DATA TRANSMISSION

LAB3 – REPORT

Configuring OSPF

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1. Introduction

In this lab, the aim is to become familiarize with OSPF protocol, which is one of the most popular and used protocols. At first, the IP addresses for interfaces of the routers were chosen and during the lab session the devices were configured according to those IP addresses. Figure 1 shows the IP addresses for each interface.

Router	Interface	Selected IP address
R1	e0/0	192.168.11.1/30
	Loopback0	192.168.0.1/32
R2	e0/0	192.168.11.2/30
	e0/1	192.168.10.1/30
	e0/2	192.168.10.5/30
	Loopback0	192.168.0.2/32
R3	e0/0	192.168.10.9/30
	e0/2	192.168.10.6/30
	e0/3	192.168.10.13/30
	Loopback0	192.168.0.3/32
R4	e0/1	192.168.10.2/30
	e0/2	192.168.10.17/30
	e0/3	192.168.10.14/30
	Loopback0	192.168.0.4/32
R5	e0/0	192.168.10.10/30
	e0/2	192.168.10.18/30
	Loopback0	192.168.0.5/32

Figure 1: IP addresses assigned to each interface

In the figure the interfaces on the routers that forms a network highlighted with the same color so that reader can see the matching interfaces.

According to this lab the neighborhoods can be shown like below:

- R1 - R2
- R2 - R1, R3, R4
- R3 - R2, R4, R5
- R4 - R2, R3, R5
- R5 - R3, R4

In addition to these, I have been requested from the professor that I should inform the reader that I do not have a lab partner, thus, I did all the lab on my own.

2. Task 3A – Basic Device Configuration

In this task the basic device configuration was excepted according to the topology given in the lab document. It can be seen in the Figure 1 that between the interface of R1and R2, the IP range 192.168.11.0/30 is used and for the loopback interfaces the pool 192.168.10.0/29 is used but as mask /32 is chosen as it is advised in the prelab document.

Since it is requested in the task, I subnetted the pool 192.168.10.0/27 using the mask /30 (255.255.255.252) since only two IP addresses needed to use for interfaces between in each router and this subnet is the sufficient one. After the configuration of the interfaces of routers with the designated IP addresses the commands **show cdp neighbors** and **show ip route** were

typed. First one is for verifying the addressing and the second one is to see routing table. The results of commands on each router are given below.

```
R1(config-if)#do show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R2               Eth 0/0            136        R S I      3640      Eth 0/0
R1(config-if)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0
     192.168.0.0/32 is subnetted, 1 subnets
C       192.168.0.1 is directly connected, Loopback0
R1(config-if)#
```

```
R2(config-if)#do show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R3               Eth 0/2            119        R S I      3640      Eth 0/2
R1               Eth 0/0            138        R S I      3640      Eth 0/0
R4               Eth 0/1            177        R S I      3640      Eth 0/1
R2(config-if)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 2 subnets
C       192.168.10.0 is directly connected, Ethernet0/1
C       192.168.10.4 is directly connected, Ethernet0/2
     192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0
     192.168.0.0/32 is subnetted, 1 subnets
C       192.168.0.2 is directly connected, Loopback0
R2(config-if)#
```

```
R3(config-if)#do show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R2               Eth 0/2            128        R S I      3640      Eth 0/2
R4               Eth 0/3            156        R S I      3640      Eth 0/3
R5               Eth 0/0            175        R S I      3640      Eth 0/0
R3(config-if)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.4 is directly connected, Ethernet0/2
C       192.168.10.8 is directly connected, Ethernet0/0
C       192.168.10.12 is directly connected, Ethernet0/3
     192.168.0.0/32 is subnetted, 1 subnets
C       192.168.0.3 is directly connected, Loopback0
R3(config-if)#
```

```
R4(config-if)#do show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R2               Eth 0/1            173        R S I      3640      Eth 0/1
R3               Eth 0/3            145        R S I      3640      Eth 0/3
R5               Eth 0/2            173        R S I      3640      Eth 0/2
R4(config-if)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Ethernet0/1
C       192.168.10.12 is directly connected, Ethernet0/3
C       192.168.10.16 is directly connected, Ethernet0/2
     192.168.0.0/32 is subnetted, 1 subnets
C       192.168.0.4 is directly connected, Loopback0
R4(config-if)#
```

```
R5(config-if)#do show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
R3               Eth 0/0            163        R S I      3640      Eth 0/0
R4               Eth 0/2            172        R S I      3640      Eth 0/2
R5(config-if)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 2 subnets
C       192.168.10.8 is directly connected, Ethernet0/0
C       192.168.10.16 is directly connected, Ethernet0/2
     192.168.0.0/32 is subnetted, 1 subnets
C       192.168.0.5 is directly connected, Loopback0
R5(config-if)#
```

For all of the routers, the entry for **show cdp neighbors** command shows that the router that this command is typed for is now neighbors of others just like specified in the lab document and for the **show ip route** command it is seen that the address pool was subnetted in the first line and the subnetworks which the router is directly connected with the given interface in the following lines. The letter C here means that the router is connected. For now, the router has the LSA's of the routers only it is directly connected. OSPF should be configured to send IP packets using the network in other tasks.

3. Task 3B – Initial OSPF Protocol Configuration

The first task was about configuring the IP addresses that is why I also configured the Loopback0 addresses to make my job easier as well. The next step was to configure OSPF protocol on each interface of routers including Loopbacks and after that the basic OSPF configuration was done. With the help of the commands **show ip ospf** the configuration between routers can be seen and using **show ip route** command we can show that on each router the routing tables were changed because of updating of LSA entries.

Below the results of commands can be seen for each router.

```
R1(config-router)#do show ip ospf
 Routing Process "ospf 1" with ID 192.168.0.1
 Start time: 01:11:32.512, Time elapsed: 00:07:03.448
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 Router is not originating router-LSAs with maximum metric
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 2 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:00:09.768 ago
        SPF algorithm executed 19 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x057439
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

```
R1(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
O       192.168.10.0 [110/20] via 192.168.11.2, 00:00:48, Ethernet0/0
O       192.168.10.4 [110/20] via 192.168.11.2, 00:00:48, Ethernet0/0
O       192.168.10.8 [110/30] via 192.168.11.2, 00:00:48, Ethernet0/0
O       192.168.10.12 [110/30] via 192.168.11.2, 00:00:48, Ethernet0/0
O       192.168.10.16 [110/30] via 192.168.11.2, 00:00:48, Ethernet0/0
     192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0
     192.168.0.0/32 is subnetted, 5 subnets
C       192.168.0.1 is directly connected, Loopback0
O       192.168.0.2 [110/11] via 192.168.11.2, 00:00:49, Ethernet0/0
O       192.168.0.3 [110/21] via 192.168.11.2, 00:00:49, Ethernet0/0
O       192.168.0.4 [110/21] via 192.168.11.2, 00:00:49, Ethernet0/0
O       192.168.0.5 [110/31] via 192.168.11.2, 00:02:00, Ethernet0/0
R1(config-router)#
```

```
R2(config-router)#do show ip ospf
 Routing Process "ospf 1" with ID 192.168.0.2
 Start time: 01:12:05.240, Time elapsed: 00:08:27.512
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 Router is not originating router-LSAs with maximum metric
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 4 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:02:33.496 ago
        SPF algorithm executed 17 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x057439
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

```
R2(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
C       192.168.10.0 is directly connected, Ethernet0/1
C       192.168.10.4 is directly connected, Ethernet0/2
O       192.168.10.8 [110/20] via 192.168.10.6, 00:03:08, Ethernet0/2
O       192.168.10.12 [110/20] via 192.168.10.6, 00:03:08, Ethernet0/2
                      [110/20] via 192.168.10.2, 00:03:08, Ethernet0/1
O       192.168.10.16 [110/20] via 192.168.10.2, 00:03:08, Ethernet0/1
     192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0
     192.168.0.0/32 is subnetted, 5 subnets
O       192.168.0.1 [110/11] via 192.168.11.1, 00:03:09, Ethernet0/0
C       192.168.0.2 is directly connected, Loopback0
O       192.168.0.3 [110/11] via 192.168.10.6, 00:03:09, Ethernet0/2
O       192.168.0.4 [110/11] via 192.168.10.2, 00:03:10, Ethernet0/1
O       192.168.0.5 [110/21] via 192.168.10.6, 00:03:11, Ethernet0/2
                    [110/21] via 192.168.10.2, 00:03:11, Ethernet0/1
```

```
R3(config-router)#do show ip ospf
 Routing Process "ospf 1" with ID 192.168.0.3
 Start time: 01:13:30.496, Time elapsed: 00:08:05.728
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 Router is not originating router-LSAs with maximum metric
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 4 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:03:37.116 ago
        SPF algorithm executed 14 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x057439
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

```
R3(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
O       192.168.10.0 [110/20] via 192.168.10.14, 00:04:01, Ethernet0/3
                     [110/20] via 192.168.10.5, 00:04:01, Ethernet0/2
C       192.168.10.4 is directly connected, Ethernet0/2
C       192.168.10.8 is directly connected, Ethernet0/0
C       192.168.10.12 is directly connected, Ethernet0/3
O       192.168.10.16 [110/20] via 192.168.10.14, 00:04:01, Ethernet0/3
                      [110/20] via 192.168.10.10, 00:04:01, Ethernet0/0
     192.168.11.0/30 is subnetted, 1 subnets
O       192.168.11.0 [110/20] via 192.168.10.5, 00:04:03, Ethernet0/2
     192.168.0.0/32 is subnetted, 5 subnets
O       192.168.0.1 [110/21] via 192.168.10.5, 00:04:03, Ethernet0/2
O       192.168.0.2 [110/11] via 192.168.10.5, 00:04:03, Ethernet0/2
C       192.168.0.3 is directly connected, Loopback0
O       192.168.0.4 [110/11] via 192.168.10.14, 00:04:05, Ethernet0/3
O       192.168.0.5 [110/11] via 192.168.10.10, 00:04:05, Ethernet0/0
```

```
R4(config-router)#do show ip ospf
 Routing Process "ospf 1" with ID 192.168.0.4
 Start time: 01:15:12.236, Time elapsed: 00:07:14.800
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 Router is not originating router-LSAs with maximum metric
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 4 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:04:27.348 ago
        SPF algorithm executed 10 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x057439
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

```
R4(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
C       192.168.10.0 is directly connected, Ethernet0/1
O       192.168.10.4 [110/20] via 192.168.10.13, 00:04:43, Ethernet0/3
                     [110/20] via 192.168.10.1, 00:04:43, Ethernet0/1
O       192.168.10.8 [110/20] via 192.168.10.18, 00:04:43, Ethernet0/2
                     [110/20] via 192.168.10.13, 00:04:43, Ethernet0/3
C       192.168.10.12 is directly connected, Ethernet0/3
C       192.168.10.16 is directly connected, Ethernet0/2
     192.168.11.0/30 is subnetted, 1 subnets
O       192.168.11.0 [110/20] via 192.168.10.1, 00:04:44, Ethernet0/1
     192.168.0.0/32 is subnetted, 5 subnets
O       192.168.0.1 [110/21] via 192.168.10.1, 00:04:44, Ethernet0/1
O       192.168.0.2 [110/11] via 192.168.10.1, 00:04:44, Ethernet0/1
O       192.168.0.3 [110/11] via 192.168.10.13, 00:04:45, Ethernet0/3
C       192.168.0.4 is directly connected, Loopback0
O       192.168.0.5 [110/11] via 192.168.10.18, 00:04:45, Ethernet0/2
R4(config-router)#
```

```
R5(config-router)#do show ip ospf
 Routing Process "ospf 1" with ID 192.168.0.5
 Start time: 01:16:48.436, Time elapsed: 00:06:24.560
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 Router is not originating router-LSAs with maximum metric
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 1. 1 normal 0 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 3 (1 loopback)
        Area has no authentication
        SPF algorithm last executed 00:05:30.316 ago
        SPF algorithm executed 5 times
        Area ranges are
        Number of LSA 11. Checksum Sum 0x057439
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0

R5(config-router)#
```

```
R5(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
O       192.168.10.0 [110/20] via 192.168.10.17, 00:05:46, Ethernet0/2
O       192.168.10.4 [110/20] via 192.168.10.9, 00:05:46, Ethernet0/0
C       192.168.10.8 is directly connected, Ethernet0/0
O       192.168.10.12 [110/20] via 192.168.10.17, 00:05:46, Ethernet0/2
                      [110/20] via 192.168.10.9, 00:05:46, Ethernet0/0
C       192.168.10.16 is directly connected, Ethernet0/2
     192.168.11.0/30 is subnetted, 1 subnets
O       192.168.11.0 [110/30] via 192.168.10.17, 00:05:47, Ethernet0/2
                     [110/30] via 192.168.10.9, 00:05:47, Ethernet0/0
     192.168.0.0/32 is subnetted, 5 subnets
O       192.168.0.1 [110/31] via 192.168.10.17, 00:05:47, Ethernet0/2
                    [110/31] via 192.168.10.9, 00:05:47, Ethernet0/0
O       192.168.0.2 [110/21] via 192.168.10.17, 00:05:48, Ethernet0/2
                    [110/21] via 192.168.10.9, 00:05:48, Ethernet0/0
O       192.168.0.3 [110/11] via 192.168.10.9, 00:05:49, Ethernet0/0
O       192.168.0.4 [110/11] via 192.168.10.17, 00:05:49, Ethernet0/2
C       192.168.0.5 is directly connected, Loopback0
R5(config-router)#
```

All the routing tables were updated and now all routers know each network even though they are not directly connected.

4. Task 3C – OSPF Database

In this part it is expected to set point-to-point network type for OSPF in between the routers R2-R3, R2-R4, R4-R5, and R3-R5 by using the **ip ospf network point-to-point** command on the interfaces of each of these routers. This is done due to links and they will be treated as they are point-to-point by OSPF.

After the process is done, on R5 using **show ip ospf database, show ip ospf database router** and **show ip ospf database network** commands the routing information is checked, the results were put below.

```
R5(config-if)#do show ip ospf database

            OSPF Router with ID (192.168.0.5) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
192.168.0.1     192.168.0.1     992         0x80000003 0x0008E4 2
192.168.0.2     192.168.0.2     171         0x80000009 0x004191 6
192.168.0.3     192.168.0.3     115         0x8000000A 0x006543 6
192.168.0.4     192.168.0.4     64          0x8000000A 0x001983 6
192.168.0.5     192.168.0.5     11          0x80000009 0x00B6ED 5

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
192.168.10.13   192.168.0.3     752         0x80000001 0x00DD98
192.168.11.1    192.168.0.1     992         0x80000001 0x002760
```

a) For this question in the document, as it is seen above there are 5 router LSA's and 2 network LSA's. We have 5 router link states because each router, R1-R2-R3-R4-R5, created LSA for themselves and flooded these within the area of OSPF which is set 'area 0' for all OSPF at the configuration step. The Link ID's shows the Loopback IPs, also router ids, for each router. We have 2 Net Link States because I set all the links point-to-point besides the ones between R1-R2 and R3-R4 and since Network LSA's are generated by DR (Designated Router) those two were left as only DR links. Normally all links are by default considered as DR but in the previous stage some of them changed as point-to-point.

The result for the command **show ip ospf database router** on R5 can be seen below as text:

```
R5(config-if)#do show ip ospf database router
            OSPF Router with ID (192.168.0.5) (Process ID 1)
                Router Link States (Area 0)

  LS age: 1038
```

```
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 192.168.0.1
  Advertising Router: 192.168.0.1
  LS Seq Number: 80000003
  Checksum: 0x8E4
  Length: 48
  Number of Links: 2

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.0.1
     (Link Data) Network Mask: 255.255.255.255
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 192.168.11.1
     (Link Data) Router Interface address: 192.168.11.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 10


  LS age: 224
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 192.168.0.2
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000009
  Checksum: 0x4191
  Length: 96
  Number of Links: 6

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.0.2
     (Link Data) Network Mask: 255.255.255.255
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.3
     (Link Data) Router Interface address: 192.168.10.5
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.4
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.4
     (Link Data) Router Interface address: 192.168.10.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

```
    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.0
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 192.168.11.1
     (Link Data) Router Interface address: 192.168.11.2
      Number of TOS metrics: 0
       TOS 0 Metrics: 10


  LS age: 172
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 192.168.0.3
  Advertising Router: 192.168.0.3  //advertising router is R3
  LS Seq Number: 8000000A
  Checksum: 0x6543
  Length: 96
  Number of Links: 6

Connection of loopback

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.0.3
     (Link Data) Network Mask: 255.255.255.255
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

R3-R4 forms a transit network with designated router

    Link connected to: a Transit Network
     (Link ID) Designated Router address: 192.168.10.13
     (Link Data) Router Interface address: 192.168.10.13
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

R2-R3 defined as point to point before

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.2
     (Link Data) Router Interface address: 192.168.10.6
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

There is a stub network between R2-R3

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.4
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

R3-R5 link is defined as point to point as can be seen

```
    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.5
     (Link Data) Router Interface address: 192.168.10.9
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

R3-R5 forms a stub network

```
    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.8
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

```
  LS age: 127
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 192.168.0.4
  Advertising Router: 192.168.0.4
  LS Seq Number: 8000000A
  Checksum: 0x1983
  Length: 96
  Number of Links: 6
```

```
    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.0.4
     (Link Data) Network Mask: 255.255.255.255
      Number of TOS metrics: 0
       TOS 0 Metrics: 1
```

```
    Link connected to: a Transit Network
     (Link ID) Designated Router address: 192.168.10.13
     (Link Data) Router Interface address: 192.168.10.14
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

```
    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.5
     (Link Data) Router Interface address: 192.168.10.17
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

```
    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.16
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

```
    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.2
     (Link Data) Router Interface address: 192.168.10.2
```

```
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.0
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10


  LS age: 83
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 192.168.0.5
  Advertising Router: 192.168.0.5
  LS Seq Number: 80000009
  Checksum: 0xB6ED
  Length: 84
  Number of Links: 5

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.0.5
     (Link Data) Network Mask: 255.255.255.255
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.4
     (Link Data) Router Interface address: 192.168.10.18
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.16
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.3
     (Link Data) Router Interface address: 192.168.10.10
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.8
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10
```

b) As it can be derived from the commands above the network topology has been fully satisfied for R3. Overall, it is seen that R3 advertises all point-to-point connection to a router and stub networks. The networks between R3-R5 and R3-R2 are advertised as

stub network as they should be. These stub networks used to get the topology by OSPF process. Links connected to a transit network means that this network requires a DR, which is referring R3-R4 in here since R4 is designated router.

```
R5(config-if)#do show ip ospf database network

            OSPF Router with ID (192.168.0.5) (Process ID 1)

                Net Link States (Area 0)

  Routing Bit Set on this LSA
  LS age: 851
  Options: (No TOS-capability, DC)
  LS Type: Network Links
  Link State ID: 192.168.10.13 (address of Designated Router)
  Advertising Router: 192.168.0.3
  LS Seq Number: 80000001
  Checksum: 0xDD98
  Length: 32
  Network Mask: /30
        Attached Router: 192.168.0.3
        Attached Router: 192.168.0.4

  Routing Bit Set on this LSA
  LS age: 1091
  Options: (No TOS-capability, DC)
  LS Type: Network Links
  Link State ID: 192.168.11.1 (address of Designated Router)
  Advertising Router: 192.168.0.1
  LS Seq Number: 80000001
  Checksum: 0x2760
  Length: 32
  Network Mask: /30
        Attached Router: 192.168.0.1
        Attached Router: 192.168.0.2
```

c) As it is explained in the above and can be seen when it is analyzed in detail, the network topology matches the one with we have. By looking the figure above, we can figure out the network topology we have two networks between R3-R4 and R1-R2 this is due to the fact that we changed these networks as point-to-point and now we have one DR in each network. The network topology can be understood from here because we have information about all other routers.

d) There is only one net link advertised by R3 and since net links are flooded by designated routers and only DR that R3 has connection with is R4 and it is advertising that link.

e) Overall, R5 is advertised by R3 through 192.168.10.9 and R5 advertises the network 192.168.10.10 to a stub network. This means that it is used to get the map of topology.

5. Task 3D – Multi Area OSPF

In this part the network between R1 and R2 redefined and OSPF area has changed as 'area 1'.

- The result of **show ip ospf database** command on both R1 and R5:

```
R1(config-router)#do show ip ospf database

            OSPF Router with ID (192.168.0.1) (Process ID 1)

                Router Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum Link count
192.168.0.1     192.168.0.1     21          0x80000003 0x001ECD 2
192.168.0.2     192.168.0.2     1244        0x80000002 0x008FD4 1

                Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum
192.168.11.2    192.168.0.2     1244        0x80000001 0x001372

                Summary Net Link States (Area 1)

Link ID         ADV Router      Age         Seq#       Checksum
192.168.0.2     192.168.0.2     1285        0x80000001 0x00B5AF
192.168.0.3     192.168.0.2     1285        0x80000001 0x00104A
192.168.0.4     192.168.0.2     1285        0x80000001 0x000653
192.168.0.5     192.168.0.2     1285        0x80000001 0x0060ED
192.168.10.0    192.168.0.2     1285        0x80000001 0x00A3B3
192.168.10.4    192.168.0.2     1285        0x80000001 0x007BD7
192.168.10.8    192.168.0.2     1285        0x80000001 0x00B78D
192.168.10.12   192.168.0.2     1288        0x80000001 0x008FB1
192.168.10.16   192.168.0.2     1288        0x80000001 0x0067D5
```

As it is expected R1 is now in area 1 and has only 2 router link states since router link states (LSA type 1) are for internal areas and in this area, we have only R1 and R2. One net link state (LSA type 2) which shows DR, and it is R2. All other networks can be seen in the Summary Net Link States because it is LSA Type 3, and it shows the summary of other networks belonging to other areas which in this case it is area 0.

In R5 we see that it belongs to area 0, therefore, has LSA type 1 states of 4 routers which are R2, R3, R4 and R5 itself, but mistakenly in here there is also information about R1, and this is because I forgot to redefine Loopback 0 interface into area 1 at first then when I realized I did it but since I take screenshot before that it is shown in here. Unfortunately, I see this mistake after the lab is done hence, I could not take another screenshot. To see that I corrected this mistake, R1.txt file of terminal of R1 can be checked. For the LSA type 2 we have advertising router R3 as DR and mistakenly R1 is here due to the issue mentioned above. R1 must be in

only summary area as advertised by R2, which is ABR, which can be seen below. This is the case because R1 is in area 1 and R5 can only know about R1 with the help of advertisement of R2. The other routers are in area 0 and they can advertise themselves, R2 is included as well.

```
R5(config-if)#do show ip ospf database

            OSPF Router with ID (192.168.0.5) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
192.168.0.1     192.168.0.1     2752        0x80000003 0x0008E4 2
192.168.0.2     192.168.0.2     1418        0x8000000A 0x005F76 5
192.168.0.3     192.168.0.3     1874        0x8000000A 0x006543 6
192.168.0.4     192.168.0.4     16          0x8000000B 0x001784 6
192.168.0.5     192.168.0.5     1770        0x80000009 0x00B6ED 5

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
192.168.10.13   192.168.0.3     668         0x80000002 0x00DB99
192.168.11.1    192.168.0.1     2752        0x80000001 0x002760

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
192.168.0.1     192.168.0.2     150         0x80000001 0x002438
192.168.11.0    192.168.0.2     1413        0x80000001 0x0098BD
```

- The result of **show ip ospf database summary** command on both R1 and R5:

```
R1(config-router)#do show ip ospf database summary
            OSPF Router with ID (192.168.0.1) (Process ID 1)
                Summary Net Link States (Area 1)

  Routing Bit Set on this LSA
  LS age: 1331
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.0.2 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0xB5AF
  Length: 28
  Network Mask: /32
        TOS: 0  Metric: 1

  Routing Bit Set on this LSA
  LS age: 1331
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.0.3 (summary Network Number)
  Advertising Router: 192.168.0.2
```

```
  LS Seq Number: 80000001
  Checksum: 0x104A
  Length: 28
  Network Mask: /32
        TOS: 0  Metric: 11

  Routing Bit Set on this LSA
  LS age: 1338
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.0.4 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0x653
  Length: 28
  Network Mask: /32
        TOS: 0  Metric: 11

  Routing Bit Set on this LSA
  LS age: 1338
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.0.5 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0x60ED
  Length: 28
  Network Mask: /32
        TOS: 0  Metric: 21

  Routing Bit Set on this LSA
  LS age: 1340
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.10.0 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0xA3B3
  Length: 28
  Network Mask: /30
        TOS: 0  Metric: 10

  Routing Bit Set on this LSA
  LS age: 1342
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.10.4 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0x7BD7
  Length: 28
  Network Mask: /30
        TOS: 0  Metric: 10

  Routing Bit Set on this LSA
```

```
  LS age: 1342
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.10.8 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0xB78D
  Length: 28
  Network Mask: /30
        TOS: 0  Metric: 20

  Routing Bit Set on this LSA
  LS age: 1344
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.10.12 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0x8FB1
  Length: 28
  Network Mask: /30
        TOS: 0  Metric: 20

  Routing Bit Set on this LSA
  LS age: 1346
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.10.16 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0x67D5
  Length: 28
  Network Mask: /30
        TOS: 0  Metric: 20
```

```
R5(config-if)#do show ip ospf database summary

            OSPF Router with ID (192.168.0.5) (Process ID 1)

                Summary Net Link States (Area 0)

  Routing Bit Set on this LSA
  LS age: 165
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.0.1 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0x2438
  Length: 28
  Network Mask: /32
        TOS: 0  Metric: 11

  Routing Bit Set on this LSA
  LS age: 1428
  Options: (No TOS-capability, DC, Upward)
  LS Type: Summary Links(Network)
  Link State ID: 192.168.11.0 (summary Network Number)
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0x98BD
  Length: 28
  Network Mask: /30
        TOS: 0  Metric: 10
```

In the summary of R1 database we see that all other routers are advertised by R2 and that is why we have long entry for R1. As it is stated before R2 is ABR and R3, R4, R5 are routers in area 0 meaning that R1 only know about these routers if R2 advertises them. In the summary of R5 database we see that R2 advertises R1 since all other routers, R3, R4, R5, are in the same area. Database summary shows the LSA entries for different areas than the area of the router is in.

- The result of **show ip route** command on both R1 and R5:

```
R1(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
O IA    192.168.10.0 [110/20] via 192.168.11.2, 00:01:52, Ethernet0/0
O IA    192.168.10.4 [110/20] via 192.168.11.2, 00:01:52, Ethernet0/0
O IA    192.168.10.8 [110/30] via 192.168.11.2, 00:01:52, Ethernet0/0
O IA    192.168.10.12 [110/30] via 192.168.11.2, 00:01:52, Ethernet0/0
O IA    192.168.10.16 [110/30] via 192.168.11.2, 00:01:52, Ethernet0/0
     192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0
     192.168.0.0/32 is subnetted, 5 subnets
C       192.168.0.1 is directly connected, Loopback0
O IA    192.168.0.2 [110/11] via 192.168.11.2, 00:01:53, Ethernet0/0
O IA    192.168.0.3 [110/21] via 192.168.11.2, 00:01:53, Ethernet0/0
O IA    192.168.0.4 [110/21] via 192.168.11.2, 00:01:53, Ethernet0/0
O IA    192.168.0.5 [110/31] via 192.168.11.2, 00:01:55, Ethernet0/0
```

```
R5(config-if)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
O       192.168.10.0 [110/20] via 192.168.10.17, 00:24:08, Ethernet0/2
O       192.168.10.4 [110/20] via 192.168.10.9, 00:24:08, Ethernet0/0
C       192.168.10.8 is directly connected, Ethernet0/0
O       192.168.10.12 [110/20] via 192.168.10.17, 00:24:08, Ethernet0/2
                      [110/20] via 192.168.10.9, 00:24:08, Ethernet0/0
C       192.168.10.16 is directly connected, Ethernet0/2
     192.168.11.0/30 is subnetted, 1 subnets
O IA    192.168.11.0 [110/30] via 192.168.10.17, 00:24:09, Ethernet0/2
                     [110/30] via 192.168.10.9, 00:24:09, Ethernet0/0
     192.168.0.0/32 is subnetted, 5 subnets
O IA    192.168.0.1 [110/31] via 192.168.10.17, 00:03:06, Ethernet0/2
                    [110/31] via 192.168.10.9, 00:03:06, Ethernet0/0
O       192.168.0.2 [110/21] via 192.168.10.17, 00:24:12, Ethernet0/2
                    [110/21] via 192.168.10.9, 00:24:12, Ethernet0/0
O       192.168.0.3 [110/11] via 192.168.10.9, 00:24:13, Ethernet0/0
O       192.168.0.4 [110/11] via 192.168.10.17, 00:24:14, Ethernet0/2
C       192.168.0.5 is directly connected, Loopback0
```

6. Task 3E – OSPF Link Costs

```
R4#ping 192.168.11.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/40/44 ms
R4#
```

The command **ping** is used to send some IP packages to specified address and check whether they are transported or not. It is seen that R4 can ping from the fact that the sent 5 packets are successfully sent with 100% rate. This means that R1 gets the packages and send confirmations about them. This shows that even though R1 and R4 are in different areas, which means they are not directly connected but still connected, packages can be transferred using their common neighbor R2 thanks to OSPF protocol.

```
R4#traceroute 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.11.1

  1 192.168.10.1 12 msec 16 msec 20 msec
  2 192.168.11.1 56 msec 40 msec 40 msec
R4#
```

By typing **traceroute** command we can see the path that packages go to reach from R4 to R1. Since successful transfer has been made, we see the IP address of interface of R1(192.168.11.1) as the last hop.

```
R2(config-router)#do show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          1     0               192.168.0.2/32     1     LOOP  0/0
Et0/2        1     0               192.168.10.5/30    10    P2P   1/1
Et0/1        1     0               192.168.10.1/30    10    P2P   1/1
Et0/0        1     1               192.168.11.2/30    10    DR    1/1
R2(config-router)#
```

To see only the costs the command **show ip ospf interface brief** is used instead of **show ip ospf interface** as it is suggested in the lab document, and we see the interfaces of R1 and the costs for each of them. For loopback it is 1, between R2-R4, R2-R3 and R2-R1 the costs are set to 10 as default.

```
R1(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
O IA    192.168.10.0 [110/20] via 192.168.11.2, 00:01:52, Ethernet0/0
```

```
O IA    192.168.10.4 [110/20] via 192.168.11.2, 00:01:52, Ethernet0/0
O IA    192.168.10.8 [110/30] via 192.168.11.2, 00:01:52, Ethernet0/0
O IA    192.168.10.12 [110/30] via 192.168.11.2, 00:01:52, Ethernet0/0
O IA    192.168.10.16 [110/30] via 192.168.11.2, 00:01:52, Ethernet0/0
     192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0
     192.168.0.0/32 is subnetted, 5 subnets
C       192.168.0.1 is directly connected, Loopback0
O IA    192.168.0.2 [110/11] via 192.168.11.2, 00:01:53, Ethernet0/0
O IA    192.168.0.3 [110/21] via 192.168.11.2, 00:01:53, Ethernet0/0
O IA    192.168.0.4 [110/21] via 192.168.11.2, 00:01:53, Ethernet0/0
O IA    192.168.0.5 [110/31] via 192.168.11.2, 00:01:55, Ethernet0/0
```

To find the interface bandwidth between R2 and R4 the command **show interface** is used and to find costs the command **show ip ospf interface brief** command is used on bout R2 and R4. Below the results can be seen:

```
R2(config-if)#do show interface
Ethernet0/0 is up, line protocol is up
  Hardware is AmdP2, address is cc03.2c0b.0000 (bia cc03.2c0b.0000)
  Internet address is 192.168.11.2/30
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:04, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     872 packets input, 117069 bytes, 0 no buffer
     Received 830 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     1753 packets output, 172938 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Ethernet0/1 is up, line protocol is up
  Hardware is AmdP2, address is cc03.2c0b.0001 (bia cc03.2c0b.0001)
  Internet address is 192.168.10.1/30
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:01, output 00:00:02, output hang never
```

```
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     711 packets input, 102674 bytes, 0 no buffer
     Received 678 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     1723 packets output, 168692 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Ethernet0/2 is up, line protocol is up
  Hardware is AmdP2, address is cc03.2c0b.0002 (bia cc03.2c0b.0002)
  Internet address is 192.168.10.5/30
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:01, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     847 packets input, 116116 bytes, 0 no buffer
     Received 828 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     1717 packets output, 168920 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Ethernet0/3 is administratively down, line protocol is down
  Hardware is AmdP2, address is cc03.2c0b.0003 (bia cc03.2c0b.0003)
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
```

```
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     666 packets output, 66497 bytes, 0 underruns
     0 output errors, 0 collisions, 11 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Loopback0 is up, line protocol is up
  Hardware is Loopback
  Internet address is 192.168.0.2/32
  MTU 1514 bytes, BW 8000000 Kbit/sec, DLY 5000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation LOOPBACK, loopback not set
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/0 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
```

```
R4#show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          1     0               192.168.0.4/32     1     LOOP  0/0
Et0/3        1     0               192.168.10.14/30   10    BDR   1/1
Et0/2        1     0               192.168.10.17/30   10    P2P   1/1
Et0/1        1     0               192.168.10.2/30    10    P2P   1/1
R4#
```

```
R4#show interface
Ethernet0/0 is administratively down, line protocol is down
  Hardware is AmdP2, address is cc00.2c0b.0000 (bia cc00.2c0b.0000)
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
```

```
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     703 packets output, 70383 bytes, 0 underruns
     0 output errors, 0 collisions, 11 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Ethernet0/1 is up, line protocol is up
  Hardware is AmdP2, address is cc00.2c0b.0001 (bia cc00.2c0b.0001)
  Internet address is 192.168.10.2/30
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:08, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     915 packets input, 122074 bytes, 0 no buffer
     Received 877 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     1661 packets output, 164062 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Ethernet0/2 is up, line protocol is up
  Hardware is AmdP2, address is cc00.2c0b.0002 (bia cc00.2c0b.0002)
  Internet address is 192.168.10.17/30
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:02, output 00:00:06, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     716 packets input, 104287 bytes, 0 no buffer
     Received 708 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     1606 packets output, 158614 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
```

```
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Ethernet0/3 is up, line protocol is up
  Hardware is AmdP2, address is cc00.2c0b.0003 (bia cc00.2c0b.0003)
  Internet address is 192.168.10.14/30
  MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 00:00:06, output 00:00:05, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     855 packets input, 116256 bytes, 0 no buffer
     Received 850 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
     0 input packets with dribble condition detected
     1618 packets output, 159589 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 babbles, 0 late collision, 0 deferred
     0 lost carrier, 0 no carrier
     0 output buffer failures, 0 output buffers swapped out
Loopback0 is up, line protocol is up
  Hardware is Loopback
  Internet address is 192.168.0.4/32
  MTU 1514 bytes, BW 8000000 Kbit/sec, DLY 5000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation LOOPBACK, loopback not set
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/0 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
```

We have already seen and the costs of R2, provided with it explanation and for R4 we can see that the cost for loopback is 1, between R4-R3, R4-R5 and R4-R2 the cost is 10. We see that the bandwidths are all 10000 Kbit/sec except for the Loopbacks it is 8000000Kbit/sec. The

bandwidth is decreasing when the cost is increasing as it is expected.

```
R4(config)#do show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          1     0               192.168.0.4/32     1     LOOP  0/0
Et0/3        1     0               192.168.10.14/30   10    BDR   1/1
Et0/2        1     0               192.168.10.17/30   10    P2P   1/1
Et0/1        1     0               192.168.10.2/30    100   P2P   1/1
R4(config)#
```

```
R2(config-if)#do show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          1     0               192.168.0.2/32     1     LOOP  0/0
Et0/2        1     0               192.168.10.5/30    10    P2P   1/1
Et0/1        1     0               192.168.10.1/30    100   P2P   1/1
Et0/0        1     1               192.168.11.2/30    10    DR    1/1
R2(config-if)#
```

After setting the cost as 100 between R2 and R4, the result of the **show ip ospf interface brief** command can be seen from above figures for both R2 and R4. They were 10 before and now 100. Then, the ping from R4 to R1 was done and the transfer was done succesfully as shown below.

```
R4#ping 192.168.11.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/61/72 ms
R4#
```

```
R4#traceroute 192.168.11.1

Type escape sequence to abort.
Tracing the route to 192.168.11.1

  1 192.168.10.13 20 msec 12 msec 28 msec
  2 192.168.10.5 40 msec 40 msec 44 msec
  3 192.168.11.1 40 msec 56 msec 72 msec
R4#
```

After using traceroute command we see that this time our packages goes to R1 using R3-R2 path not using R4 anymore because the cost of R2-R4 is higher than this path.

7. Task 3F – Route Redistribution

After disabling OSPF protocol from R1 and enabling RIP then enabling both OSPF and RIP on R2 the ip route of R1 becomes:

```
R1(config-router)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

R    192.168.10.0/24 [120/2] via 192.168.11.2, 00:00:05, Ethernet0/0
     192.168.11.0/30 is subnetted, 1 subnets
C       192.168.11.0 is directly connected, Ethernet0/0
     192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
R       192.168.0.0/24 [120/2] via 192.168.11.2, 00:00:05, Ethernet0/0
C       192.168.0.1/32 is directly connected, Loopback0
R1(config-router)#
```

```
R5(config-if)#do show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     192.168.10.0/30 is subnetted, 5 subnets
O       192.168.10.0 [110/110] via 192.168.10.17, 00:01:40, Ethernet0/2
O       192.168.10.4 [110/20] via 192.168.10.9, 00:01:40, Ethernet0/0
C       192.168.10.8 is directly connected, Ethernet0/0
O       192.168.10.12 [110/20] via 192.168.10.17, 00:01:40, Ethernet0/2
                      [110/20] via 192.168.10.9, 00:01:40, Ethernet0/0
C       192.168.10.16 is directly connected, Ethernet0/2
     192.168.11.0/30 is subnetted, 1 subnets
O E2    192.168.11.0 [110/100] via 192.168.10.9, 00:01:16, Ethernet0/0
     192.168.0.0/32 is subnetted, 4 subnets
O       192.168.0.2 [110/21] via 192.168.10.9, 00:01:42, Ethernet0/0
O       192.168.0.3 [110/11] via 192.168.10.9, 00:01:42, Ethernet0/0
O       192.168.0.4 [110/11] via 192.168.10.17, 00:01:42, Ethernet0/2
C       192.168.0.5 is directly connected, Loopback0
R5(config-if)#
```

In R5 we have a line having E2 code. E2 code is written for external areas meaning that it shows the network that uses a different protocol. In our case R2 and R1 have RIP protocol in between and they are in area 1, we have OSPF between R2, R3, R4, and R5. As a result, we see E2 code in the route having 192.168.11.0 network (which is the network between R1-R2)

```
R5(config-if)#do show ip ospf database

            OSPF Router with ID (192.168.0.5) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
192.168.0.2     192.168.0.2     144         0x80000010 0x00B069 5
192.168.0.3     192.168.0.3     1640        0x8000000C 0x006145 6
192.168.0.4     192.168.0.4     1060        0x8000000D 0x00E5FE 6
192.168.0.5     192.168.0.5     1691        0x8000000B 0x00B2EF 5

                Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
192.168.10.13   192.168.0.3     345         0x80000004 0x00D79B

                Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#       Checksum Tag
192.168.11.0    192.168.0.2     114         0x80000001 0x00B5BD 0
R5(config-if)#
```

Here we see Type 5 LSA which is for external links meaning that R1-R2 link (uses RIP that is why it is external anymore).

```
R5(config-if)#do show ip ospf database external

            OSPF Router with ID (192.168.0.5) (Process ID 1)

                Type-5 AS External Link States

  Routing Bit Set on this LSA
  LS age: 136
  Options: (No TOS-capability, DC)
  LS Type: AS External Link
  Link State ID: 192.168.11.0 (External Network Number )
  Advertising Router: 192.168.0.2
  LS Seq Number: 80000001
  Checksum: 0xB5BD
  Length: 36
  Network Mask: /30
        Metric Type: 2 (Larger than any link state path)
        TOS: 0
        Metric: 100
        Forward Address: 0.0.0.0
        External Route Tag: 0
```

In the above figure the network 192.168.11.0 is advertised and it is done by R2. This network represents the network between R1-R2 as I stated before.

```
R5(config-if)#do show ip ospf database router
            OSPF Router with ID (192.168.0.5) (Process ID 1)
                Router Link States (Area 0)

  Routing Bit Set on this LSA
  LS age: 194
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 192.168.0.2
  Advertising Router: 192.168.0.2  //see that this IP is for R2
  LS Seq Number: 80000010
  Checksum: 0xB069
  Length: 84
  AS Boundary Router //Means that R2 is now ASBR
  Number of Links: 5

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.0.2
     (Link Data) Network Mask: 255.255.255.255
      Number of TOS metrics: 0
       TOS 0 Metrics: 1

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.3
     (Link Data) Router Interface address: 192.168.10.5
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.4
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 10

    Link connected to: another Router (point-to-point)
     (Link ID) Neighboring Router ID: 192.168.0.4
     (Link Data) Router Interface address: 192.168.10.1
      Number of TOS metrics: 0
       TOS 0 Metrics: 100

    Link connected to: a Stub Network
     (Link ID) Network/subnet number: 192.168.10.0
     (Link Data) Network Mask: 255.255.255.252
      Number of TOS metrics: 0
       TOS 0 Metrics: 100


  LS age: 1693
  Options: (No TOS-capability, DC)
  LS Type: Router Links
  Link State ID: 192.168.0.3
  Advertising Router: 192.168.0.3
  LS Seq Number: 8000000C
  Checksum: 0x6145
  Length: 96
```

```
Number of Links: 6

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.0.3
   (Link Data) Network Mask: 255.255.255.255
    Number of TOS metrics: 0
     TOS 0 Metrics: 1

  Link connected to: a Transit Network
   (Link ID) Designated Router address: 192.168.10.13
   (Link Data) Router Interface address: 192.168.10.13
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.2
   (Link Data) Router Interface address: 192.168.10.6
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.10.4
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.5
   (Link Data) Router Interface address: 192.168.10.9
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.10.8
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metrics: 10


LS age: 1119
Options: (No TOS-capability, DC)
LS Type: Router Links
Link State ID: 192.168.0.4
Advertising Router: 192.168.0.4
LS Seq Number: 8000000D
Checksum: 0xE5FE
Length: 96
Number of Links: 6

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.0.4
   (Link Data) Network Mask: 255.255.255.255
    Number of TOS metrics: 0
     TOS 0 Metrics: 1
```

```
  Link connected to: a Transit Network
   (Link ID) Designated Router address: 192.168.10.13
   (Link Data) Router Interface address: 192.168.10.14
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.5
   (Link Data) Router Interface address: 192.168.10.17
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.10.16
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.2
   (Link Data) Router Interface address: 192.168.10.2
    Number of TOS metrics: 0
     TOS 0 Metrics: 100

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.10.0
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metrics: 100


LS age: 1754
Options: (No TOS-capability, DC)
LS Type: Router Links
Link State ID: 192.168.0.5
Advertising Router: 192.168.0.5
LS Seq Number: 8000000B
Checksum: 0xB2EF
Length: 84
Number of Links: 5

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.0.5
   (Link Data) Network Mask: 255.255.255.255
    Number of TOS metrics: 0
     TOS 0 Metrics: 1

  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.4
   (Link Data) Router Interface address: 192.168.10.18
    Number of TOS metrics: 0
     TOS 0 Metrics: 10

  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.10.16
```

```
 (Link Data) Network Mask: 255.255.255.252
  Number of TOS metrics: 0
    TOS 0 Metrics: 10

Link connected to: another Router (point-to-point)
 (Link ID) Neighboring Router ID: 192.168.0.3
 (Link Data) Router Interface address: 192.168.10.10
  Number of TOS metrics: 0
    TOS 0 Metrics: 10

Link connected to: a Stub Network
 (Link ID) Network/subnet number: 192.168.10.8
 (Link Data) Network Mask: 255.255.255.252
  Number of TOS metrics: 0
    TOS 0 Metrics: 10
```