Task 2

a.) show ip ospf route

```
Hello, this is Quagga (version 1.1.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

router10# show ip ospf route
============ OSPF network routing table ============
N    10.0.0.0/24          [50] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.1.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.2.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.3.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.4.0/24          [30] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.5.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.6.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.7.0/24          [50] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.8.0/24          [30] area: 0.0.0.0
                          via 10.0.11.2, eth0
                          via 10.0.12.2, eth1
N    10.0.9.0/24          [20] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.10.0/24         [30] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.11.0/24         [10] area: 0.0.0.0
                          directly attached to eth0
N    10.0.12.0/24         [10] area: 0.0.0.0
                          directly attached to eth1
N    10.0.13.0/24         [20] area: 0.0.0.0
                          via 10.0.12.2, eth1
N    10.0.14.0/24         [10] area: 0.0.0.0
                          directly attached to eth2
N    127.0.0.1/32         [0] area: 0.0.0.0
                          directly attached to lo

============ OSPF router routing table =============
R    10.0.1.2             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.3.1             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.4.1             [30] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.6.1             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.7.1             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.10.1            [20] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.10.2            [30] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.11.2            [10] area: 0.0.0.0, ASBR
                          via 10.0.12.2, eth1
R    10.0.13.2            [20] area: 0.0.0.0, ASBR
                          via 10.0.12.2, eth1

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

b.) 10.0.11.2

```
Hello, this is Quagga (version 1.1.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

router10# show ip ospf route
============ OSPF network routing table ============
N    10.0.0.0/24          [50] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.1.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.2.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.3.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.4.0/24          [30] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.5.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.6.0/24          [40] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.7.0/24          [50] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.8.0/24          [30] area: 0.0.0.0
                          via 10.0.11.2, eth0
                          via 10.0.12.2, eth1
N    10.0.9.0/24          [20] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.10.0/24         [30] area: 0.0.0.0
                          via 10.0.11.2, eth0
N    10.0.11.0/24         [10] area: 0.0.0.0
                          directly attached to eth0
N    10.0.12.0/24         [10] area: 0.0.0.0
                          directly attached to eth1
N    10.0.13.0/24         [20] area: 0.0.0.0
                          via 10.0.12.2, eth1
N    10.0.14.0/24         [10] area: 0.0.0.0
                          directly attached to eth2
N    127.0.0.1/32         [0] area: 0.0.0.0
                          directly attached to lo

============ OSPF router routing table =============
R    10.0.1.2             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.3.1             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.4.1             [30] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.6.1             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.7.1             [40] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.10.1            [20] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.10.2            [30] area: 0.0.0.0, ASBR
                          via 10.0.11.2, eth0
R    10.0.11.2            [10] area: 0.0.0.0, ASBR
                          via 10.0.12.2, eth1
R    10.0.13.2            [20] area: 0.0.0.0, ASBR
                          via 10.0.12.2, eth1

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

c.) 30

```
Hello, this is Quagga (version 1.1.1).
Copyright 1996-2005 Kunihiro Ishiguro, et al.

router10# show ip ospf route
============ OSPF network routing table ============
N    10.0.0.0/24           [50] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.1.0/24           [40] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.2.0/24           [40] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.3.0/24           [40] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.4.0/24           [30] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.5.0/24           [40] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.6.0/24           [40] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.7.0/24           [50] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.8.0/24           [30] area: 0.0.0.0
                           via 10.0.11.2, eth0
                           via 10.0.12.2, eth1
N    10.0.9.0/24           [20] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.10.0/24          [30] area: 0.0.0.0
                           via 10.0.11.2, eth0
N    10.0.11.0/24          [10] area: 0.0.0.0
                           directly attached to eth0
N    10.0.12.0/24          [10] area: 0.0.0.0
                           directly attached to eth1
N    10.0.13.0/24          [20] area: 0.0.0.0
                           via 10.0.12.2, eth1
N    10.0.14.0/24          [10] area: 0.0.0.0
                           directly attached to eth2
N    127.0.0.1/32          [0] area: 0.0.0.0
                           directly attached to lo

============ OSPF router routing table ============
R    10.0.1.2              [40] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.3.1              [40] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.4.1              [30] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.6.1              [40] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.7.1              [40] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.10.1             [20] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.10.2             [30] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.11.2             [10] area: 0.0.0.0, ASBR
                           via 10.0.11.2, eth0
R    10.0.13.1             [10] area: 0.0.0.0, ASBR
                           via 10.0.12.2, eth1
R    10.0.13.2             [20] area: 0.0.0.0, ASBR
                           via 10.0.12.2, eth1

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

d.) The path installation times for router 9 is 18s while the path installation for router 5 is 50s. Router 9 was installed first as the ospf algorithm sets up each router one at a time and router 9 is before router 5.

```
router10# show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, A - Babel,
       > - selected route, * - FIB route

O>* 10.0.0.0/24 [110/50] via 10.0.11.2, eth0, 00:00:18
O>* 10.0.1.0/24 [110/40] via 10.0.11.2, eth0, 00:00:18
O>* 10.0.2.0/24 [110/40] via 10.0.11.2, eth0, 00:00:18
O>* 10.0.3.0/24 [110/40] via 10.0.11.2, eth0, 00:00:17
O>* 10.0.4.0/24 [110/30] via 10.0.11.2, eth0, 00:00:18
O>* 10.0.5.0/24 [110/40] via 10.0.11.2, eth0, 00:00:17
O>* 10.0.6.0/24 [110/40] via 10.0.11.2, eth0, 00:00:17
O>* 10.0.7.0/24 [110/50] via 10.0.11.2, eth0, 00:00:17
O>* 10.0.8.0/24 [110/30] via 10.0.11.2, eth0, 00:00:07
  *                       via 10.0.12.2, eth1, 00:00:07
O>* 10.0.9.0/24 [110/20] via 10.0.11.2, eth0, 00:00:18
O>* 10.0.10.0/24 [110/30] via 10.0.11.2, eth0, 00:00:18
O   10.0.11.0/24 [110/10] is directly connected, eth0, 00:01:08
C>* 10.0.11.0/24 is directly connected, eth0
O   10.0.12.0/24 [110/10] is directly connected, eth1, 00:01:07
C>* 10.0.12.0/24 is directly connected, eth1
O>* 10.0.13.0/24 [110/20] via 10.0.12.2, eth1, 00:00:17
O   10.0.14.0/24 [110/10] is directly connected, eth2, 00:01:07
C>* 10.0.14.0/24 is directly connected, eth2
C>* 127.0.0.0/8 is directly connected, lo
O>* 127.0.0.1/32 [110/0] is directly connected, lo, 00:01:08
```

Task 3

a.) traceroute 10.0.7.20

```
root@pc1:/# traceroute 10.0.7.20
traceroute to 10.0.7.20 (10.0.7.20), 30 hops max, 60 byte packets
 1  10.0.14.1 (10.0.14.1)  0.459 ms  0.389 ms  0.374 ms
 2  10.0.11.2 (10.0.11.2)  0.359 ms  0.332 ms  0.304 ms
 3  10.0.9.2 (10.0.9.2)  0.287 ms  0.260 ms  0.241 ms
 4  10.0.10.2 (10.0.10.2)  0.225 ms  0.196 ms  0.174 ms
 5  10.0.5.1 (10.0.5.1)  0.153 ms  0.118 ms  0.095 ms
 6  10.0.7.20 (10.0.7.20)  0.073 ms  0.064 ms  0.023 ms
root@pc1:/#
```

b.) Commands:
iperf -s 10.0.14.20
iperf -c 10.0.14.20
Bandwidth: 24.9Gbits/sec

```
root@pc1:/# iperf -s 10.0.14.20
iperf: ignoring extra argument -- 10.0.14.20
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size:  128 KByte (default)
------------------------------------------------------------
[  4] local 10.0.14.20 port 5001                    10.0.7.20 port 57308
[ ID] Interval       Transfer     Bandwidth
[  4]  0.0-10.0 sec  29.0 GByt    24.9 Gbits/sec
```

```
root@pc2:/# iperf -c 10.0.14.20
------------------------------------------------------------
Client connecting to 10.0.14.20, TCP port 5001
TCP window size:  170 KByte (default)
------------------------------------------------------------
[  3] local 10.0.7.20 port 57308                    10.0.14.20 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  29.0 GByt    24.9 Gbits/sec
root@pc2:/#
```

c.) traceroute 10.0.7.20
Sequence of routers:
10.0.14.1
10.0.11.2
10.0.9.2
10.0.10.2
10.0.5.1
10.0.7.20

```
root@pc1:/# traceroute 10.0.7.20
traceroute to 10.0.7.20 (10.0.7.20), 30 hops max, 60 byte packets
 1  10.0.14.1 (10.0.14.1)  0.459 ms  0.389 ms  0.374 ms
 2  10.0.11.2 (10.0.11.2)  0.359 ms  0.332 ms  0.304 ms
 3  10.0.9.2 (10.0.9.2)  0.287 ms  0.260 ms  0.241 ms
 4  10.0.10.2 (10.0.10.2)  0.225 ms  0.196 ms  0.174 ms
 5  10.0.5.1 (10.0.5.1)  0.153 ms  0.118 ms  0.095 ms
 6  10.0.7.20 (10.0.7.20)  0.073 ms  0.064 ms  0.023 ms
root@pc1:/#
```

d.) ping 10.0.7.20
rtt min/avg/max/mdev = 0.075/0.0102/0.188/0.030ms

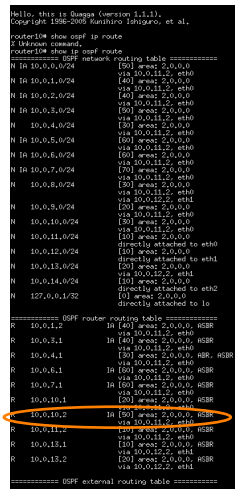
```
root@pc1:/# ping 10.0.7.20
PING 10.0.7.20 (10.0.7.20) 56(84) bytes of data.
64 bytes from 10.0.7.20: icmp_seq=1 ttl=59 time=0.152 ms
64 bytes from 10.0.7.20: icmp_seq=2 ttl=59 time=0.082 ms
64 bytes from 10.0.7.20: icmp_seq=3 ttl=59 time=0.092 ms
64 bytes from 10.0.7.20: icmp_seq=4 ttl=59 time=0.086 ms
64 bytes from 10.0.7.20: icmp_seq=5 ttl=59 time=0.113 ms
64 bytes from 10.0.7.20: icmp_seq=6 ttl=59 time=0.094 ms
64 bytes from 10.0.7.20: icmp_seq=7 ttl=59 time=0.104 ms
64 bytes from 10.0.7.20: icmp_seq=8 ttl=59 time=0.188 ms
64 bytes from 10.0.7.20: icmp_seq=9 ttl=59 time=0.126 ms
64 bytes from 10.0.7.20: icmp_seq=10 ttl=59 time=0.084 ms
64 bytes from 10.0.7.20: icmp_seq=11 ttl=59 time=0.104 ms
64 bytes from 10.0.7.20: icmp_seq=12 ttl=59 time=0.075 ms
64 bytes from 10.0.7.20: icmp_seq=13 ttl=59 time=0.105 ms
64 bytes from 10.0.7.20: icmp_seq=14 ttl=59 time=0.087 ms
64 bytes from 10.0.7.20: icmp_seq=15 ttl=59 time=0.092 ms
64 bytes from 10.0.7.20: icmp_seq=16 ttl=59 time=0.081 ms
c64 bytes from 10.0.7.20: icmp_seq=17 ttl=59 time=0.078 ms
^C
--- 10.0.7.20 ping statistics ---
17 packets transmitted, 17 received, 0% packet loss, time 16385ms
rtt min/avg/max/mdev = 0.075/0.102/0.188/0.030 ms
root@pc1:/#
```

Task 5)

a.) Area 0 (Green area) as it provides reachability to area1 (blue area) to area 2 (red area).

b.)

Next hop is still the same for both topologies which is 10.0.10.2. However, for the first topology the cost to get to router 4 was 30 and for the second topology it was 50. The reason the value changed was that in the first topology router 7 and router 4 could communicate using ospf however in topology 4 they can no longer communicate using ospf so it must go by via the backbone of the topology.



c.)

i.)

```
root@router4:/# traceroute 10.0.10.1
traceroute to 10.0.10.1 (10.0.10.1), 30 hops max, 60 byte packets
 1  10.0.10.1 (10.0.10.1)  0.335 ms  0.255 ms  0.241 ms
```

ii.)

```
root@router7:/# traceroute 10.0.9.2
traceroute to 10.0.9.2 (10.0.9.2), 30 hops max, 60 byte packets
 1  10.0.9.2 (10.0.9.2)  0.486 ms  0.393 ms  0.364 ms
root@router7:/#
```

iii.)

```
root@router4:/# traceroute 10.0.9.1
traceroute to 10.0.9.1 (10.0.9.1), 30 hops max, 60 byte packets
 1  10.0.3.1 (10.0.3.1)  0.437 ms  0.388 ms  0.359 ms
 2  10.0.2.1 (10.0.2.1)  0.341 ms  0.308 ms  0.293 ms
 3  10.0.4.2 (10.0.4.2)  0.277 ms  0.244 ms  0.225 ms
 4  10.0.9.1 (10.0.9.1)  0.207 ms  0.176 ms  0.152 ms
root@router4:/#
```

The path in iii is not the same as the concatenation of path i and path ii. This is because path i can traceroute via 10.0.10.2 to 10.0.10.1 as they are directly connected. However, for iii router 4 and router 9 aren't directly connected so it can't go via the link 10.0.10.2 to 10.0.10.1.

Task 6

b.)

i.)

```
root@router10:/# traceroute 10.0.5.1
traceroute to 10.0.5.1 (10.0.5.1), 30 hops max, 60 byte packets
 1  10.0.12.2 (10.0.12.2)  0.639 ms  0.558 ms  0.542 ms
 2  10.0.13.2 (10.0.13.2)  0.529 ms  0.506 ms  0.480 ms
 3  10.0.9.2 (10.0.9.2)  0.463 ms  0.413 ms  0.395 ms
 4  10.0.4.1 (10.0.4.1)  0.380 ms  0.343 ms  0.322 ms
 5  10.0.2.2 (10.0.2.2)  0.170 ms  0.130 ms  0.109 ms
 6  10.0.3.2 (10.0.3.2)  0.087 ms  0.492 ms  0.440 ms
 7  10.0.5.1 (10.0.5.1)  0.416 ms  0.364 ms  0.338 ms
root@router10:/#
```

10.0.12.2
10.0.13.2
10.0.9.2
10.0.4.1
10.0.2.2
10.0.3.2
10.0.5.1

ii.)

```
root@router5:/# traceroute 10.0.14.1
traceroute to 10.0.14.1 (10.0.14.1), 30 hops max, 60 byte packets
 1  10.0.5.2 (10.0.5.2)  0.590 ms  0.537 ms  0.524 ms
 2  10.0.3.1 (10.0.3.1)  0.484 ms  0.448 ms  0.429 ms
 3  10.0.2.1 (10.0.2.1)  0.407 ms  0.369 ms  0.343 ms
 4  10.0.4.2 (10.0.4.2)  0.320 ms  0.289 ms  0.270 ms
 5  10.0.9.1 (10.0.9.1)  0.247 ms  0.205 ms  0.178 ms
 6  10.0.14.1 (10.0.14.1)  0.137 ms  0.047 ms  0.037 ms
root@router5:/#
```

10.0.5.2
10.0.3.1
10.0.2.1
10.0.4.2
10.0.9.1
10.0.14.1

iii.) These two paths arent symetrical. They go down different paths as the bandwidth between router 10 and router 9 is really low so going from router 10 to router 5 it will go down router 11. However going from router 5 to router 10 the bandwidth between router 7 and router 9 is the same as all the rest so it gets send down router 9 instead.

Task 7)

Changed eth0 of router 2 to 10.0.0.1
Changed router6 eth0 MTU to 1500