CS3543 Lab Assignment for Jan 24th

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General Information

1. This assignment is a pair assignment. The same mark will be offered to the pair of students regardless of individual contributions.
2. The assignment is customized for Ubuntu + KVM environment. It is highly recommended for non-Ubuntu users to enable dual boot on your laptop computer and install Ubuntu. If you would like to work on another operating system and virtualization platform, you need to interpret the Ubuntu/KVM terminology to another environment's terminology.
3. Each pair can create a locally copy of this question file, give the answer to the local copy, and submit in a form of PDF file.
4. Only one submission is good enough as far as the student name and ID are properly mentioned.
5. Do not send any private comments to separately mention the buddy.

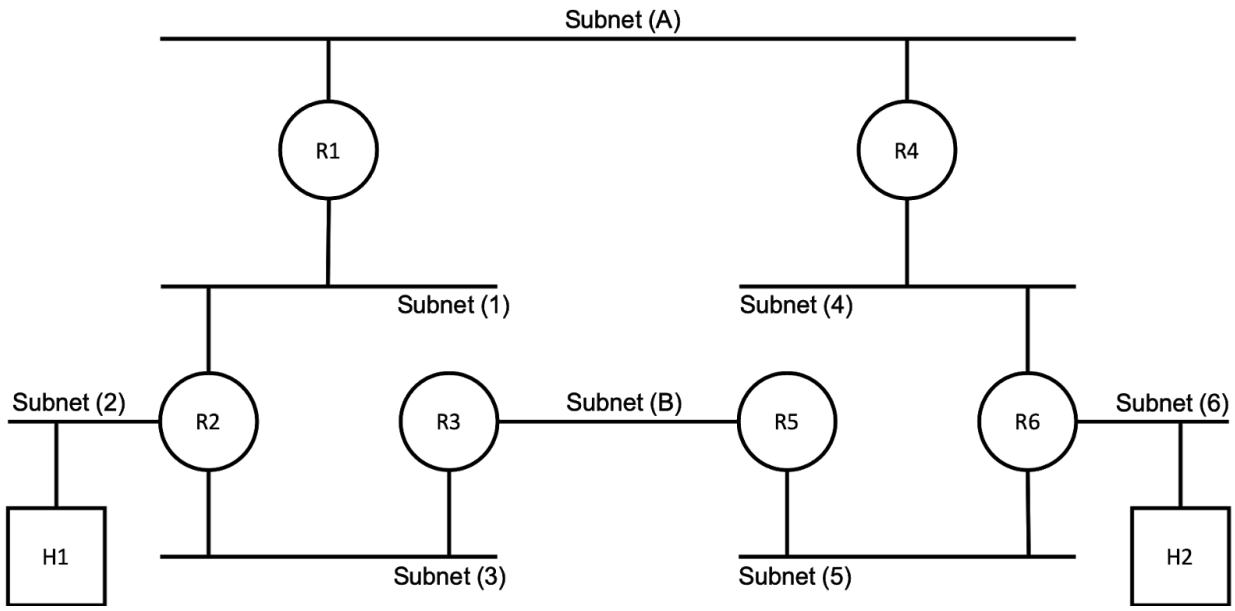


Fig.1. Blank Network Diagram

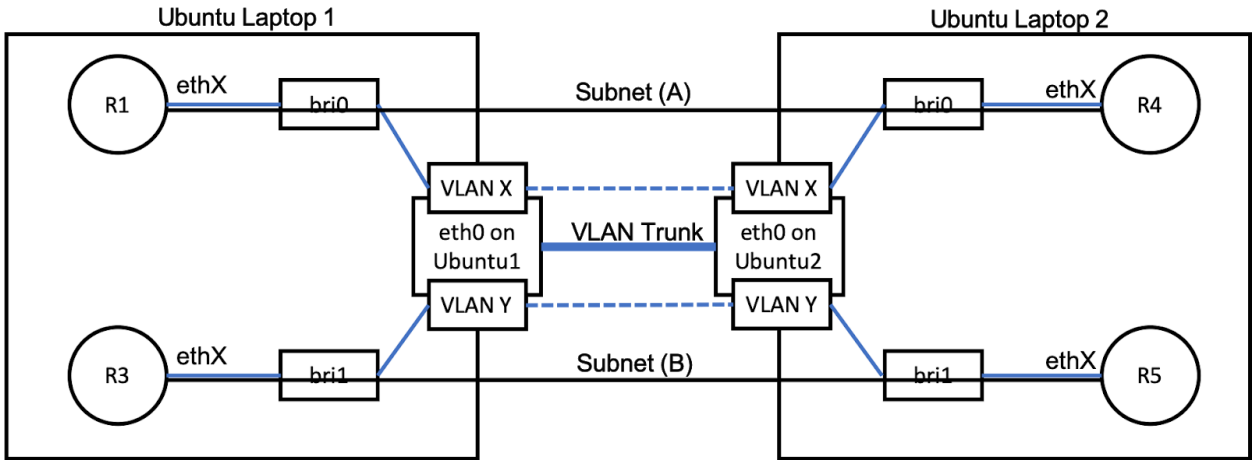


Fig.2. Conceptual Illustration of VLAN Configuration on Ubuntu Laptops 1 and 2

(Instruction)

This assignment requires to directly connect two Ubuntu laptops using a LAN cable to form a slightly bigger network than the previous assignment as shown in Fig. 1. In order to enable inter-router connections via Subnets (A) and (B) between the Ubuntu laptops, VLAN I/F (for VLAN Trunk) needs to be created on the physical LAN port of both Ubuntu laptops, and VLAN I/F needs to be attached to the corresponding bridge I/F as illustrated in Fig.2. Explore the ubuntu configuration 1) to create VLANs on Ubuntu, 2) to configure VLAN I/F (Trunking), and 3) attach VLAN I/F to a bridge I/F, 4) to let the traffic go through a separate VLAN/Bridge between respective pairs of VMs {R1 and R4} and {R3 and R5}.

Question 0.

Complete the following table about the VLAN and Bridge configurations for Subnets (A) and (B). It is strongly recommended to unify the bridge name between Laptops 1 and 2 for each subnet to avoid confusion.

	For Subnet (A)	For Subnet (B)
VLAN ID	10	20
Name of VLAN I/F on Laptop 1	enp4s0f1.10	enp4s0f1.20
Name of VLAN I/F on Laptop 2	enp2s0.10	enp2s0.20
Name of Bridge I/F on Laptop 1	bri0	bri4
Name of Bridge I/F on Laptop 2	bri0	bri4

Question 1.

Assign the necessary configuration (NIC and IPv4/v6 addresses) to implement the network illustrated in Fig. 1, note down the configuration in the network diagram, and insert the update network diagram as an image as the answer to the question.

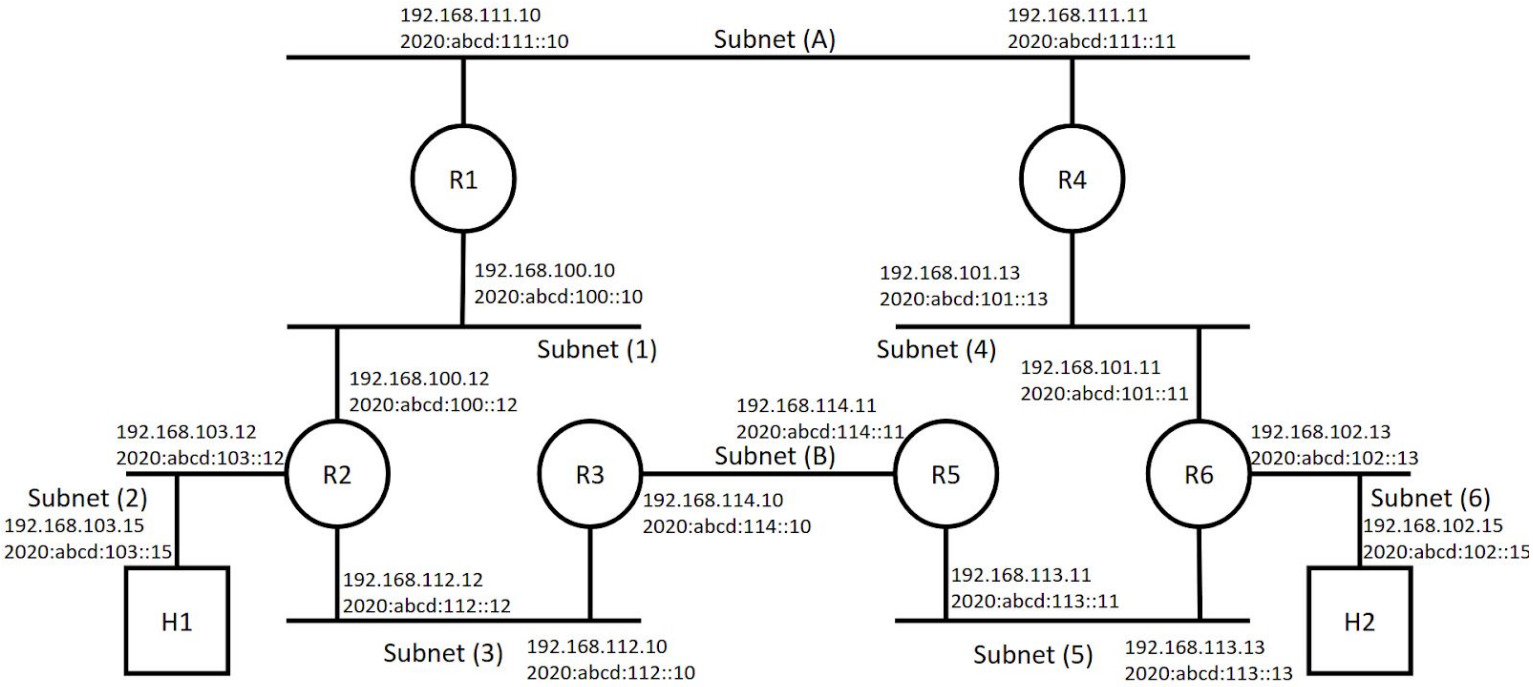
Supplemental Instructions for Question 1.

1. This assignment does not provide any addressing information. It must be determined and noted down in the network diagram by yourself. Make sure that the following minimum information are clearly visible.
    a. To each subnet: Bridge Name, IPv4 Prefix, IPv6 Prefix
    b. To each NIC: I/F Name, MAC Address, IPv4 Address, IPv6 Address
2. You may use the base network diagram given in the supplemental power-point file or your hand illustration. The example of subnet and NIC information is also available in the same power-point file. If you don't have a better idea, follow the example.

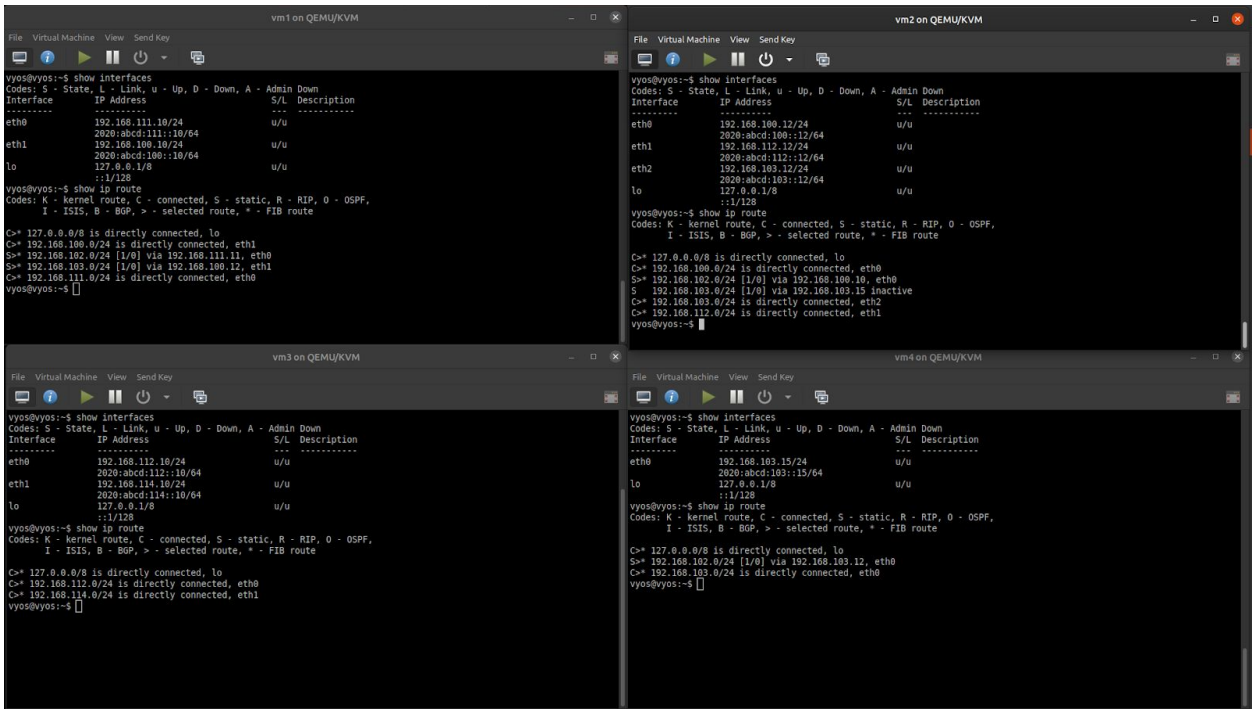
Subnet Name	IPv4 prefix	IPv6 prefix	bridge
A	192.168.111.0	2020:abcd:111::0	bri0 in both
B	192.168.114.0	2020:abcd:114::0	bri4 in both
1	192.168.100.0	2020:abcd:100::0	bri1
2	192.168.103.0	2020:abcd:103::0	bri2
3	192.168.112.0	2020:abcd:112::0	bri3
4	192.168.101.0	2020:abcd:101::0	bri1
5	192.168.113.0	2020:abcd:113::0	bri2
6	192.168.102.0	2020:abcd:102::0	bri3

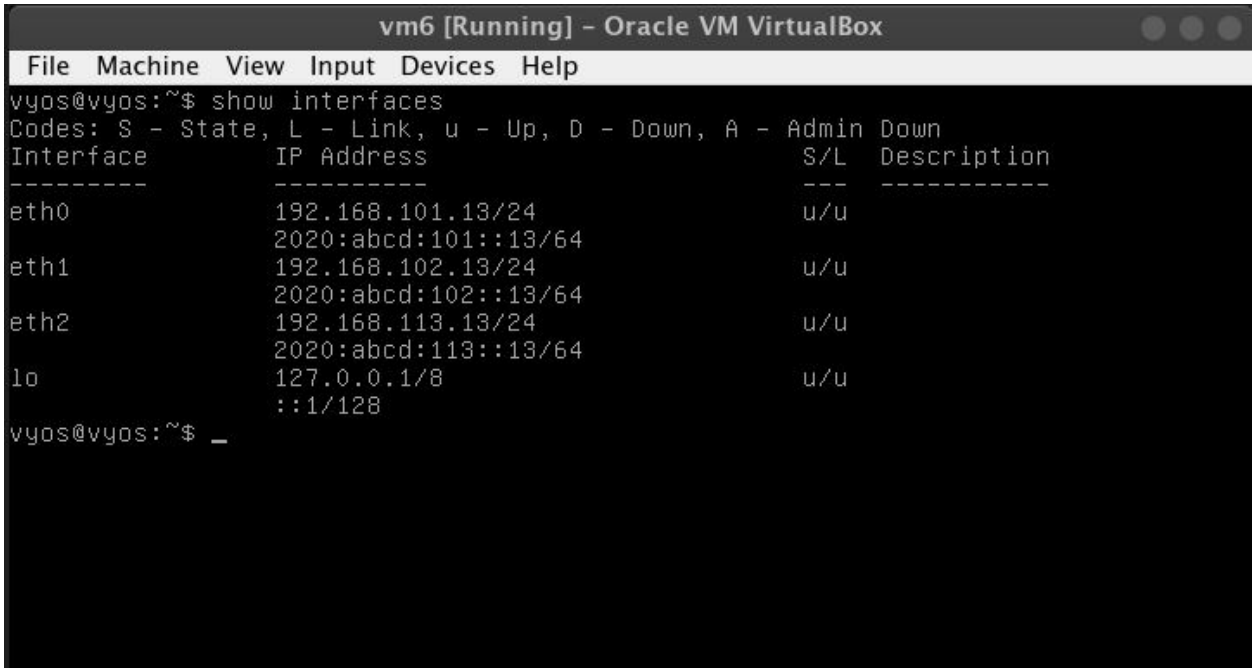
NIC	Mac address	bridge	I/F name
R1.1	52:54:00:f7:14:c4	bri0	eth0
R2.1	52:54:00:12:83:f2	bri1	eth0
R3.1	52:54:00:fa:fd:15	bri3	eth0
R1.2	52:54:00:9c:3b:14	bri1	eth1
R2.2	52:54:00:d2:ae:c6	bri3	eth1
R3.2	52:54:00:02:77:31	bri4	eth1
R2.3	52:54:00:48:cd:5c	bri2	eth2
H1.1	52:54:00:9a:bc:0d	bri2	eth0

NIC	Mac address	bridge	I/F name
R4.1	80:00:27:CE:93:6D	bri0	eth0
R5.1	08:00:27:31:46:03	bri3	eth0
R6.1	08:00:27:E1:97:67	bri1	eth0
R4.2	08:00:27:B9:49:72	bri1	eth1
R5.2	08:00:27:32:49:AD	bri4	eth1
R6.2	08:00:27:76:0B:1F	bri2	eth1
R6.3	08:00:27:09:4A:C3	bri3	eth2
H2.1	08:00:27:4D:DB:5E	bri2	eth0

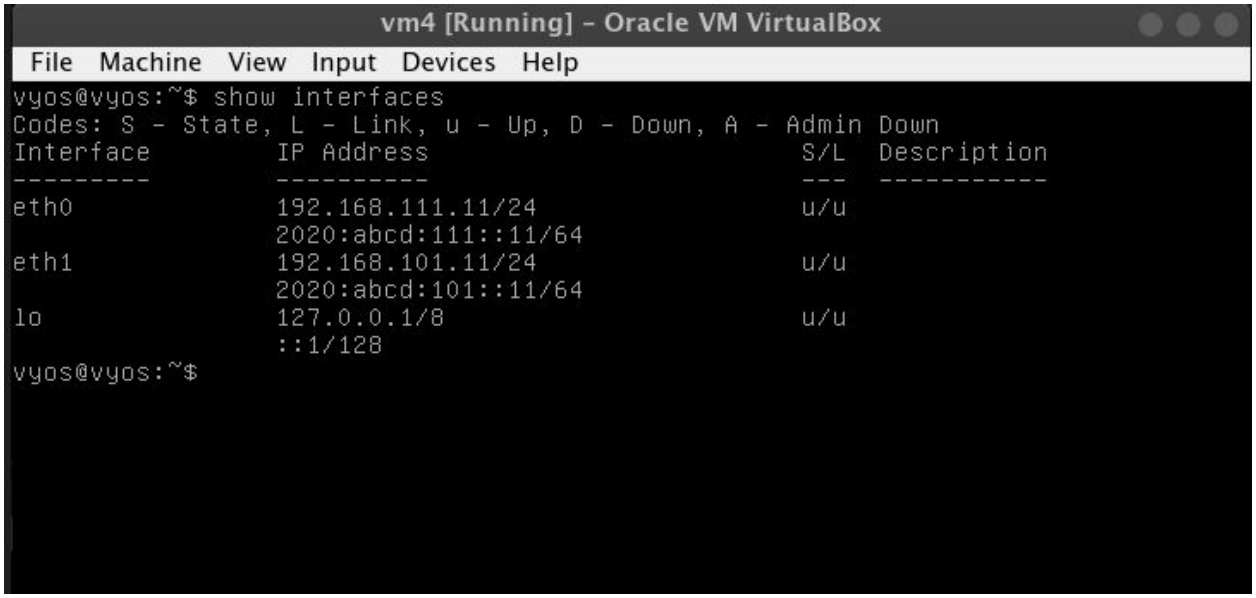


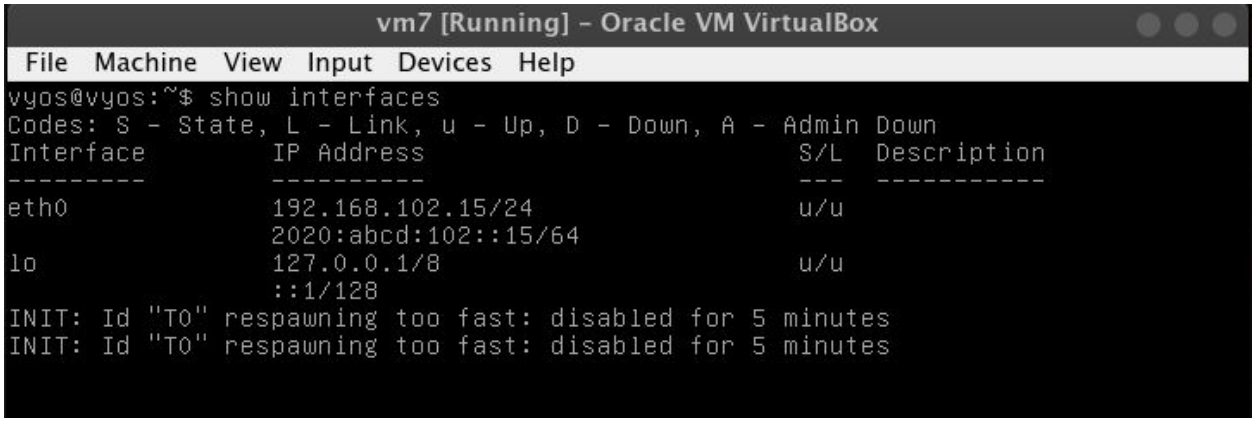
Some screenshots




vm6 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
vyos@vyos:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface IP Address S/L Description
--------- ---------- --- -----------
eth0 192.168.101.13/24 u/u
2020:abcd:101::13/64
eth1 192.168.102.13/24 u/u
2020:abcd:102::13/64
eth2 192.168.113.13/24 u/u
2020:abcd:113::13/64
lo 127.0.0.1/8 u/u
::1/128
vyos@vyos:~$


vm5 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
vyos@vyos:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface IP Address S/L Description
--------- ---------- --- -----------
eth0 192.168.113.11/24 u/u
2020:abcd:113::11/64
eth1 192.168.114.11/24 u/u
2020:abcd:114::11/64
lo 127.0.0.1/8 u/u
::1/128
vyos@vyos:~$


vm4 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
vyos@vyos:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface IP Address S/L Description
--------- ---------- --- -----------
eth0 192.168.111.11/24 u/u
2020:abcd:111::11/64
eth1 192.168.101.11/24 u/u
2020:abcd:101::11/64
lo 127.0.0.1/8 u/u
::1/128
vyos@vyos:~$


vm7 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
vyos@vyos:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface IP Address S/L Description
--------- ---------- --- -----------
eth0 192.168.102.15/24 u/u
2020:abcd:102::15/64
lo 127.0.0.1/8 u/u
::1/128
INIT: Id "T0" respawning too fast: disabled for 5 minutes
INIT: Id "T0" respawning too fast: disabled for 5 minutes

Question 2.

Configure static routes so that the traffic between H1 and H2 goes through Subnet (A) for both directions. Answer by inserting the screen captures of routing table of R2 and R6, and traceroute results between H1 and H2.

R6 route table

```
vyos@vyos:~$ show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
       I - ISIS, B - BGP, > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
C>* 192.168.101.0/24 is directly connected, eth0
S   192.168.102.0/24 [1/0] via 192.168.102.0 inactive
C>* 192.168.102.0/24 is directly connected, eth1
S>* 192.168.103.0/24 [1/0] via 192.168.101.11, eth0
C>* 192.168.113.0/24 is directly connected, eth2
vyos@vyos:~$
```

R2 route table

```
vyos@vyos:~$ show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
       I - ISIS, B - BGP, > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
C>* 192.168.100.0/24 is directly connected, eth0
S>* 192.168.102.0/24 [1/0] via 192.168.100.10, eth0
S   192.168.103.0/24 [1/0] via 192.168.103.15 inactive
C>* 192.168.103.0/24 is directly connected, eth2
C>* 192.168.112.0/24 is directly connected, eth1
vyos@vyos:~$
```

From H2 to H1

```
vyos@vyos:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                        S/L  Description
---------        ----------                        ---  -----------
eth0             192.168.102.15/24                 u/u
                 2020:abcd:102::15/64
lo               127.0.0.1/8                       u/u
                 ::1/128
INIT: Id "T0" respawning too fast: disabled for 5 minutes
^C
vyos@vyos:~$ traceroute 192.168.103.15
traceroute to 192.168.103.15 (192.168.103.15), 30 hops max, 60 byte packets
 1  192.168.102.13 (192.168.102.13)  0.235 ms  0.122 ms  0.120 ms
 2  192.168.101.11 (192.168.101.11)  0.831 ms  1.021 ms  0.969 ms
 3  192.168.111.10 (192.168.111.10)  1.426 ms  1.383 ms  1.786 ms
 4  192.168.100.12 (192.168.100.12)  2.141 ms  2.099 ms  2.646 ms
 5  192.168.103.15 (192.168.103.15)  2.604 ms  2.557 ms  2.508 ms
vyos@vyos:~$ _
```

Ping H2 to H1

```
vyos@vyos:~$ ping 192.168.103.15
PING 192.168.103.15 (192.168.103.15) 56(84) bytes of data.
64 bytes from 192.168.103.15: icmp_req=1 ttl=60 time=2.19 ms
64 bytes from 192.168.103.15: icmp_req=2 ttl=60 time=2.24 ms
64 bytes from 192.168.103.15: icmp_req=3 ttl=60 time=2.60 ms
64 bytes from 192.168.103.15: icmp_req=4 ttl=60 time=1.74 ms
64 bytes from 192.168.103.15: icmp_req=5 ttl=60 time=1.95 ms
```

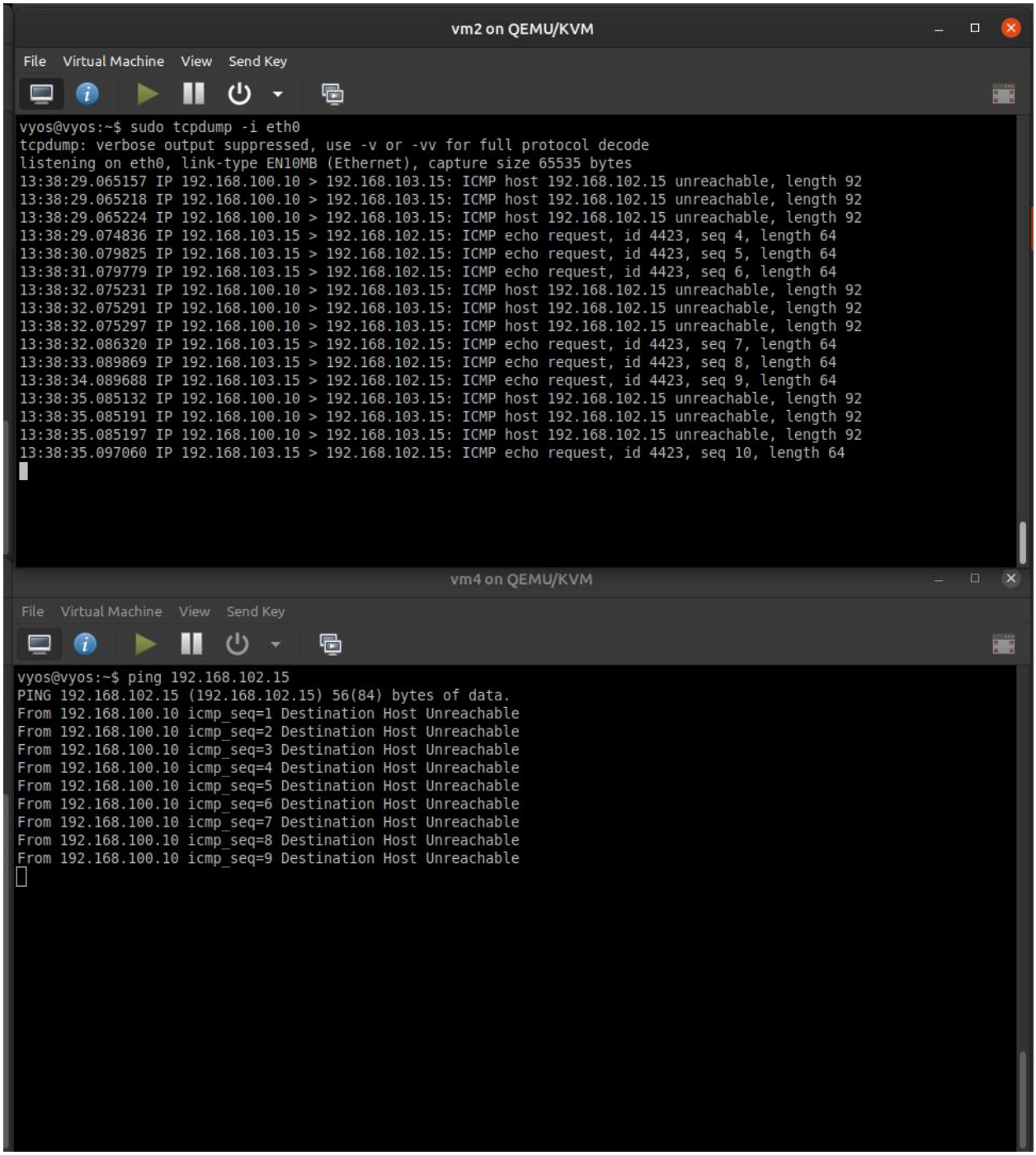
From H1 to H2:

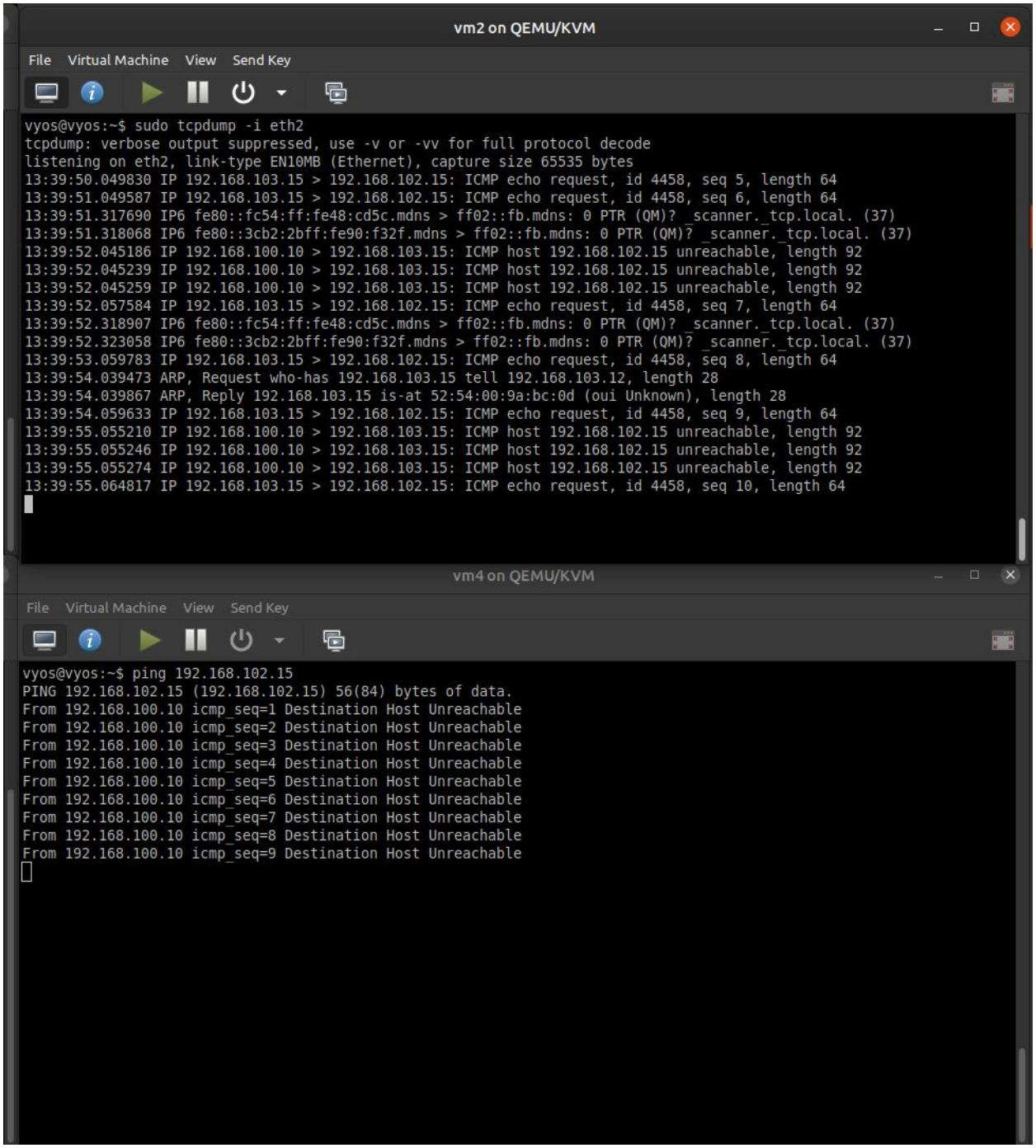
```
vyos@vyos:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface        IP Address                        S/L  Description
---------        ----------                        ---  -----------
eth0             192.168.103.15/24                 u/u
                 2020:abcd:103::15/64
lo               127.0.0.1/8                       u/u
                 ::1/128
vyos@vyos:~$ traceroute 192.168.102.15
traceroute to 192.168.102.15 (192.168.102.15), 30 hops max, 60 byte packets
 1  192.168.103.12 (192.168.103.12)  0.465 ms  0.432 ms  0.422 ms
 2  192.168.100.10 (192.168.100.10)  0.565 ms  0.569 ms  0.566 ms
 3  192.168.111.11 (192.168.111.11)  1.942 ms  1.945 ms  1.943 ms
 4  192.168.101.13 (192.168.101.13)  2.973 ms  2.976 ms  4.083 ms
 5  192.168.102.15 (192.168.102.15)  4.556 ms  4.612 ms  4.625 ms
vyos@vyos:~$
```

Ping H1 to H2:

```
vyos@vyos:~$ ping 192.168.102.15
PING 192.168.102.15 (192.168.102.15) 56(84) bytes of data.
64 bytes from 192.168.102.15: icmp_req=1 ttl=60 time=2.86 ms
64 bytes from 192.168.102.15: icmp_req=2 ttl=60 time=2.31 ms
64 bytes from 192.168.102.15: icmp_req=3 ttl=60 time=3.75 ms
64 bytes from 192.168.102.15: icmp_req=4 ttl=60 time=3.40 ms
64 bytes from 192.168.102.15: icmp_req=5 ttl=60 time=3.38 ms
64 bytes from 192.168.102.15: icmp_req=6 ttl=60 time=2.90 ms
64 bytes from 192.168.102.15: icmp_req=7 ttl=60 time=3.10 ms
64 bytes from 192.168.102.15: icmp_req=8 ttl=60 time=3.42 ms
```

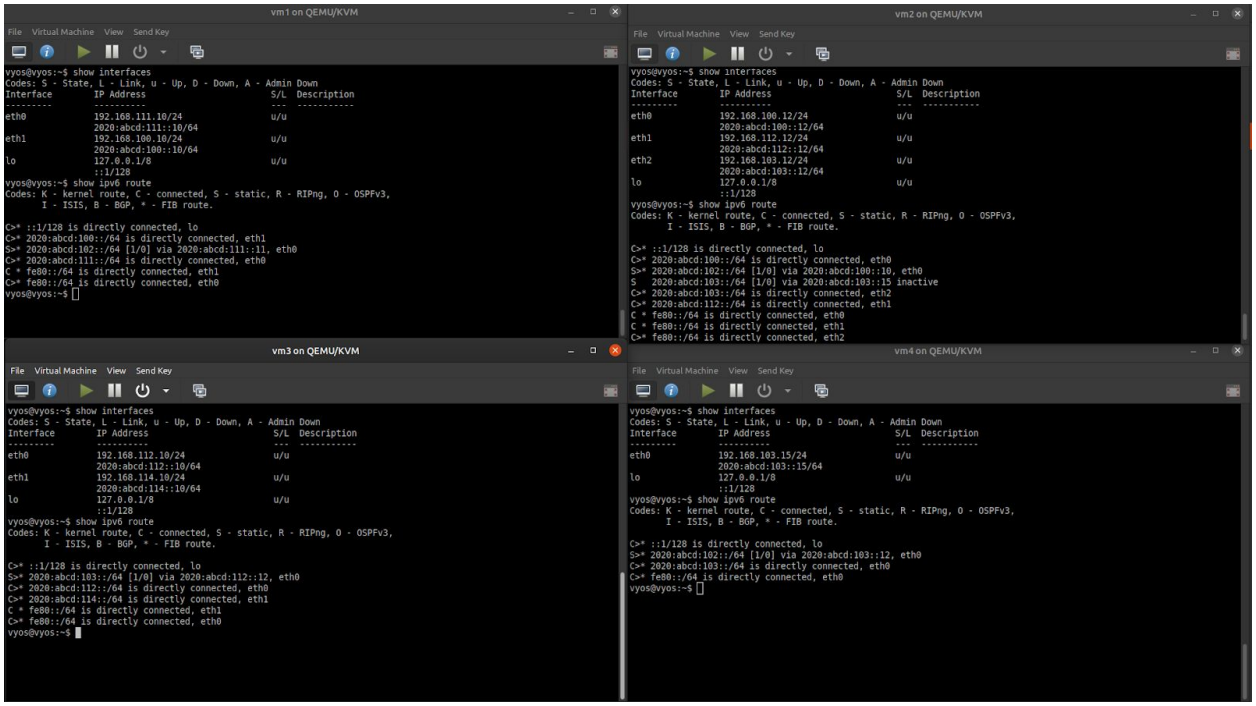
Question 3. (For Static Routing)
Execute ping (only IPv4 is OK) from H1 to H2, and disconnect Subnet (A) by unplugging the LAN cable between the laptops, and explain what happens in the network and how a router react when the next hop router becomes unreachable. Insert the screen captures of tcpdump on both NICs of R1, and provide additional explanation of what you observe as part of the answer.





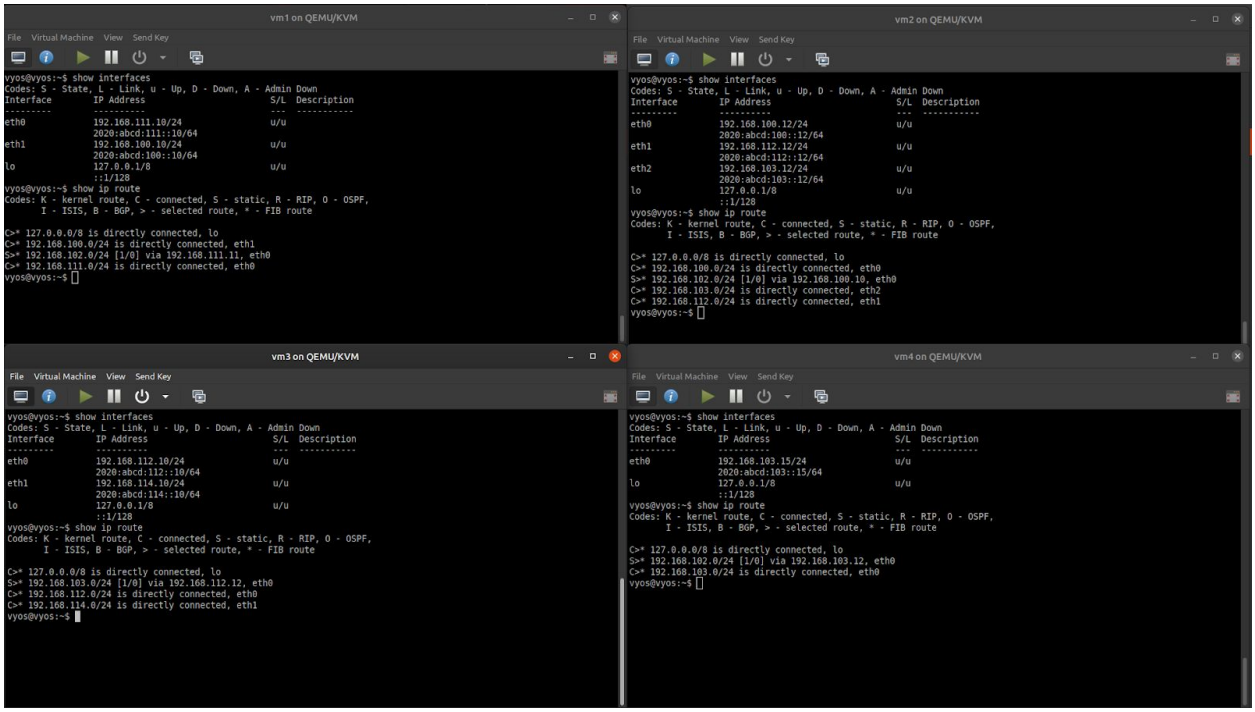
Ping shows destination host Unreachable as it clearly cannot contact the destination. We can observe ICMP destination unreachable messages in the tcpdump.

Question 4. (For Static Routing)
Configure static routes on the routers so that 1) ping traffic from H1 to H2 goes through Subnet (A), and 2) that from H2 to H1 goes through Subnet (B) using both IPv4 and IPv6. Answer by inserting the screen captures of the routing table on R2 and R6, and the tcpdump result on R1 and R5 on those you should observe the traffic is one way.
IPV6:



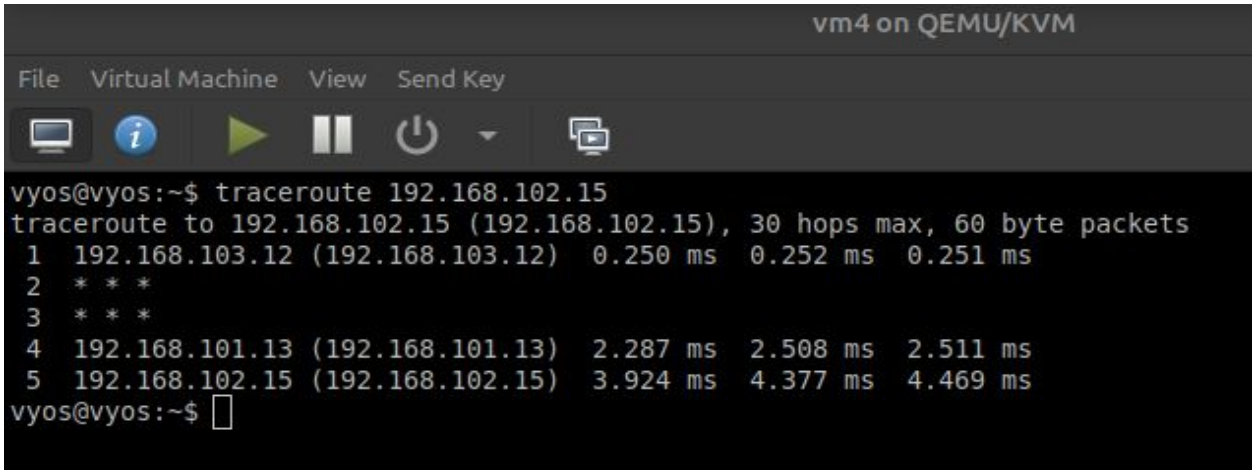

```
vyos@vyos:~$ ping6 2020:abcd:102::15
PING 2020:abcd:102::15(2020:abcd:102::15) 56 data bytes
64 bytes from 2020:abcd:102::15: icmp_seq=1 ttl=60 time=2.63 ms
64 bytes from 2020:abcd:102::15: icmp_seq=2 ttl=60 time=3.70 ms
64 bytes from 2020:abcd:102::15: icmp_seq=3 ttl=60 time=3.94 ms
64 bytes from 2020:abcd:102::15: icmp_seq=4 ttl=60 time=4.49 ms
64 bytes from 2020:abcd:102::15: icmp_seq=5 ttl=60 time=3.96 ms
64 bytes from 2020:abcd:102::15: icmp_seq=6 ttl=60 time=1.65 ms
64 bytes from 2020:abcd:102::15: icmp_seq=7 ttl=60 time=3.45 ms
64 bytes from 2020:abcd:102::15: icmp_seq=8 ttl=60 time=4.30 ms
64 bytes from 2020:abcd:102::15: icmp_seq=9 ttl=60 time=3.50 ms
64 bytes from 2020:abcd:102::15: icmp_seq=10 ttl=60 time=3.58 ms
64 bytes from 2020:abcd:102::15: icmp_seq=11 ttl=60 time=2.64 ms
```

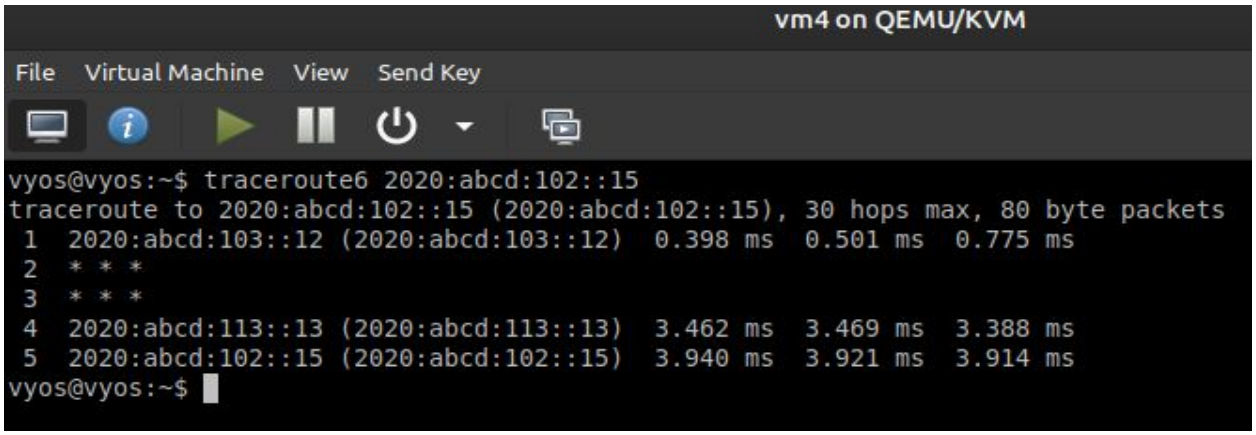
IPv4

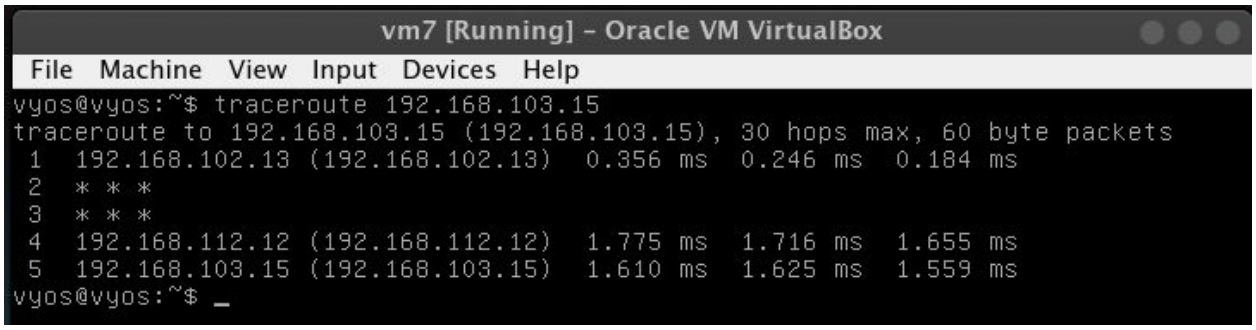


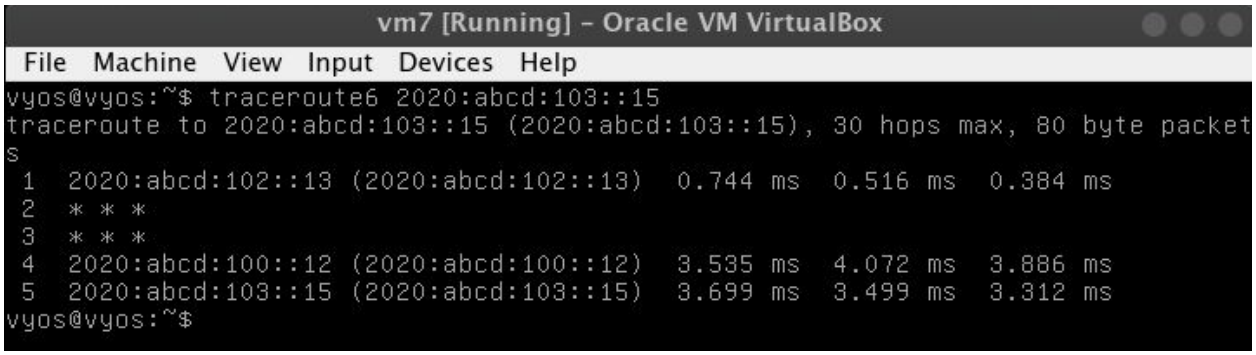

```
vyos@vyos:~$ ping 192.168.102.15
PING 192.168.102.15 (192.168.102.15) 56(84) bytes of data.
64 bytes from 192.168.102.15: icmp_req=1 ttl=60 time=3.37 ms
64 bytes from 192.168.102.15: icmp_req=2 ttl=60 time=3.96 ms
64 bytes from 192.168.102.15: icmp_req=3 ttl=60 time=3.99 ms
64 bytes from 192.168.102.15: icmp_req=4 ttl=60 time=3.56 ms
64 bytes from 192.168.102.15: icmp_req=5 ttl=60 time=3.75 ms
64 bytes from 192.168.102.15: icmp_req=6 ttl=60 time=2.81 ms
64 bytes from 192.168.102.15: icmp_req=7 ttl=60 time=3.89 ms
64 bytes from 192.168.102.15: icmp_req=8 ttl=60 time=3.41 ms
64 bytes from 192.168.102.15: icmp_req=9 ttl=60 time=4.56 ms
64 bytes from 192.168.102.15: icmp_req=10 ttl=60 time=3.58 ms
```

Traceroutes from both sides:





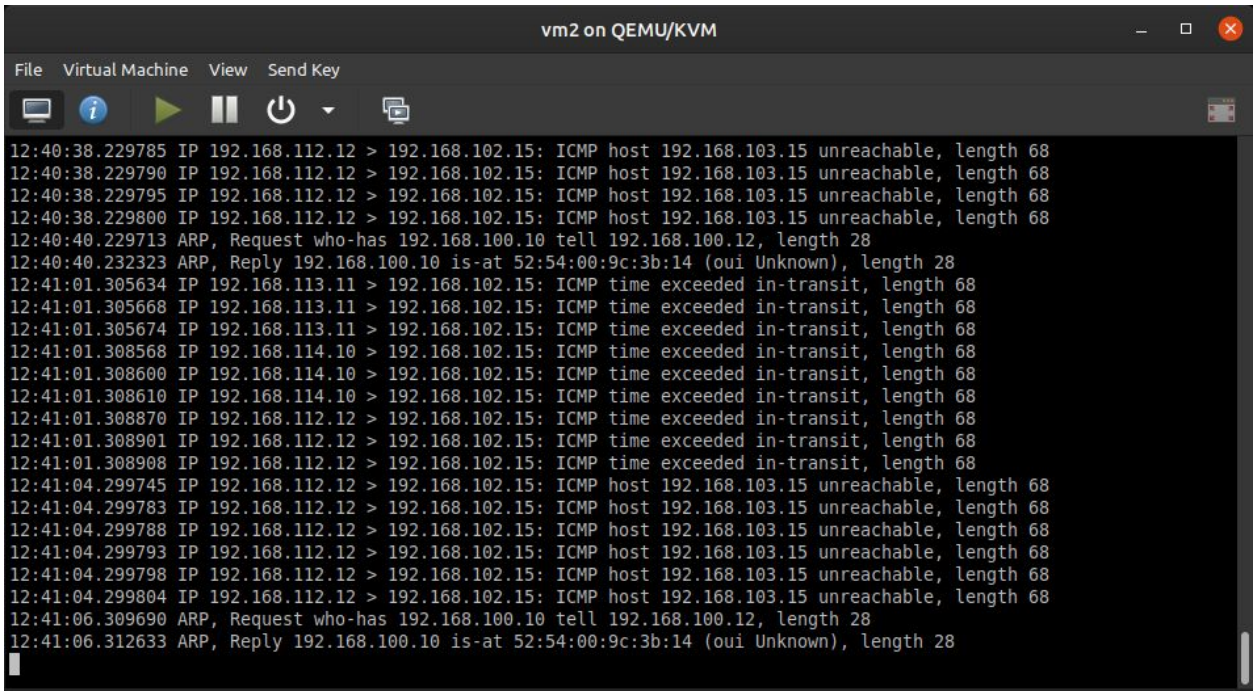




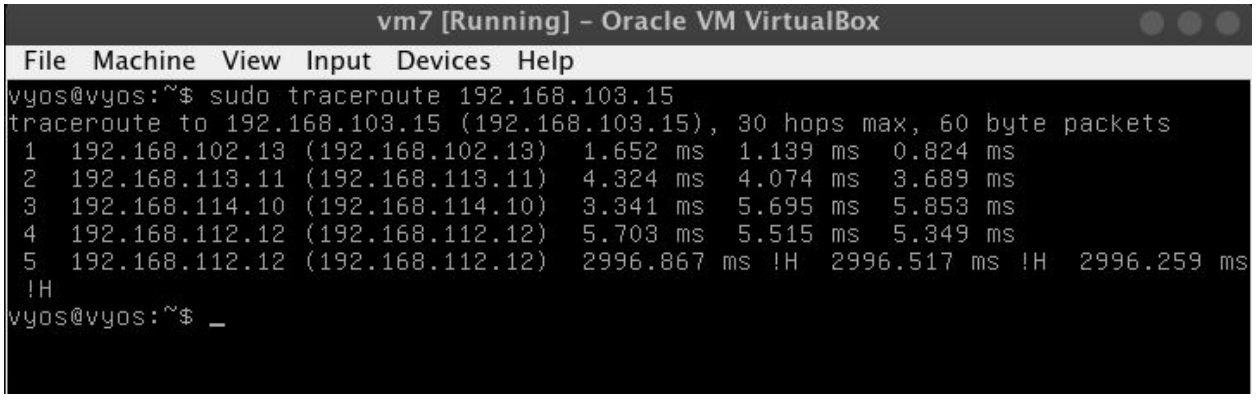
Question 5.
Create a routing loop among R1, R2, … R6, and explain what happens in the network. Insert the screen captures of tcpdump on H1 and IPv4/v6 traceroute performed from H1 to H2. And explain 1) the traceroute results, and 2) what kind of message H1 receives when the routing loop happens.

We created a clockwise loop such that messages from H2 to H1 will loop infinitely.

Tcpdump at R2 showing ICMP time exceeded message.

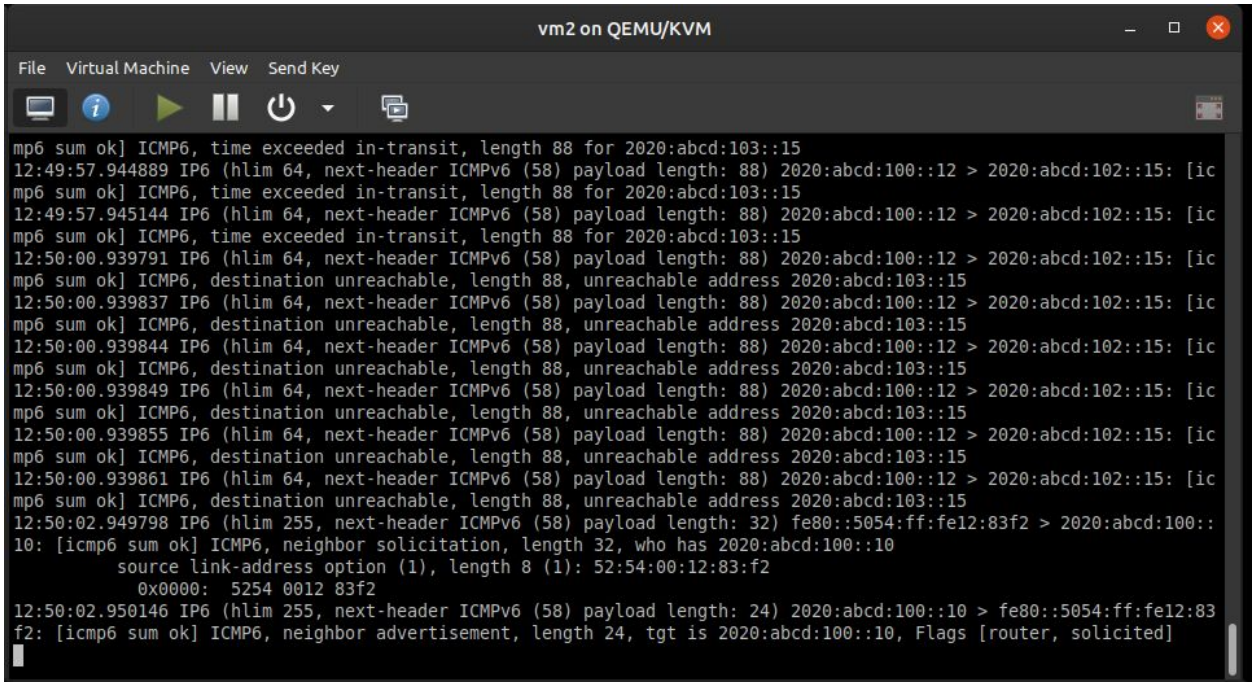


Traceroute from H2 to H1

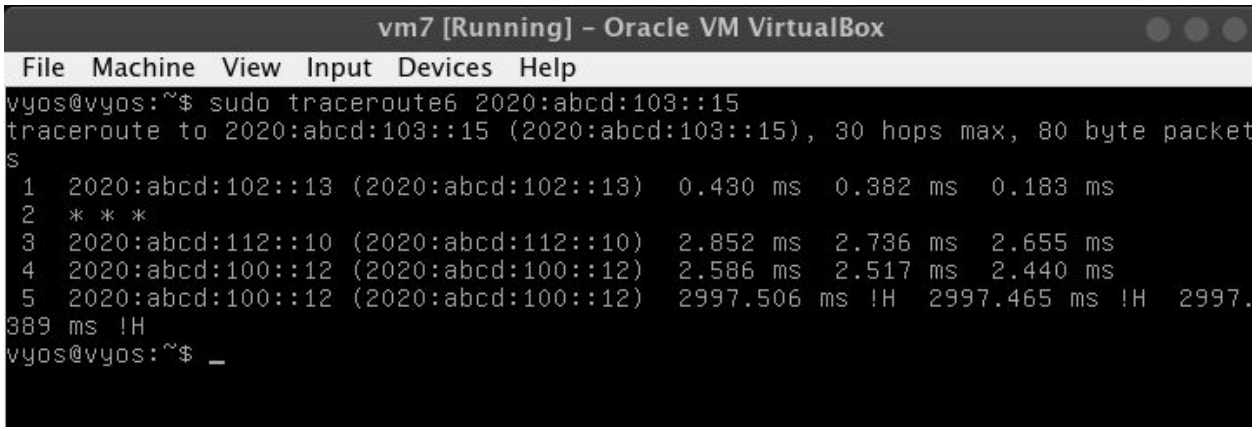


IPv6

Tcpdump on R2 showing time limit exceeded



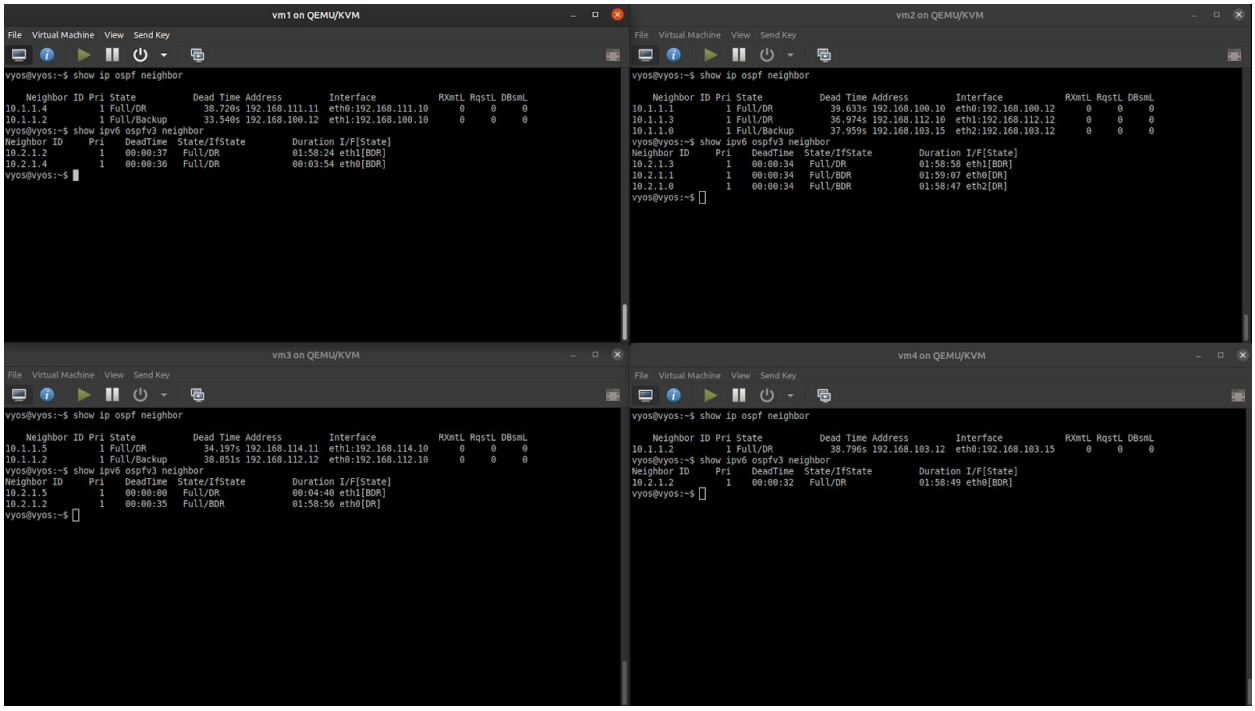
Traceroute6 from H2 to H1



The traceroute detects loop and shows high timings with 3 tries (around 2997 ms) and the !H shows traceroute is unable to reach host i.e. the destination. Message from H2 to R2 goes as expected but then the loop is detected and traceroute shows high timings.

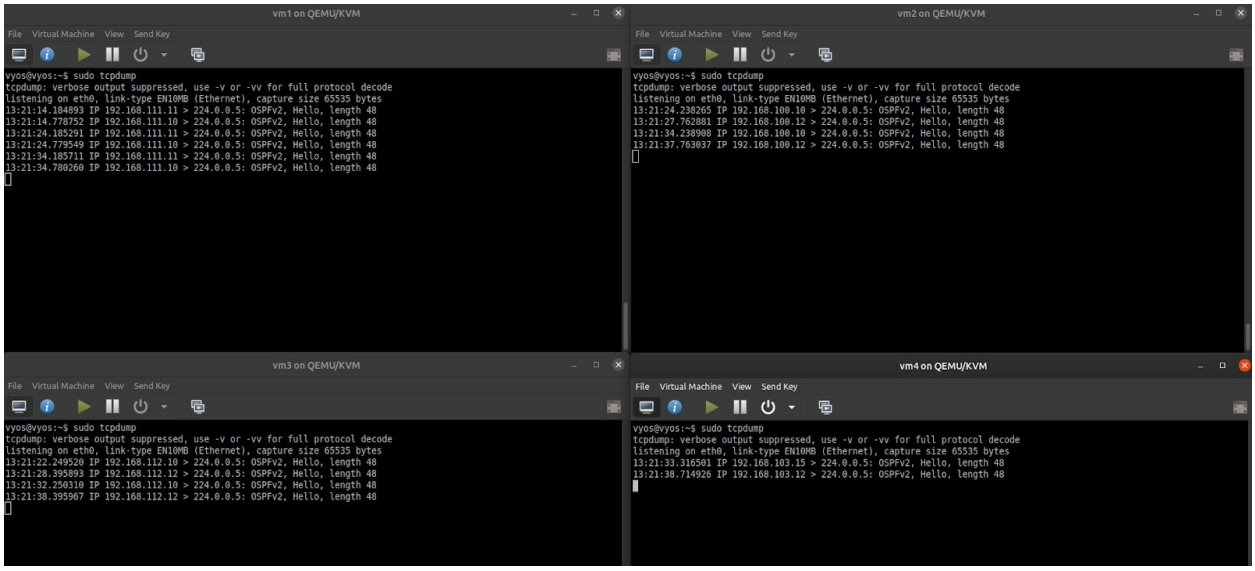
Question 6.1.

Delete the static routes from all the routers, and enable OSPF for IPv4 and OSPFv3 for IPv6 on them so that ping and ping6 are successful between H1 and H2. Insert screen captures of the OSPF/OSPFv3 neighbor tables, IPv4/v6 routing tables on R2 and R6, successful ping/ping6 results on H1 or H2.

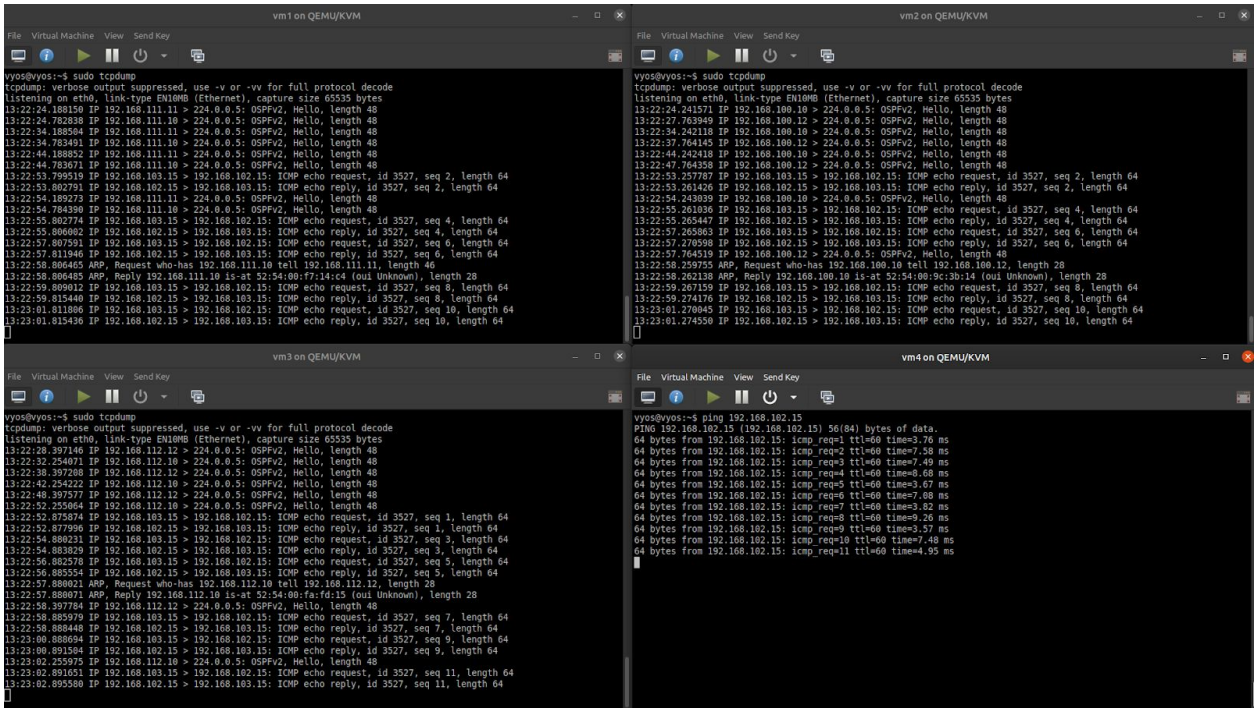


IPv4

1) Tcpdump showing ospf working with different messages.

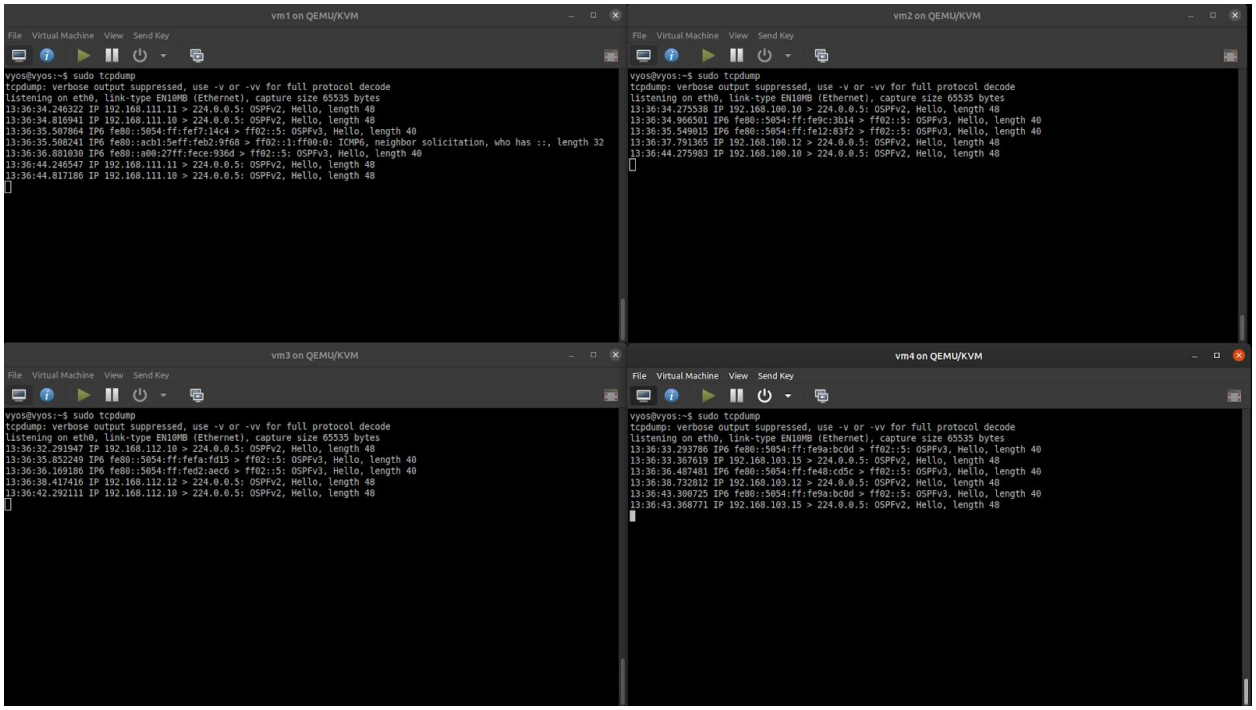


2) Ping from H1 to H2 with tcpdumps on other routers

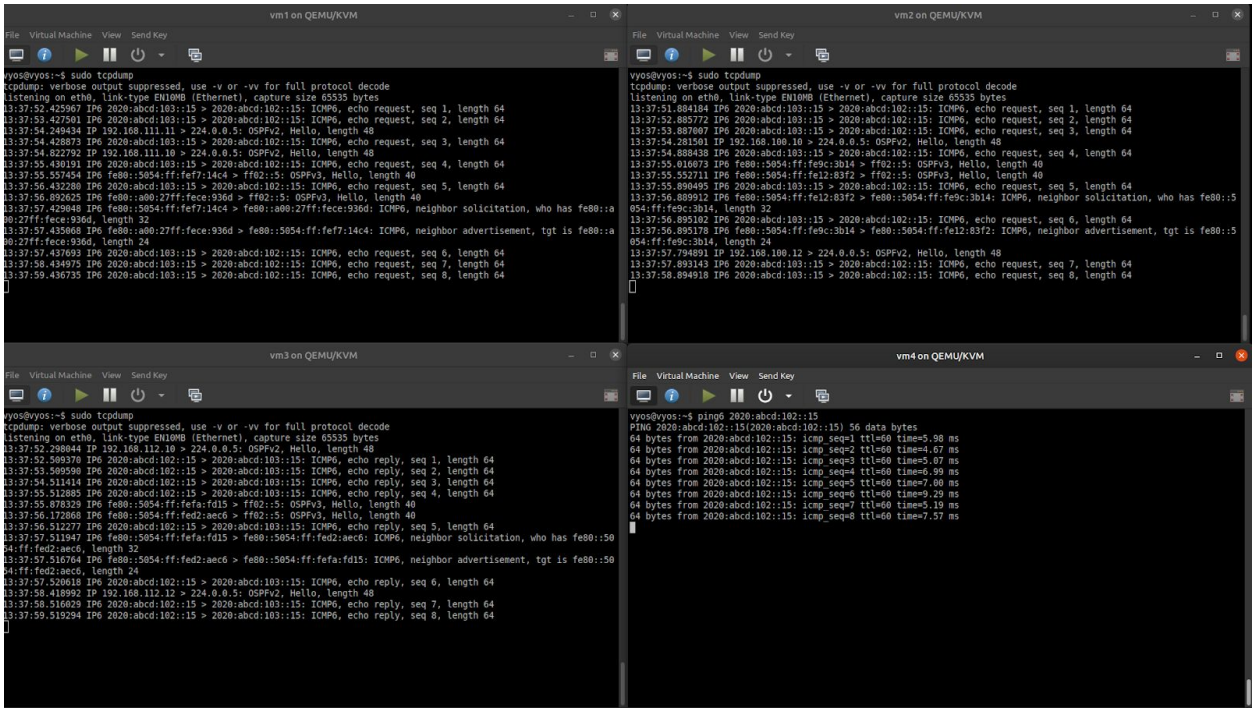


IPv6

1) ospfv3 working with different messages seen in tcpdump



2) Ping6 from H1 to H2 and tcpdumps on other routers



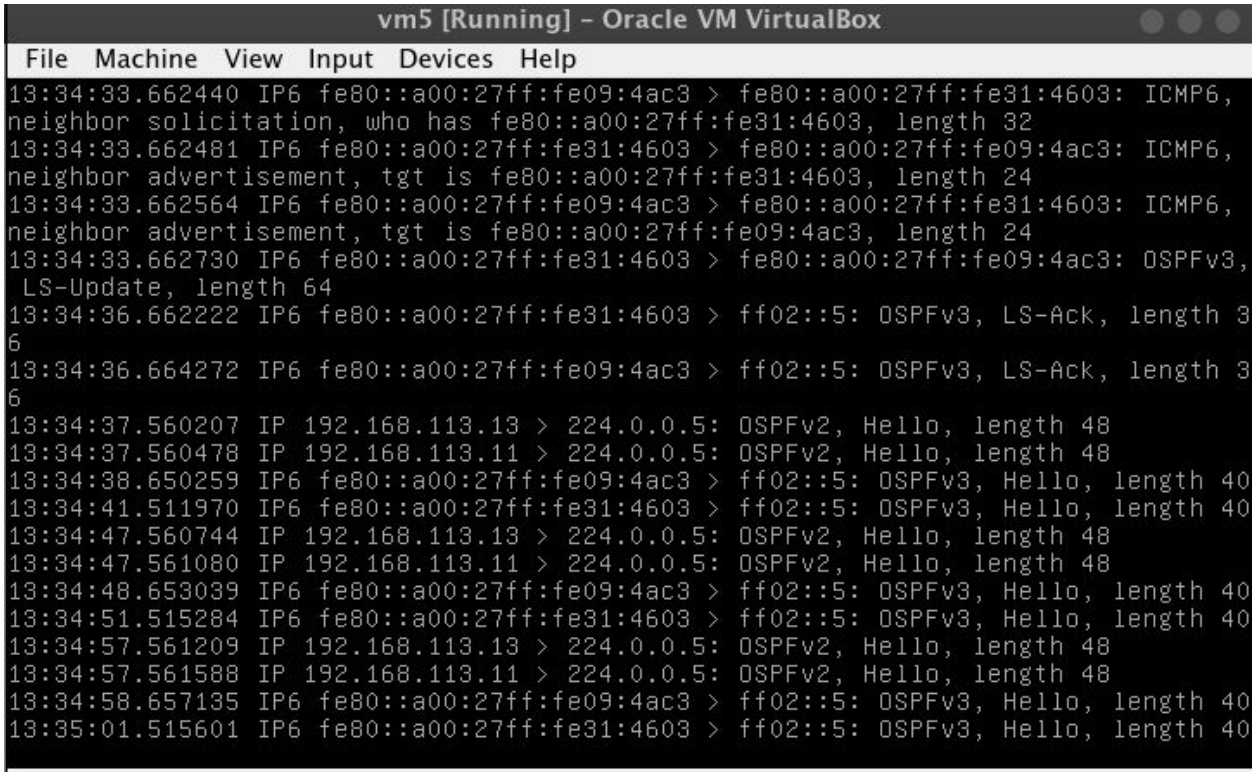
Question 6.2.
Select two different types that you observe in the experiment, and explain what kind of information they carry and what their role is respectively.

There are many different types of OSPF-related messages.
In the screenshot below we can observe the following OSPF messages:

1. **Hello:** These messages discover neighbors and build adjacencies between them. It also performs some other functions like Adjacency negotiation and Adjacency keepalive.
   It contains the following information in the packets.
   a. Designated Router IP (DR)
   b. Backup Designated Router IP (BDR)

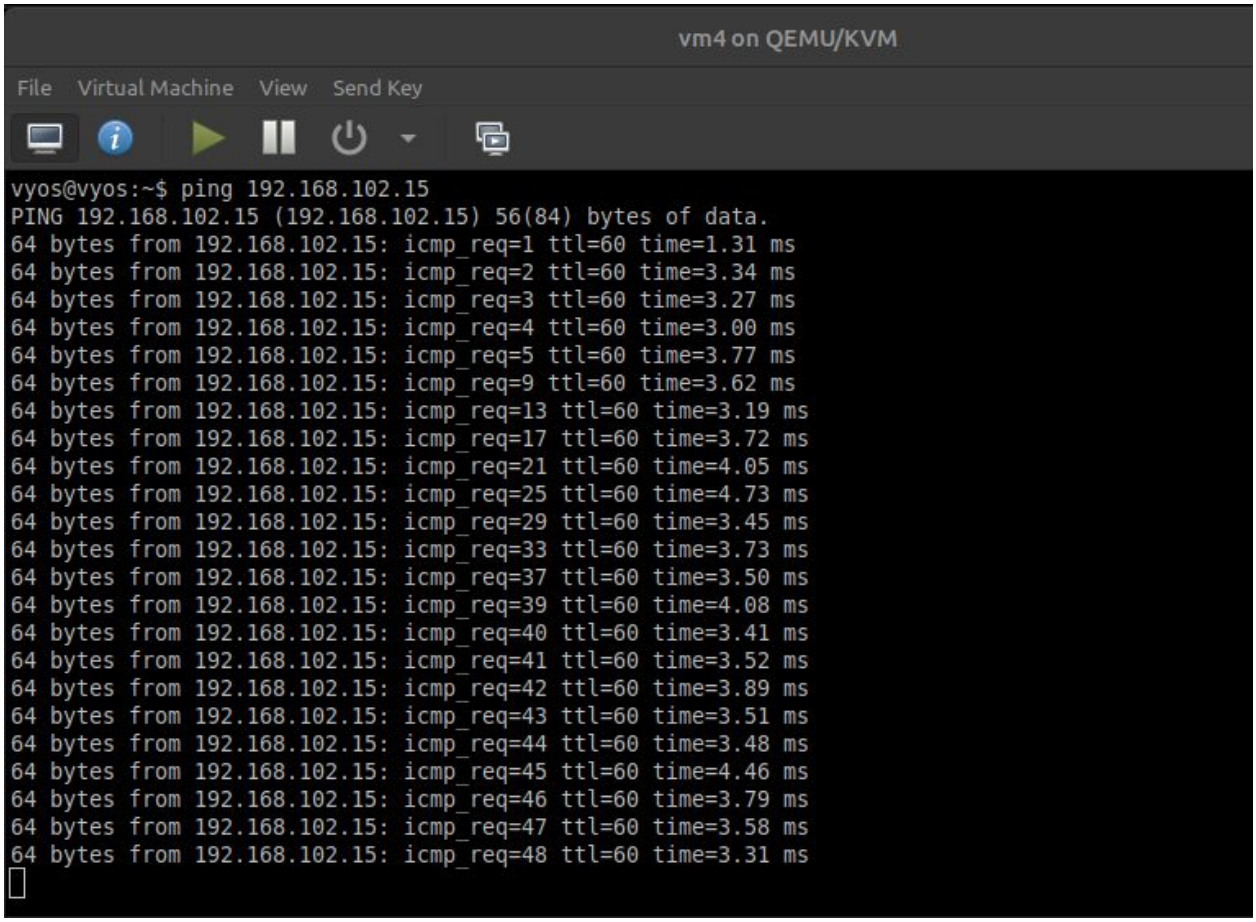
2. **Link State Update:** It sends specifically requested link-state records. Its function is Database synchronization and flooding. When a router receives Link state request, responds with an LSU that contains the details information for the requested Link State Acknowledgement.

Sample screenshot showing some messages



Question 7.1. (For OSPF)

Execute ping (only IPv4 is OK) from H1 to H2, and disconnect Subnet (A) by unplugging the LAN cable between the laptops. Keep pinging even after you disconnect the LAN cable (up to 1 minute should be enough), and observe what happens to the ping result.



First feq tcmp requests succeed as expected before taking the bride down. Some requests start failing after 5th after we take the bridge down. Success rate is low for some time as only fraction of packages goes from subnet B. then ospf detects the situation and configures routing. And after this every requests succeed as we can see after 39th requests.

Question 7.2.

Insert the screen captures of the routing table on R2 to compare those before and after unplugging the LAN cable. And explain which change in the routing table is the cause of observation that you gave in the previous answer in 7.1.

Before:

```
vyos@vyos:~$ show ip ospf route
============ OSPF network routing table ============
N    192.168.100.0/24      [10] area: 0.0.0.0
                           directly attached to eth0
N    192.168.101.0/24      [30] area: 0.0.0.0
                           via 192.168.100.10, eth0
N    192.168.102.0/24      [40] area: 0.0.0.0
                           via 192.168.100.10, eth0
                           via 192.168.112.10, eth1
N    192.168.103.0/24      [10] area: 0.0.0.0
                           directly attached to eth2
N    192.168.111.0/24      [20] area: 0.0.0.0
                           via 192.168.100.10, eth0
N    192.168.112.0/24      [10] area: 0.0.0.0
                           directly attached to eth1
N    192.168.113.0/24      [30] area: 0.0.0.0
                           via 192.168.112.10, eth1
N    192.168.114.0/24      [20] area: 0.0.0.0
                           via 192.168.112.10, eth1

============ OSPF router routing table =============

============ OSPF external routing table ===========

vyos@vyos:~$ show ipv6 ospfv3 route
*N IA 2020:abcd:100::/64             ::                          eth0 00:27:28
*N IA 2020:abcd:101::/64             fe80::5054:ff:fe9c:3b14     eth0 00:25:04
*N IA 2020:abcd:102::/64             fe80::5054:ff:fe9c:3b14     eth0 00:25:04
 N IA 2020:abcd:102::/64             fe80::5054:ff:fe9c:3b14     eth0 00:25:04
*N IA 2020:abcd:103::/64             ::                          eth2 00:27:08
 N IA 2020:abcd:103::/64             fe80::5054:ff:fe9a:bc0d     eth2 00:27:08
*N IA 2020:abcd:111::/64             fe80::5054:ff:fe9c:3b14     eth0 00:25:09
 N IA 2020:abcd:111::/64             fe80::5054:ff:fe9c:3b14     eth0 00:25:04
*N IA 2020:abcd:112::/64             ::                          eth1 00:27:19
*N IA 2020:abcd:113::/64             fe80::5054:ff:fefa:fd15     eth1 00:24:25
 N IA 2020:abcd:113::/64             fe80::5054:ff:fefa:fd15     eth1 00:24:25
*N IA 2020:abcd:114::/64             fe80::5054:ff:fefa:fd15     eth1 00:24:29
vyos@vyos:~$
```

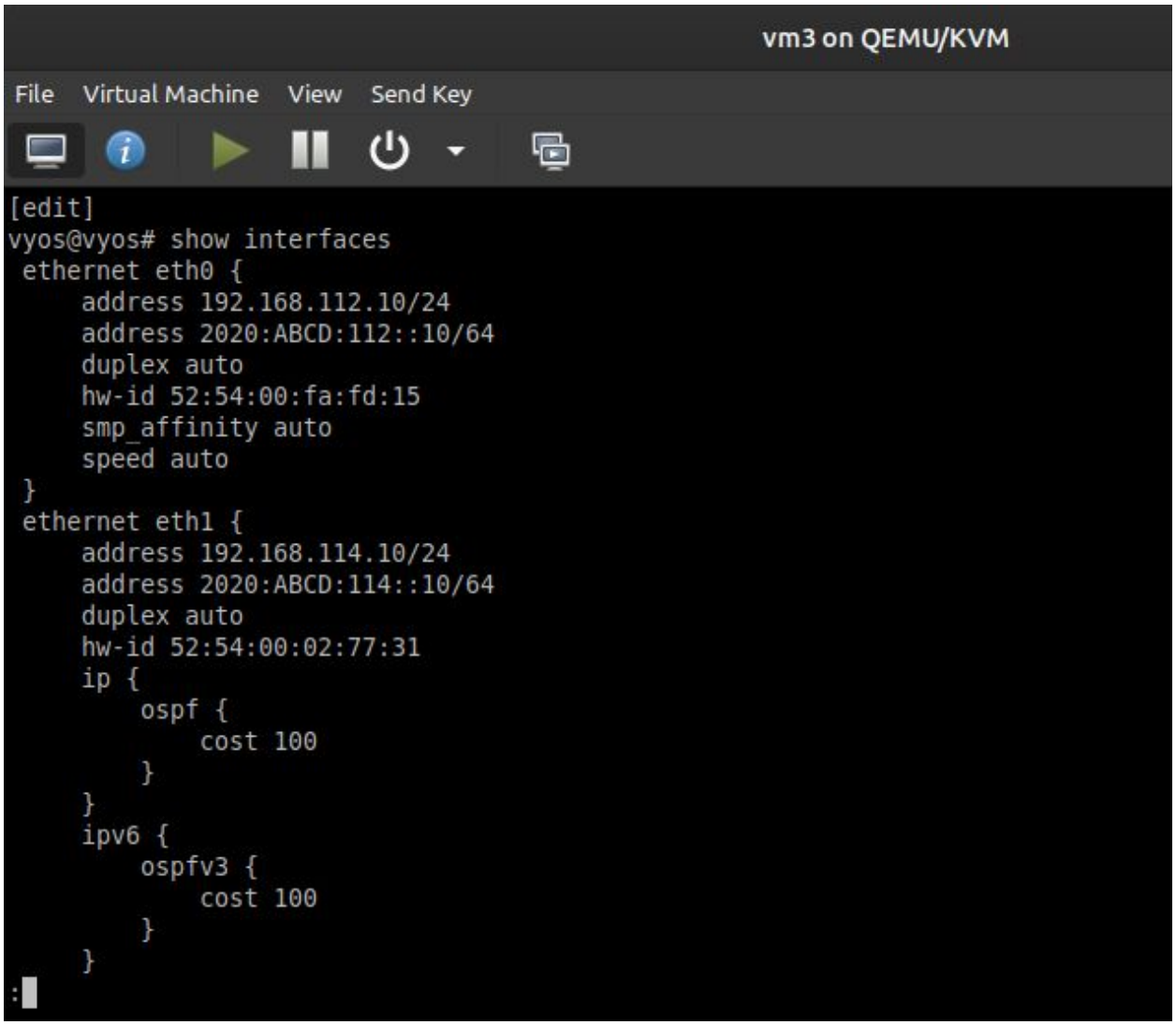
After :

```
vyos@vyos:~$ show ip ospf route
============ OSPF network routing table ============
N    192.168.100.0/24      [10] area: 0.0.0.0
                           directly attached to eth0
N    192.168.101.0/24      [40] area: 0.0.0.0
                           via 192.168.112.10, eth1
N    192.168.102.0/24      [40] area: 0.0.0.0
                           via 192.168.112.10, eth1
N    192.168.103.0/24      [10] area: 0.0.0.0
                           directly attached to eth2
N    192.168.111.0/24      [20] area: 0.0.0.0
                           via 192.168.100.10, eth0
N    192.168.112.0/24      [10] area: 0.0.0.0
                           directly attached to eth1
N    192.168.113.0/24      [30] area: 0.0.0.0
                           via 192.168.112.10, eth1
N    192.168.114.0/24      [20] area: 0.0.0.0
                           via 192.168.112.10, eth1

============ OSPF router routing table =============

============ OSPF external routing table ===========

vyos@vyos:~$ show ipv6 ospfv3 route
*N IA 2020:abcd:100::/64             ::                          eth0 00:31:50
*N IA 2020:abcd:101::/64             fe80::5054:ff:fefa:fd15     eth1 00:01:10
*N IA 2020:abcd:102::/64             fe80::5054:ff:fefa:fd15     eth1 00:01:10
 N IA 2020:abcd:102::/64             fe80::5054:ff:fefa:fd15     eth1 00:01:10
*N IA 2020:abcd:103::/64             ::                          eth2 00:31:30
 N IA 2020:abcd:103::/64             fe80::5054:ff:fe9a:bc0d     eth2 00:31:30
*N IA 2020:abcd:111::/64             fe80::5054:ff:fe9c:3b14     eth0 00:00:59
 N IA 2020:abcd:111::/64             fe80::5054:ff:fefa:fd15     eth1 00:01:10
*N IA 2020:abcd:112::/64             ::                          eth1 00:31:40
*N IA 2020:abcd:113::/64             fe80::5054:ff:fefa:fd15     eth1 00:28:46
 N IA 2020:abcd:113::/64             fe80::5054:ff:fefa:fd15     eth1 00:28:46
*N IA 2020:abcd:114::/64             fe80::5054:ff:fefa:fd15     eth1 00:28:50
vyos@vyos:~$
```

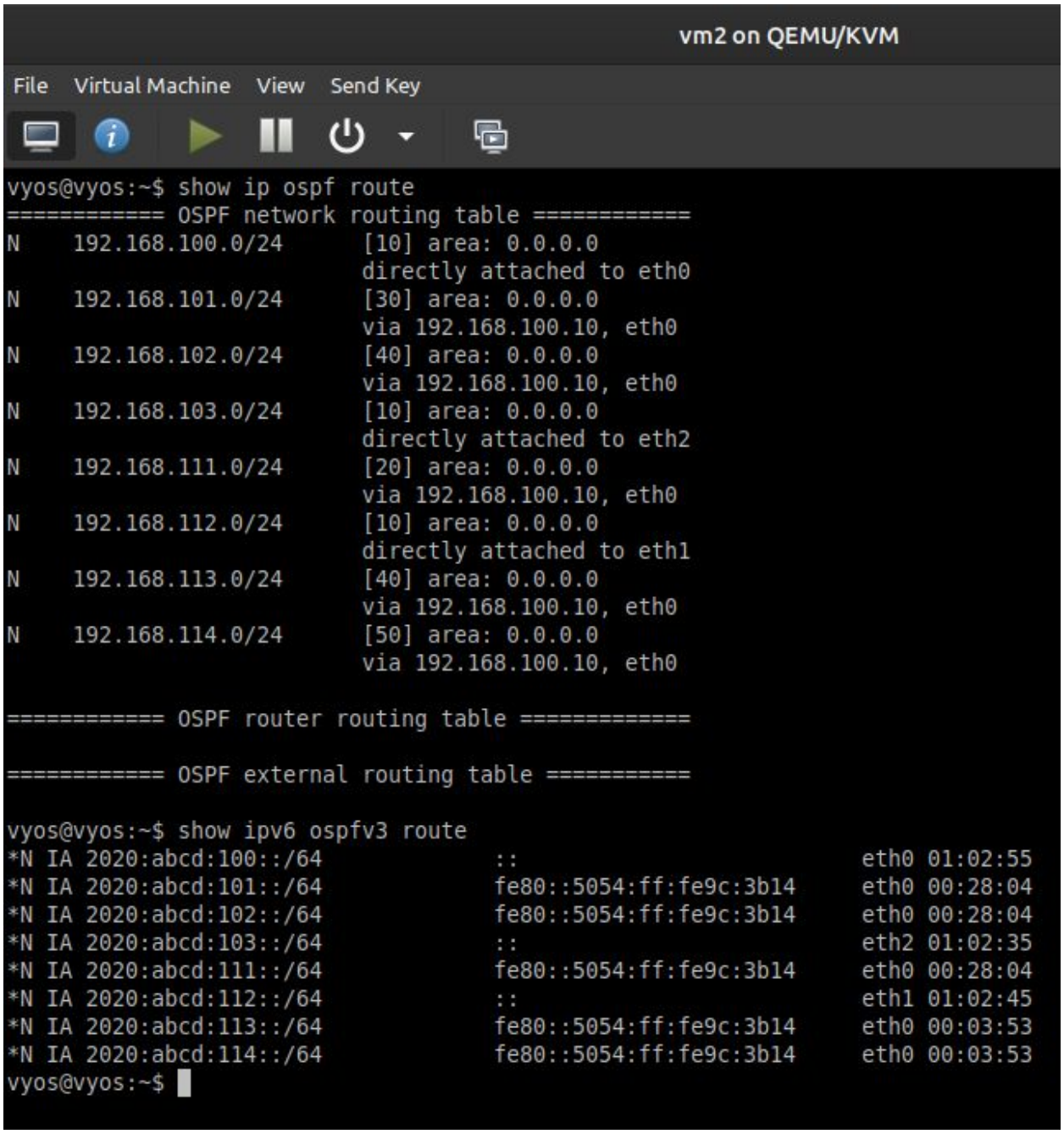
We can see some changes in the table for example the entry for 192.168.101.0/24(R4). Before taking the bridge down the target was 192.168.100.10(R1) after taking it down it was changed to 192.168.112.10(R3) as the link from R1 to R4 was taken down.

Question 8.
Configure OSPF Link Costs on the routers so that 1) ping traffic from H1 to H2 goes through Subnet (A), and 2) that from H2 to H1 goes through Subnet (B) using both IPv4 and IPv6. Answer by inserting the screen captures of the routing table on R2 and R6, and the tcpdump result on R1 and R5 on those you should observe the traffic is one way.

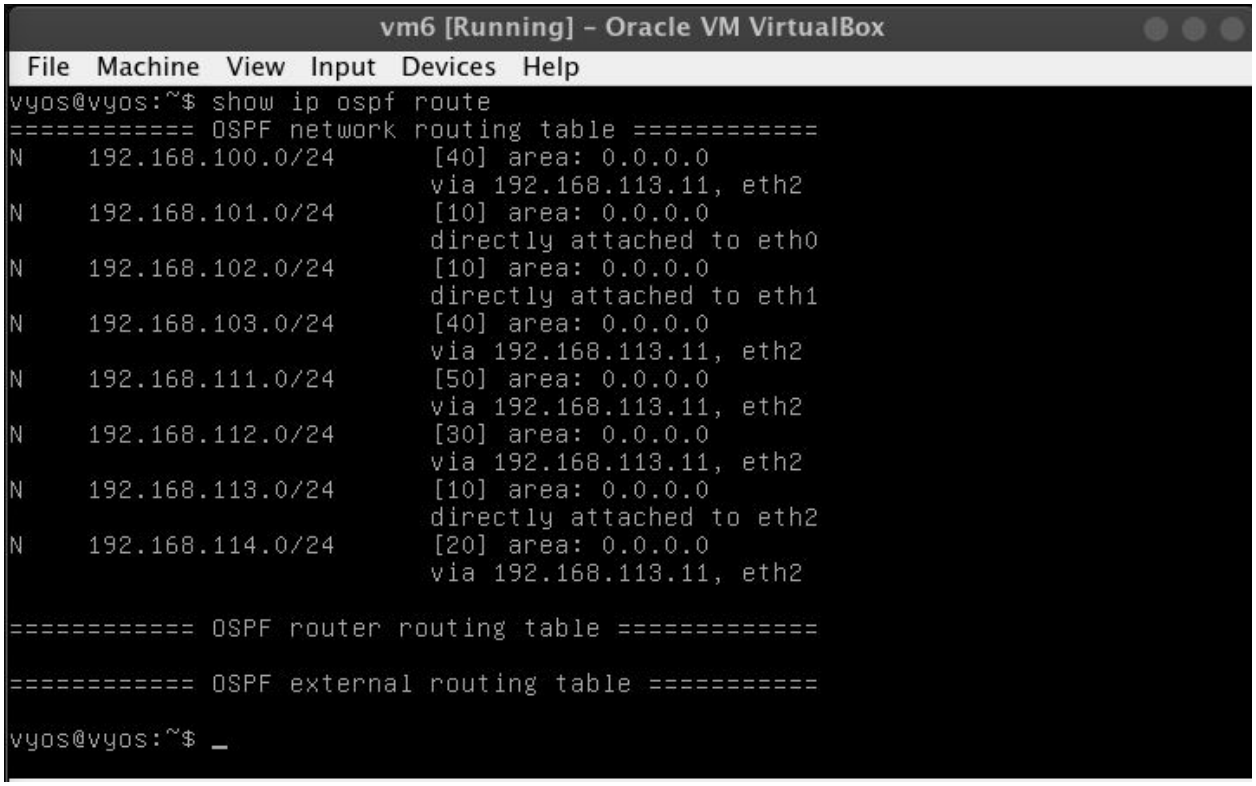
We updated link costs at R3 and R5 to a high value (100)
We can see the updated cost at R3 in the following screenshot.

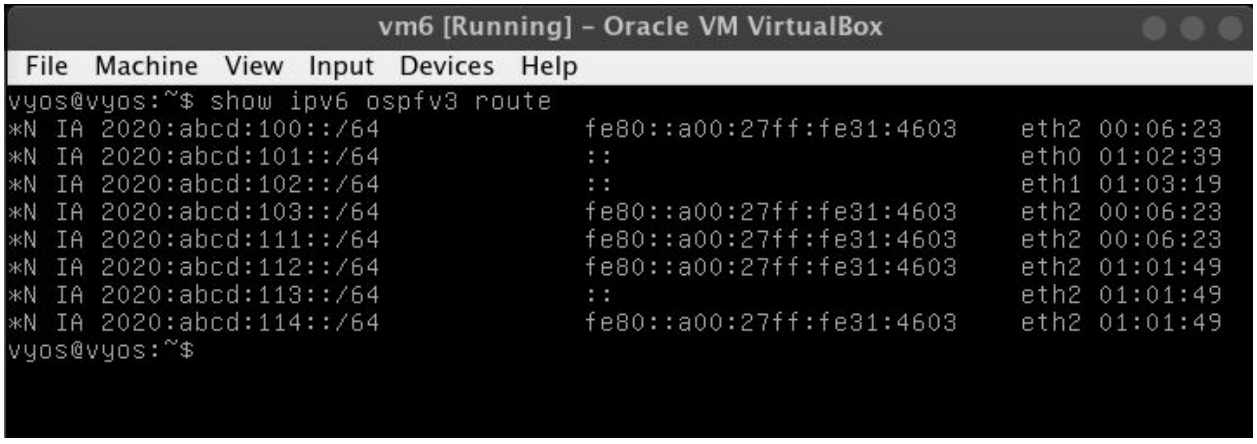


ospf routing tables at R2



ospf routing table at R6





We can see that at R2 the entry for H2(192.168.102.15) goes to R1 (subnet A) and the entry for H1(192.168.103.15) at R6 goes to R5(192.168.113.11)

Done!!

Some notes:

1. OSPF ECMP was omitted because it makes less sense in this scenario.
2. If you're stuck in VLAN configuration, ping TAs or come to the lab session.