PART B

B1)

a) Commands to set to set R1, R2, R3, R4 as RIP router:

- Configure each host and router by copying */usr/share/doc/quagga/examples/zebra.conf.sample* to */etc/quagga/zebra.conf* as well as to our config folder for each host and routers (configs/H1, configs/H2, configs/R1, .. etc). Similarly copy */usr/share/doc/quagga/examples/ripd.conf.sample* and edit the */etc/quagga/daemons* file and the daemon file present inside the config directory present for each router to make zebra=*yes* and ripd=*yes*.
- Edit the script file from PartA and remove the static routing table.

```
H1 echo 1 > /proc/sys/net/ipv4/ip_forward
R1 echo 1 > /proc/sys/net/ipv4/ip_forward
R2 echo 1 > /proc/sys/net/ipv4/ip_forward
R3 echo 1 > /proc/sys/net/ipv4/ip_forward
R4 echo 1 > /proc/sys/net/ipv4/ip_forward
H2 echo 1 > /proc/sys/net/ipv4/ip_forward

R1 ip addr add 173.0.1.1/16 dev R1-eth1
R1 ip addr add 174.0.1.1/16 dev R1-eth2
R2 ip addr add 175.0.1.1/16 dev R2-eth1
R3 ip addr add 176.0.1.1/16 dev R3-eth1
R4 ip addr add 175.0.1.2/16 dev R4-eth1
R4 ip addr add 176.0.1.2/16 dev R4-eth2
```

- Run the start.py on a terminal so that topology is made.
- Open another terminal through ssh and login into each router to configure them as RIP routers. Steps for doing it are:
    - cd /miniNExT/util
    - ./mx H1
    - telnet localhost 2602 : connect to localhost:2602 (ripd daemon)
    - Enter the password (zebra)
    - en
    - Configure terminal (To enter configuration mode of the router)
    - Router rip (Configure the router as rip router)

- Network <interface> : (<interface> are the interfaces which the router wants to advertise to other routers such that rip daemon can identify these interfaces)
- Write : (It will save the configuration to ripd.conf file of the router)
- Exit (quit the router terminal)

Do the above steps for each host and router.
One example screenshot is:

```
mininet@mininet-vm:~/miniNExT/util$ ./mx H1
root@mininet-vm:/# telnet localhost 2602
Trying ::1...
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.

Hello, this is Quagga (version 0.99.22.4).
Copyright 1996-2005 Kunihiro Ishiguro, et al.


User Access Verification

Password:
ripd> en
ripd# configure terminal
ripd(config)# router rip
ripd(config-router)# network H1-eth0
There is a same network configuration H1-eth0
ripd(config-router)# write
Configuration saved to /etc/quagga/ripd.conf
ripd(config-router)# exit
ripd(config)# exit
ripd# exit
```

B2)

H1 Quagga routing table:

```
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
C(i) 172.0.0.0/16    0.0.0.0               1 self              0
R(n) 173.0.0.0/16    172.0.1.2             2 172.0.1.2         0 02:43
R(n) 174.0.0.0/16    172.0.1.2             2 172.0.1.2         0 02:43
R(n) 175.0.0.0/16    172.0.1.2             3 172.0.1.2         0 02:43
R(n) 176.0.0.0/16    172.0.1.2             3 172.0.1.2         0 02:43
R(n) 177.0.0.0/16    172.0.1.2             4 172.0.1.2         0 02:43
```

H1 Kernel Routing Table

```
mininext> H1 ip route
172.0.0.0/16 dev H1-eth0  proto kernel  scope link  src 172.0.1.1
173.0.0.0/16 via 172.0.1.2 dev H1-eth0  proto zebra  metric 2
174.0.0.0/16 via 172.0.1.2 dev H1-eth0  proto zebra  metric 2
175.0.0.0/16 via 172.0.1.2 dev H1-eth0  proto zebra  metric 3
176.0.0.0/16 via 172.0.1.2 dev H1-eth0  proto zebra  metric 3
177.0.0.0/16 via 172.0.1.2 dev H1-eth0  proto zebra  metric 4
```

R1 Quagga routing table:

```
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
C(i) 172.0.0.0/16    0.0.0.0               1 self              0
C(i) 173.0.0.0/16    0.0.0.0               1 self              0
C(i) 174.0.0.0/16    0.0.0.0               1 self              0
R(n) 175.0.0.0/16    173.0.1.2             2 173.0.1.2         0 02:49
R(n) 176.0.0.0/16    174.0.1.2             2 174.0.1.2         0 02:49
R(n) 177.0.0.0/16    173.0.1.2             3 173.0.1.2         0 02:49
```

R1 Kernel Routing Table:

```
mininext> R1 ip route
172.0.0.0/16 dev R1-eth0  proto kernel  scope link  src 172.0.1.2
173.0.0.0/16 dev R1-eth1  proto kernel  scope link  src 173.0.1.1
174.0.0.0/16 dev R1-eth2  proto kernel  scope link  src 174.0.1.1
175.0.0.0/16 via 173.0.1.2 dev R1-eth1  proto zebra  metric 2
176.0.0.0/16 via 174.0.1.2 dev R1-eth2  proto zebra  metric 2
177.0.0.0/16 via 173.0.1.2 dev R1-eth1  proto zebra  metric 3
```

R2 Quagga routing table

```
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) 172.0.0.0/16    173.0.1.1             2 173.0.1.1         0 02:43
C(i) 173.0.0.0/16    0.0.0.0               1 self              0
R(n) 174.0.0.0/16    173.0.1.1             2 173.0.1.1         0 02:43
C(i) 175.0.0.0/16    0.0.0.0               1 self              0
R(n) 176.0.0.0/16    175.0.1.2             2 175.0.1.2         0 02:43
R(n) 177.0.0.0/16    175.0.1.2             2 175.0.1.2         0 02:43
```

R2 Kernel Routing Table:

```
mininext> R2 ip route
172.0.0.0/16 via 173.0.1.1 dev R2-eth0  proto zebra  metric 2
173.0.0.0/16 dev R2-eth0  proto kernel  scope link  src 173.0.1.2
174.0.0.0/16 via 173.0.1.1 dev R2-eth0  proto zebra  metric 2
175.0.0.0/16 dev R2-eth1  proto kernel  scope link  src 175.0.1.1
176.0.0.0/16 via 175.0.1.2 dev R2-eth1  proto zebra  metric 2
177.0.0.0/16 via 175.0.1.2 dev R2-eth1  proto zebra  metric 2
```

R3 Quagga routing table

```
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) 172.0.0.0/16      174.0.1.1             2 174.0.1.1         0 02:54
R(n) 173.0.0.0/16      174.0.1.1             2 174.0.1.1         0 02:54
C(i) 174.0.0.0/16      0.0.0.0               1 self              0
R(n) 175.0.0.0/16      176.0.1.2             2 176.0.1.2         0 02:54
C(i) 176.0.0.0/16      0.0.0.0               1 self              0
R(n) 177.0.0.0/16      176.0.1.2             2 176.0.1.2         0 02:54
```

R4 Kernel Routing Table:

```
mininext> R4 ip route
172.0.0.0/16 via 175.0.1.1 dev R4-eth1  proto zebra  metric 3
173.0.0.0/16 via 175.0.1.1 dev R4-eth1  proto zebra  metric 2
174.0.0.0/16 via 176.0.1.1 dev R4-eth2  proto zebra  metric 2
175.0.0.0/16 dev R4-eth1  proto kernel  scope link  src 175.0.1.2
176.0.0.0/16 dev R4-eth2  proto kernel  scope link  src 176.0.1.2
177.0.0.0/16 dev R4-eth0  proto kernel  scope link  src 177.0.1.2
```

R4 Quagga routing table

```
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) 172.0.0.0/16      175.0.1.1             3 175.0.1.1         0 02:34
R(n) 173.0.0.0/16      175.0.1.1             2 175.0.1.1         0 02:34
R(n) 174.0.0.0/16      176.0.1.1             2 176.0.1.1         0 02:34
C(i) 175.0.0.0/16      0.0.0.0               1 self              0
C(i) 176.0.0.0/16      0.0.0.0               1 self              0
C(i) 177.0.0.0/16      0.0.0.0               1 self              0
```

H2 Quagga routing table

```
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) 172.0.0.0/16       177.0.1.2             4 177.0.1.2         0 02:57
R(n) 173.0.0.0/16       177.0.1.2             3 177.0.1.2         0 02:57
R(n) 174.0.0.0/16       177.0.1.2             3 177.0.1.2         0 02:57
R(n) 175.0.0.0/16       177.0.1.2             2 177.0.1.2         0 02:57
R(n) 176.0.0.0/16       177.0.1.2             2 177.0.1.2         0 02:57
C(i) 177.0.0.0/16       0.0.0.0               1 self              0
```

H2 Kernel Routing Table:

```
mininext> H2 ip route
172.0.0.0/16 via 177.0.1.2 dev H2-eth0  proto zebra  metric 4
173.0.0.0/16 via 177.0.1.2 dev H2-eth0  proto zebra  metric 3
174.0.0.0/16 via 177.0.1.2 dev H2-eth0  proto zebra  metric 3
175.0.0.0/16 via 177.0.1.2 dev H2-eth0  proto zebra  metric 2
176.0.0.0/16 via 177.0.1.2 dev H2-eth0  proto zebra  metric 2
177.0.0.0/16 dev H2-eth0  proto kernel  scope link  src 177.0.1.1
```

Traceroute between H1 and H2

```
mininext> H1 traceroute H2
traceroute to 177.0.1.1 (177.0.1.1), 30 hops max, 60 byte packets
 1  172.0.1.2 (172.0.1.2)  0.020 ms  0.003 ms  0.003 ms
 2  173.0.1.2 (173.0.1.2)  0.008 ms  0.004 ms  0.004 ms
 3  175.0.1.2 (175.0.1.2)  0.012 ms  0.006 ms  0.005 ms
 4  177.0.1.1 (177.0.1.1)  0.010 ms  0.006 ms  0.007 ms
```

c) Time Taken for Ping : 0.046 ms

d) Time Taken for Convergence : >1 second and < 2 second . I have put a sleep of 1 set for every ping request. So the ping converges in second iteration. So estimated time ~ 2 seconds.

```
connect: Network is unreachable

TimeNow : 1524510761.74
connect: Network is unreachable

TimeNow : 1524510762.74
PING 177.0.1.2 (177.0.1.2) 56(84) bytes of data.
64 bytes from 177.0.1.2: icmp_seq=1 ttl=62 time=0.046 ms

--- 177.0.1.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.046/0.046/0.046/0.000 ms

TimeNow : 1524510763.74
```

B3)

a)

Link is taken down by cmd : **net.configLinkStatus('R1', 'R2', 'down')**

b) Time Taken for convergence after R1 and R2 link is taken down.

I first take down the link and then in a loop with sleep of 5 sec , try to ping H1-H2. The ping converges in almost 25 seconds. (1524511446.19-1524511421.14 ~ 25 seconds). See below screenshot for logs.

```
----------------------Taking Link Down---------------------------------
TimeNow : 1524511421.14
PING 177.0.1.1 (177.0.1.1) 56(84) bytes of data.
From 172.0.1.2 icmp_seq=1 Destination Net Unreachable

--- 177.0.1.1 ping statistics ---
1 packets transmitted, 0 received, +1 errors, 100% packet loss, time 0ms


TimeNow : 1524511421.15
connect: Network is unreachable

TimeNow : 1524511426.16
connect: Network is unreachable

TimeNow : 1524511431.16
connect: Network is unreachable

TimeNow : 1524511436.17
connect: Network is unreachable

TimeNow : 1524511441.18
PING 177.0.1.1 (177.0.1.1) 56(84) bytes of data.
64 bytes from 177.0.1.1: icmp_seq=1 ttl=61 time=0.047 ms

--- 177.0.1.1 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.047/0.047/0.047/0.000 ms

TimeNow : 1524511446.19
```

c) Traceroute after taking R1-R2 link. We can see that now packet goes through 174.0.1.2(R3) instead of 173.0.1.2(R2).