Commands to setup the system:

```
#http://mininet.org/download/
git clone git://github.com/mininet/mininet
cd mininet
git tag
git checkout -b 2.1.0 2.1.0
cd ..

mininet/util/install.sh -a
#https://github.com/USC-NSL/miniNExT
git clone https://github.com/USC-NSL/miniNExT.git
sudo apt-get install `make deps`
sudo make install

#installing quagga
sudo apt-get install quagga

#openvswitch
sudo apt-get install openvswitch-switch
sudo apt-get install openvswitch-controller


#need traceroute
sudo apt-get install traceroute

#need to clear port
sudo fuser 6633/tcp
```

Part A:

```
#ensuring that zebra is yes at daemons
sudo sed -i '21s/no/yes/' ./H1/daemons
sudo sed -i '21s/no/yes/' ./H2/daemons
sudo sed -i '21s/no/yes/' ./R1/daemons
sudo sed -i '21s/no/yes/' ./R2/daemons
sudo sed -i '21s/no/yes/' ./R3/daemons
sudo sed -i '21s/no/yes/' ./R4/daemons

#check ripd should be no

#static ip routes are saved in zebra.conf files
#starting the program
```

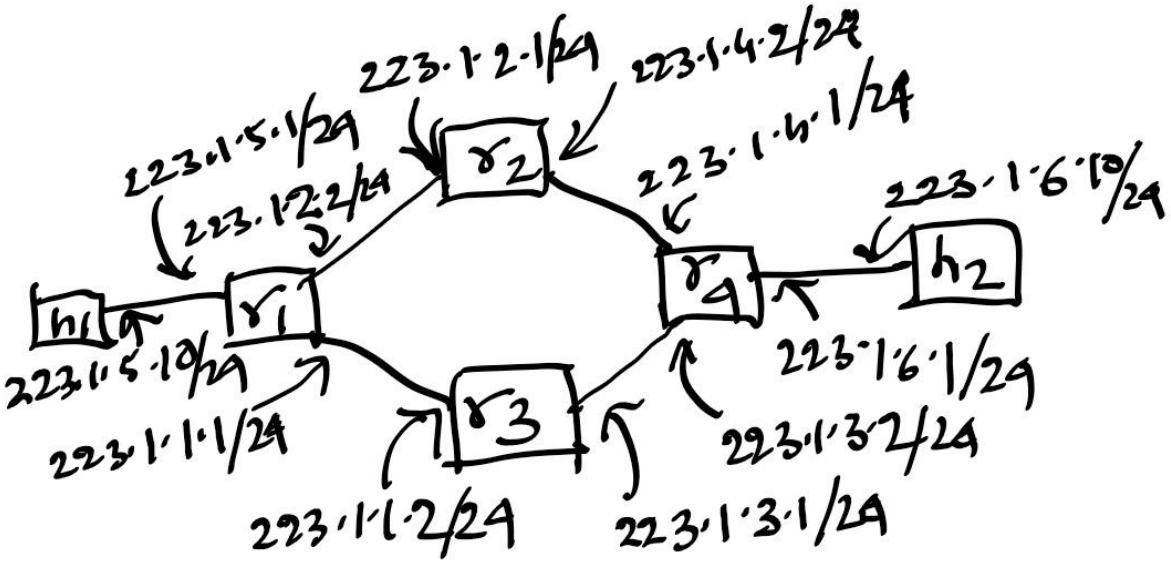
#topo.py is attached
sudo ./startA.py

#ip_routes screenshot

```
[mininext> h1 ip route
default via 223.1.5.1 dev h1-eth0  proto zebra
223.1.5.0/24 dev h1-eth0  proto kernel  scope link  src 223.1.5.10
[mininext> h2 ip route
default via 223.1.6.1 dev h2-eth0  proto zebra
223.1.6.0/24 dev h2-eth0  proto kernel  scope link  src 223.1.6.10
[mininext> r1 ip route
223.1.1.0/24 dev r1-eth2  proto kernel  scope link  src 223.1.1.1
223.1.2.0/24 dev r1-eth1  proto kernel  scope link  src 223.1.2.2
223.1.3.0/24 via 223.1.1.2 dev r1-eth2  proto zebra
223.1.4.0/24 via 223.1.2.1 dev r1-eth1  proto zebra
223.1.5.0/24 dev r1-eth0  proto kernel  scope link  src 223.1.5.1
223.1.6.0/24 via 223.1.1.2 dev r1-eth2  proto zebra
[mininext> r2 ip route
223.1.1.0/24 via 223.1.2.2 dev r2-eth0  proto zebra
223.1.2.0/24 dev r2-eth0  proto kernel  scope link  src 223.1.2.1
223.1.3.0/24 via 223.1.4.1 dev r2-eth1  proto zebra
223.1.4.0/24 dev r2-eth1  proto kernel  scope link  src 223.1.4.2
223.1.5.0/24 via 223.1.2.2 dev r2-eth0  proto zebra
223.1.6.0/24 via 223.1.4.1 dev r2-eth1  proto zebra
[mininext> r3 ip route
223.1.1.0/24 dev r3-eth1  proto kernel  scope link  src 223.1.1.2
223.1.2.0/24 via 223.1.1.1 dev r3-eth1  proto zebra
223.1.3.0/24 dev r3-eth0  proto kernel  scope link  src 223.1.3.1
223.1.4.0/24 via 223.1.3.2 dev r3-eth0  proto zebra
223.1.5.0/24 via 223.1.1.1 dev r3-eth1  proto zebra
223.1.6.0/24 via 223.1.3.2 dev r3-eth0  proto zebra
[mininext> r4 ip route
223.1.1.0/24 via 223.1.3.1 dev r4-eth1  proto zebra
223.1.2.0/24 via 223.1.4.2 dev r4-eth2  proto zebra
223.1.3.0/24 dev r4-eth1  proto kernel  scope link  src 223.1.3.2
223.1.4.0/24 dev r4-eth2  proto kernel  scope link  src 223.1.4.1
223.1.5.0/24 via 223.1.3.1 dev r4-eth1  proto zebra
223.1.6.0/24 dev r4-eth0  proto kernel  scope link  src 223.1.6.1
```

#traceroute screenshot

```
[mininext> h1 traceroute h2
traceroute to 223.1.6.10 (223.1.6.10), 30 hops max, 60 byte packets
 1  223.1.5.1 (223.1.5.1)  0.045 ms  0.008 ms  0.007 ms
 2  223.1.1.2 (223.1.1.2)  0.026 ms  0.010 ms  0.011 ms
 3  223.1.3.2 (223.1.3.2)  0.031 ms  0.016 ms  0.014 ms
 4  223.1.6.10 (223.1.6.10)  0.030 ms  0.018 ms  0.017 ms
```



Part B:

```
#rpid=yes in daemons
sudo sed -i '25s/no/yes/' ./H1/daemons
sudo sed -i '25s/no/yes/' ./H2/daemons
sudo sed -i '25s/no/yes/' ./R1/daemons
sudo sed -i '25s/no/yes/' ./R2/daemons
sudo sed -i '25s/no/yes/' ./R3/daemons
sudo sed -i '25s/no/yes/' ./R4/daemons
```

#For instance, configs/r3/daemons will look like:

```
zebra=yes
bgpd=no
ospfd=no
ospf6d=no
ripd=yes
ripngd=no
isisd=no
```

#comment out the static routing in zebra.conf files
#For instance, configs/r3/zebra.conf will look like:

```
!ip route 223.1.2.0/24 223.1.1.1
!ip route 223.1.4.0/24 223.1.3.2
!ip route 223.1.5.0/24 223.1.1.1
!ip route 223.1.6.0/24 223.1.3.2

hostname r3
password zebra
enable password zebra
```

#For instance, configs/r3/ripd.conf will look like:

```
router rip
version 2

network eth0
network 223.1.3.0/24

network eth1
network 223.1.1.0/24

```

#new codes introduced in startB.py so that h1 pings h2 10 times to get average ping time
#I am using the function #pingh1h2() for this
#also the convergence time we know from this.

#it also takes down the connection using the function linkDown()
sudo ./startB.py

#kernel ip tables

```
*** Starting CLI:
mininext> h1 ip route
223.1.1.0/24 via 223.1.5.1 dev h1-eth0  proto zebra  metric 2
223.1.3.0/24 via 223.1.5.1 dev h1-eth0  proto zebra  metric 3
223.1.4.0/24 via 223.1.5.1 dev h1-eth0  proto zebra  metric 4
223.1.5.0/24 dev h1-eth0  proto kernel  scope link  src 223.1.5.10
223.1.6.0/24 via 223.1.5.1 dev h1-eth0  proto zebra  metric 4
mininext> h2 ip route
223.1.1.0/24 via 223.1.6.1 dev h2-eth0  proto zebra  metric 3
223.1.3.0/24 via 223.1.6.1 dev h2-eth0  proto zebra  metric 2
223.1.4.0/24 via 223.1.6.1 dev h2-eth0  proto zebra  metric 2
223.1.5.0/24 via 223.1.6.1 dev h2-eth0  proto zebra  metric 4
223.1.6.0/24 dev h2-eth0  proto kernel  scope link  src 223.1.6.10
mininext> r1 ip route
223.1.1.0/24 dev r1-eth2  proto kernel  scope link  src 223.1.1.1
223.1.3.0/24 via 223.1.1.2 dev r1-eth2  proto zebra  metric 2
223.1.4.0/24 via 223.1.1.2 dev r1-eth2  proto zebra  metric 3
223.1.5.0/24 dev r1-eth0  proto kernel  scope link  src 223.1.5.1
223.1.6.0/24 via 223.1.1.2 dev r1-eth2  proto zebra  metric 3
mininext> r2 ip route
223.1.1.0/24 via 223.1.4.1 dev r2-eth1  proto zebra  metric 3
223.1.3.0/24 via 223.1.4.1 dev r2-eth1  proto zebra  metric 2
223.1.4.0/24 dev r2-eth1  proto kernel  scope link  src 223.1.4.2
223.1.5.0/24 via 223.1.4.1 dev r2-eth1  proto zebra  metric 4
223.1.6.0/24 via 223.1.4.1 dev r2-eth1  proto zebra  metric 2
mininext> r3 ip route
223.1.1.0/24 dev r3-eth1  proto kernel  scope link  src 223.1.1.2
223.1.3.0/24 dev r3-eth0  proto kernel  scope link  src 223.1.3.1
223.1.4.0/24 via 223.1.3.2 dev r3-eth0  proto zebra  metric 2
223.1.5.0/24 via 223.1.1.1 dev r3-eth1  proto zebra  metric 2
223.1.6.0/24 via 223.1.3.2 dev r3-eth0  proto zebra  metric 2
mininext> r4 ip route
223.1.1.0/24 via 223.1.3.1 dev r4-eth1  proto zebra  metric 2
223.1.3.0/24 dev r4-eth1  proto kernel  scope link  src 223.1.3.2
223.1.4.0/24 dev r4-eth2  proto kernel  scope link  src 223.1.4.1
223.1.5.0/24 via 223.1.3.1 dev r4-eth1  proto zebra  metric 3
223.1.6.0/24 dev r4-eth0  proto kernel  scope link  src 223.1.6.1
```

#quagga ip tables

```
betrfs@beakerz:~/mininet/miniNExT/util$ ./mx h2
root@beakerz:/# telnet localhost 2601
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:
h2> show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
R>* 223.1.1.0/24 [120/3] via 223.1.6.1, h2-eth0, 00:15:25
R>* 223.1.2.0/24 [120/3] via 223.1.6.1, h2-eth0, 00:15:25
R>* 223.1.3.0/24 [120/2] via 223.1.6.1, h2-eth0, 00:15:25
R>* 223.1.4.0/24 [120/2] via 223.1.6.1, h2-eth0, 00:15:25
R>* 223.1.5.0/24 [120/4] via 223.1.6.1, h2-eth0, 00:15:25
C>* 223.1.6.0/24 is directly connected, h2-eth0
```

```
h1> show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
R>* 223.1.1.0/24 [120/2] via 223.1.5.1, h1-eth0, 00:16:46
R>* 223.1.2.0/24 [120/2] via 223.1.5.1, h1-eth0, 00:16:46
R>* 223.1.3.0/24 [120/3] via 223.1.5.1, h1-eth0, 00:16:46
R>* 223.1.4.0/24 [120/3] via 223.1.5.1, h1-eth0, 00:16:46
C>* 223.1.5.0/24 is directly connected, h1-eth0
R>* 223.1.6.0/24 [120/4] via 223.1.5.1, h1-eth0, 00:16:44
```

```
r1> show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
C>* 223.1.1.0/24 is directly connected, r1-eth2
C>* 223.1.2.0/24 is directly connected, r1-eth1
R>* 223.1.3.0/24 [120/2] via 223.1.1.2, r1-eth2, 00:19:04
R>* 223.1.4.0/24 [120/2] via 223.1.2.1, r1-eth1, 00:19:04
C>* 223.1.5.0/24 is directly connected, r1-eth0
R>* 223.1.6.0/24 [120/3] via 223.1.1.2, r1-eth2, 00:19:03
```

```
r2> show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
R>* 223.1.1.0/24 [120/2] via 223.1.2.2, r2-eth0, 00:19:48
C>* 223.1.2.0/24 is directly connected, r2-eth0
R>* 223.1.3.0/24 [120/2] via 223.1.4.1, r2-eth1, 00:19:47
C>* 223.1.4.0/24 is directly connected, r2-eth1
R>* 223.1.5.0/24 [120/2] via 223.1.2.2, r2-eth0, 00:19:48
R>* 223.1.6.0/24 [120/2] via 223.1.4.1, r2-eth1, 00:19:47
```

```
r3> show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
C>* 223.1.1.0/24 is directly connected, r3-eth1
R>* 223.1.2.0/24 [120/2] via 223.1.1.1, r3-eth1, 00:20:30
C>* 223.1.3.0/24 is directly connected, r3-eth0
R>* 223.1.4.0/24 [120/2] via 223.1.3.2, r3-eth0, 00:20:29
R>* 223.1.5.0/24 [120/2] via 223.1.1.1, r3-eth1, 00:20:30
R>* 223.1.6.0/24 [120/2] via 223.1.3.2, r3-eth0, 00:20:29
```

```
r4> show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, A - Babel,
       > - selected route, * - FIB route

C>* 127.0.0.0/8 is directly connected, lo
R>* 223.1.1.0/24 [120/2] via 223.1.3.1, r4-eth1, 00:21:12
R>* 223.1.2.0/24 [120/2] via 223.1.4.2, r4-eth2, 00:21:12
C>* 223.1.3.0/24 is directly connected, r4-eth1
C>* 223.1.4.0/24 is directly connected, r4-eth2
R>* 223.1.5.0/24 [120/3] via 223.1.3.1, r4-eth1, 00:21:12
C>* 223.1.6.0/24 is directly connected, r4-eth0
```

#ping statistics from h1 to h2, average is 0.095s

```
PING 223.1.6.10 (223.1.6.10) 56(84) bytes of data.
64 bytes from 223.1.6.10: icmp_seq=1 ttl=61 time=0.077 ms
64 bytes from 223.1.6.10: icmp_seq=2 ttl=61 time=0.081 ms
64 bytes from 223.1.6.10: icmp_seq=3 ttl=61 time=0.093 ms
64 bytes from 223.1.6.10: icmp_seq=4 ttl=61 time=0.103 ms
64 bytes from 223.1.6.10: icmp_seq=5 ttl=61 time=0.103 ms
64 bytes from 223.1.6.10: icmp_seq=6 ttl=61 time=0.103 ms
64 bytes from 223.1.6.10: icmp_seq=7 ttl=61 time=0.100 ms
64 bytes from 223.1.6.10: icmp_seq=8 ttl=61 time=0.097 ms
64 bytes from 223.1.6.10: icmp_seq=9 ttl=61 time=0.099 ms
64 bytes from 223.1.6.10: icmp_seq=10 ttl=61 time=0.104 ms

--- 223.1.6.10 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 8997ms
rtt min/avg/max/mdev = 0.077/0.096/0.104/0.009 ms
```

#convergence time ~ 5 s

```
connect: Network is unreachable

Time: 1573574081.69
connect: Network is unreachable

Time: 1573574082.7
connect: Network is unreachable

Time: 1573574083.71
connect: Network is unreachable

Time: 1573574084.71
connect: Network is unreachable

Time: 1573574085.72
connect: Network is unreachable

Time: 1573574086.73
PING 223.1.6.10 (223.1.6.10) 56(84) bytes of data.

--- 223.1.6.10 ping statistics ---
1 packets transmitted, 0 received, 100% packet loss, time 0ms
```

#traceroute before taking down link, r1-r3 path used

```
traceroute to 223.1.6.10 (223.1.6.10), 30 hops max, 60 byte packets
 1  223.1.5.1 (223.1.5.1)  0.042 ms  0.010 ms  0.007 ms
 2  223.1.1.2 (223.1.1.2)  0.026 ms  0.011 ms  0.011 ms
 3  223.1.3.2 (223.1.3.2)  0.034 ms  0.016 ms  0.015 ms
 4  223.1.6.10 (223.1.6.10)  0.027 ms  0.017 ms  0.017 ms
```

#traceroute after taking down link r1-r3 which was being used

```
traceroute to 223.1.6.10 (223.1.6.10), 30 hops max, 60 byte packets
 1  223.1.5.1 (223.1.5.1)  0.043 ms  0.009 ms  0.007 ms
 2  223.1.2.1 (223.1.2.1)  0.026 ms  0.012 ms  0.011 ms
 3  223.1.4.1 (223.1.4.1)  0.030 ms  0.015 ms  0.015 ms
 4  223.1.6.10 (223.1.6.10)  0.030 ms  0.017 ms  0.017 ms
```

#rtt and ping statistics

```
Time: 1573573616.73
Taking link down
Time: 1573573617.73
PING 223.1.6.10 (223.1.6.10) 56(84) bytes of data.
64 bytes from 223.1.6.10: icmp_seq=1 ttl=61 time=0.083 ms

--- 223.1.6.10 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.083/0.083/0.083/0.000 ms

Time: 1573573617.75
PING 223.1.6.10 (223.1.6.10) 56(84) bytes of data.
64 bytes from 223.1.6.10: icmp_seq=1 ttl=61 time=0.088 ms

--- 223.1.6.10 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.088/0.088/0.088/0.000 ms

Time: 1573573618.75
** Testing network connectivity
h1 -> h2 r1 r2 r3 r4
h2 -> h1 r1 r2 r3 r4
r1 -> h1 h2 r2 r3 r4
r2 -> h1 h2 r1 r3 r4
r3 -> h1 h2 r1 r2 r4
r4 -> h1 h2 r1 r2 r3
*** Results: 0% dropped (30/30 received)
```

Part C:

#riplite.py and distancevector.py is attached
#neighbors folder holds the distance between the nodes data