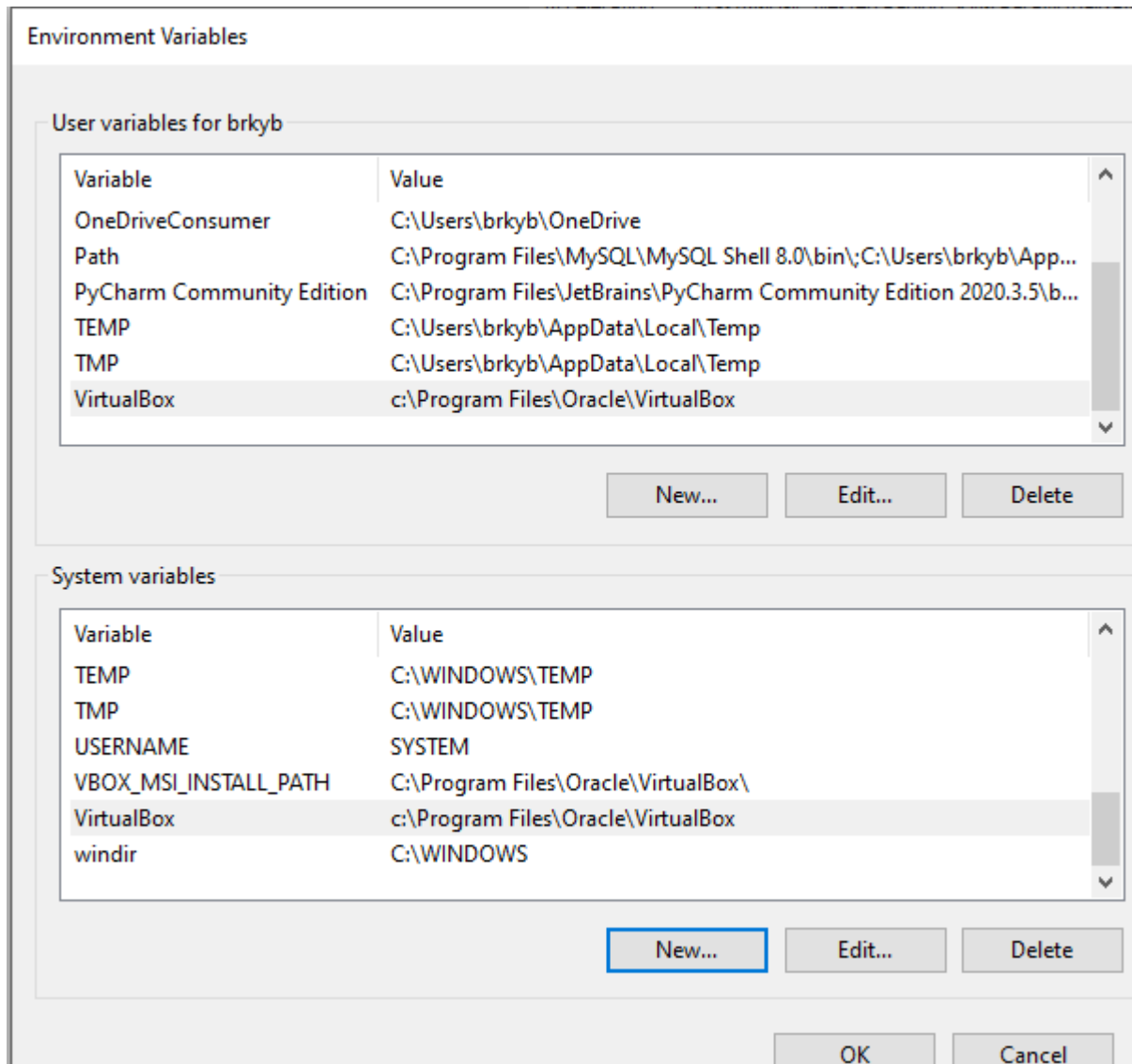


2.1 Lab prerequisites:

Adding the path of oracle VM VirtualBox to the environment variables:



First routing lab file from e-portal downloaded and then open it using cmd and created the virtual machines using cook-vms command

```
Microsoft Windows [Version 10.0.19041.630]
(c) 2020 Microsoft Corporation. All rights reserved.

C:\Users\brkyb>cd C:\Users\brkyb\OneDrive\Masaüstü

C:\Users\brkyb\OneDrive\Masaüstü>cd routinglab

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>dir
Volume in drive C has no label.
Volume Serial Number is CA80-B5BF

Directory of C:\Users\brkyb\OneDrive\Masaüstü\routinglab

04/13/2020  04:02 PM  <DIR>          .
04/13/2020  04:02 PM  <DIR>          ..
05/08/2020  12:52 AM                2,442 cook-vms.cmd
04/13/2020  03:28 PM                2,167 cook-vms.ps1
05/08/2020  12:48 AM                2,413 cook-vms.sh
04/21/2020  10:30 AM                2,241 README.txt
04/13/2020  12:23 PM                 71 start-vms.cmd
04/13/2020  03:31 PM                 85 start-vms.ps1
04/13/2020  04:00 PM                 74 start-vms.sh
04/13/2020  11:54 AM                 73 stop-vms.cmd
04/13/2020  03:31 PM                 91 stop-vms.ps1
04/13/2020  04:00 PM                 80 stop-vms.sh
04/13/2020  01:20 PM            57,344 vm1.iso
04/13/2020  01:20 PM            57,344 vm2.iso
04/13/2020  01:20 PM            57,344 vm3.iso
04/13/2020  01:20 PM            57,344 vm4.iso
04/13/2020  01:27 PM      1,023,666,176 vmhdd.vhd
                                15 File(s)      1,023,905,289 bytes
                                2 Dir(s)        228,475,592,704 bytes free

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>cook-vms

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>set LABSIZE=4

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>for /L %x in (1 1 4) do (vboxmanage unregistervm %m%x --delete )

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>(vboxmanage unregistervm vm1 --delete )
VBoxManage.exe: error: Could not find a registered machine named 'vm1'
VBoxManage.exe: error: Details: code VBOX_E_OBJECT_NOT_FOUND (0x800b0001), component VirtualBoxWrap, interface IVirtualBox, callee IUnknown
VBoxManage.exe: error: Context: "FindMachine(Bstr(VMName).raw(), machine.asOutParam())" at line 150 of file VBoxManageMisc.cpp

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>(vboxmanage unregistervm vm2 --delete )
VBoxManage.exe: error: Could not find a registered machine named 'vm2'
VBoxManage.exe: error: Details: code VBOX_E_OBJECT_NOT_FOUND (0x800b0001), component VirtualBoxWrap, interface IVirtualBox, callee IUnknown
VBoxManage.exe: error: Context: "FindMachine(Bstr(VMName).raw(), machine.asOutParam())" at line 150 of file VBoxManageMisc.cpp

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>(vboxmanage unregistervm vm3 --delete )
VBoxManage.exe: error: Could not find a registered machine named 'vm3'
VBoxManage.exe: error: Details: code VBOX_E_OBJECT_NOT_FOUND (0x800b0001), component VirtualBoxWrap, interface IVirtualBox, callee IUnknown
VBoxManage.exe: error: Context: "FindMachine(Bstr(VMName).raw(), machine.asOutParam())" at line 150 of file VBoxManageMisc.cpp

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>(vboxmanage unregistervm vm4 --delete )
VBoxManage.exe: error: Could not find a registered machine named 'vm4'
VBoxManage.exe: error: Details: code VBOX_E_OBJECT_NOT_FOUND (0x800b0001), component VirtualBoxWrap, interface IVirtualBox, callee IUnknown
VBoxManage.exe: error: Context: "FindMachine(Bstr(VMName).raw(), machine.asOutParam())" at line 150 of file VBoxManageMisc.cpp
```

```
Administrator: Command Prompt

vboxmanage createmedium disk --filename "C:\Users\brkyb\OneDrive\Masaüstü\routinglab\vm4.vhd" --diffparent "C:\Users\brkyb\OneDrive\Masaüstü\routinglab\vmhdd.vhd"
vboxmanage storageattach vm4 --storagectl "IDE" --port 0 --device 0 --type hdd --medium "C:\Users\brkyb\OneDrive\Masaüstü\routinglab\vm4.vhd" --setuid "" --setparentuid 0690d8f3-2712-49c4-9bfa-aff5b2456bf1
vboxmanage storageattach vm4 --storagectl "IDE" --port 1 --device 0 --type dvddrive --medium "C:\Users\brkyb\OneDrive\Masaüstü\routinglab\vm4.iso"
vboxmanage modifyvm vm4 --uart1 0x3F8 4 --uartmode1 disconnected
)
Virtual machine 'vm4' is created and registered.
UUID: e226ad6c-3305-4b1b-a8fe-55049c4f66dc
Settings file: 'C:\Users\brkyb\VirtualBox VMs\vm4\vm4.vbox'
0%...10%...20%...30%...40%...50%...60%...70%...80%...90%...100%
Medium created. UUID: 10dd18fd-b73a-4ccc-9844-ac798b7db8e9

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>vboxmanage modifyvm vm1 --nic1 intnet --macaddress1 525400000012 --cableconnected1 on --intnet1 "Network1-2"

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>vboxmanage modifyvm vm2 --nic1 intnet --macaddress1 525400000021 --cableconnected1 on --intnet1 "Network1-2"

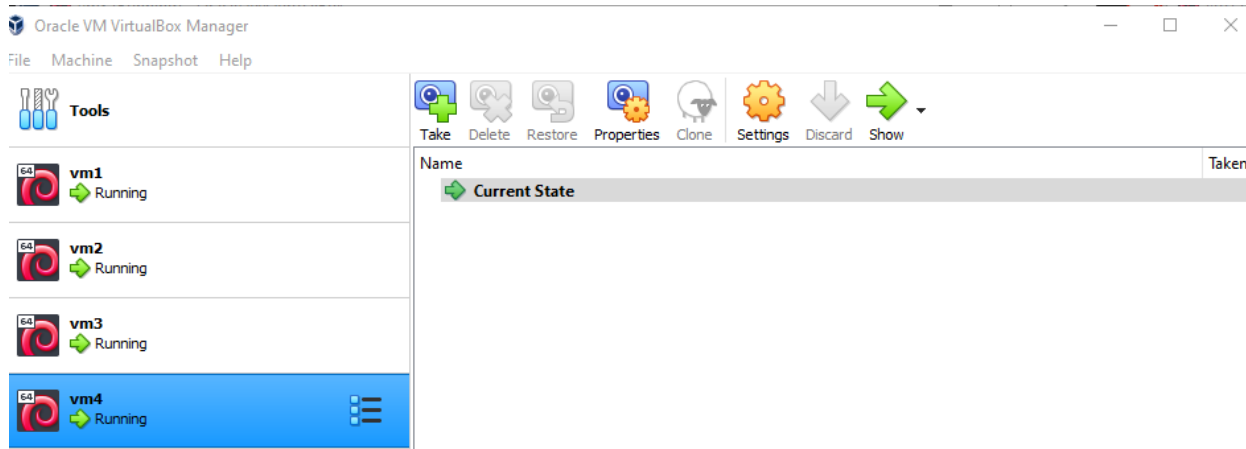
C:\Users\brkyb\OneDrive\Masaüstü\routinglab>vboxmanage modifyvm vm2 --nic2 intnet --macaddress2 525400000023 --cableconnected2 on --intnet2 "Network2-3"

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>vboxmanage modifyvm vm3 --nic1 intnet --macaddress1 525400000032 --cableconnected1 on --intnet1 "Network2-3"

C:\Users\brkyb\OneDrive\Masaüstü\routinglab>vboxmanage modifyvm vm3 --nic2 intnet --macaddress2 525400000034 --cableconnected2 on --intnet2 "Network3-4"

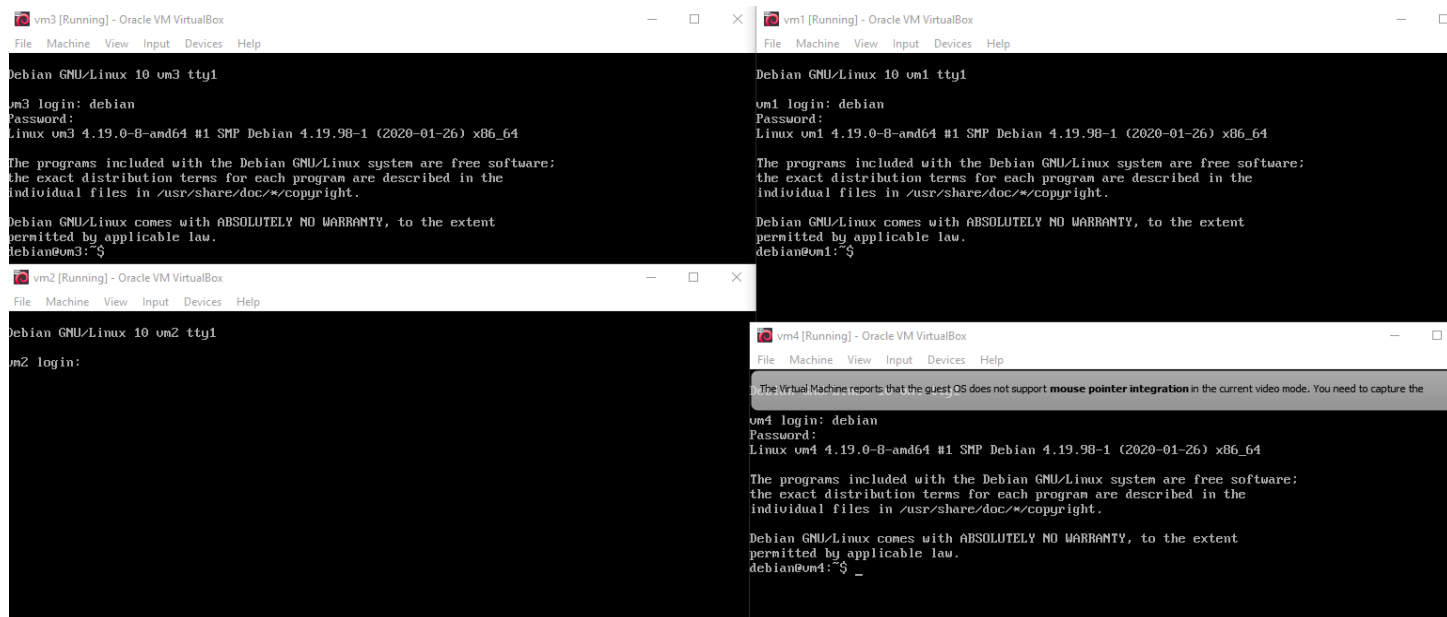
C:\Users\brkyb\OneDrive\Masaüstü\routinglab>vboxmanage modifyvm vm4 --nic1 intnet --macaddress1 525400000043 --cableconnected1 on --intnet1 "Network3-4"
```

There is below presentation of the virtual machines added to the virtual box after cook-vms command



After I got some problem I removed my debian11 server after export appliance in order to save it. So there is no problem.

2.2 Virtual machines start:



2.3 Lab configuration discovery:

1) checking network interfaces available: ip ad command;

```
vm2 [Running] - Oracle VM VirtualBox
Debian GNU/Linux 10 vm2 tty1
vm2 login: debian
Password:
Linux vm2 4.19.0-8-amd64 #1 SMP Debian 4.19.98-1 (2020-01-26) x86_64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
debian@vm2:~$ ip ad
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
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:00:00:21 brd ff:ff:ff:ff:ff:ff
    inet 10.1.2.102/24 brd 10.1.2.255 scope global eth0
        valid_lft forever preferred_lft forever
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:00:00:23 brd ff:ff:ff:ff:ff:ff
    inet 10.2.3.102/24 brd 10.2.3.255 scope global eth1
        valid_lft forever preferred_lft forever
debian@vm2:~$ _

vm1 [Running] - Oracle VM VirtualBox
Debian GNU/Linux 10 vm1 tty1
vm1 login: debian
Password:
Linux vm1 4.19.0-8-amd64 #1 SMP Debian 4.19.98-1 (2020-01-26) x86_64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
debian@vm1:~$ ip ad
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
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:00:00:12 brd ff:ff:ff:ff:ff:ff
    inet 10.1.2.101/24 brd 10.1.2.255 scope global eth0
        valid_lft forever preferred_lft forever
debian@vm1:~$ _

vm4 [Running] - Oracle VM VirtualBox
Debian GNU/Linux 10 vm4 tty1
vm4 login: debian
Password:
Linux vm4 4.19.0-8-amd64 #1 SMP Debian 4.19.98-1 (2020-01-26) x86_64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

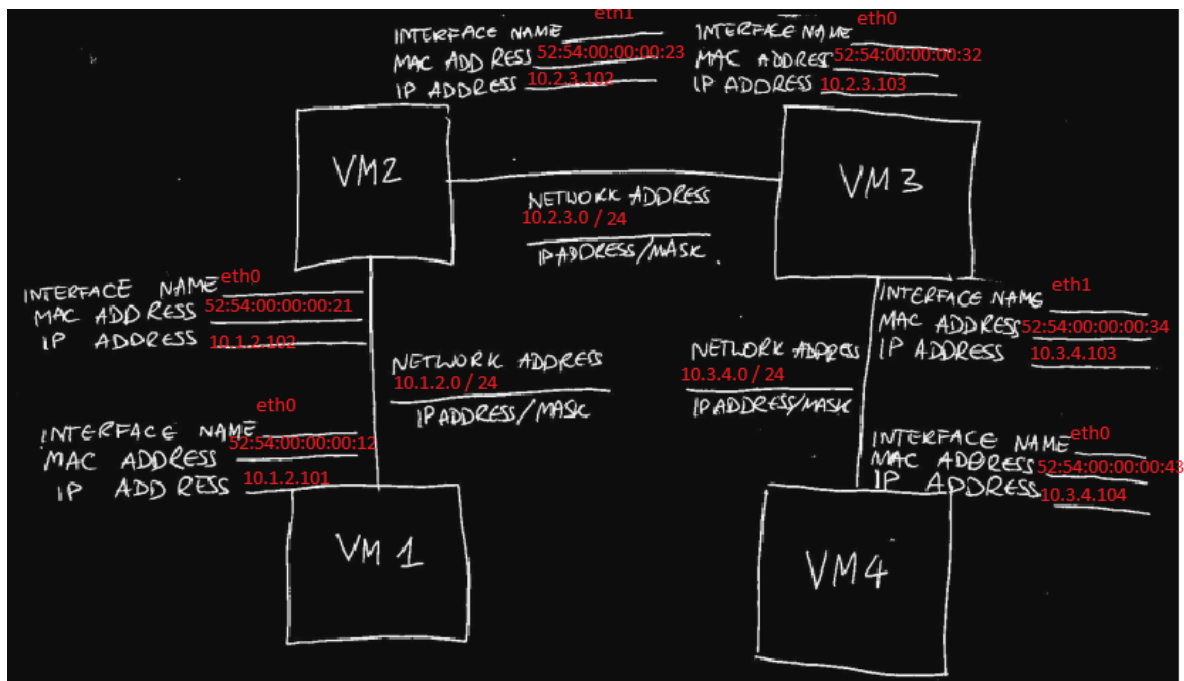
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
debian@vm4:~$ ip ad
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:00:00:43 brd ff:ff:ff:ff:ff:ff
    inet 10.3.4.104/24 brd 10.3.4.255 scope global eth0
        valid_lft forever preferred_lft forever
debian@vm4:~$ _

vm3 [Running] - Oracle VM VirtualBox
Debian GNU/Linux 10 vm3 tty1
vm3 login: debian
Password:
Linux vm3 4.19.0-8-amd64 #1 SMP Debian 4.19.98-1 (2020-01-26) x86_64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
debian@vm3:~$ ip ad
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
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:00:00:32 brd ff:ff:ff:ff:ff:ff
    inet 10.2.3.103/24 brd 10.2.3.255 scope global eth0
        valid_lft forever preferred_lft forever
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:00:00:34 brd ff:ff:ff:ff:ff:ff
    inet 10.3.4.103/24 brd 10.3.4.255 scope global eth1
        valid_lft forever preferred_lft forever
debian@vm3:~$ _
```

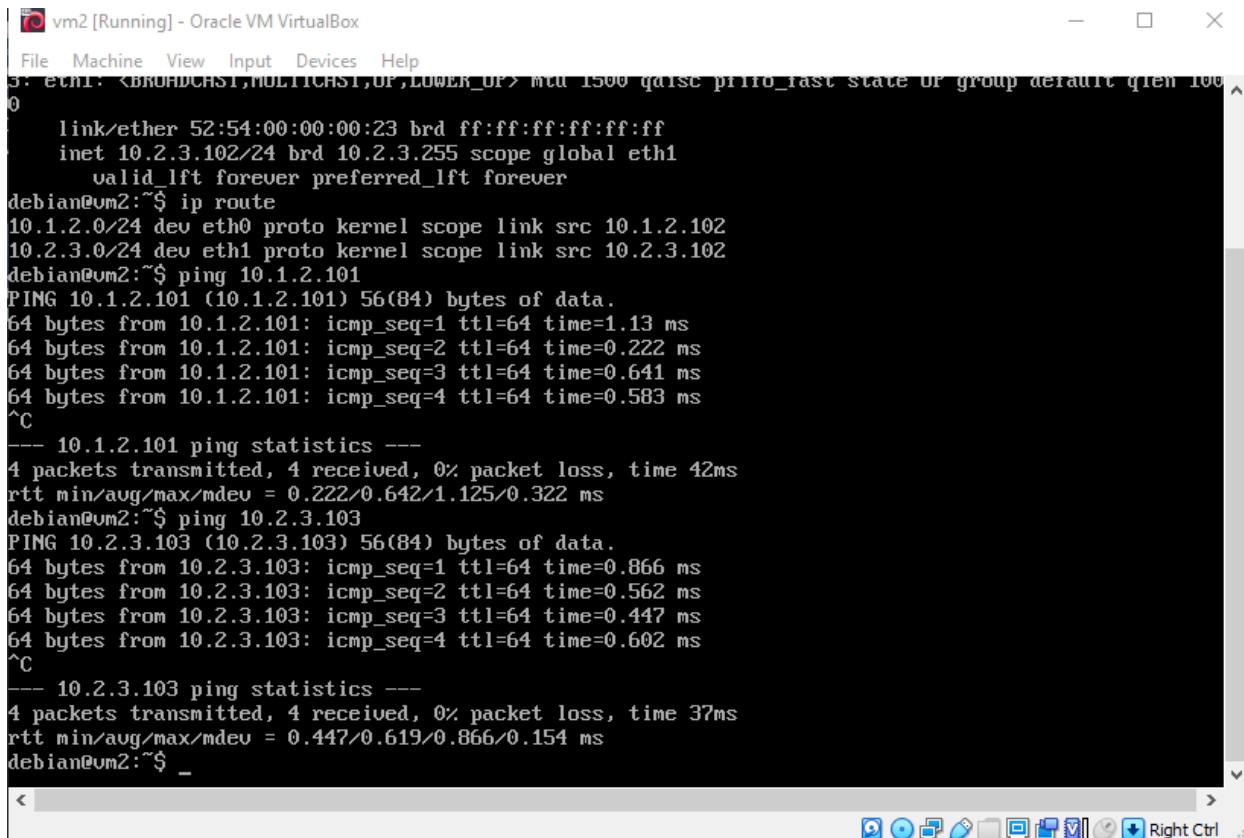
2) Filling up network map with discovered numbers:



3) Running command `ip route` in VM2:

```
valid_lft forever preferred_lft forever
debian@vm2:~$ ip route
10.1.2.0/24 dev eth0 proto kernel scope link src 10.1.2.102
10.2.3.0/24 dev eth1 proto kernel scope link src 10.2.3.102
debian@vm2:~$
```

4) Pinging neighbor machines from VM2:



```
File Machine View Input Devices Help
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc prio_fast state UP group default qlen 1000
link/ether 52:54:00:00:00:23 brd ff:ff:ff:ff:ff:ff
inet 10.2.3.102/24 brd 10.2.3.255 scope global eth1
    valid_lft forever preferred_lft forever
debian@vm2:~$ ip route
10.1.2.0/24 dev eth0 proto kernel scope link src 10.1.2.102
10.2.3.0/24 dev eth1 proto kernel scope link src 10.2.3.102
debian@vm2:~$ ping 10.1.2.101
PING 10.1.2.101 (10.1.2.101) 56(84) bytes of data:
64 bytes from 10.1.2.101: icmp_seq=1 ttl=64 time=1.13 ms
64 bytes from 10.1.2.101: icmp_seq=2 ttl=64 time=0.222 ms
64 bytes from 10.1.2.101: icmp_seq=3 ttl=64 time=0.641 ms
64 bytes from 10.1.2.101: icmp_seq=4 ttl=64 time=0.583 ms
^C
--- 10.1.2.101 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 42ms
rtt min/avg/max/mdev = 0.222/0.642/1.125/0.322 ms
debian@vm2:~$ ping 10.2.3.103
PING 10.2.3.103 (10.2.3.103) 56(84) bytes of data:
64 bytes from 10.2.3.103: icmp_seq=1 ttl=64 time=0.866 ms
64 bytes from 10.2.3.103: icmp_seq=2 ttl=64 time=0.562 ms
64 bytes from 10.2.3.103: icmp_seq=3 ttl=64 time=0.447 ms
64 bytes from 10.2.3.103: icmp_seq=4 ttl=64 time=0.602 ms
^C
--- 10.2.3.103 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 37ms
rtt min/avg/max/mdev = 0.447/0.619/0.866/0.154 ms
debian@vm2:~$ _
```

5) Tracing route to vm1 from vm2, it only takes one hop as the machines are directly connected to each other:

```
rtt min/avg/max/mdev = 0.447/0.619/0.866/0.154 ms
debian@vm2:~$ traceroute 10.1.2.101
traceroute to 10.1.2.101 (10.1.2.101), 30 hops max, 60 byte packets
 1  10.1.2.101 (10.1.2.101)  0.469 ms  0.438 ms  0.568 ms
debian@vm2:~$
```

6)Running ping and traceroute to non-existent destination and checking the error messages:

```
1 10.1.2.101 (10.1.2.101) 0.465 ms 0.458 ms 0.568 ms
debian@vm2:~$ ping 10.1.2.58
PING 10.1.2.58 (10.1.2.58) 56(84) bytes of data.
From 10.1.2.102 icmp_seq=1 Destination Host Unreachable
From 10.1.2.102 icmp_seq=2 Destination Host Unreachable
From 10.1.2.102 icmp_seq=3 Destination Host Unreachable
^C
--- 10.1.2.58 ping statistics ---
6 packets transmitted, 0 received, +3 errors, 100% packet loss, time 111ms
pipe 4
debian@vm2:~$ traceroute 10.1.2.58
traceroute to 10.1.2.58 (10.1.2.58), 30 hops max, 60 byte packets
1 10.1.2.102 (10.1.2.102) 3074.479 ms !H 3074.444 ms !H 3074.433 ms !H
debian@vm2:~$ _
```

7) In case with 8.8.8.8 ip we see error message that the network is unreachable because we don't have a corresponding entry in the routing table:

```
debian@vm2:~$ ping 8.8.8.8
connect: Network is unreachable
debian@vm2:~$ traceroute 8.8.8.8
traceroute to 8.8.8.8 (8.8.8.8), 30 hops max, 60 byte packets
connect: Network is unreachable
debian@vm2:~$ _
```

8)Compare vm1 and vm2 routing tables entries:

Vm1:

```
valid_lft forever preferred_lft forever
debian@vm1:~$ ip route
default via 10.1.2.102 dev eth0 onlink
10.1.2.0/24 dev eth0 proto kernel scope link src 10.1.2.101
debian@vm1:~$
```

Vm2:

```
debian@vm2:~$ ip route
10.1.2.0/24 dev eth0 proto kernel scope link src 10.1.2.102
10.2.3.0/24 dev eth1 proto kernel scope link src 10.2.3.102
debian@vm2:~$ _
```

VM1 has the default route configured to eth0, which means if no entry in the routing table was found for a certain destination, packet will be sent over default route. VM2 doesn't have a default route, so packets, for which the destination is not found in the routing table, will not be sent.

9) Ping and traceroute vm2 from vm1:

```
debian@vm1:~$ ping 10.1.2.102
PING 10.1.2.102 (10.1.2.102) 56(84) bytes of data.
64 bytes from 10.1.2.102: icmp_seq=1 ttl=64 time=0.480 ms
64 bytes from 10.1.2.102: icmp_seq=2 ttl=64 time=0.702 ms
64 bytes from 10.1.2.102: icmp_seq=3 ttl=64 time=0.411 ms
64 bytes from 10.1.2.102: icmp_seq=4 ttl=64 time=0.321 ms
64 bytes from 10.1.2.102: icmp_seq=5 ttl=64 time=0.600 ms
64 bytes from 10.1.2.102: icmp_seq=6 ttl=64 time=0.473 ms
64 bytes from 10.1.2.102: icmp_seq=7 ttl=64 time=0.513 ms
64 bytes from 10.1.2.102: icmp_seq=8 ttl=64 time=0.362 ms
64 bytes from 10.1.2.102: icmp_seq=9 ttl=64 time=0.554 ms
64 bytes from 10.1.2.102: icmp_seq=10 ttl=64 time=0.585 ms
^C
--- 10.1.2.102 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 194ms
rtt min/avg/max/mdev = 0.321/0.500/0.702/0.110 ms
debian@vm1:~$ traceroute 10.1.2.102
traceroute to 10.1.2.102 (10.1.2.102), 30 hops max, 60 byte packets
 1  10.1.2.102 (10.1.2.102)  0.531 ms  0.464 ms  0.431 ms
debian@vm1:~$
```

10) Error messages for non-existent ip:

```
debian@vm1:~$ ping 10.1.2.58
PING 10.1.2.58 (10.1.2.58) 56(84) bytes of data.
From 10.1.2.101 icmp_seq=1 Destination Host Unreachable
From 10.1.2.101 icmp_seq=2 Destination Host Unreachable
From 10.1.2.101 icmp_seq=3 Destination Host Unreachable
^C
--- 10.1.2.58 ping statistics ---
6 packets transmitted, 0 received, +3 errors, 100% packet loss, time 111ms
pipe 4
debian@vm1:~$ traceroute 10.1.2.58
traceroute to 10.1.2.58 (10.1.2.58), 30 hops max, 60 byte packets
 1  vm1 (10.1.2.101)  3075.546 ms  !H  3075.498 ms  !H  3075.489 ms  !H
debian@vm1:~$
```

In case with vm1 the error message is different, because it does sent the packets to the default route, just doesn't get any answers.

11) Testing ping and traceroute to 8.8.8.8

```
1  vm1 (10.1.2.101)  3075.546 ms  !H  3075.498 ms  !H  3075.489 ms  !H
debian@vm1:~$ ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
From 10.1.2.102 icmp_seq=1 Destination Net Unreachable
From 10.1.2.102 icmp_seq=2 Destination Net Unreachable
From 10.1.2.102 icmp_seq=3 Destination Net Unreachable
From 10.1.2.102 icmp_seq=4 Destination Net Unreachable
^C
--- 8.8.8.8 ping statistics ---
4 packets transmitted, 0 received, +4 errors, 100% packet loss, time 6ms

debian@vm1:~$ traceroute 8.8.8.8
traceroute to 8.8.8.8 (8.8.8.8), 30 hops max, 60 byte packets
 1  10.1.2.102 (10.1.2.102)  0.326 ms  !N  0.278 ms  !N *
debian@vm1:~$ _
```

In this case VM2 informs us that the destination is unreachable. It acts as a default gateway for vm1, so the packet arrives to vm2, but vm2 has no corresponding entry in its routing table so it says that the destination is unreachable.

2.4 Routing configuration:

1) Verifying forwarding is enabled:

Enabled VM2 and VM3;

vm2:

```
debian@vm2:~$ cat /proc/sys/net/ipv4/ip_forward
1
debian@vm2:~$
```

vm3:

```
valid_lft forever preferred_lft forever
debian@vm3:~$ cat /proc/sys/net/ipv4/ip_forward
1
debian@vm3:~$ _
```

2) Ping and traceroute vm3 from vm1:

```
debian@vm1:~$ ping 10.2.3.103
PING 10.2.3.103 (10.2.3.103) 56(84) bytes of data.
^C
--- 10.2.3.103 ping statistics ---
18 packets transmitted, 0 received, 100% packet loss, time 403ms

debian@vm1:~$ traceroute 10
traceroute to 10 (0.0.0.10), 30 hops max, 60 byte packets
connect: Invalid argument
debian@vm1:~$ traceroute 10.2.3.103
traceroute to 10.2.3.103 (10.2.3.103), 30 hops max, 60 byte packets
 1  10.1.2.102 (10.1.2.102)  0.229 ms  0.164 ms  0.174 ms
 2  * * *
 3  * * *
 4  * * *
 5  * * *
 6  * * *
 7  * ^C
debian@vm1:~$
```

Does not receive answers to ping and traceroute can only determine one hop which is vm2.

Ping and traceroute are not working because in vm3's routing table there's no entry corresponding for network 10.1.2.0/24, so the packet is not sent back from vm3 to vm1;

4) Adding route to vm3's routing table, to enable it to connect to vm1's network:

```
debian@vm3:~$ sudo -i
root@vm3:~# ip route add 10.1.2.0/24 via 10.2.3.102
root@vm3:~# _
```

5) Viewing new routing table:

```
debian@vm3:~$ ip route
10.1.2.0/24 via 10.2.3.102 dev eth0
10.2.3.0/24 dev eth0 proto kernel scope link src 10.2.3.103
10.3.4.0/24 dev eth1 proto kernel scope link src 10.3.4.103
debian@vm3:~$ _
```

Now it contains entry to connect to vm1's network (10.1.2.0/24)

6) Ping from vm3 to vm1:

Successfully ping completed ->

```
debian@vm3:~$ ping 10.1.2.101
PING 10.1.2.101 (10.1.2.101) 56(84) bytes of data.
64 bytes from 10.1.2.101: icmp_seq=1 ttl=63 time=1.14 ms
64 bytes from 10.1.2.101: icmp_seq=2 ttl=63 time=0.902 ms
64 bytes from 10.1.2.101: icmp_seq=3 ttl=63 time=1.01 ms
64 bytes from 10.1.2.101: icmp_seq=4 ttl=63 time=0.738 ms
64 bytes from 10.1.2.101: icmp_seq=5 ttl=63 time=0.900 ms
64 bytes from 10.1.2.101: icmp_seq=6 ttl=63 time=0.876 ms
64 bytes from 10.1.2.101: icmp_seq=7 ttl=63 time=1.16 ms
^C
--- 10.1.2.101 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 16ms
rtt min/avg/max/mdev = 0.738/0.959/1.160/0.145 ms
debian@vm3:~$ _
```

8) Traceroute from vm3 to vm1:

```
debian@vm3:~$ traceroute 10.1.2.101
traceroute to 10.1.2.101 (10.1.2.101), 30 hops max, 60 byte packets
 1  10.2.3.102 (10.2.3.102)  0.403 ms  0.338 ms  0.322 ms
 2  10.1.2.101 (10.1.2.101)  0.917 ms  0.860 ms  0.830 ms
debian@vm3:~$ _
```

Traceroute successful, we can see packets going through vm2 and arriving to vm1

9) Ping and traceroute from vm1 to vm3:

Successful ->

```
debian@vm1:~$ ping 10.2.3.103
PING 10.2.3.103 (10.2.3.103) 56(84) bytes of data.
64 bytes from 10.2.3.103: icmp_seq=1 ttl=63 time=1.03 ms
64 bytes from 10.2.3.103: icmp_seq=2 ttl=63 time=0.939 ms
64 bytes from 10.2.3.103: icmp_seq=3 ttl=63 time=0.979 ms
64 bytes from 10.2.3.103: icmp_seq=4 ttl=63 time=1.19 ms
64 bytes from 10.2.3.103: icmp_seq=5 ttl=63 time=1.20 ms
64 bytes from 10.2.3.103: icmp_seq=6 ttl=63 time=1.10 ms
64 bytes from 10.2.3.103: icmp_seq=7 ttl=63 time=1.12 ms
64 bytes from 10.2.3.103: icmp_seq=8 ttl=63 time=1.18 ms
64 bytes from 10.2.3.103: icmp_seq=9 ttl=63 time=1.21 ms
64 bytes from 10.2.3.103: icmp_seq=10 ttl=63 time=1.09 ms
64 bytes from 10.2.3.103: icmp_seq=11 ttl=63 time=1.16 ms
^C
--- 10.2.3.103 ping statistics ---
11 packets transmitted, 11 received, 0% packet loss, time 24ms
rtt min/avg/max/mdev = 0.939/1.108/1.211/0.089 ms
debian@vm1:~$ traceroute 10.2.3.103
traceroute to 10.2.3.103 (10.2.3.103), 30 hops max, 60 byte packets
 1  10.1.2.102 (10.1.2.102)  0.620 ms  0.576 ms  0.550 ms
 2  10.2.3.103 (10.2.3.103)  0.791 ms  0.744 ms  0.666 ms
debian@vm1:~$ _
```

10) Configuring vm2's routing table to connect to vm4's network, doing ping and traceroute.

```
debian@vm2:~$ sudo -i
root@vm2:~# ip route add 10.3.4.0/24 via 10.2.3.103
root@vm2:~# su debian
debian@vm2:/root$ ip route
10.1.2.0/24 dev eth0 proto kernel scope link src 10.1.2.102
10.2.3.0/24 dev eth1 proto kernel scope link src 10.2.3.102
10.3.4.0/24 via 10.2.3.103 dev eth1
debian@vm2:/root$ ping 10.3.4.104
PING 10.3.4.104 (10.3.4.104) 56(84) bytes of data.
64 bytes from 10.3.4.104: icmp_seq=1 ttl=63 time=1.48 ms
64 bytes from 10.3.4.104: icmp_seq=2 ttl=63 time=1.12 ms
64 bytes from 10.3.4.104: icmp_seq=3 ttl=63 time=1.06 ms
64 bytes from 10.3.4.104: icmp_seq=4 ttl=63 time=1.12 ms
64 bytes from 10.3.4.104: icmp_seq=5 ttl=63 time=0.793 ms
64 bytes from 10.3.4.104: icmp_seq=6 ttl=63 time=1.10 ms
^C
--- 10.3.4.104 ping statistics ---
6 packets transmitted, 6 received, 0% packet loss, time 15ms
rtt min/avg/max/mdev = 0.793/1.110/1.477/0.203 ms
debian@vm2:/root$ traceroute 10.3.4.104
traceroute to 10.3.4.104 (10.3.4.104), 30 hops max, 60 byte packets
 1  10.2.3.103 (10.2.3.103)  0.485 ms  0.532 ms  0.500 ms
 2  10.3.4.104 (10.3.4.104)  0.746 ms  0.706 ms  0.822 ms
debian@vm2:/root$
```

11) Ping and traceroute vm4 from vm1:

```
debian@vm1:~$ ping 10.3.4.104
PING 10.3.4.104 (10.3.4.104) 56(84) bytes of data.
64 bytes from 10.3.4.104: icmp_seq=1 ttl=62 time=1.71 ms
64 bytes from 10.3.4.104: icmp_seq=2 ttl=62 time=1.63 ms
64 bytes from 10.3.4.104: icmp_seq=3 ttl=62 time=1.57 ms
64 bytes from 10.3.4.104: icmp_seq=4 ttl=62 time=1.39 ms
64 bytes from 10.3.4.104: icmp_seq=5 ttl=62 time=0.650 ms
64 bytes from 10.3.4.104: icmp_seq=6 ttl=62 time=0.566 ms
64 bytes from 10.3.4.104: icmp_seq=7 ttl=62 time=1.44 ms
^C
--- 10.3.4.104 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 42ms
rtt min/avg/max/mdev = 0.566/1.279/1.710/0.438 ms
debian@vm1:~$ traceroute 10.3.4.104
traceroute to 10.3.4.104 (10.3.4.104), 30 hops max, 60 byte packets
 1  10.1.2.102 (10.1.2.102)  0.266 ms  0.220 ms  0.185 ms
 2  10.2.3.103 (10.2.3.103)  0.442 ms  0.427 ms  0.411 ms
 3  10.3.4.104 (10.3.4.104)  0.554 ms  0.634 ms  0.579 ms
debian@vm1:~$
```

2.5 Network interfaces configuration

2) Disabling network interface on vm1:

```
debian@vm1:~$ sudo -i
root@vm1:~# ifdown eth0
root@vm1:~# _
```

3, 4) Opening /etc/network/interfaces.d/40-network-cfg with nano and modifying ip to 10.1.2.105

```
root@vm1:~# nano /etc/network/interfaces.d/40-network-cfg_
```



The screenshot shows a VirtualBox window titled "vm1 [Running] - Oracle VM VirtualBox". Inside the window, the GNU nano 3.2 text editor is open, editing the file /etc/network/interfaces.d/40-network-cfg. The editor shows the following content:

```
# Network configuration
auto lo
iface lo inet loopback

auto eth0
iface eth0 inet static
    address 10.1.2.105/24
    gateway 10.1.2.102
```

The window has a menu bar with "File", "Machine", "View", "Input", "Devices", and "Help". The status bar at the bottom indicates "Modified".

5) Enabling the interface:

```
root@vm1:~# ifup eth0
[14679.681104] e1000: eth0 NIC Link is Up 1000 Mbps Full Duplex, Flow Control: RX
```

6) Verifying the ip address is updated:

```
debian@vm1:/root$ ip ad
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
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:00:00:12 brd ff:ff:ff:ff:ff:ff
    inet 10.1.2.105/24 brd 10.1.2.255 scope global eth0
        valid_lft forever preferred_lft forever
debian@vm1:/root$
```

Now it is 10.1.2.105

7) Checking connectivity to vm2, vm3, vm4:

Successfully pinging

```
debian@vm1:/root$ ping 10.1.2.102
PING 10.1.2.102 (10.1.2.102) 56(84) bytes of data.
64 bytes from 10.1.2.102: icmp_seq=1 ttl=64 time=0.722 ms
64 bytes from 10.1.2.102: icmp_seq=2 ttl=64 time=0.422 ms
^C
--- 10.1.2.102 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 20ms
rtt min/avg/max/mdev = 0.422/0.572/0.722/0.150 ms
debian@vm1:/root$ ping 10.2.3.103
PING 10.2.3.103 (10.2.3.103) 56(84) bytes of data.
64 bytes from 10.2.3.103: icmp_seq=1 ttl=63 time=0.787 ms
64 bytes from 10.2.3.103: icmp_seq=2 ttl=63 time=0.900 ms
^C
--- 10.2.3.103 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 24ms
rtt min/avg/max/mdev = 0.787/0.843/0.900/0.063 ms
debian@vm1:/root$ ping 10.3.4.104
PING 10.3.4.104 (10.3.4.104) 56(84) bytes of data.
64 bytes from 10.3.4.104: icmp_seq=1 ttl=62 time=1.11 ms
64 bytes from 10.3.4.104: icmp_seq=2 ttl=62 time=1.22 ms
^C
--- 10.3.4.104 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 2ms
rtt min/avg/max/mdev = 1.108/1.161/1.215/0.063 ms
debian@vm1:/root$ _
```

8) Pinging vm1 with new ip from vm4:

```
debian@vm4:~$ ping 10.1.2.105
PING 10.1.2.105 (10.1.2.105) 56(84) bytes of data.
64 bytes from 10.1.2.105: icmp_seq=1 ttl=62 time=1.17 ms
64 bytes from 10.1.2.105: icmp_seq=2 ttl=62 time=1.29 ms
64 bytes from 10.1.2.105: icmp_seq=3 ttl=62 time=0.976 ms
^C
--- 10.1.2.105 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 5ms
rtt min/avg/max/mdev = 0.976/1.147/1.293/0.133 ms
debian@vm4:~$
```

10) Disabling eth1 on vm2:

```
debian@vm2:/root$ sudo -i
root@vm2:~# ifdown eth1
root@vm2:~# _
```

11) Adding routing table configuration commands to vm2's eth1 configuration:

```
GNU nano 3.2 /etc/network/interfaces.d/40-network-cfg modified
# Network configuration
auto lo
iface lo inet loopback

auto eth0
iface eth0 inet static
    address 10.1.2.102/24

auto eth1
iface eth1 inet static
    address 10.2.3.102/24

up route add -net 10.3.4.0 netmask 255.255.255.0 gw 10.2.3.103
down route del -net 10.3.4.0 netmask 255.255.255.0 gw 10.2.3.103
```

12) Enabling eth1 interface on vm2 and pinging vm4:

```
root@vm2:~# ifup eth1
[15721.710593] e1000: eth1 NIC Link is Up 1000 Mbps Full Duplex, Flow Control: RX
root@vm2:~# ping 10.3.4.104
PING 10.3.4.104 (10.3.4.104) 56(84) bytes of data:
64 bytes from 10.3.4.104: icmp_seq=1 ttl=63 time=0.529 ms
64 bytes from 10.3.4.104: icmp_seq=2 ttl=63 time=0.917 ms
64 bytes from 10.3.4.104: icmp_seq=3 ttl=63 time=0.784 ms
^C
--- 10.3.4.104 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 55ms
rtt min/avg/max/mdev = 0.529/0.743/0.917/0.162 ms
root@vm2:~#
```

13) Rebooting and checking if the entries are still in the routing table:

```
debian@vm2:/root$ sudo -i
root@vm2:~# reboot
```

```
Debian GNU/Linux 10 vm2 tty1
vm2 login: debian
Password:
Last login: Sun May  8 15:22:23 CEST 2022 on tty1
Linux vm2 4.19.0-8-and64 #1 SMP Debian 4.19.90-1 (2020-01-26) x86_64

The programs included with the Debian GNU/Linux system are free software:
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
debian@vm2:~$ ip route
10.1.2.0/24 dev eth0 proto kernel scope link src 10.1.2.102
10.2.3.0/24 dev eth1 proto kernel scope link src 10.2.3.102
10.3.4.0/24 via 10.2.3.103 dev eth1
debian@vm2:~$
```

Now after rebooting we log into the system and we still have the routing table entry to 10.3.4.0/24

Pinging vm4 from vm1:

```
debian@vm1:/root$ ping 10.3.4.104
PING 10.3.4.104 (10.3.4.104) 56(84) bytes of data.
64 bytes from 10.3.4.104: icmp_seq=1 ttl=62 time=1.76 ms
64 bytes from 10.3.4.104: icmp_seq=2 ttl=62 time=1.83 ms
64 bytes from 10.3.4.104: icmp_seq=3 ttl=62 time=1.56 ms
^C
--- 10.3.4.104 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 6ms
rtt min/avg/max/mdev = 1.560/1.713/1.826/0.122 ms
debian@vm1:/root$ _
```

Pinging vm1 from vm4:

```
debian@vm4:~$ ping 10.1.2.102
PING 10.1.2.102 (10.1.2.102) 56(84) bytes of data.
64 bytes from 10.1.2.102: icmp_seq=1 ttl=63 time=0.897 ms
64 bytes from 10.1.2.102: icmp_seq=2 ttl=63 time=1.16 ms
64 bytes from 10.1.2.102: icmp_seq=3 ttl=63 time=1.07 ms
^C
--- 10.1.2.102 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 8ms
rtt min/avg/max/mdev = 0.897/1.043/1.161/0.112 ms
debian@vm4:~$ _
```