

# CN Assignment 3

Client- 20.1.1.1/24, Gateway- 20.1.1.2/24 and 40.1.1.2/24

Server1- 40.1.1.1/24, Server2- 40.1.1.3/24

## Q1)

a) IP Addresses for the 4 machines

1. Client

```
GNU nano 0.2
network:
version: 2
renderer: networkd
ethernets:
  enp0s3:
    addresses: [20.1.1.1/24]
    dhcp4: no
    routes:
      - to: 40.1.1.1/24
        via: 20.1.1.2
      - to: 40.1.1.3/24
        via: 20.1.1.2
```

```
root@Client:/home/vboxuser# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:20:d8:0e brd ff:ff:ff:ff:ff:ff
    inet 20.1.1.1/24 brd 20.1.1.255 scope global enp0s3
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fe20:d80e/64 scope link
        valid_lft forever preferred_lft forever
root@Client:/home/vboxuser#
root@Client:/home/vboxuser#
root@Client:/home/vboxuser# ip route
20.1.1.0/24 dev enp0s3 proto kernel scope link src 20.1.1.1
40.1.1.0/24 via 20.1.1.2 dev enp0s3
root@Client:/home/vboxuser#
```

2. Gateway

```
network:
version: 2
renderer: networkd
ethernets:
  enp0s3:
    addresses:
      - 20.1.1.2/24
      - 40.1.1.2/24
    dhcp4: no
    routes:
      - to: 40.1.1.0/24
        via: 40.1.1.2
      - to: 20.1.1.0/24
        via: 20.1.1.2
```

```
root@Gateway:/home/vboxuser# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:f1:7a:1b brd ff:ff:ff:ff:ff:ff
    inet 20.1.1.2/24 brd 20.1.1.255 scope global enp0s3
        valid_lft forever preferred_lft forever
    inet 40.1.1.2/24 brd 40.1.1.255 scope global enp0s3
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fef1:7a1b/64 scope link
        valid_lft forever preferred_lft forever
root@Gateway:/home/vboxuser# ip route
20.1.1.0/24 dev enp0s3 proto kernel scope link src 20.1.1.2
20.1.1.0/24 via 20.1.1.2 dev enp0s3 proto static
40.1.1.0/24 dev enp0s3 proto kernel scope link src 40.1.1.2
40.1.1.0/24 via 40.1.1.2 dev enp0s3 proto static
root@Gateway:/home/vboxuser#
```

### 3. Server1

```
network:
  version: 2
  renderer: networkd
  ethernets:
    enp0s3:
      addresses: [40.1.1.1/24]
      dhcp4: no
      routes:
        - to: 20.1.1.1
          via: 40.1.1.2
```

```
root@Server1:/home/vboxuser# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:bc:1d:08 brd ff:ff:ff:ff:ff:ff
    inet 40.1.1.1/24 brd 40.1.1.255 scope global enp0s3
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:febc:1d08/64 scope link
        valid_lft forever preferred_lft forever
root@Server1:/home/vboxuser# ip route
20.1.1.1 via 40.1.1.2 dev enp0s3 proto static
40.1.1.0/24 dev enp0s3 proto kernel scope link src 40.1.1.1
root@Server1:/home/vboxuser#
```

### 4. Server2

```
network:
  version: 2
  renderer: networkd
  ethernets:
    enp0s3:
      addresses: [40.1.1.3/24]
      dhcp4: no
      routes:
        - to: 20.1.1.1/24
          via: 40.1.1.2/24
```

```
root@Server2:/home/vboxuser# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:ba:8d:db brd ff:ff:ff:ff:ff:ff
    inet 40.1.1.3/24 brd 40.1.1.255 scope global enp0s3
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:feba:8ddb/64 scope link
        valid_lft forever preferred_lft forever
root@Server2:/home/vboxuser# ip route
20.1.1.1 via 40.1.1.2 dev enp0s3
40.1.1.0/24 dev enp0s3 proto kernel scope link src 40.1.1.3
root@Server2:/home/vboxuser#
```

### b) IP Forwarding at the gateway with example

```
root@Gateway:/home/vboxuser# sysctl -w net.ipv4.ip_forward=1
net.ipv4.ip_forward = 1
root@Gateway:/home/vboxuser#
```

```

root@Client:/home/vboxuser# ping -c 4 40.1.1.1
PING 40.1.1.1 (40.1.1.1) 56(84) bytes of data.
64 bytes from 40.1.1.1: icmp_seq=1 ttl=64 time=0.417 ms
64 bytes from 40.1.1.1: icmp_seq=2 ttl=64 time=0.609 ms
64 bytes from 40.1.1.1: icmp_seq=3 ttl=64 time=0.627 ms
64 bytes from 40.1.1.1: icmp_seq=4 ttl=64 time=0.358 ms

--- 40.1.1.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3095ms
rtt min/avg/max/mdev = 0.358/0.502/0.627/0.117 ms
root@Client:/home/vboxuser#
root@Client:/home/vboxuser# ping -c 4 40.1.1.3
PING 40.1.1.3 (40.1.1.3) 56(84) bytes of data.
From 20.1.1.2 icmp_seq=1 Redirect Host(New nexthop: 40.1.1.3)
64 bytes from 40.1.1.3: icmp_seq=1 ttl=63 time=0.752 ms
64 bytes from 40.1.1.3: icmp_seq=2 ttl=64 time=0.420 ms
64 bytes from 40.1.1.3: icmp_seq=3 ttl=64 time=0.475 ms

--- 40.1.1.3 ping statistics ---
3 packets transmitted, 3 received, +1 errors, 0% packet loss, time 2030ms
rtt min/avg/max/mdev = 0.420/0.549/0.752/0.145 ms
root@Client:/home/vboxuser# █

```

Q2)

a) Blocking all traffic except ping at gateway from Client to Server 1

```

root@Gateway:/home/vboxuser# iptables -A FORWARD -d 40.1.1.1 -p icmp -j ACCEPT
root@Gateway:/home/vboxuser# iptables -A FORWARD -d 40.1.1.1 -j DROP
root@Gateway:/home/vboxuser#

```

```

root@Client:/home/vboxuser# nc -v 40.1.1.1 8080
█

```

```

root@Server1:/home/vboxuser# nc -lv 8080
Listening on 0.0.0.0 8080

```

```

root@Client:/home/vboxuser# ping -c 5 40.1.1.1
PING 40.1.1.1 (40.1.1.1) 56(84) bytes of data.
64 bytes from 40.1.1.1: icmp_seq=1 ttl=63 time=0.994 ms
64 bytes from 40.1.1.1: icmp_seq=2 ttl=64 time=0.288 ms
64 bytes from 40.1.1.1: icmp_seq=3 ttl=64 time=0.613 ms
64 bytes from 40.1.1.1: icmp_seq=4 ttl=64 time=0.778 ms
64 bytes from 40.1.1.1: icmp_seq=5 ttl=64 time=0.941 ms

--- 40.1.1.1 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4110ms
rtt min/avg/max/mdev = 0.288/0.722/0.994/0.255 ms
root@Client:/home/vboxuser#

```

## b) Blocking tcp traffic from Client

```
root@Gateway:/home/vboxuser# iptables -A FORWARD -s 20.1.1.1 -j DROP -p tcp
```

```
root@Client:/home/vboxuser# nc -v 40.1.1.3 8080
```

```
█
```

```
root@Server2:/home/vboxuser# nc -lv 8080
Listening on 0.0.0.0 8080
```

```
root@Client:/home/vboxuser# nc -uv 40.1.1.3 8080
Connection to 40.1.1.3 8080 port [udp/*] succeeded!
```

```
hello
```

```
root@Server2:/home/vboxuser# nc -ulv 8080
Bound on 0.0.0.0 8080
nc: getnameinfo: Temporary failure in name resolution
XXXXX
```

```
hello
█
```

## Q3)

a)

```
root@Server2:/home/vboxuser# iperf -s
-----
Server listening on TCP port 5001
TCP window size: 128 KByte (default)
-----
[ 1] local 40.1.1.3 port 5001 connected with 20.1.1.1 port 44942
[ ID] Interval      Transfer      Bandwidth
[ 1] 0.0000-10.0080 sec 3.54 GBytes  3.04 Gbits/sec
^Croot@Server2:/home/vboxuser# █
```

Bandwidth- 3.54 Gigabits/s

```
root@Client:/home/vboxuser# iperf -c 40.1.1.3
-----
Client connecting to 40.1.1.3, TCP port 5001
TCP window size: 85.0 KByte (default)
-----
[ 1] local 20.1.1.1 port 44942 connected with 40.1.1.3 port 5001
[ ID] Interval      Transfer      Bandwidth
[ 1] 0.0000-10.0155 sec 3.54 GBytes  3.03 Gbits/sec
root@Client:/home/vboxuser# █
```

```
root@Client:/home/vboxuser# iperf -c 40.1.1.3 -u
-----
Client connecting to 40.1.1.3, UDP port 5001
Sending 1470 byte datagrams, IPG target: 11215.21 us (kalman adjust)
UDP buffer size: 208 KByte (default)
-----
[ 1] local 20.1.1.1 port 56520 connected with 40.1.1.3 port 5001
[ ID] Interval      Transfer      Bandwidth
[ 1] 0.0000-10.0199 sec 1.25 MBytes  1.05 Mbits/sec
[ 1] Sent 896 datagrams
[ 1] Server Report:
[ ID] Interval      Transfer      Bandwidth      Jitter    Lost/Total Datagrams
[ 1] 0.0000-10.0198 sec 1.25 MBytes  1.05 Mbits/sec  0.101 ms  0/895 (0%)
root@Client:/home/vboxuser#
```

Bandwidth- 1.05 Megabits/s

```
root@Server2:/home/vboxuser# iperf -s -u
-----
Server listening on UDP port 5001
UDP buffer size: 208 KByte (default)
-----
[ 1] local 40.1.1.3 port 5001 connected with 20.1.1.1 port 56520
[ ID] Interval      Transfer      Bandwidth      Jitter    Lost/Total Datagrams
[ 1] 0.0000-10.0198 sec 1.25 MBytes  1.05 Mbits/sec  0.102 ms  0/895 (0%)
[ 3] WARNING: ack of last datagram failed.
█
```



## b) RTT stats from Client to Server1 and Server2

```
root@Client:/home/vboxuser# ping 40.1.1.1 -c 10
PING 40.1.1.1 (40.1.1.1) 56(84) bytes of data.
64 bytes from 40.1.1.1: icmp_seq=1 ttl=64 time=0.641 ms
64 bytes from 40.1.1.1: icmp_seq=2 ttl=64 time=0.895 ms
64 bytes from 40.1.1.1: icmp_seq=3 ttl=64 time=0.793 ms
64 bytes from 40.1.1.1: icmp_seq=4 ttl=64 time=0.756 ms
64 bytes from 40.1.1.1: icmp_seq=5 ttl=64 time=0.959 ms
64 bytes from 40.1.1.1: icmp_seq=6 ttl=64 time=0.489 ms
64 bytes from 40.1.1.1: icmp_seq=7 ttl=64 time=0.733 ms
64 bytes from 40.1.1.1: icmp_seq=8 ttl=64 time=0.809 ms
64 bytes from 40.1.1.1: icmp_seq=9 ttl=64 time=0.814 ms
64 bytes from 40.1.1.1: icmp_seq=10 ttl=64 time=0.933 ms

--- 40.1.1.1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9193ms
rtt min/avg/max/mdev = 0.489/0.782/0.959/0.133 ms
root@Client:/home/vboxuser#
```

```
PING 40.1.1.3 (40.1.1.3) 56(84) bytes of data.
64 bytes from 40.1.1.3: icmp_seq=1 ttl=64 time=0.620 ms
64 bytes from 40.1.1.3: icmp_seq=2 ttl=64 time=0.763 ms
64 bytes from 40.1.1.3: icmp_seq=3 ttl=64 time=0.288 ms
64 bytes from 40.1.1.3: icmp_seq=4 ttl=64 time=0.285 ms
64 bytes from 40.1.1.3: icmp_seq=5 ttl=64 time=0.632 ms
64 bytes from 40.1.1.3: icmp_seq=6 ttl=64 time=0.491 ms
64 bytes from 40.1.1.3: icmp_seq=7 ttl=64 time=0.693 ms
64 bytes from 40.1.1.3: icmp_seq=8 ttl=64 time=0.897 ms
64 bytes from 40.1.1.3: icmp_seq=9 ttl=64 time=0.511 ms
64 bytes from 40.1.1.3: icmp_seq=10 ttl=64 time=0.686 ms

--- 40.1.1.3 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9201ms
rtt min/avg/max/mdev = 0.285/0.586/0.897/0.186 ms
```

The observed difference in RTT of approx 100ms in max case and 200 ms in average and min case is due to the additional overheads applied on Server 1 for checking the network requests.

## Q4)

a) Changing the source and destination IPs and checking with tcpdump, IP address is being changed from 20.1.1.1 to 40.1.1.2

```
root@Gateway:/home/vboxuser# iptables -t nat -A POSTROUTING -s 20.1.1.1/24 -o enp0s3 -j SNAT --to-source 40.1.1.2
```

```
root@Gateway:/home/vboxuser# tcpdump -i enp0s3 -n
tcpdump: verbose output suppressed, use -v[v]... for full protocol decode
listening on enp0s3, link-type EN10MB (Ethernet), snapshot length 262144 bytes
00:27:09.259854 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:27:12.764428 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:27:16.268156 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:27:18.943617 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 36, seq 5, length 64
00:27:18.943617 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 36, seq 5, length 64
00:27:18.944165 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 36, seq 5, length 64
00:27:18.944208 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 36, seq 5, length 64
00:27:19.773646 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:27:19.944397 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 36, seq 6, length 64
00:27:19.944431 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 36, seq 6, length 64
00:27:19.944816 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 36, seq 6, length 64
00:27:19.944835 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 36, seq 6, length 64
00:27:20.991396 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 36, seq 7, length 64
00:27:20.991462 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 36, seq 7, length 64
00:27:20.992180 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 36, seq 7, length 64
00:27:20.992216 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 36, seq 7, length 64
00:27:21.992995 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 36, seq 8, length 64
00:27:21.993055 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 36, seq 8, length 64
00:27:21.993845 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 36, seq 8, length 64
00:27:21.993874 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 36, seq 8, length 64
00:27:22.994371 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 36, seq 9, length 64
00:27:22.994416 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 36, seq 9, length 64
00:27:22.994869 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 36, seq 9, length 64
00:27:22.994897 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 36, seq 9, length 64
00:27:23.278496 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:27:23.995642 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 36, seq 10, length 64
00:27:23.995687 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 36, seq 10, length 64
00:27:23.996170 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 36, seq 10, length 64
00:27:23.996191 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 36, seq 10, length 64
```

```
root@Client:/home/vboxuser# ping 40.1.1.1 -c 10
PING 40.1.1.1 (40.1.1.1) 56(84) bytes of data.
64 bytes from 40.1.1.1: icmp_seq=1 ttl=64 time=0.200 ms
64 bytes from 40.1.1.1: icmp_seq=2 ttl=64 time=0.485 ms
64 bytes from 40.1.1.1: icmp_seq=3 ttl=64 time=0.275 ms
64 bytes from 40.1.1.1: icmp_seq=4 ttl=64 time=0.484 ms
64 bytes from 40.1.1.1: icmp_seq=5 ttl=63 time=1.50 ms
64 bytes from 40.1.1.1: icmp_seq=6 ttl=63 time=0.856 ms
64 bytes from 40.1.1.1: icmp_seq=7 ttl=63 time=1.45 ms
64 bytes from 40.1.1.1: icmp_seq=8 ttl=63 time=1.65 ms
64 bytes from 40.1.1.1: icmp_seq=9 ttl=63 time=1.11 ms
64 bytes from 40.1.1.1: icmp_seq=10 ttl=63 time=1.11 ms
```

b) Here, IP address of reply destination is changed from 40.1.1.2 to 20.1.1.1

```
root@Gateway:/home/vboxuser# iptables -t nat -A PREROUTING -d 40.1.1.2 -i enp0s3 -j DNAT --to-destination 20.1.1.1
```

```

root@Gateway:/home/vboxuser# tcpdump -i enp0s3 -n
tcpdump: verbose output suppressed, use -v[v]... for full protocol decode
listening on enp0s3, link-type EN10MB (Ethernet), snapshot length 262144 bytes
00:37:08.724140 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:37:08.769906 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 1, length 64
00:37:08.769958 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 1, length 64
00:37:08.770419 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 1, length 64
00:37:08.770432 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 1, length 64
00:37:09.770348 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 2, length 64
00:37:09.770388 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 2, length 64
00:37:09.770729 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 2, length 64
00:37:09.770751 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 2, length 64
00:37:10.815939 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 3, length 64
00:37:10.815978 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 3, length 64
00:37:10.816157 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 3, length 64
00:37:10.816164 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 3, length 64
00:37:11.839796 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 4, length 64
00:37:11.839849 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 4, length 64
00:37:11.840427 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 4, length 64
00:37:11.840453 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 4, length 64
00:37:12.230524 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:37:12.841034 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 5, length 64
00:37:12.841118 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 5, length 64
00:37:12.841633 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 5, length 64
00:37:12.841658 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 5, length 64
00:37:13.842592 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 6, length 64
00:37:13.842623 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 6, length 64
00:37:13.842875 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 6, length 64
00:37:13.842892 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 6, length 64
00:37:13.918313 ARP, Request who-has 20.1.1.1 tell 20.1.1.2, length 28
00:37:13.918355 ARP, Request who-has 40.1.1.1 tell 40.1.1.2, length 28
00:37:13.918722 ARP, Reply 40.1.1.1 is-at 08:00:27:bc:1d:08, length 46
00:37:13.918723 ARP, Reply 20.1.1.1 is-at 08:00:27:20:d8:0e, length 46
00:37:14.079234 ARP, Request who-has 20.1.1.2 tell 20.1.1.1, length 46
00:37:14.079246 ARP, Reply 20.1.1.2 is-at 08:00:27:f1:7a:1b, length 28
00:37:14.098164 ARP, Request who-has 40.1.1.2 tell 40.1.1.1, length 46
00:37:14.098176 ARP, Reply 40.1.1.2 is-at 08:00:27:f1:7a:1b, length 28
00:37:14.847404 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 7, length 64

```

```

00:37:14.079234 ARP, Request who-has 20.1.1.2 tell 20.1.1.1, length 46
00:37:14.079246 ARP, Reply 20.1.1.2 is-at 08:00:27:f1:7a:1b, length 28
00:37:14.098164 ARP, Request who-has 40.1.1.2 tell 40.1.1.1, length 46
00:37:14.098176 ARP, Reply 40.1.1.2 is-at 08:00:27:f1:7a:1b, length 28
00:37:14.847404 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 7, length 64
00:37:14.847436 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 7, length 64
00:37:14.847768 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 7, length 64
00:37:14.847778 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 7, length 64
00:37:15.735368 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:37:15.871831 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 8, length 64
00:37:15.871864 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 8, length 64
00:37:15.872151 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 8, length 64
00:37:15.872171 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 8, length 64
00:37:16.895260 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 9, length 64
00:37:16.895284 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 9, length 64
00:37:16.896135 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 9, length 64
00:37:16.896143 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 9, length 64
00:37:17.896379 IP 20.1.1.1 > 40.1.1.1: ICMP echo request, id 37, seq 10, length 64
00:37:17.896407 IP 40.1.1.2 > 40.1.1.1: ICMP echo request, id 37, seq 10, length 64
00:37:17.896753 IP 40.1.1.1 > 40.1.1.2: ICMP echo reply, id 37, seq 10, length 64
00:37:17.896764 IP 40.1.1.1 > 20.1.1.1: ICMP echo reply, id 37, seq 10, length 64
00:37:19.238003 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:37:22.742505 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:37:26.247109 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128
00:37:29.754031 IP 192.168.56.1.55088 > 192.168.56.255.51007: UDP, length 128

```

```

root@Client:/home/vboxuser# ping 40.1.1.1 -c 10
PING 40.1.1.1 (40.1.1.1) 56(84) bytes of data.
64 bytes from 40.1.1.1: icmp_seq=1 ttl=63 time=1.09 ms
64 bytes from 40.1.1.1: icmp_seq=2 ttl=63 time=0.591 ms
64 bytes from 40.1.1.1: icmp_seq=3 ttl=63 time=0.826 ms
64 bytes from 40.1.1.1: icmp_seq=4 ttl=63 time=1.17 ms
64 bytes from 40.1.1.1: icmp_seq=5 ttl=63 time=1.36 ms
64 bytes from 40.1.1.1: icmp_seq=6 ttl=63 time=0.535 ms
64 bytes from 40.1.1.1: icmp_seq=7 ttl=63 time=0.614 ms
64 bytes from 40.1.1.1: icmp_seq=8 ttl=63 time=0.802 ms
64 bytes from 40.1.1.1: icmp_seq=9 ttl=63 time=1.25 ms
64 bytes from 40.1.1.1: icmp_seq=10 ttl=63 time=0.778 ms

--- 40.1.1.1 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9127ms
rtt min/avg/max/mdev = 0.535/0.900/1.355/0.278 ms
root@Client:/home/vboxuser#

```

## Q5)

a) Since 40.1.1.1 has a higher RTT as compared to 40.1.1.3, we give Server1 probability of 0.2 and Server2 the probability of 0.8.

```
root@Client:/home/vboxuser# for i in {1..10}; do ping -c 1 20.1.1.2; sleep 1; done
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=1.16 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.160/1.160/1.160/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=1.25 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.248/1.248/1.248/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=1.63 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.631/1.631/1.631/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=1.38 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.382/1.382/1.382/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=1.62 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.617/1.617/1.617/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=1.16 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.159/1.159/1.159/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
```

```
--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.772/0.772/0.772/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=1.35 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.345/1.345/1.345/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=0.856 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.856/0.856/0.856/0.000 ms
PING 20.1.1.2 (20.1.1.2) 56(84) bytes of data.
64 bytes from 20.1.1.2: icmp_seq=1 ttl=63 time=0.475 ms

--- 20.1.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.475/0.475/0.475/0.000 ms
root@Client:/home/vboxuser#
```

```
root@Server1:/home/vboxuser# tcpdump -i enp0s3 'icmp'
tcpdump: verbose output suppressed, use -v[v]... for full protocol decode
listening on enp0s3, link-type EN10MB (Ethernet), snapshot length 262144 bytes
08:48:17.687027 IP 40.1.1.2 > Server1: ICMP echo request, id 74, seq 1, length 64
08:48:17.687068 IP Server1 > 40.1.1.2: ICMP echo reply, id 74, seq 1, length 64
08:48:19.698589 IP 40.1.1.2 > Server1: ICMP echo request, id 76, seq 1, length 64
08:48:19.698626 IP Server1 > 40.1.1.2: ICMP echo reply, id 76, seq 1, length 64
```

```
root@Gateway:/home/vboxuser# tcpdump -i enp0s3 'icmp'
tcpdump: verbose output suppressed, use -v[v]... for full protocol decode
listening on enp0s3, link-type EN10MB (Ethernet), snapshot length 262144 bytes
02:32:46.503721 IP 20.1.1.1 > Gateway: ICMP echo request, id 72, seq 1, length 64
02:32:46.503773 IP Gateway > 40.1.1.3: ICMP echo request, id 72, seq 1, length 64
02:32:46.504241 IP 40.1.1.3 > Gateway: ICMP echo reply, id 72, seq 1, length 64
02:32:46.504258 IP Gateway > 20.1.1.1: ICMP echo reply, id 72, seq 1, length 64
02:32:47.509129 IP 20.1.1.1 > Gateway: ICMP echo request, id 73, seq 1, length 64
02:32:47.509189 IP Gateway > 40.1.1.3: ICMP echo request, id 73, seq 1, length 64
02:32:47.509825 IP 40.1.1.3 > Gateway: ICMP echo reply, id 73, seq 1, length 64
02:32:47.509847 IP Gateway > 20.1.1.1: ICMP echo reply, id 73, seq 1, length 64
02:32:48.514311 IP 20.1.1.1 > Gateway: ICMP echo request, id 74, seq 1, length 64
02:32:48.514384 IP Gateway > 40.1.1.1: ICMP echo request, id 74, seq 1, length 64
02:32:48.515107 IP 40.1.1.1 > Gateway: ICMP echo reply, id 74, seq 1, length 64
02:32:48.515140 IP Gateway > 20.1.1.1: ICMP echo reply, id 74, seq 1, length 64
02:32:49.520585 IP 20.1.1.1 > Gateway: ICMP echo request, id 75, seq 1, length 64
02:32:49.520629 IP Gateway > 40.1.1.3: ICMP echo request, id 75, seq 1, length 64
02:32:49.521154 IP 40.1.1.3 > Gateway: ICMP echo reply, id 75, seq 1, length 64
02:32:49.521165 IP Gateway > 20.1.1.1: ICMP echo reply, id 75, seq 1, length 64
02:32:50.525833 IP 20.1.1.1 > Gateway: ICMP echo request, id 76, seq 1, length 64
02:32:50.525908 IP Gateway > 40.1.1.1: ICMP echo request, id 76, seq 1, length 64
02:32:50.526680 IP 40.1.1.1 > Gateway: ICMP echo reply, id 76, seq 1, length 64
02:32:50.526722 IP Gateway > 20.1.1.1: ICMP echo reply, id 76, seq 1, length 64
02:32:51.531797 IP 20.1.1.1 > Gateway: ICMP echo request, id 77, seq 1, length 64
02:32:51.531851 IP Gateway > 40.1.1.3: ICMP echo request, id 77, seq 1, length 64
02:32:51.532377 IP 40.1.1.3 > Gateway: ICMP echo reply, id 77, seq 1, length 64
02:32:51.532407 IP Gateway > 20.1.1.1: ICMP echo reply, id 77, seq 1, length 64
02:32:52.535000 IP 20.1.1.1 > Gateway: ICMP echo request, id 78, seq 1, length 64
02:32:52.535038 IP Gateway > 40.1.1.3: ICMP echo request, id 78, seq 1, length 64
02:32:52.535416 IP 40.1.1.3 > Gateway: ICMP echo reply, id 78, seq 1, length 64
02:32:52.535432 IP Gateway > 20.1.1.1: ICMP echo reply, id 78, seq 1, length 64
02:32:53.540048 IP 20.1.1.1 > Gateway: ICMP echo request, id 79, seq 1, length 64
02:32:53.540140 IP Gateway > 40.1.1.3: ICMP echo request, id 79, seq 1, length 64
02:32:53.540865 IP 40.1.1.3 > Gateway: ICMP echo reply, id 79, seq 1, length 64
02:32:53.540909 IP Gateway > 20.1.1.1: ICMP echo reply, id 79, seq 1, length 64
02:32:54.546148 IP 20.1.1.1 > Gateway: ICMP echo request, id 80, seq 1, length 64
02:32:54.546200 IP Gateway > 40.1.1.3: ICMP echo request, id 80, seq 1, length 64
02:32:54.546518 IP 40.1.1.3 > Gateway: ICMP echo reply, id 80, seq 1, length 64
02:32:54.546537 IP Gateway > 20.1.1.1: ICMP echo reply, id 80, seq 1, length 64
02:32:55.550127 IP 20.1.1.1 > Gateway: ICMP echo request, id 81, seq 1, length 64
```

```
root@Server2:/home/vboxuser# tcpdump -i enp0s3 'icmp'
tcpdump: verbose output suppressed, use -v[v]... for full protocol decode
listening on enp0s3, link-type EN10MB (Ethernet), snapshot length 262144 bytes
08:47:36.015803 IP 40.1.1.2 > Server2: ICMP echo request, id 72, seq 1, length 64
08:47:36.015829 IP Server2 > 40.1.1.2: ICMP echo reply, id 72, seq 1, length 64
08:47:37.021394 IP 40.1.1.2 > Server2: ICMP echo request, id 73, seq 1, length 64
08:47:37.021420 IP Server2 > 40.1.1.2: ICMP echo reply, id 73, seq 1, length 64
08:47:39.032800 IP 40.1.1.2 > Server2: ICMP echo request, id 75, seq 1, length 64
08:47:39.032825 IP Server2 > 40.1.1.2: ICMP echo reply, id 75, seq 1, length 64
08:47:41.043964 IP 40.1.1.2 > Server2: ICMP echo request, id 77, seq 1, length 64
08:47:41.043984 IP Server2 > 40.1.1.2: ICMP echo reply, id 77, seq 1, length 64
08:47:42.047065 IP 40.1.1.2 > Server2: ICMP echo request, id 78, seq 1, length 64
08:47:42.047086 IP Server2 > 40.1.1.2: ICMP echo reply, id 78, seq 1, length 64
08:47:43.052310 IP 40.1.1.2 > Server2: ICMP echo request, id 79, seq 1, length 64
08:47:43.052347 IP Server2 > 40.1.1.2: ICMP echo reply, id 79, seq 1, length 64
08:47:44.058205 IP 40.1.1.2 > Server2: ICMP echo request, id 80, seq 1, length 64
08:47:44.058238 IP Server2 > 40.1.1.2: ICMP echo reply, id 80, seq 1, length 64
08:47:45.062153 IP 40.1.1.2 > Server2: ICMP echo request, id 81, seq 1, length 64
08:47:45.062173 IP Server2 > 40.1.1.2: ICMP echo reply, id 81, seq 1, length 64
```

Out of 10 ping commands, two are sent to 40.1.1.1 and eight are sent to 40.1.1.3