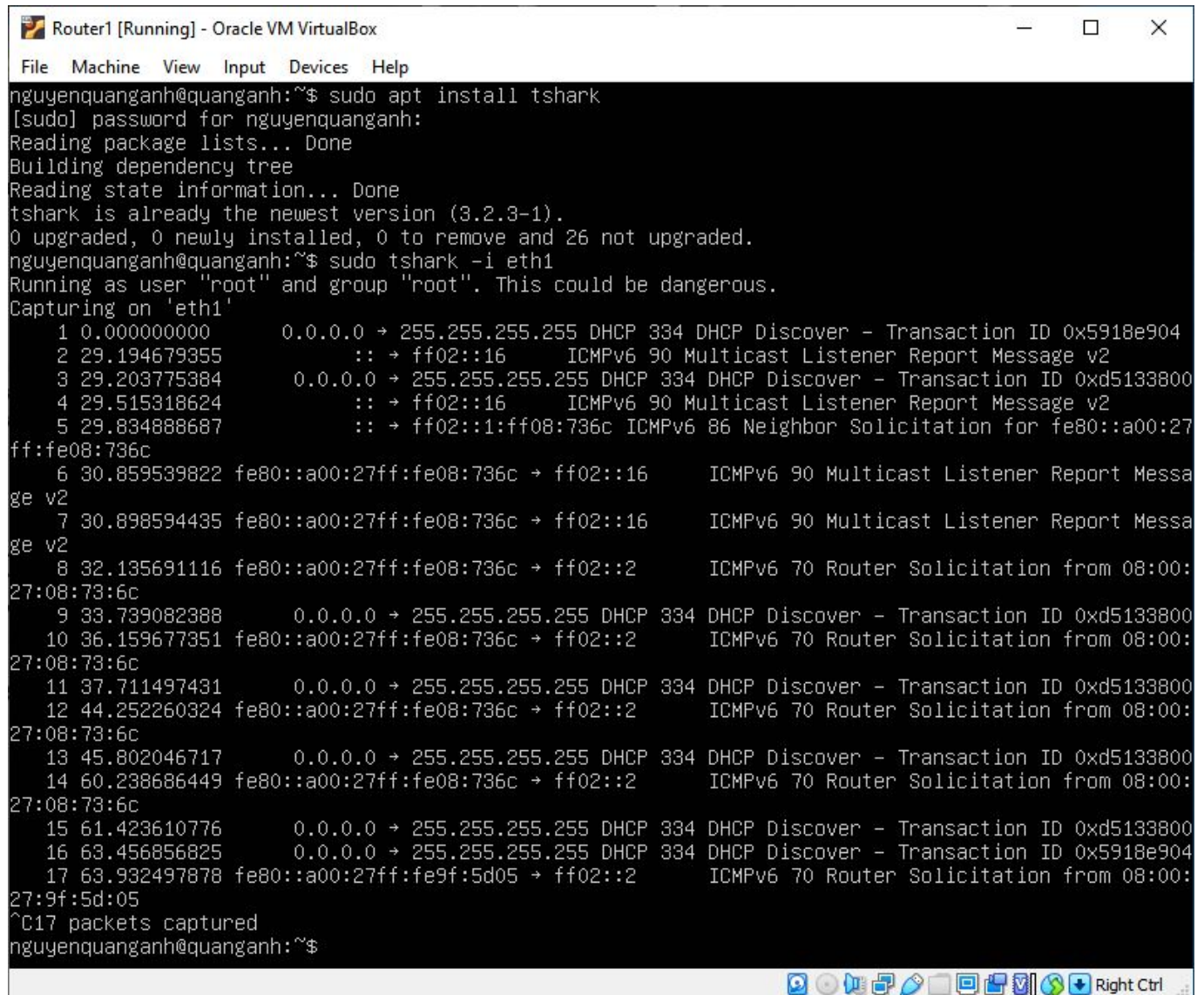
```
sudo ip route flush table main  
ip route show
```

Observe with Wireshark

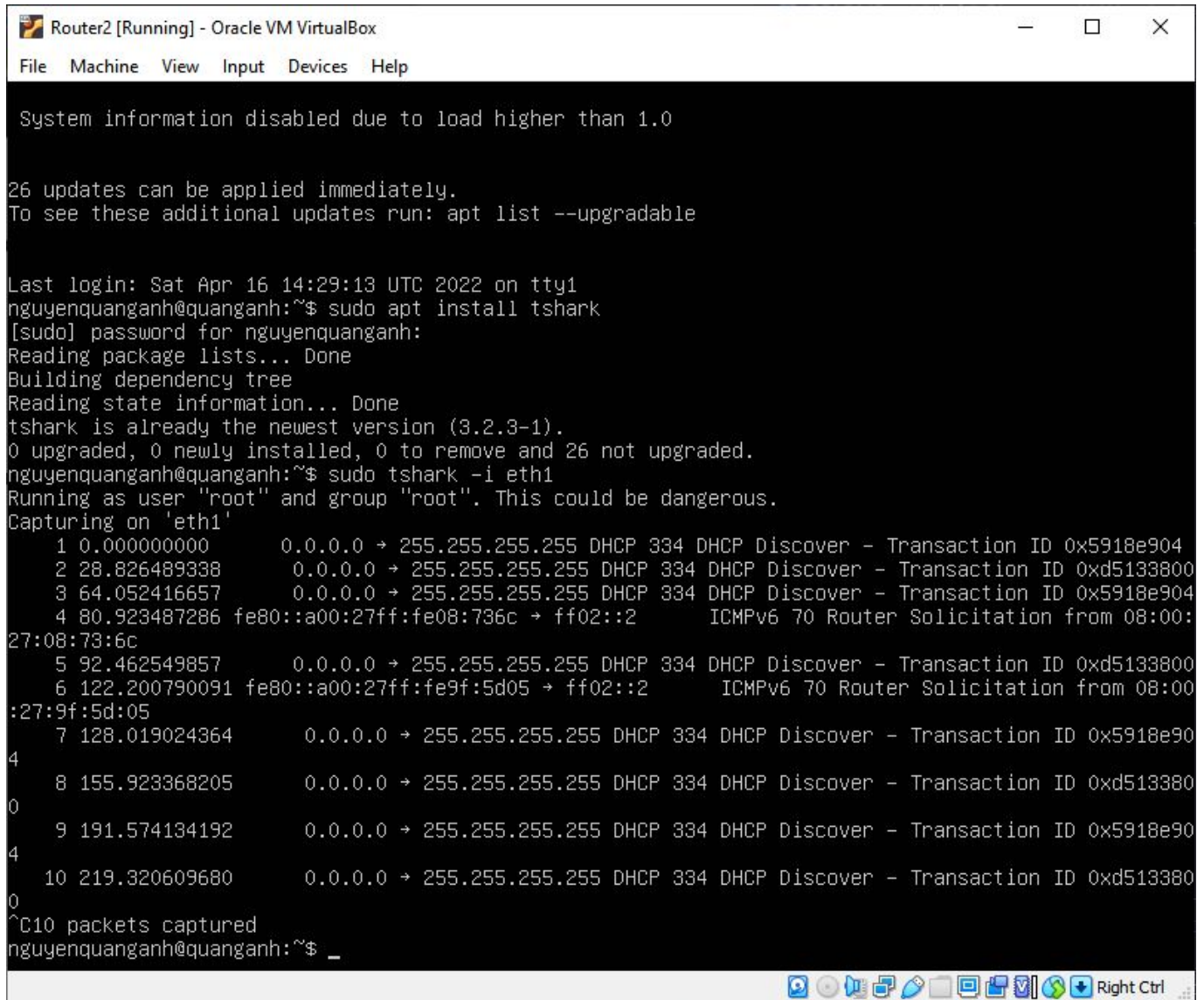
For Router1 or Router2

```
sudo apt install tshark  
sudo tshark -i eth1
```


The results are:



```
Router1 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
nguyenquanganh@quanganh:~$ sudo apt install tshark
[sudo] password for nguyenquanganh:
Reading package lists... Done
Building dependency tree
Reading state information... Done
tshark is already the newest version (3.2.3-1).
0 upgraded, 0 newly installed, 0 to remove and 26 not upgraded.
nguyenquanganh@quanganh:~$ sudo tshark -i eth1
Running as user "root" and group "root". This could be dangerous.
Capturing on 'eth1'
  1 0.000000000 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0x5918e904
  2 29.194679355 :: → ff02::16 ICMPv6 90 Multicast Listener Report Message v2
  3 29.203775384 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd5133800
  4 29.515318624 :: → ff02::16 ICMPv6 90 Multicast Listener Report Message v2
  5 29.834888687 :: → ff02::1:ff08:736c ICMPv6 86 Neighbor Solicitation for fe80::a00:27
ff:fe08:736c
  6 30.859539822 fe80::a00:27ff:fe08:736c → ff02::16 ICMPv6 90 Multicast Listener Report Messa
ge v2
  7 30.898594435 fe80::a00:27ff:fe08:736c → ff02::16 ICMPv6 90 Multicast Listener Report Messa
ge v2
  8 32.135691116 fe80::a00:27ff:fe08:736c → ff02::2 ICMPv6 70 Router Solicitation from 08:00:
27:08:73:6c
  9 33.739082388 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd5133800
 10 36.159677351 fe80::a00:27ff:fe08:736c → ff02::2 ICMPv6 70 Router Solicitation from 08:00:
27:08:73:6c
 11 37.711497431 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd5133800
 12 44.252260324 fe80::a00:27ff:fe08:736c → ff02::2 ICMPv6 70 Router Solicitation from 08:00:
27:08:73:6c
 13 45.802046717 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd5133800
 14 60.238686449 fe80::a00:27ff:fe08:736c → ff02::2 ICMPv6 70 Router Solicitation from 08:00:
27:08:73:6c
 15 61.423610776 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd5133800
 16 63.456856825 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0x5918e904
 17 63.932497878 fe80::a00:27ff:fe9f:5d05 → ff02::2 ICMPv6 70 Router Solicitation from 08:00:
27:9f:5d:05
^C17 packets captured
nguyenquanganh@quanganh:~$
```



The screenshot shows a terminal window titled "Router2 [Running] - Oracle VM VirtualBox". The terminal output includes system information, update notifications, login details, and the execution of 'apt install tshark' and 'tshark -i eth1'. It then displays a list of captured network packets, including DHCP Discover and ICMPv6 Router Solicitation messages. The terminal ends with a Ctrl-C signal and the prompt 'nguyenquanganh@quanganh:~\$ _'.

```
Router2 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

System information disabled due to load higher than 1.0

26 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Last login: Sat Apr 16 14:29:13 UTC 2022 on tty1
nguyenquanganh@quanganh:~$ sudo apt install tshark
[sudo] password for nguyenquanganh:
Reading package lists... Done
Building dependency tree
Reading state information... Done
tshark is already the newest version (3.2.3-1).
0 upgraded, 0 newly installed, 0 to remove and 26 not upgraded.
nguyenquanganh@quanganh:~$ sudo tshark -i eth1
Running as user "root" and group "root". This could be dangerous.
Capturing on 'eth1'
  1 0.000000000 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0x5918e904
  2 28.826489338 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd5133800
  3 64.052416657 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0x5918e904
  4 80.923487286 fe80::a00:27ff:fe08:736c → ff02::2 ICMPv6 70 Router Solicitation from 08:00:
27:08:73:6c
  5 92.462549857 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd5133800
  6 122.200790091 fe80::a00:27ff:fe9f:5d05 → ff02::2 ICMPv6 70 Router Solicitation from 08:00
:27:9f:5d:05
  7 128.019024364 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0x5918e90
4
  8 155.923368205 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd513380
0
  9 191.574134192 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0x5918e90
4
 10 219.320609680 0.0.0.0 → 255.255.255.255 DHCP 334 DHCP Discover - Transaction ID 0xd513380
0
^C10 packets captured
nguyenquanganh@quanganh:~$ _
```