

**LAB 3**  
**CONSTRUCT A SIMPLE NETWORK**



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*Submission: an ID\_NAME\_Lab03.pdf file describes clearly how did you solve the problem*

**Exercise 12:**

**Solution:**

**Files:**

A screenshot of a Linux desktop environment, specifically Ubuntu, running in Oracle VM VirtualBox. The desktop interface includes a dock with icons for the Dash, Home, Applications, and Help. A terminal window is open, showing the command 'tree' being run in a directory structure. The terminal output shows the following directory tree:

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise12$ tree
.
├── lab.conf
├── LICENSE
└── r1
    └── etc
        └── quagga
            ├── daemons
            ├── ripd.conf
            └── zebra.conf
├── r1.startup
└── r2
    └── etc
        └── quagga
            ├── daemons
            ├── ripd.conf
            └── zebra.conf
├── r2.startup
└── r3
    └── etc
        └── quagga
            ├── daemons
            └── ripd.conf
```

The terminal window has a dark theme and is titled 'Terminal'. The user's name 'ubuntub2206008' and session information are visible at the top of the window.

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal

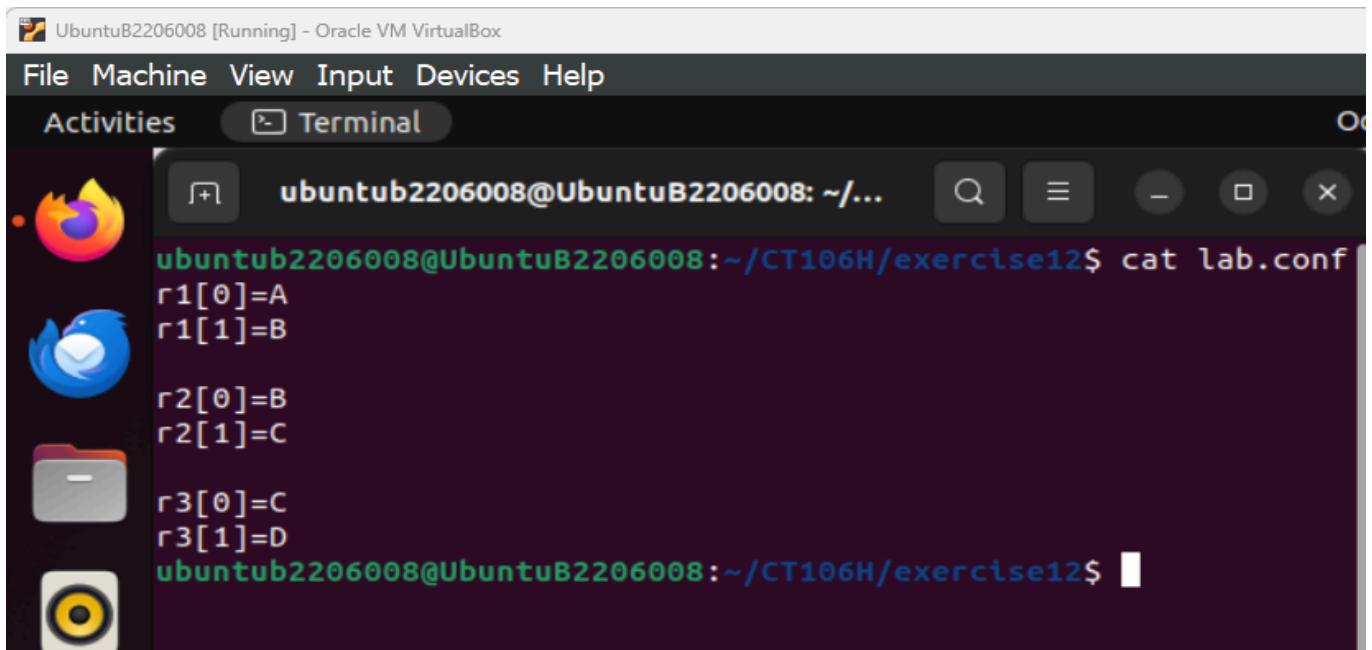
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12\$ cat lab.conf

```
r1[0]=A
r1[1]=B

r2[0]=B
r2[1]=C

r3[0]=C
r3[1]=D
```

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12\$



UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12\$ cat r1.start

```
up
ifconfig eth0 100.0.0.1/24 up
ifconfig eth1 150.0.0.1/30 up
/etc/init.d/zebra start
```

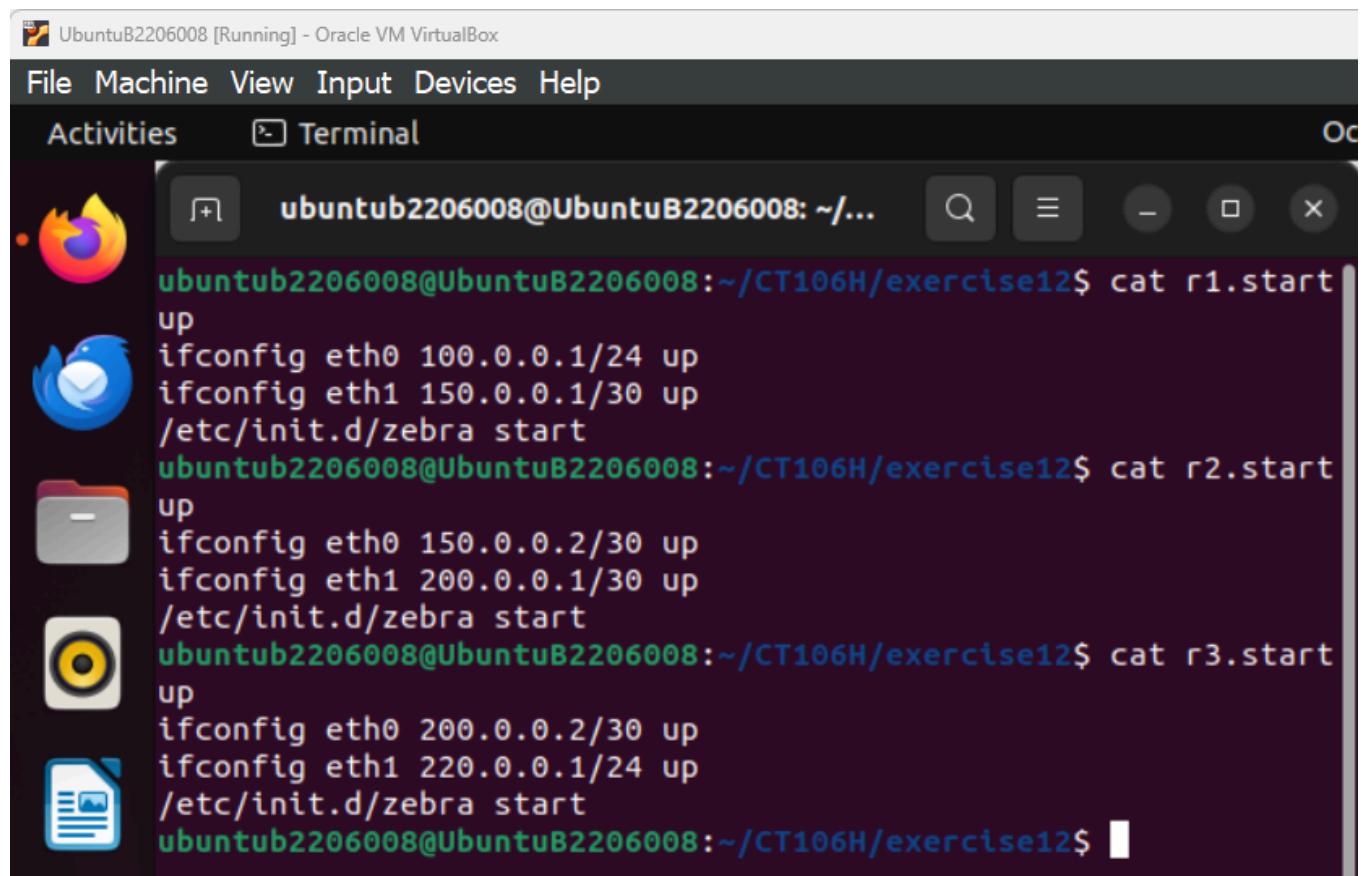
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12\$ cat r2.start

```
up
ifconfig eth0 150.0.0.2/30 up
ifconfig eth1 200.0.0.1/30 up
/etc/init.d/zebra start
```

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12\$ cat r3.start

```
up
ifconfig eth0 200.0.0.2/30 up
ifconfig eth1 220.0.0.1/24 up
/etc/init.d/zebra start
```

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12\$



UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal

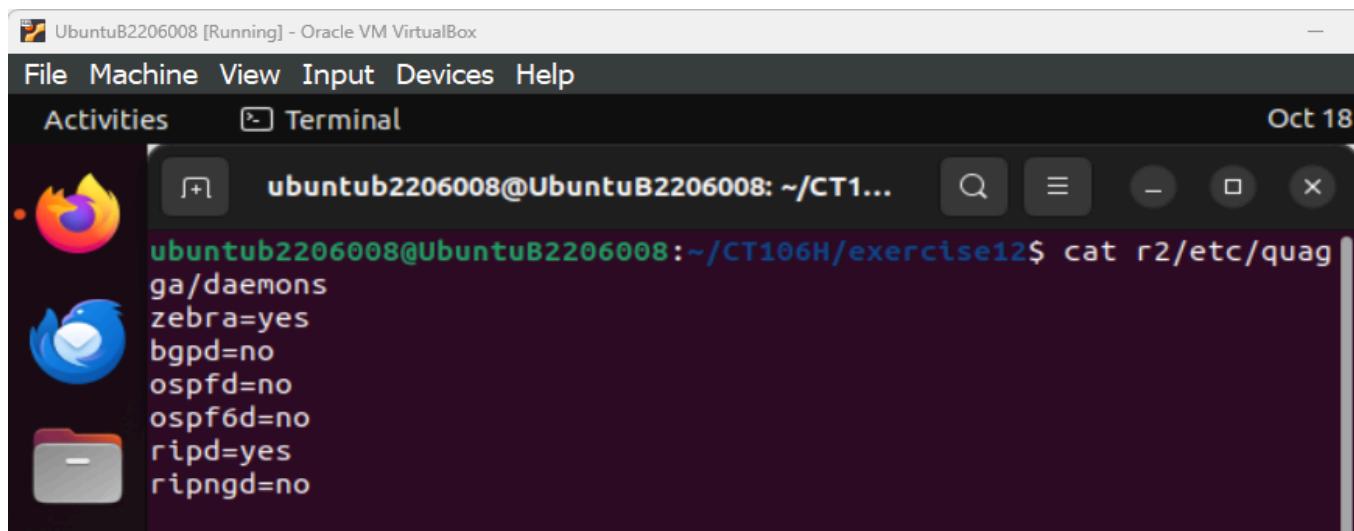
```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise12$ cat r1/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise12$ cat r1/etc/quagga/ripd.conf
!
hostname ripd
password zebra
enable password zebra
!
router rip
redistribute connected
network eth0
network eth1
!
log file /var/log/quagga/ripd.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise12$ cat r1/etc/quagga/zebra.conf
! -*- zebra -*-
!
! zebra configuration file
!
hostname zebra
password zebra
enable password zebra
!
! Static default route sample.
!
!ip route 0.0.0.0/0 203.181.89.241
!
log file /var/log/quagga/zebra.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise12$
```

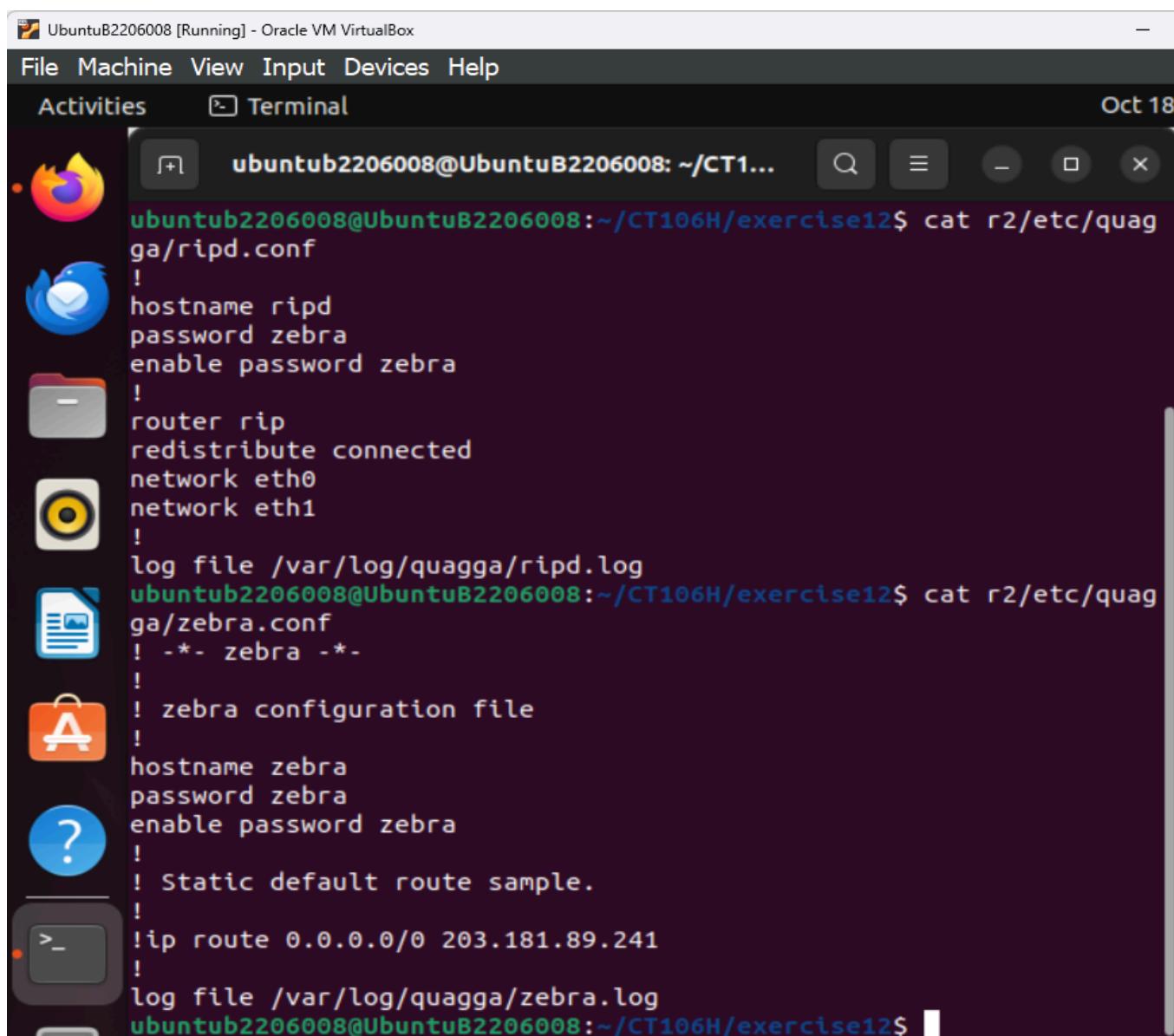


UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 18

```
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12$ cat r2/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no
```

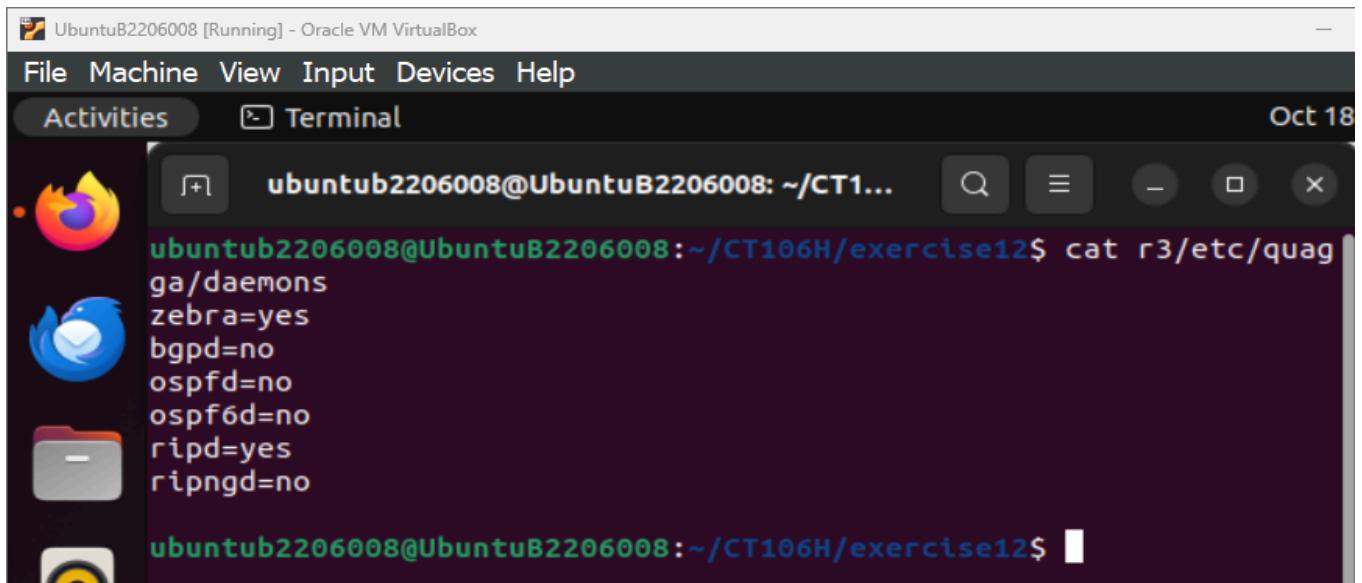


UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 18

```
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12$ cat r2/etc/quagga/ripd.conf
!
hostname ripd
password zebra
enable password zebra
!
router rip
redistribute connected
network eth0
network eth1
!
log file /var/log/quagga/ripd.log
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12$ cat r2/etc/quagga/zebra.conf
! -*- zebra -*-
!
! zebra configuration file
!
hostname zebra
password zebra
enable password zebra
!
! Static default route sample.
!
!ip route 0.0.0.0/0 203.181.89.241
!
log file /var/log/quagga/zebra.log
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12$
```



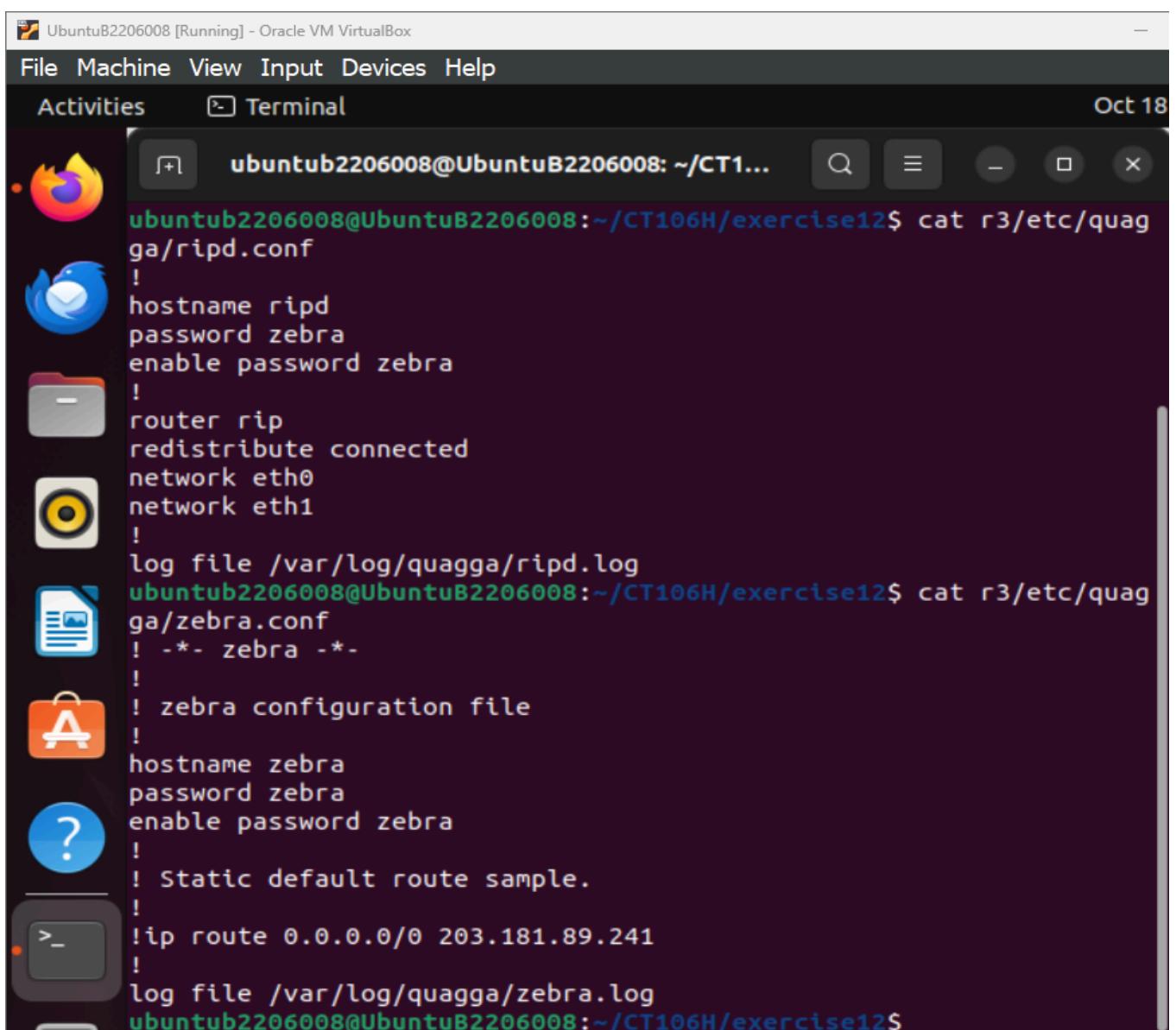
UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 18

```
ubuntub2206008@UbuntuB2206008: ~/CT1...$ cat r3/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12$
```



UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 18

```
ubuntub2206008@UbuntuB2206008: ~/CT1...$ cat r3/etc/quagga/ripd.conf
!
hostname ripd
password zebra
enable password zebra
!
router rip
redistribute connected
network eth0
network eth1
!
log file /var/log/quagga/ripd.log
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12$ cat r3/etc/quagga/zebra.conf
! -*- zebra -*-
!
! zebra configuration file
!
hostname zebra
password zebra
enable password zebra
!
! Static default route sample.
!
!ip route 0.0.0.0/0 203.181.89.241
!
log file /var/log/quagga/zebra.log
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise12$
```

- Start Scenario

The screenshot shows a Linux desktop environment within Oracle VM VirtualBox. On the left, there is a dock with icons for a browser, file manager, terminal, and help. Three terminal windows are open in the background:

- root@r3: /**: Shows startup logs for router r3, including interface configuration (ifconfig eth0 100.0.0.1/24 up) and Quagga daemon startup (zebra, ripd, watchquagga).
- root@r2: /**: Shows startup logs for router r2.
- root@r1: /**: Shows startup logs for router r1.

The terminal window for r1 is active, displaying the command "root@r1:/#".

```
[Down] --- Startup Commands Log
[Down] Starting ifconfig eth0 100.0.0.1/24 up
[Down] Starting ifconfig eth1 150.0.0.1/30 up
[Down] --- End /etc/init.d/zebra start
[Down] Starting Quagga daemons (prio:10): zebra ripd.
[Down] Starting Quagga monitor daemon: watchquagga.
[Down] --- End Startup Commands Log
[Down] root@r1:/#
```

- Test route table

Route -n

The screenshot shows three terminal windows side-by-side, each running on an Ubuntu 8.04 LTS system (as indicated by the desktop icons). The windows are titled 'root@r1:/', 'root@r2:/', and 'root@r3:/'. Each window displays the output of the 'route -n' command, showing the kernel IP routing table.

**root@r1:/**

```
--- Startup Commands Log
++ ifconfig eth0 100.0.0.1/24 up
++ ifconfig eth1 150.0.0.1/30 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r1:/# route -n
Kernel IP routing table
Destination     Gateway      Genmask       Flags Metric Ref
se Iface
100.0.0.0        0.0.0.0    255.255.255.0   U      0      0
0 eth0
150.0.0.0        0.0.0.0    255.255.255.252 U      0      0
0 eth1
200.0.0.0        150.0.0.2   255.255.255.252 UG     20      0
0 eth1
220.0.0.0        150.0.0.2   255.255.255.0   UG     20      0
0 eth1
root@r1:/# []
```

**root@r3:/**

```
--- Startup Commands Log
++ ifconfig eth0 200.0.0.2/30 up
++ ifconfig eth1 220.0.0.1/24 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r3:/# route -n
Kernel IP routing table
U Destination     Gateway      Genmask       Flags Metric Ref
Use Iface
100.0.0.0        200.0.0.1   255.255.255.0   UG      20      0
0 eth0
150.0.0.0        200.0.0.1   255.255.255.252 UG      20      0
0 eth0
200.0.0.0        0.0.0.0    255.255.255.252 UG      0      0
0 eth0
220.0.0.0        0.0.0.0    255.255.255.0   UG      0      0
0 eth1
root@r3:/# []
```

**root@r2:/**

```
--- Startup Commands Log
++ ifconfig eth0 150.0.0.2/30 up
++ ifconfig eth1 200.0.0.1/30 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r2:/# route -n
Kernel IP routing table
Destination     Gateway      Genmask       Flags Metric Ref
se Iface
100.0.0.0        150.0.0.1   255.255.255.0   UG     20      0
0 eth0
150.0.0.0        0.0.0.0    255.255.255.252 U      0      0
0 eth0
200.0.0.0        0.0.0.0    255.255.255.252 UG     0      0
0 eth1
220.0.0.0        200.0.0.2   255.255.255.0   UG     20      0
0 eth1
root@r2:/# []
```

The rightmost terminal window shows a series of commands being run:

```
100% 0:00:00
100% 0:00:00
100% 0:00:00
100% 0:00:00
100% 0:00:00
100% 0:00:00
100% 0:00:00
100% 0:00:00
3/3
12$ gedit r{1..3}.startup
12$ kathara lrestart
Stopping Network Scenario
```

### - Sniffing

```
Tcpdump -i any -w /shared/Ex12_r1.pcap
```

```
Ping 100.0.0.1
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

root@r1: /

```
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r1:/# route -n
Kernel IP routing table
Destination     Gateway      Genmask      Flags Metric Ref
          Use Iface
100.0.0.0    0.0.0.0    255.255.255.0 U         0      0
              0 eth0
150.0.0.0    0.0.0.0    255.255.255.252 U        20      0
              0 eth1
200.0.0.0   150.0.0.2   255.255.255.252 UG       20      0
              0 eth1
220.0.0.0   150.0.0.2   255.255.255.0 UG       20      0
              0 eth1
root@r1:/# tcpdump -i any -w /shared/Ex12_r1.pcap
tcpdump: data link type LINUX_SLL2
tcpdump: listening on any, link-type LINUX_SLL2 (Linux cooked v2), sn 64 bytes from 100.0.0.1: icmp_seq=1 ttl=63 time=7.45 ms
^C17 packets captured
17 packets received by filter
0 packets dropped by kernel
root@r1:/#
```

root@r3: /

```
root@r3:/# route -n
Kernel IP routing table
Destination     Gateway      Genmask      Flags Metric Ref
          Use Iface
100.0.0.0    200.0.0.1  255.255.255.0 UG     20      0
              0 eth0
150.0.0.0    200.0.0.1  255.255.255.252 UG     20      0
              0 eth0
200.0.0.0    0.0.0.0    255.255.255.252 UG     0      0
              0 eth0
220.0.0.0    0.0.0.0    255.255.255.0 UG     0      0
              0 eth1
root@r3:/# ping 100.0.0.1
PING 100.0.0.1 (100.0.0.1) 56(84) bytes of data.
64 bytes from 100.0.0.1: icmp_seq=1 ttl=63 time=7.45 ms
64 bytes from 100.0.0.1: icmp_seq=2 ttl=63 time=4.66 ms
64 bytes from 100.0.0.1: icmp_seq=3 ttl=63 time=16.6 ms
64 bytes from 100.0.0.1: icmp_seq=4 ttl=63 time=4.40 ms
64 bytes from 100.0.0.1: icmp_seq=5 ttl=63 time=3.73 ms
^C
--- 100.0.0.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4007ms
rtt min/avg/max/mdev = 3.733/7.364/16.579/4.779 ms
root@r3:/#
```

- Rip

- Telnet localhost ripd

- Show ip rip

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

root@r3: /

```
root@r3:/# telnet localhost ripd
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

User Access Verification

Password:
ripd> show ip rip
Codes: R - RIP, C - connected, S - Static, O - OSPF, B - BGP
Sub-codes:
      (n) - normal, (s) - static, (d) - default, (r) - redistribute,
      (i) - interface

      Network          Next Hop        Metric From
Tag Time
R(n) 100.0.0.0/24      200.0.0.1        3 200.0.0.1
          0 02:39
R(n) 150.0.0.0/30      200.0.0.1        2 200.0.0.1
          0 02:39
C(i) 200.0.0.0/30      0.0.0.0         1 self
          0
C(i) 220.0.0.0/24      0.0.0.0         1 self
          0
ripd> |
```

- **Wireshark**

Wireshark shared/Ex12\_r1.pcap

The screenshot shows the Wireshark interface with the following details:

- File Menu:** File, Machine, View, Input, Devices, Help.
- Title Bar:** Ex12\_r1.pcap.
- Toolbar:** Standard file operations (Open, Save, Print, etc.) and search/filter tools.
- Display Filter:** Apply a display filter ... <Ctrl-/>
- Panels:**
  - Packet List:** Shows 15 captured frames. Frame 1 is highlighted in yellow. It is an RIPv2 Response (112 bytes) from source 100.0.0.1 to destination 224.0.0.9.
  - Details:** Displays the structure of the selected frame (Frame 1). It includes fields like Version: RIPv2 (2), Command: Response (2), and IP Address: 150.0.0.0, Metric: 1.
  - Bytes:** Displays the raw hex and ASCII data of the selected frame.
- Left Sidebar:** Icons for various applications (Firefox, Mail, Terminal, etc.) and a question mark icon.

=> Length of packet 1: 112 bytes

Source: 100.0.0.1

Destination: 224.0.0.9

Metrics: 1) 150.0.0.0 2) 200.0.0.0 3) 220.0.0.0

Route: 100.0.0.1 -> 150.0.0.0 -> 200.0.0.0 -> 220.0.0.0 -> 224.0.0.9

**Exercise 13:**

- File content:

The screenshot shows a terminal window titled "UbuntuB2206008 [Running] - Oracle VM VirtualBox". The terminal window has a dark background and contains the following text:

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13$ cat lab.conf
r1[0]=H
r1[1]=G
r1[2]=E
r1[3]=A

r2[0]=E
r2[1]=F
r2[2]=B

r3[0]=F
r3[1]=G
r3[2]=I
r3[3]=C

r4[0]=L
r4[1]=D
r4[2]=I
r4[3]=H

r5[0]=L
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13$
```

The terminal window also displays a sidebar with various icons for file management and system tools.

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13\$ cat r1.startup  
ifconfig eth0 100.1.0.13/30 up  
ifconfig eth1 100.1.0.9/30 up  
ifconfig eth2 100.1.0.1/30 up  
ifconfig eth3 100.1.1.1/24 up  
/etc/init.d/quagga start  
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13\$ cat r2.startup  
ifconfig eth0 100.1.0.2/30 up  
ifconfig eth1 100.1.0.5/30 up  
ifconfig eth2 100.1.2.1/24 up  
/etc/init.d/quagga start  
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13\$ cat r3.startup  
ifconfig eth0 100.1.0.6/30 up  
ifconfig eth1 100.1.0.10/30 up  
ifconfig eth2 100.1.0.17/30 up  
ifconfig eth3 100.1.3.1/24 up  
/etc/init.d/quagga start  
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13\$ cat r4.startup  
ifconfig eth0 100.2.0.1/30 up  
ifconfig eth1 100.1.4.1/24 up  
ifconfig eth2 100.1.0.18/30 up  
ifconfig eth3 100.1.0.14/30 up  
/etc/init.d/quagga start  
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13\$ cat r5.startup  
ifconfig eth0 100.2.0.2/30 up  
route add -net 100.1.0.0/16 gw 100.2.0.1  
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13\$

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 09:40

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13$ cat r1/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13$ cat r1/etc/quagga/ripd.conf
!
hostname ripd
password zebra
enable password zebra
!
router rip
redistribute connected
network 100.1.0.0/16
!
log file /var/log/quagga/ripd.log

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13$ cat r1/etc/quagga/zebra.conf
?
hostname r1
password zebra
enable password zebra
!
log file /var/log/quagga/zebra.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise13$
```

- Check route table

Route -n

```

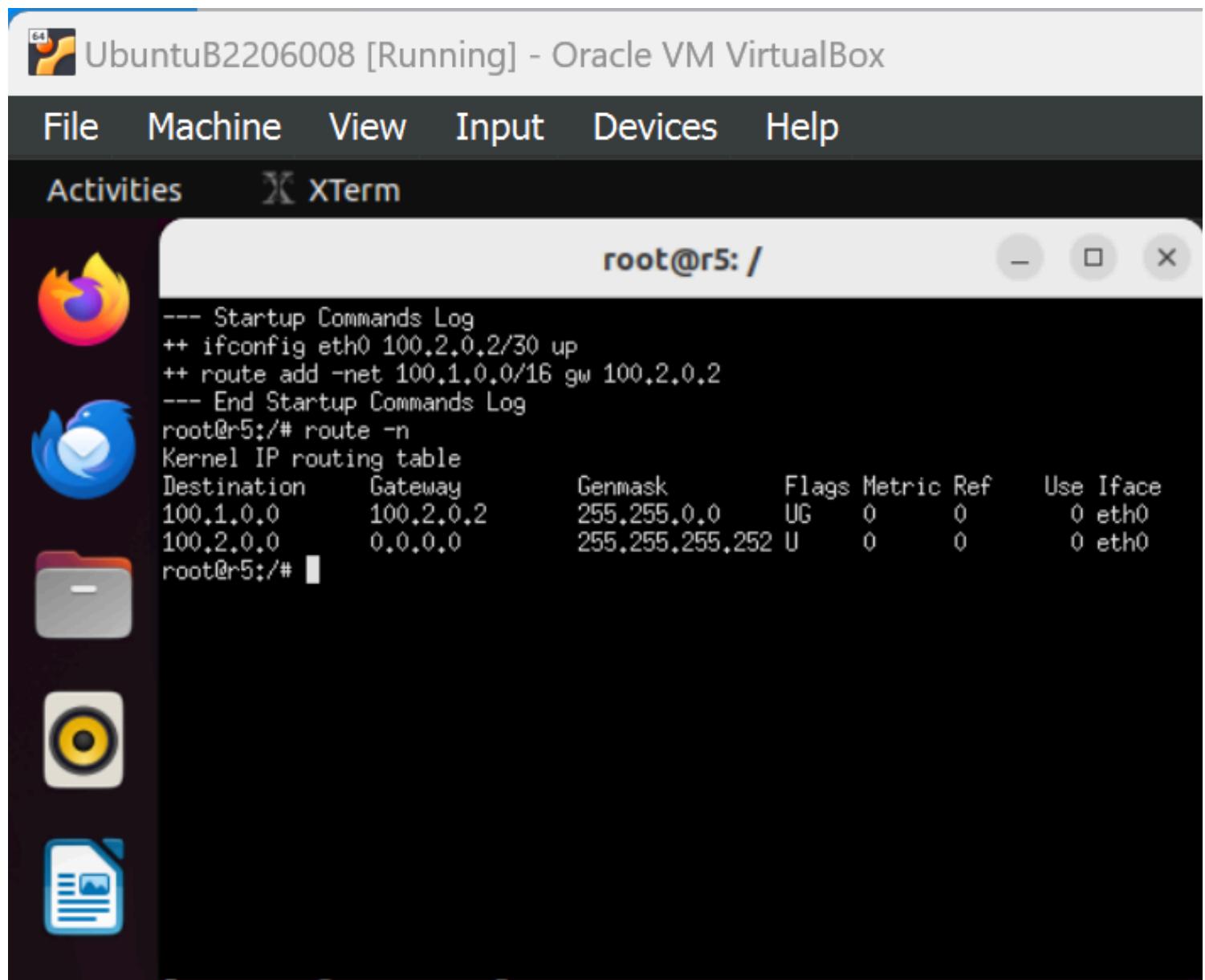
UbuntuB2206008 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities XTerm Oct 21 08:49
root@r1:/# route -n
--- Startup Commands Log
++ ifconfig eth0 100.1.0.13/30 up
++ ifconfig eth1 100.1.0.9/30 up
++ ifconfig eth2 100.1.0.1/30 up
++ ifconfig eth3 100.1.1.1/24 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r1:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
100.1.0.0 0.0.0.0 255.255.255.252 U 0 0 0 eth2
100.1.0.4 100.1.0.2 255.255.255.252 UG 20 0 0 eth2
100.1.0.8 0.0.0.0 255.255.255.252 U 0 0 0 eth1
100.1.0.12 0.0.0.0 255.255.255.252 U 0 0 0 eth0
100.1.0.16 100.1.0.14 255.255.255.252 UG 20 0 0 eth0
100.1.1.0 0.0.0.0 255.255.255.0 U 0 0 0 eth3
100.1.2.0 100.1.0.2 255.255.255.0 UG 20 0 0 eth2
100.1.3.0 100.1.0.10 255.255.255.0 UG 20 0 0 eth1
100.1.4.0 100.1.0.14 255.255.255.0 UG 20 0 0 eth0
100.2.0.0 100.1.0.14 255.255.255.252 UG 20 0 0 eth0
root@r1:/# 

root@r2:/# route -n
--- Startup Commands Log
++ ifconfig eth0 100.1.0.2/30 up
++ ifconfig eth1 100.1.0.5/30 up
++ ifconfig eth2 100.1.2.1/24 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r2:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
100.1.0.0 0.0.0.0 255.255.255.252 U 0 0 0 eth0
100.1.0.4 0.0.0.0 255.255.255.252 U 0 0 0 eth1
100.1.0.8 100.1.0.1 255.255.255.252 UG 20 0 0 eth0
100.1.0.12 100.1.0.16 255.255.255.252 UG 20 0 0 eth0
100.1.1.0 100.1.0.1 255.255.255.0 UG 20 0 0 eth1
100.1.2.0 100.1.3.0 255.255.255.0 UG 20 0 0 eth2
100.1.3.0 100.1.4.0 255.255.255.0 UG 20 0 0 eth1
100.1.4.0 100.2.0.0 255.255.255.0 UG 20 0 0 eth0
100.2.0.0 100.1.0.14 255.255.255.252 UG 20 0 0 eth0
root@r2:/# 

root@r3:/# route -n
--- Startup Commands Log
++ ifconfig eth0 100.1.0.6/30 up up
++ ifconfig eth1 100.1.0.10/30 up
++ ifconfig eth2 100.1.0.17/30 up
++ ifconfig eth3 100.1.1.3/12/24 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r3:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
100.1.0.0 100.1.0.5 255.255.255.252 UG 20 0 0 eth0
100.1.0.4 0.0.0.0 255.255.255.252 U 0 0 0 eth0
100.1.0.8 0.0.0.0 255.255.255.252 U 0 0 0 eth1
100.1.0.12 100.1.0.18 255.255.255.252 UG 20 0 0 eth2
100.1.0.16 0.0.0.0 255.255.255.252 U 0 0 0 eth2
100.1.1.0 100.1.0.9 255.255.255.0 UG 20 0 0 eth1
100.1.2.0 100.1.0.5 255.255.255.0 UG 20 0 0 eth0
100.1.3.0 0.0.0.0 255.255.255.0 U 0 0 0 eth3
100.1.4.0 100.1.0.18 255.255.255.0 UG 20 0 0 eth2
100.2.0.0 100.1.0.18 255.255.255.252 UG 20 0 0 eth2
root@r3:/# 

root@r4:/# route -n
--- Startup Commands Log
++ ifconfig eth0 100.2.0.1/30 up
++ ifconfig eth1 100.1.4.1/24 up
++ ifconfig eth2 100.1.0.18/30 up
++ ifconfig eth3 100.1.0.14/30 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r4:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
100.1.0.0 100.1.0.13 255.255.255.252 UG 20 0 0 eth3
100.1.0.4 100.1.0.17 255.255.255.252 UG 20 0 0 eth2
100.1.0.8 100.1.0.13 255.255.255.252 UG 20 0 0 eth3
100.1.0.12 0.0.0.0 255.255.255.252 U 0 0 0 eth3
100.1.0.16 100.1.0.16 255.255.255.252 UG 0 0 0 eth2
100.1.1.0 100.1.0.13 255.255.255.0 UG 20 0 0 eth1
100.1.2.0 100.1.0.17 255.255.255.0 UG 20 0 0 eth2
100.1.3.0 100.1.0.17 255.255.255.0 UG 20 0 0 eth1
100.1.4.0 100.1.4.0 255.255.255.0 UG 20 0 0 eth0
100.2.0.0 100.2.0.0 255.255.255.252 UG 0 0 0 eth0
root@r4:/# 

```



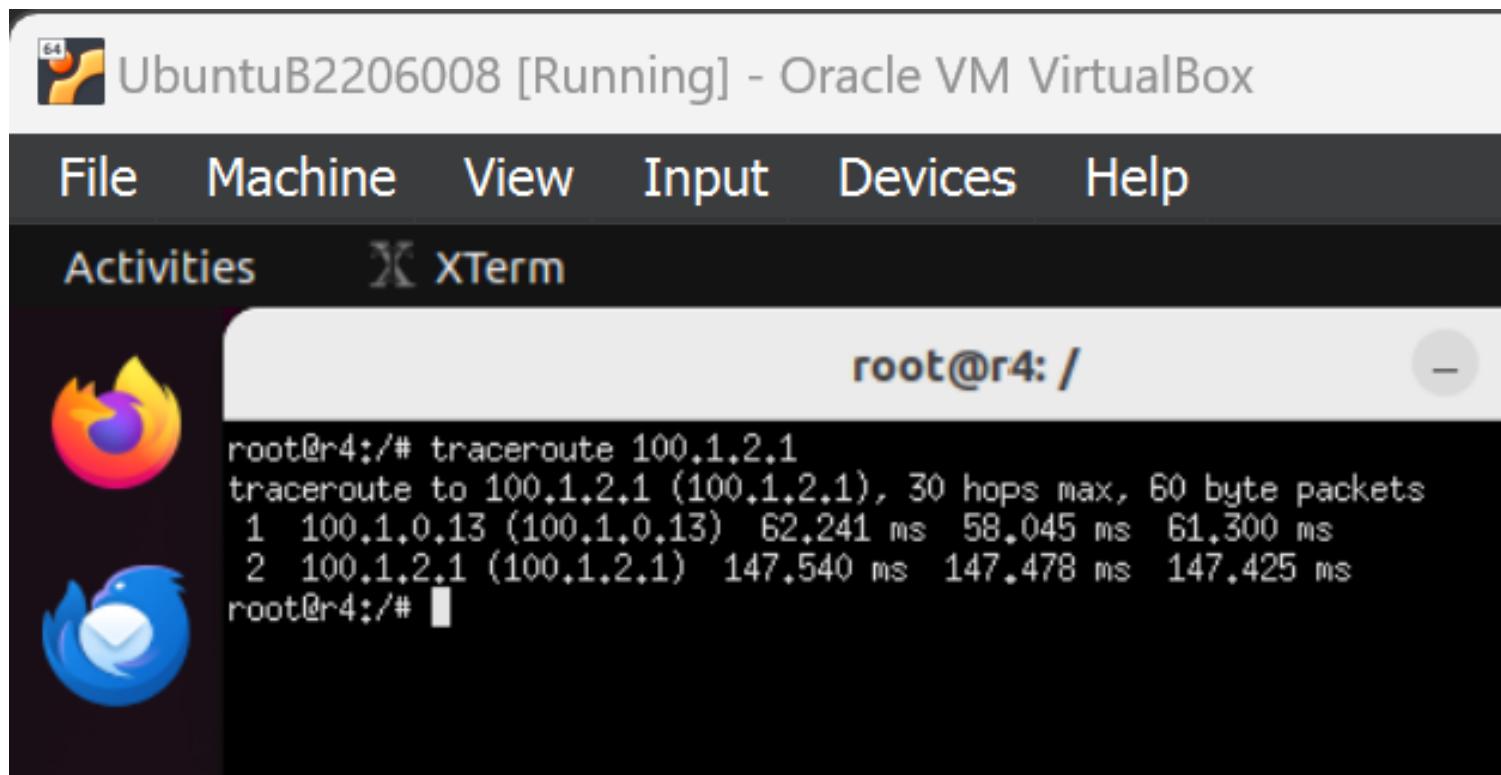
- Check connectivity by ping command

The screenshot shows a desktop environment with four terminal windows open in XTerm:

- root@r1:/**: Pinged 100.2.0.2. Response: PING 100.2.0.2 (100.2.0.2) 56(84) bytes of data. 64 bytes from 100.2.0.2: icmp\_seq=1 ttl=63 time=104 ms 64 bytes from 100.2.0.2: icmp\_seq=2 ttl=63 time=5.62 ms 64 bytes from 100.2.0.2: icmp\_seq=3 ttl=63 time=6.15 ms  
--- 100.2.0.2 ping statistics --- 3 packets transmitted, 3 received, 0% packet loss, time 2343ms rtt min/avg/max/mdev = 5.620/38.531/103.826/46.170 ms
- root@r2:/**: Pinged 100.1.1.1. Response: PING 100.1.1.1 (100.1.1.1) 56(84) bytes of data. 4 bytes from 100.1.1.1: icmp\_seq=1 ttl=64 time=28.7 ms 4 bytes from 100.1.1.1: icmp\_seq=2 ttl=64 time=1.87 ms 4 bytes from 100.1.1.1: icmp\_seq=3 ttl=64 time=2.61 ms  
-- 100.1.1.1 ping statistics --- 3 packets transmitted, 3 received, 0% packet loss, time 2008ms rtt min/avg/max/mdev = 1.873/11.046/28.656/12.455 ms
- root@r3:/**: Pinged 100.1.2.1. Response: PING 100.1.2.1 (100.1.2.1) 56(84) bytes of data. 64 bytes from 100.1.2.1: icmp\_seq=1 ttl=64 time=27.4 ms 64 bytes from 100.1.2.1: icmp\_seq=2 ttl=64 time=1.28 ms 64 bytes from 100.1.2.1: icmp\_seq=3 ttl=64 time=0.823 ms  
--- 100.1.2.1 ping statistics --- 3 packets transmitted, 3 received, 0% packet loss, time 2034ms rtt min/avg/max/mdev = 0.823/9.826/27.373/12.408 ms
- root@r5:/**: Pinged 100.1.0.18. Response: PING 100.1.0.18 (100.1.0.18) 56(84) bytes of data. 4 bytes from 100.1.0.18: icmp\_seq=1 ttl=64 time=4.29 ms 4 bytes from 100.1.0.18: icmp\_seq=2 ttl=64 time=2.97 ms 4 bytes from 100.1.0.18: icmp\_seq=3 ttl=64 time=2.14 ms  
-- 100.1.0.18 ping statistics --- 3 packets transmitted, 3 received, 0% packet loss, time 2065ms rtt min/avg/max/mdev = 2.135/3.133/4.293/0.888 ms

- At R4, traceroute 100.1.2.1 and explain

=> the screen shows the route from r4 to 100.1.2.1, with the first next hop is 100.1.0.13 through gateway 100.1.0.14, the next hop (destination) is 100.1.2.1



UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities XTerm

root@r4: /

```
root@r4:/# traceroute 100.1.2.1
traceroute to 100.1.2.1 (100.1.2.1), 30 hops max, 60 byte packets
 1  100.1.0.13 (100.1.0.13)  62.241 ms  58.045 ms  61.300 ms
 2  100.1.2.1 (100.1.2.1)  147.540 ms  147.478 ms  147.425 ms
root@r4:/#
```

- At r1, turn eth1 down and traceroute to 100.1.0.10, examine the route

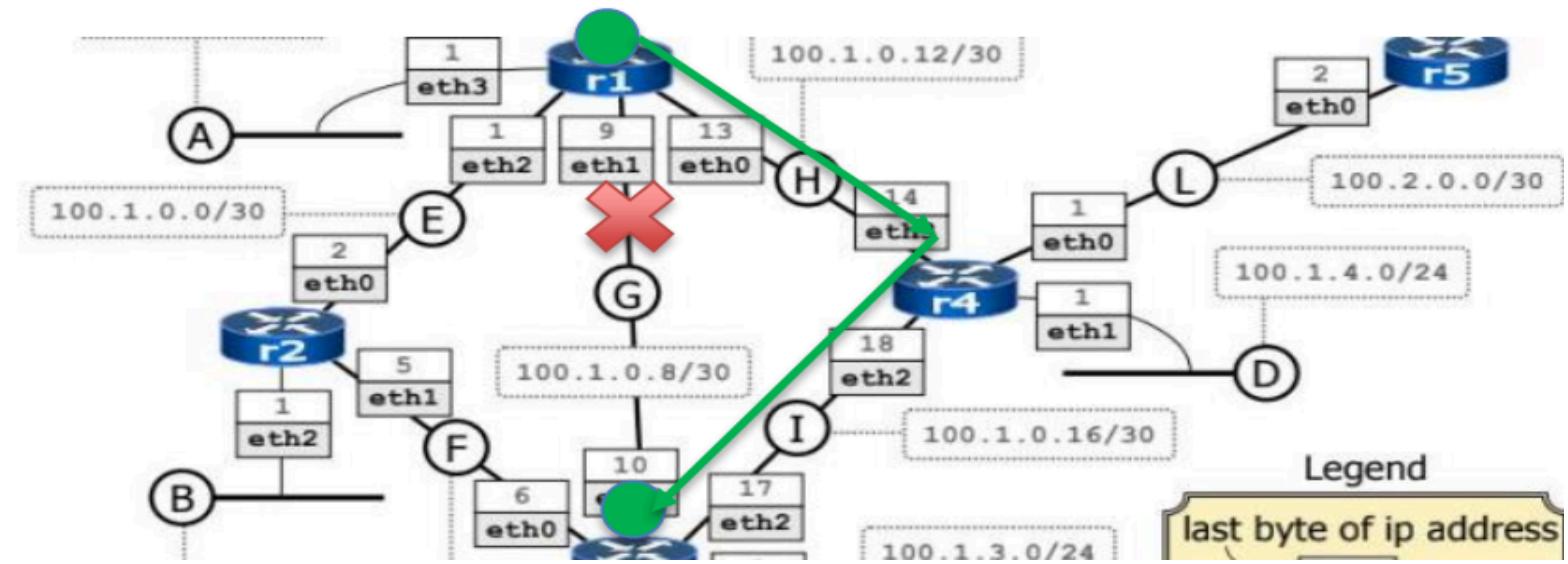
UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities XTerm

root@r1: /

```
root@r1:/# ifconfig eth1 down
root@r1:/# traceroute 100.1.0.10
traceroute to 100.1.0.10 (100.1.0.10), 30 hops max, 60 byte packets
 1  100.1.0.14 (100.1.0.14)  104.068 ms  86.779 ms  86.669 ms
 2  100.1.0.10 (100.1.0.10)  145.158 ms  159.121 ms  159.065 ms
root@r1:/#
```



**Exercise 14:**

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21

```
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise14$ cat lab.conf
bb0[0]=A
bb0[1]=C
bb1[0]=A
bb1[1]=D
bb2[0]=A
bb2[1]=B
bb3[0]=B
bb3[1]=C
bb4[0]=C
bb4[1]=D
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21

```
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise14$ cat bb0.startup
ifconfig eth0 10.0.0.3/24 up
ifconfig eth1 10.0.2.3/24 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb1.startup
ifconfig eth0 10.0.0.1/24 up
ifconfig eth1 10.0.3.1/24 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb2.startup
ifconfig eth0 10.0.0.2/24 up
ifconfig eth1 10.0.1.1/24 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb3.startup
ifconfig eth0 10.0.1.2/24 up
ifconfig eth1 10.0.2.2/24 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb4.startup
ifconfig eth0 10.0.2.1/24 up
ifconfig eth1 10.0.3.2/24 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 11:11

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb0/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=yes
ospf6d=no
ripd=no
ripngd=no
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb0/etc/quagga/ospfd.conf
hostname ospfd
password zebra
enable password zebra

interface eth0
ospf cost 21
interface eth1
ospf cost 36

router ospf
network 10.0.0.0/16 area 0.0.0.0
redistribute connected

log file /var/log/zebra/ospfd.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 11:12

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb1/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=yes
ospf6d=no
ripd=no
ripngd=no
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb1/etc/quagga/ospfd.conf
hostname ospfd
password zebra
enable password zebra

interface eth0
ospf cost 10
interface eth1
ospf cost 45

router ospf
network 10.0.0.0/16 area 0.0.0.0
redistribute connected

log file /var/log/zebra/ospfd.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 11:13

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb2/etc/quagga/daemons
zebra=yes
bgpd=no
ospf=yes
ospf6d=no
ripd=no
ripngd=no
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb2/etc/quagga/ospfd.conf
hostname ospfd
password zebra
enable password zebra

interface eth0
ospf cost 10
interface eth1
ospf cost 10

router ospf
network 10.0.0.0/16 area 0.0.0.0
redistribute connected

log file /var/log/zebra/ospfd.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 11:14

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb3/etc/quagga/daemons
zebra=yes
bgpd=no
ospf=yes
ospf6d=no
ripd=no
ripngd=no
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb3/etc/quagga/ospfd.conf
hostname ospfd
password zebra
enable password zebra

interface eth0
ospf cost 7
interface eth1
ospf cost 10

router ospf
network 10.0.0.0/16 area 0.0.0.0
redistribute connected

log file /var/log/zebra/ospfd.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 11:15

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb4/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=yes
ospf6d=no
ripd=no
ripngd=no
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$ cat bb4/etc/quagga/ospfd.conf
hostname ospfd
password zebra
enable password zebra

interface eth0
ospf cost 10
interface eth1
ospf cost 10

router ospf
network 10.0.0.0/16 area 0.0.0.0
redistribute connected

log file /var/log/zebra/ospfd.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise14$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

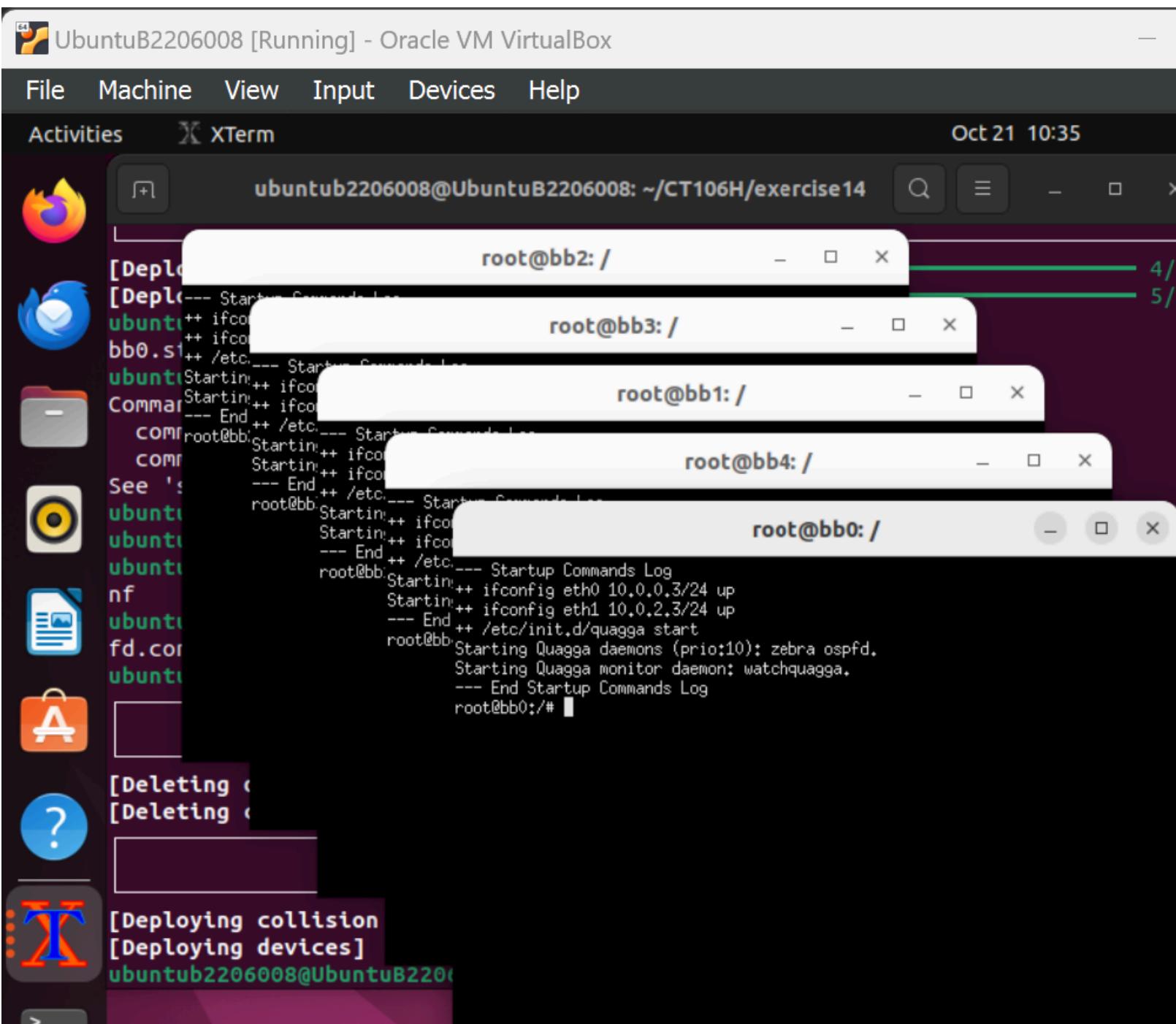
File Machine View Input Devices Help

Activities Terminal

```
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise14$ tree
.
├── bb0
│   └── etc
│       └── quagga
│           ├── daemons
│           └── ospfd.conf
├── bb0.startup
├── bb1
│   └── etc
│       └── quagga
│           ├── daemons
│           └── ospfd.conf
├── bb1.startup
├── bb2
│   └── etc
│       └── quagga
│           ├── daemons
│           └── ospfd.conf
├── bb2.startup
├── bb3
│   └── etc
│       └── quagga
│           ├── daemons
│           └── ospfd.conf
├── bb3.startup
├── bb4
│   └── etc
│       └── quagga
│           ├── daemons
│           └── ospfd.conf
├── bb4.startup
└── lab.conf
    └── shared

16 directories, 16 files
```

- Start network



- Check route table

```

UbuntuB2206008 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities X XTerm Oct 21 10:39
root@bb2: / - □ ×
--- Startup Commands Log
++ ifconfig eth0 10.0.0.2/24 up
++ ifconfig eth1 10.0.1.2/24 up
++ /etc/init.d/quagga start
Starting Quagga daemons (priorities: zebra ospfd).
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@bb2:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
10.0.0.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.1.0 0.0.0.0 255.255.255.0 U 0 0 0 eth1
10.0.2.0 10.0.1.2 255.255.255.0 UG 20 0 0 eth1
10.0.3.0 10.0.1.2 255.255.255.0 UG 20 0 0 eth1
root@bb2:/# 

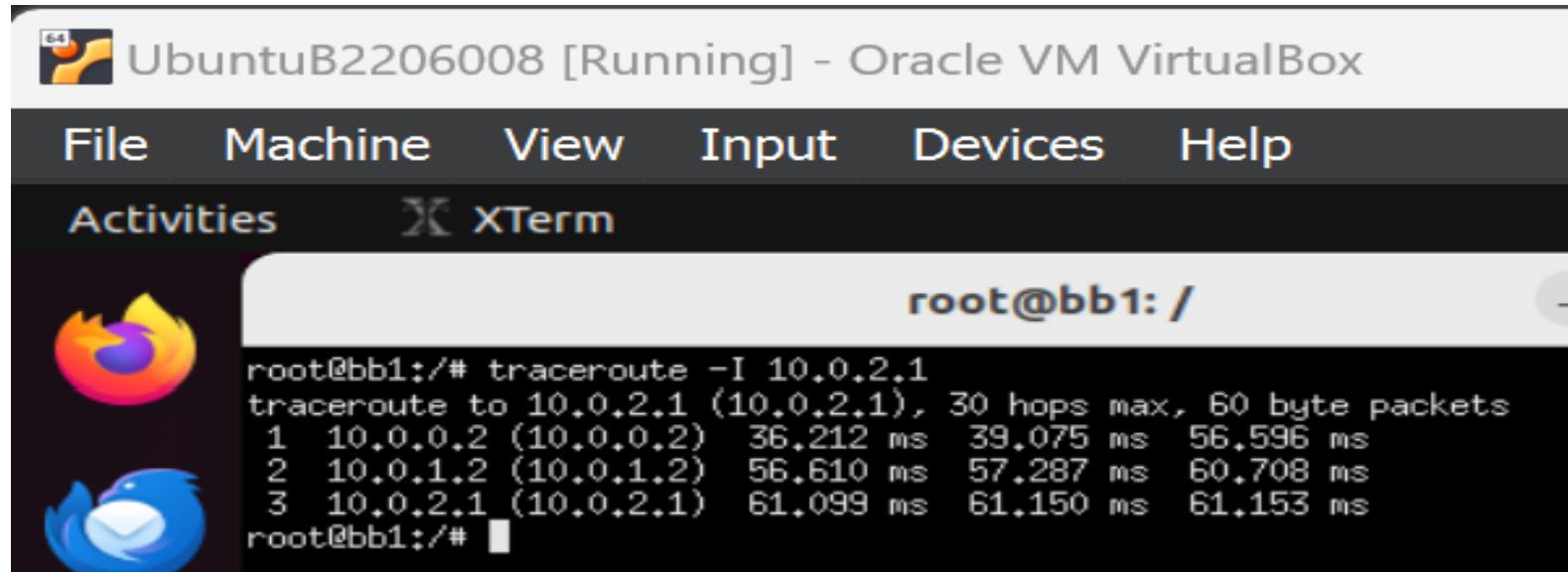
root@bb3: / - □ ×
--- Startup Commands Log
++ ifconfig eth0 10.0.1.2/24 up
++ ifconfig eth1 10.0.2.2/24 up
++ /etc/init.d/quagga start
Starting Quagga daemons (priorities: zebra ospfd).
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@bb3:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
10.0.0.0 10.0.1.1 255.255.255.0 UG 20 0 0 eth0
10.0.1.0 0.0.0.0 255.255.255.0 U 0 0 0 eth1
10.0.2.0 0.0.0.0 255.255.255.0 U 0 0 0 eth1
10.0.3.0 10.0.2.1 255.255.255.0 UG 20 0 0 eth1
root@bb3:/# 

root@bb1: / - □ ×
--- Startup Commands Log
++ ifconfig eth0 10.0.0.1/24 up
++ ifconfig eth1 10.0.3.1/24 up
++ /etc/init.d/quagga start
Starting Quagga daemons (priorities: zebra ospfd).
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@bb1:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
10.0.0.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.1.0 10.0.0.2 255.255.255.0 UG 20 0 0 eth0
10.0.2.0 10.0.0.2 255.255.255.0 UG 20 0 0 eth0
10.0.3.0 0.0.0.0 255.255.255.0 U 0 0 0 eth1
root@bb1:/# 

root@bb0: / - □ ×
--- Startup Commands Log
++ ifconfig eth0 10.0.0.3/24 up
++ ifconfig eth1 10.0.2.3/24 up
++ /etc/init.d/quagga start
Starting Quagga daemons (priorities: zebra ospfd).
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@bb0:/# route -n
Kernel IP routing table
Destination Gateway Genmask Flags Metric Ref Use Iface
10.0.0.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0
10.0.1.0 10.0.0.2 255.255.255.0 UG 20 0 0 eth0
10.0.2.0 0.0.0.0 255.255.255.0 U 0 0 0 eth1
10.0.3.0 10.0.2.1 255.255.255.0 UG 20 0 0 eth1
root@bb0:/# 

```

- Traceroute -I 10.0.2.1

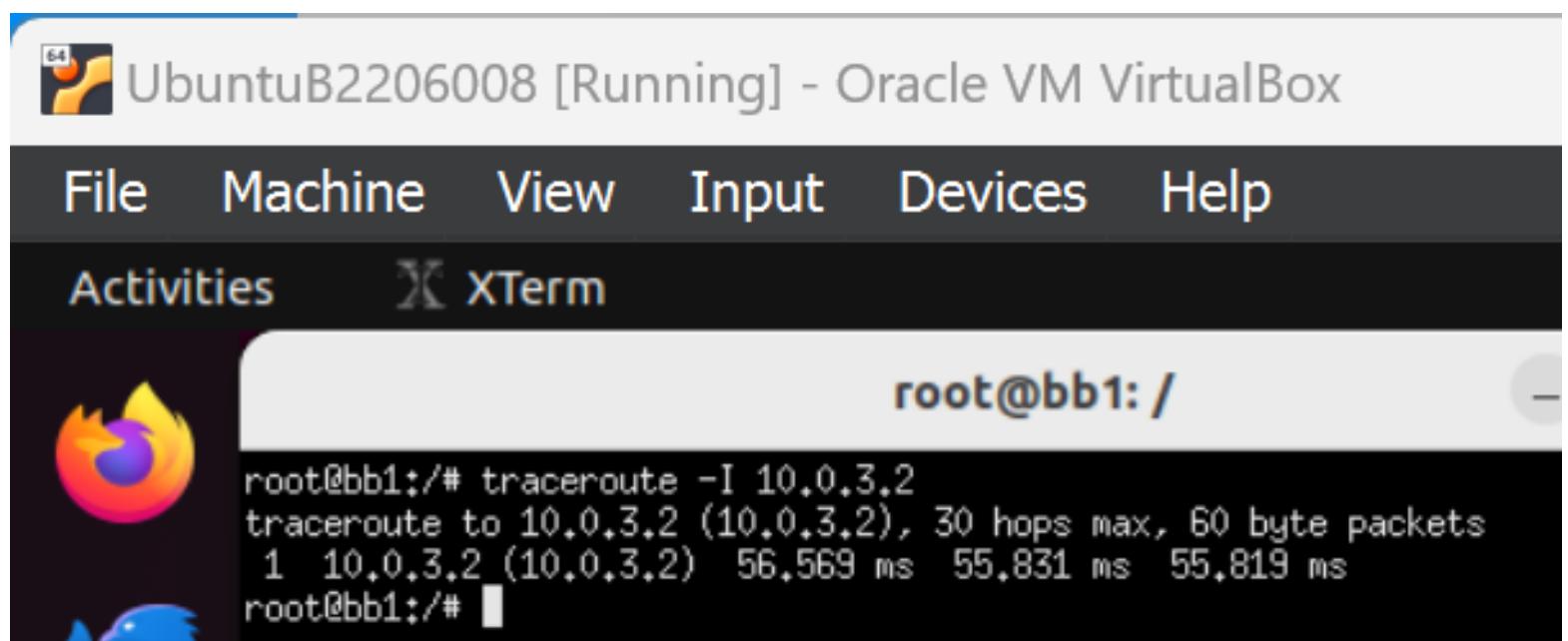


The screenshot shows a Linux desktop environment within a VirtualBox machine. The title bar reads "UbuntuB2206008 [Running] - Oracle VM VirtualBox". A terminal window is open, showing the command "traceroute -I 10.0.2.1" being run by root. The output of the traceroute command is displayed, showing three hops from the source to the destination.

```
root@bb1:/# traceroute -I 10.0.2.1
traceroute to 10.0.2.1 (10.0.2.1), 30 hops max, 60 byte packets
 1  10.0.0.2 (10.0.0.2)  36.212 ms  39.075 ms  56.596 ms
 2  10.0.1.2 (10.0.1.2)  56.610 ms  57.287 ms  60.708 ms
 3  10.0.2.1 (10.0.2.1)  61.099 ms  61.150 ms  61.153 ms
root@bb1:/#
```

- **What path is the traceroute expected to take?**  
Bb1 -> 10.0.0.2 -> 10.0.1.2 -> 10.0.2.1
- **What path is the ICMP expected to take?**  
The reverse of traceroute, 10.0.2.1 -> 10.0.1.2 -> 10.0.0.2 -> bb1

- Traceroute -I 10.0.3.2



The screenshot shows a virtual machine window titled "UbuntuB2206008 [Running] - Oracle VM VirtualBox". The window contains a terminal session with the following output:

```
root@bb1: /  
root@bb1:/# traceroute -I 10.0.3.2  
traceroute to 10.0.3.2 (10.0.3.2), 30 hops max, 60 byte packets  
 1  10.0.3.2 (10.0.3.2)  56.569 ms  55.831 ms  55.819 ms  
root@bb1:/#
```

- What path is the traceroute expected to take?  
Bb1 -> 10.0.3.2

- Observe the interplay between ospf routes and directly connected networks (i.e., perform a show ip route in quagga)

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities X XTerm

root@bb1: /

```
ospfd> show ip ospf route
=====
OSPF network routing table
N 10.0.0.0/24      [10] area: 0.0.0.0
                           directly attached to eth0
N 10.0.1.0/24      [20] area: 0.0.0.0
                           via 10.0.0.2, eth0
N 10.0.2.0/24      [30] area: 0.0.0.0
                           via 10.0.0.2, eth0
N 10.0.3.0/24      [40] area: 0.0.0.0
                           via 10.0.0.2, eth0

=====
OSPF router routing table
R 10.0.1.1      [10] area: 0.0.0.0, ASBR
                           via 10.0.0.2, eth0
R 10.0.2.2      [20] area: 0.0.0.0, ASBR
                           via 10.0.0.2, eth0
R 10.0.2.3      [10] area: 0.0.0.0, ASBR
                           via 10.0.0.3, eth0
R 10.0.3.2      [30] area: 0.0.0.0, ASBR
                           via 10.0.0.2, eth0

=====
OSPF external routing table
--More--
```

- **Route:** 10.0.1.1 -> 10.0.2.2 -> 10.0.2.3 -> 10.0.3.2

- Access ospfd cli on bb0, bb3

Show ip ospf database

Show ip ospf neighbor

```

UbuntuB2206008 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities XTerm
root@bb0: / Oct 21 10:50
root@bb0: / - X
root@bb3: / - X

Password:
ospfd> show ip ospf database

OSPF Router with ID (10.0.2.3)

Router Link States (Area 0.0.0.0)

Link ID      ADV Router      Age Seq#      CkSum Link count
10.0.1.1    10.0.1.1      872 0x80000008 0xdfff 2
10.0.2.2    10.0.2.2      876 0x80000007 0xdbfe 2
10.0.2.3    10.0.2.3      865 0x8000000a 0xd9d4 2
10.0.3.1    10.0.3.1      871 0x80000008 0x288d 2
10.0.3.2    10.0.3.2      866 0x80000007 0x4290 2

Net Link States (Area 0.0.0.0)

Link ID      ADV Router      Age Seq#      CkSum
10.0.0.1    10.0.3.1      871 0x80000002 0x69a9
10.0.1.2    10.0.2.2      876 0x80000001 0x69bb
10.0.2.1    10.0.3.2      866 0x80000002 0x729a
10.0.3.2    10.0.3.2      877 0x80000001 0x6bb3

root@bb3:/# telnet localhost ospfd
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 1.2.4).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

User Access Verification

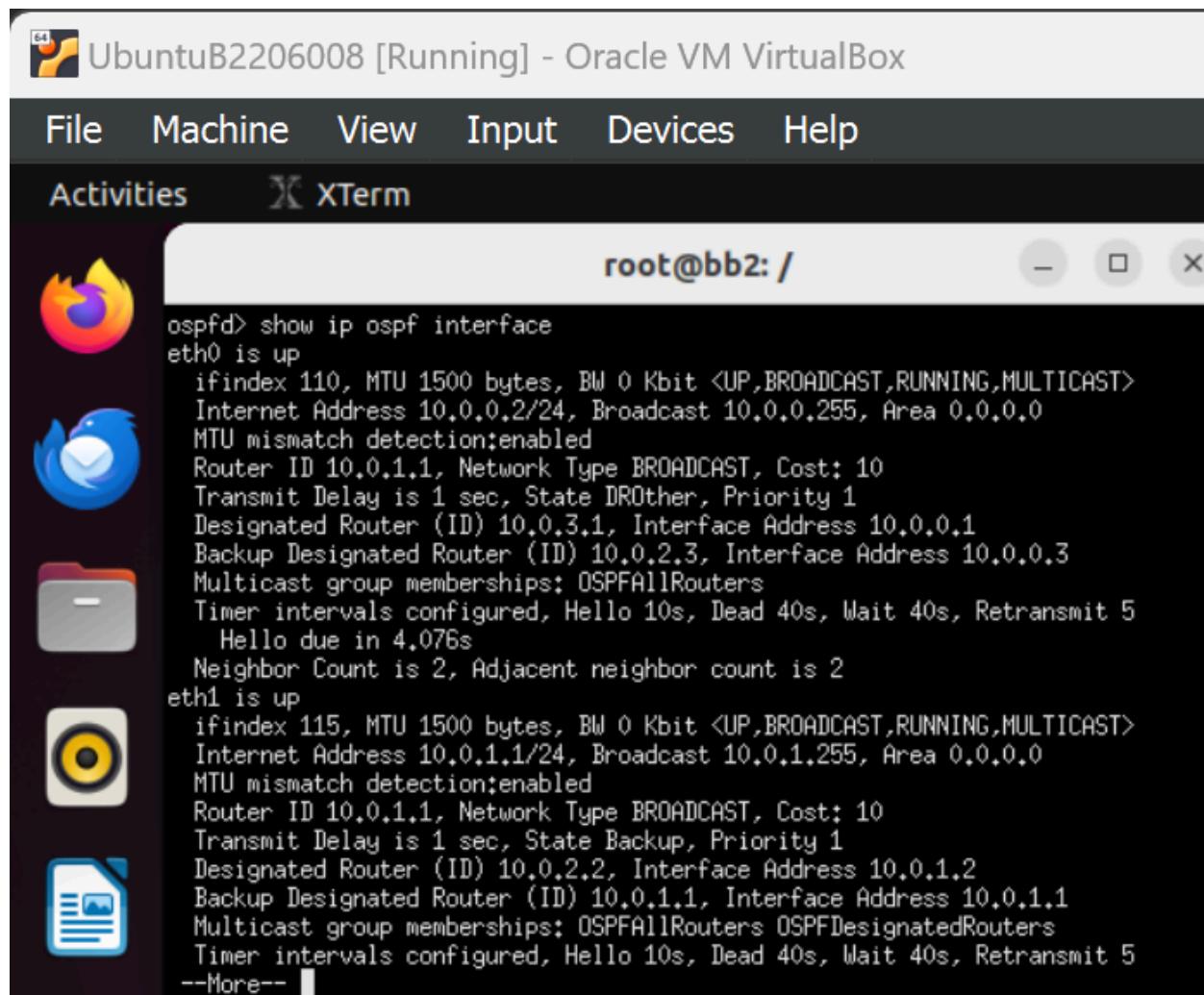
Password:
ospfd> show ospf neighbor
% [OSPF] Unknown command: show ospf neighbor
ospfd> show ip ospf neighbor

Neighbor ID      Pri State      Dead Time Address      Interface
                  RXmtL RqstL DBsmL
10.0.1.1          1 Full/Backup      32.254s 10.0.1.1      eth0:10.0.1.2
                  0   0   0
10.0.3.2          1 Full/DR        32.306s 10.0.2.1      eth1:10.0.2.2
                  0   0   0
10.0.2.3          1 Full/Backup      32.263s 10.0.2.3      eth1:10.0.2.2
                  0   0   0

```

- Access ospf cli on bb2:

Show ip ospf interface



UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities XTerm

root@bb2: /

```
ospfd> show ip ospf interface
eth0 is up
    ifindex 110, MTU 1500 bytes, BW 0 Kbit <UP,BROADCAST,RUNNING,MULTICAST>
    Internet Address 10.0.0.2/24, Broadcast 10.0.0.255, Area 0.0.0.0
    MTU mismatch detection:enabled
    Router ID 10.0.1.1, Network Type BROADCAST, Cost: 10
    Transmit Delay is 1 sec, State DROther, Priority 1
    Designated Router (ID) 10.0.3.1, Interface Address 10.0.0.1
    Backup Designated Router (ID) 10.0.2.3, Interface Address 10.0.0.3
    Multicast group memberships: OSPFAllRouters
    Timer intervals configured, Hello 10s, Dead 40s, Wait 40s, Retransmit 5
        Hello due in 4.076s
    Neighbor Count is 2, Adjacent neighbor count is 2
eth1 is up
    ifindex 115, MTU 1500 bytes, BW 0 Kbit <UP,BROADCAST,RUNNING,MULTICAST>
    Internet Address 10.0.1.1/24, Broadcast 10.0.1.255, Area 0.0.0.0
    MTU mismatch detection:enabled
    Router ID 10.0.1.1, Network Type BROADCAST, Cost: 10
    Transmit Delay is 1 sec, State Backup, Priority 1
    Designated Router (ID) 10.0.2.2, Interface Address 10.0.1.2
    Backup Designated Router (ID) 10.0.1.1, Interface Address 10.0.1.1
    Multicast group memberships: OSPFAllRouters OSPFDesignatedRouters
    Timer intervals configured, Hello 10s, Dead 40s, Wait 40s, Retransmit 5
--More-- █
```

- Use **tcpdump** capture packets transmitted between routers and discover  
They automatically ping to each other without ping command

```
root@bb0:/# tcpdump
tcpdump: verbose output suppressed, use -v[v]... for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), snapshot length 262144 bytes
03:54:07.138281 IP 10.0.0.3 > 224.0.0.5: OSPFv2, Hello, length 52
03:54:07.139679 IP 10.0.0.1 > 224.0.0.5: OSPFv2, Hello, length 52
03:54:07.140356 IP 10.0.0.2 > 224.0.0.5: OSPFv2, Hello, length 52
03:54:17.149846 IP 10.0.0.1 > 224.0.0.5: OSPFv2, Hello, length 52
03:54:17.150072 IP 10.0.0.3 > 224.0.0.5: OSPFv2, Hello, length 52
03:54:17.150793 IP 10.0.0.2 > 224.0.0.5: OSPFv2, Hello, length 52
^C
6 packets captured
6 packets received by filter
0 packets dropped by kernel
root@bb0:/#
```

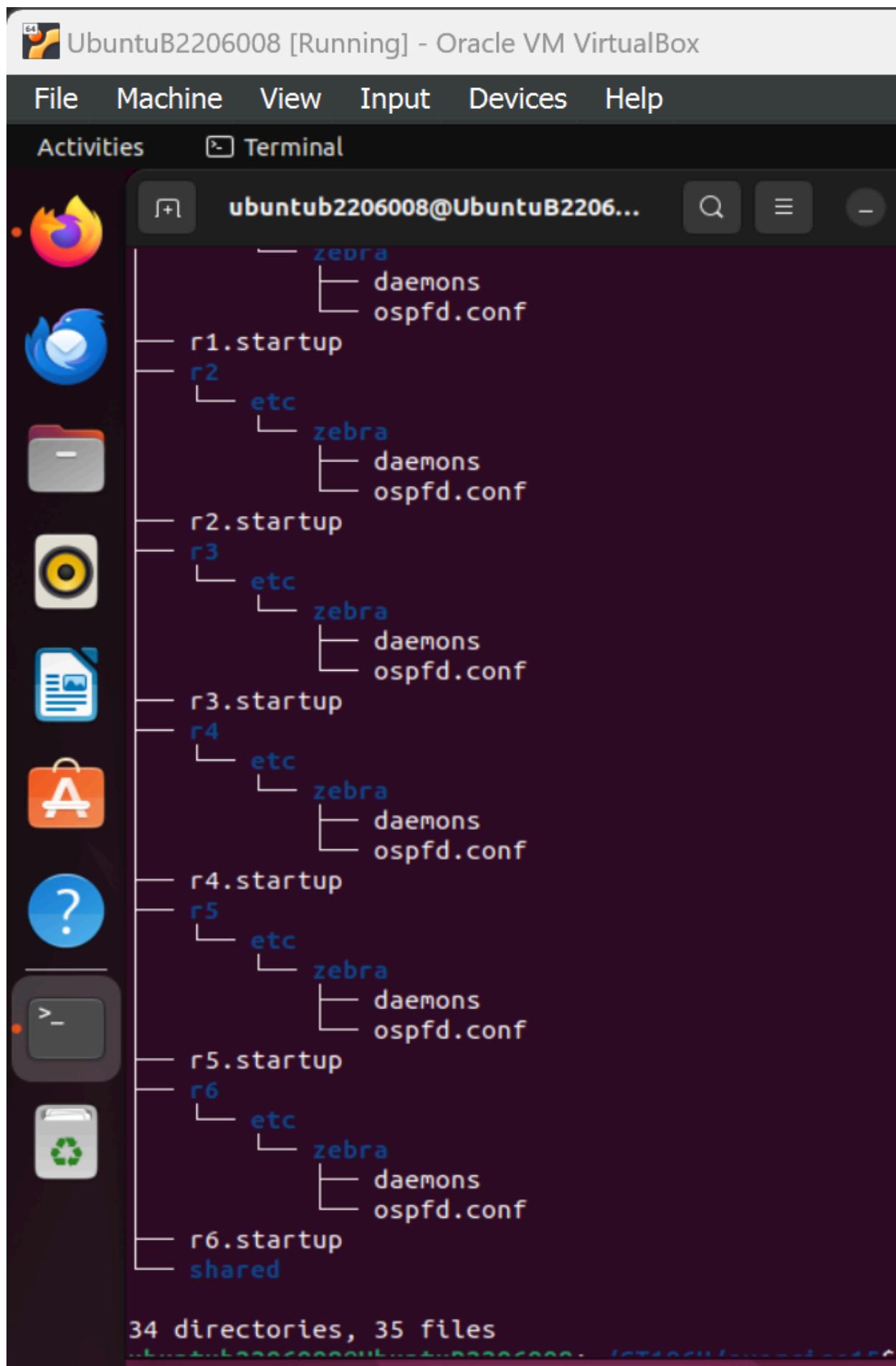
**Exercise 15:**

**Solution: Contents of files**

The screenshot shows a terminal window titled "ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$ tree". The terminal displays a hierarchical file structure:

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15$ tree
.
├── bb0
│   └── etc
│       └── zebra
│           └── daemons
│               └── ospfd.conf
├── bb0.startup
├── bb1
│   └── etc
│       └── zebra
│           └── daemons
│               └── ospfd.conf
├── bb1.startup
├── bb2
│   └── etc
│       └── zebra
│           └── daemons
│               └── ospfd.conf
├── bb2.startup
├── bb3
│   └── etc
│       └── zebra
│           └── daemons
│               └── ospfd.conf
├── bb3.startup
├── bb4
│   └── etc
│       └── zebra
│           └── daemons
│               └── ospfd.conf
├── bb4.startup
├── lab.conf
└── LICENSE

r1
└── etc
    └── zebra
```



UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$ cat lab

```
.conf
bb0[0]=A
bb0[1]=C

bb1[0]=A
bb1[1]=D
bb1[2]=E
bb1[3]=F

bb2[0]=A
bb2[1]=B
bb2[2]=H
bb2[3]=G

bb3[0]=B
bb3[1]=C

bb4[0]=C
bb4[1]=D

r1[0]=E
r1[1]=I
r2[0]=I
r2[1]=J
r3[0]=G
r3[1]=F
r3[2]=K
r4[0]=L
r4[1]=N
r5[0]=M
r5[1]=N
r5[2]=H
r6[0]=L
r6[1]=M

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 1

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$ cat bb0.startup  
ifconfig eth0 10.0.0.3 netmask 255.255.255.0 up  
ifconfig eth1 10.0.2.3 netmask 255.255.255.0 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$ cat bb1.startup  
ifconfig eth0 10.0.0.1 netmask 255.255.255.0 up  
ifconfig eth1 10.0.3.1 netmask 255.255.255.0 up  
ifconfig eth2 100.0.0.1 netmask 255.255.255.252 up  
ifconfig eth3 110.0.0.1 netmask 255.255.255.252 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$ cat bb2.startup  
ifconfig eth0 10.0.0.2 netmask 255.255.255.0 up  
ifconfig eth1 10.0.1.1 netmask 255.255.255.0 up  
ifconfig eth2 130.0.0.1 netmask 255.255.255.252 up  
ifconfig eth3 120.0.0.1 netmask 255.255.255.252 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$ cat bb3.startup  
ifconfig eth0 10.0.1.2 netmask 255.255.255.0 up  
ifconfig eth1 10.0.2.2 netmask 255.255.255.0 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$ cat bb4.startup  
ifconfig eth0 10.0.2.1 netmask 255.255.255.0 up  
ifconfig eth1 10.0.3.2 netmask 255.255.255.0 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15\$

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21

ubuntub2206008@UbuntuB2206008: ~/CT106H... cat r1.startup  
ifconfig eth0 100.0.0.2 netmask 255.255.255.252 up  
ifconfig eth1 200.0.0.1 netmask 255.255.255.252 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15\$ cat r2.startup  
ifconfig eth0 200.0.0.2 netmask 255.255.255.252 up  
ifconfig eth1 200.0.1.1 netmask 255.255.255.0 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15\$ cat r3.startup  
ifconfig eth0 120.0.0.2 netmask 255.255.255.252 up  
ifconfig eth1 110.0.0.2 netmask 255.255.255.252 up  
ifconfig eth2 210.0.0.1 netmask 255.255.255.0 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15\$ cat r4.startup  
ifconfig eth0 220.0.0.1 netmask 255.255.255.252 up  
ifconfig eth1 220.0.1.1 netmask 255.255.255.252 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15\$ cat r5.startup  
ifconfig eth0 220.0.2.2 netmask 255.255.255.252 up  
ifconfig eth1 220.0.1.2 netmask 255.255.255.252 up  
ifconfig eth2 130.0.0.2 netmask 255.255.255.252 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15\$ cat r6.startup  
ifconfig eth0 220.0.0.2 netmask 255.255.255.252 up  
ifconfig eth1 220.0.2.1 netmask 255.255.255.252 up  
/etc/init.d/zebra start

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15\$

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 17:33

```
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15$ cat r1/etc/zebra/ospfd.conf
!
hostname ospfd
password zebra
enable password zebra
!
router ospf
! Speak OSPF on all interfaces falling in the listed subnets
network 100.0.0.0/30 area 1.1.1.1
network 200.0.0.0/16 area 1.1.1.1
area 1.1.1.1 stub
redistribute connected
!
log file /var/log/zebra/ospfd.log
!

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15$ cat r1/etc/zebra/daemons
# This file tells the zebra package
# which daemons to start.
# Entries are in the format: <daemon>=(yes|no|priority)
# where 'yes' is equivalent to infinitely low priority, and
# lower numbers mean higher priority. Read
# /usr/doc/zebra/README.Debian for details.
# Daemons are: bgpd zebra ospfd ospf6d ripd ripngd
zebra=yes
bgpd=no
ospfd=yes
ospf6d=no
ripd=no
ripngd=no

ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise15$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

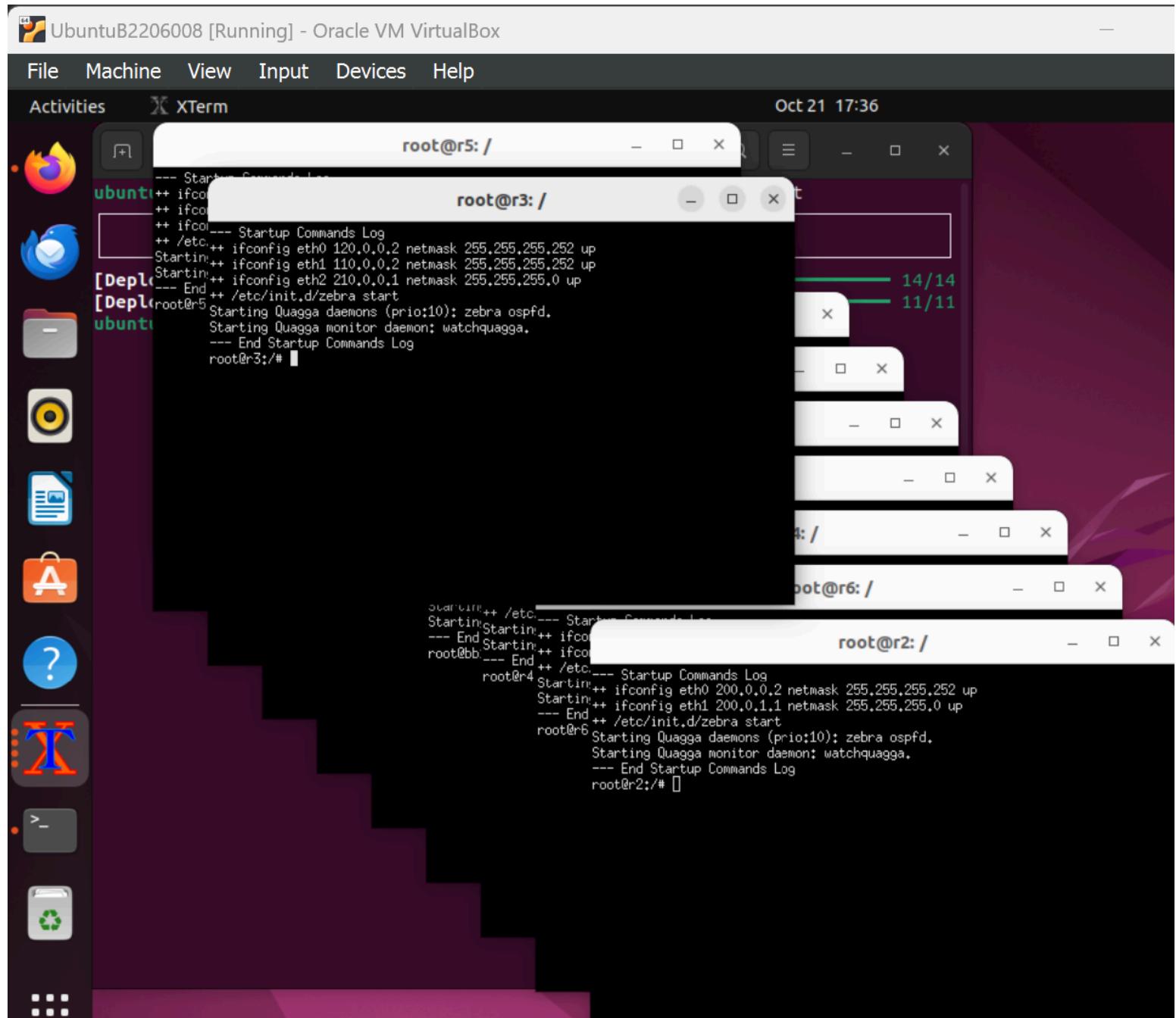
Activities Terminal Oct 21 17:34

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15$ cat bb0/etc/zebra/daemons
# This file tells the zebra package
# which daemons to start.
# Entries are in the format: <daemon>=(yes|no|priority)
# where 'yes' is equivalent to infinitely low priority, and
# lower numbers mean higher priority. Read
# /usr/doc/zebra/README.Debian for details.
# Daemons are: bgpd zebra ospfd ospf6d ripd ripngd
zebra=yes
bgpd=no
ospfd=yes
ospf6d=no
ripd=no
ripngd=no

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15$ cat bb0/etc/zebra/ospfd.conf
!
hostname ospfd
password zebra
enable password zebra
!
router ospf
! Speak OSPF on all interfaces falling in 10.0.0.0/16
network 10.0.0.0/16 area 0.0.0.0
redistribute connected
!
log file /var/log/zebra/ospfd.log
!

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise15$
```

- Start scenario and check connectivity



UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities XTerm Oct 21 17:40

**root@bb0: /**

```
64 bytes from 220.0.0.2: icmp_seq=2 ttl=62 time=3.76 ms
64 bytes from 220.0.0.2: icmp_seq=3 ttl=62 time=4.57 ms
--- 220.0.0.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 3.756/22.167/58.174/25.462 ms
root@bb0:~# route -n
Kernel IP routing table
Destination     Gateway      Genmask      Flags Metric Ref  Use Iface
0.0.0.0         0.0.0.0    255.255.255.0 U     0      0      0 eth0
10.0.1.0        10.0.0.2   255.255.255.0 UG    20     0      0 eth0
10.0.2.0        0.0.0.0    255.255.255.0 U     0      0      0 eth1
10.0.3.0        10.0.0.1   255.255.255.0 UG    20     0      0 eth0
100.0.0.0       10.0.0.1   255.255.255.252 UG   20     0      0 eth0
110.0.0.0       10.0.0.1   255.255.255.252 UG   20     0      0 eth0
120.0.0.0       10.0.0.2   255.255.255.252 UG   20     0      0 eth0
130.0.0.0       10.0.0.2   255.255.255.252 UG   20     0      0 eth0
200.0.0.0       10.0.0.1   255.255.255.252 UG   20     0      0 eth0
200.0.1.0       10.0.0.1   255.255.255.0 UG    20     0      0 eth0
210.0.0.0       10.0.0.1   255.255.255.0 UG    20     0      0 eth0
220.0.0.0       10.0.0.2   255.255.255.252 UG   20     0      0 eth0
220.0.1.0       10.0.0.2   255.255.255.252 UG   20     0      0 eth0
220.0.2.0       10.0.0.2   255.255.255.252 UG   20     0      0 eth0
root@bb0:~# 
```

**root@bb3: /**

```
root@bb3:~# ping -c 3 200.0.1.1
PING 200.0.1.1 (200.0.1.1) 56(84) bytes of data.
64 bytes from 200.0.1.1: icmp_seq=1 ttl=61 time=80.0 ms
64 bytes from 200.0.1.1: icmp_seq=2 ttl=61 time=4.41 ms
64 bytes from 200.0.1.1: icmp_seq=3 ttl=61 time=4.33 ms
--- 200.0.1.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2005ms
rtt min/avg/max/mdev = 4.326/29.567/79.968/35.638 ms
root@bb3:~# 
```

**root@r6: /**

```
--- Startup Commands Log
++ ifconfig eth0 220.0.0.2 netmask 255.255.255.252 up
++ ifconfig eth1 220.0.0.1 netmask 255.255.255.252 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ospfd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r6:~# ping -c 3 10.0.3.2
PING 10.0.3.2 (10.0.3.2) 56(84) bytes of data.
64 bytes from 10.0.3.2: icmp_seq=1 ttl=61 time=56.9 ms
64 bytes from 10.0.3.2: icmp_seq=2 ttl=61 time=3.45 ms
64 bytes from 10.0.3.2: icmp_seq=3 ttl=61 time=3.26 ms
--- 10.0.3.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2004ms
rtt min/avg/max/mdev = 3.262/21.192/56.867/25.225 ms
root@r6:~# 
```

**root@r3: /**

```
++ ifconfig eth2 210.0.0.1 netmask 255.255.255.0 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ospfd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r3:~# route -n
Kernel IP routing table
Destination     Gateway      Genmask      Flags Metric Ref  Use Iface
0.0.0.0         110.0.0.1   0.0.0.0    UG     20     0      0 eth1
10.0.0.0        110.0.0.1   255.255.255.0 UG    20     0      0 eth1
10.0.1.0        120.0.0.1   255.255.255.0 UG    20     0      0 eth0
10.0.2.0        110.0.0.1   255.255.255.0 UG    20     0      0 eth1
10.0.3.0        110.0.0.1   255.255.255.0 UG    20     0      0 eth1
100.0.0.0       110.0.0.1   255.255.255.252 UG   20     0      0 eth1
110.0.0.0       0.0.0.0    255.255.255.252 U     0      0      0 eth1
120.0.0.0       0.0.0.0    255.255.255.252 U     0      0      0 eth0
130.0.0.0       120.0.0.1   255.255.255.252 UG   20     0      0 eth0
200.0.0.0       110.0.0.1   255.255.255.252 UG   20     0      0 eth1
200.0.1.0       110.0.0.1   255.255.255.0 UG    20     0      0 eth1
210.0.0.0       0.0.0.0    255.255.255.0 U     0      0      0 eth2
220.0.0.0       120.0.0.1   255.255.255.252 UG   20     0      0 eth0
220.0.1.0       120.0.0.1   255.255.255.252 UG   20     0      0 eth0
220.0.2.0       120.0.0.1   255.255.255.252 UG   20     0      0 eth0
root@r3:~# 
```

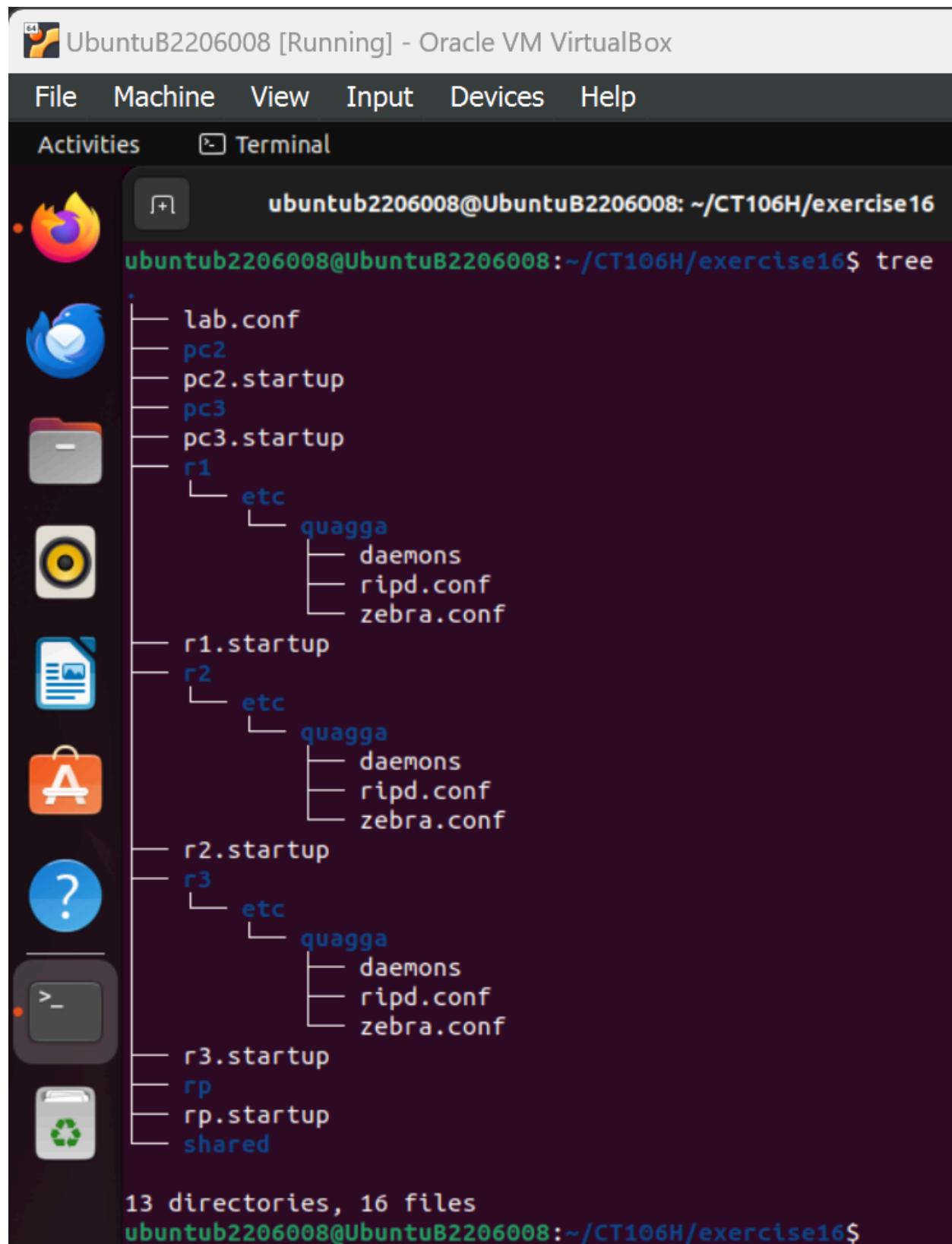
**root@r2: /**

```
--- Startup Commands Log
++ ifconfig eth0 200.0.0.2 netmask 255.255.255.252 up
++ ifconfig eth1 200.0.0.1 netmask 255.255.255.0 up
++ /etc/init.d/zebra start
Starting Quagga daemons (prio:10): zebra ospfd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r2:~# ping -c 3 220.0.1.1
PING 220.0.1.1 (220.0.1.1) 56(84) bytes of data.
64 bytes from 220.0.1.1: icmp_seq=1 ttl=58 time=124 ms
64 bytes from 220.0.1.1: icmp_seq=2 ttl=58 time=8.09 ms
64 bytes from 220.0.1.1: icmp_seq=3 ttl=58 time=7.12 ms
--- 220.0.1.1 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2003ms
rtt min/avg/max/mdev = 7.121/46.318/123.749/54.753 ms
root@r2:~# 
```

**Exercise 16:**

**Solution:**

**Files contents:**



The screenshot shows a terminal window titled "UbuntuB2206008 [Running] - Oracle VM VirtualBox". The terminal displays the output of the "tree" command, showing the directory structure of the "/CT106H/exercise16" directory. The structure includes sub-directories for "pc2", "pc3", "r1", "r2", and "r3", each containing an "etc" folder with "quagga", "daemons", "ripd.conf", and "zebra.conf" files. There are also "r1.startup", "r2.startup", and "r3.startup" files. The terminal also shows the count of directories and files at the bottom.

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ tree
.
├── lab.conf
├── pc2
├── pc2.startup
├── pc3
├── pc3.startup
└── r1
    └── etc
        └── quagga
            ├── daemons
            ├── ripd.conf
            └── zebra.conf
├── r1.startup
└── r2
    └── etc
        └── quagga
            ├── daemons
            ├── ripd.conf
            └── zebra.conf
├── r2.startup
└── r3
    └── etc
        └── quagga
            ├── daemons
            ├── ripd.conf
            └── zebra.conf
├── r3.startup
└── rp
    └── rp.startup
└── shared

13 directories, 16 files

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat lab.conf
r1[0]=A
r1[1]=D
r1[2]=E

r2[0]=B
r2[1]=D
r2[2]=F

r3[0]=C
r3[1]=E
r3[2]=F

rp[0]=A

pc2[0]=B
pc3[0]=C

ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat pc2.startup
ifconfig eth0 192.168.1.200/24 up
route add default gw 192.168.1.1
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat pc3.startup
ifconfig eth0 192.168.2.111/24 up
route add default gw 192.168.2.1
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 17:59

```
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat r1.startup
ifconfig eth0 200.117.68.1/30 up
ifconfig eth1 10.0.1.1/30 up
ifconfig eth2 10.0.1.5/30 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat r2.startup
ifconfig eth0 192.168.1.1/24 up
ifconfig eth1 10.0.1.2/30 up
ifconfig eth2 10.0.1.9/30 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat r3.startup
ifconfig eth0 192.168.2.1/24 up
ifconfig eth1 10.0.1.6/30 up
ifconfig eth2 10.0.1.10/30 up
/etc/init.d/quagga start
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat rp.startup
ifconfig eth0 200.117.68.2/30 up
route add default gw 200.117.68.1
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat r1/etc/quagga/daemons
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat r1/etc/quagga/ripd.conf
hostname ripd
password zebra
enable password zebra

router rip
redistribute connected
network 10.0.1.0/28

log file /var/log/quagga/ripd.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$
```

UbuntuB2206008 [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

Activities Terminal Oct 21 18:00

```
ubuntub2206008@UbuntuB2206008: ~/CT106H/exercise16$ cat r1/etc/quagga/zebra.conf
hostname r1
password zebra
enable password zebra

log file /var/log/quagga/zebra.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat r2/etc/quagga/zebra.conf
hostname r2
password zebra
enable password zebra

log file /var/log/quagga/zebra.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$ cat r3/etc/quagga/zebra.conf
hostname r3
password zebra
enable password zebra

log file /var/log/quagga/zebra.log
ubuntub2206008@UbuntuB2206008:~/CT106H/exercise16$
```

- Start scenario and check connectivity

```

UbuntuB2206008 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities XTerm Oct 21 18:04
root@rp: / - Xroot@pc3: / -
--- Startup Commands Log
++ ifconfig eth0 200.117.68.2/30 up
++ route add default gw 200.117.68.1
--- End Startup Commands Log
root@rp:/# route -n
Kernel IP routing table
Destination     Gateway      Genmask      Flags Metric Ref    Use Iface
0.0.0.0         200.117.68.1  0.0.0.0      UG     0      0        0 eth0
200.117.68.0    0.0.0.0     255.255.255.252 U      0      0        0 eth0
root@rp:/# []

root@pc3: / - X
- Startup Commands Log
ifconfig eth0 192.168.2.111/24 up
route add default gw 192.168.2.1
- End Startup Commands Log
jt@pc3:/# ping -c 3 192.168.1.200
PING 192.168.1.200 (192.168.1.200) 56(84) bytes of data.
bytes from 192.168.1.200: icmp_seq=1 ttl=62 time=74.4 ms
bytes from 192.168.1.200: icmp_seq=2 ttl=62 time=2.78 ms
bytes from 192.168.1.200: icmp_seq=3 ttl=62 time=2.13 ms
- 192.168.1.200 ping statistics ---
packets transmitted, 3 received, 0% packet loss, time 2003ms
min/avg/max/mdev = 2.131/26.425/74.369/33.902 ms
jt@pc3:/# []

root@r1: / - Xroot@r3: / -
--- Startup Commands Log
++ ifconfig eth0 200.117.68.1/30 up
++ ifconfig eth1 10.0.1.1/30 up
++ ifconfig eth2 10.0.1.5/30 up
++ /etc/init.d/quagga start
Starting Quagga daemons (prio:10): zebra ripd.
Starting Quagga monitor daemon: watchquagga.
--- End Startup Commands Log
root@r1:/# route -n
Kernel IP routing table
Destination     Gateway      Genmask      Flags Metric Ref    Use Iface
10.0.1.0        0.0.0.0     255.255.255.252 U      0      0        0 eth1
10.0.1.4        0.0.0.0     255.255.255.252 U      0      0        0 eth2
10.0.1.8        10.0.1.2    255.255.255.252 UG     20      0        0 eth1
192.168.1.0     10.0.1.2    255.255.255.0   UG     20      0        0 eth1
192.168.2.0     10.0.1.6    255.255.255.0   UG     20      0        0 eth2
200.117.68.0    0.0.0.0     255.255.255.252 U      0      0        0 eth0
root@r1:/# []

root@r3: / - X
-- Startup Commands Log
+ ifconfig eth0 192.168.2.1/24 up
+ ifconfig eth1 10.0.1.6/30 up
+ ifconfig eth2 10.0.1.10/30 up
+ /etc/init.d/quagga start
tarting Quagga daemons (prio:10): zebra ripd.
tarting Quagga monitor daemon: watchquagga.
-- End Startup Commands Log
jt@r3:/# ping -c 3 200.117.68.2
PING 200.117.68.2 (200.117.68.2) 56(84) bytes of data.
4 bytes from 200.117.68.2: icmp_seq=1 ttl=63 time=67.5 ms
4 bytes from 200.117.68.2: icmp_seq=2 ttl=63 time=2.28 ms
4 bytes from 200.117.68.2: icmp_seq=3 ttl=63 time=2.20 ms
-- 200.117.68.2 ping statistics --
packets transmitted, 3 received, 0% packet loss, time 2002ms
min/avg/max/mdev = 2.199/23.987/67.487/30.758 ms
jt@r3:/# []

```