# EINTE Lab 3-OSPF

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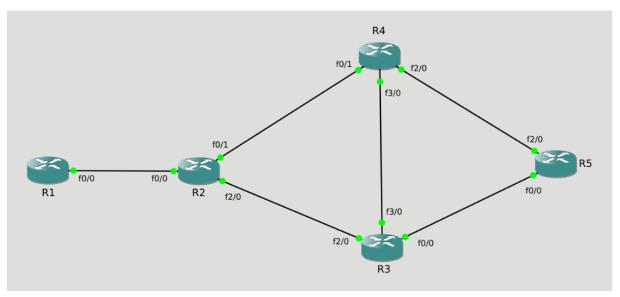


Figure 1 Topology refered to in the task

# Task 1

# **Router Configuration:**

1. R1: F0/0: 192.168.11.1/30

## 2. R2:

a. F0/0: 192.168.11.2/30

b. F0/1: 192.168.10.5/30

c. F2/0: 192.168.10.1/30

## 3. R3:

a. F3/0: 192.168.10.9/30

b. F2/0: 192.168.10.2/30

c. F0/0: 192.168.10.13/30

### 4. R4:

a. F0/1: 192.168.10.6/30

b. F3/0: 192.168.10.10/30

c. F2/0: 192.168.10.17/30

## 5. **R5**:

a. F2/0: 192.168.10.18/30

b. F0/0: 192.168.10.14/30

## Router Loopbacks:

1. R1: 192.168.0.1/29

R2: 192.168.0.2/29
 R3: 192.168.0.3/29
 R4: 192.168.0.4/29
 R5: 192.168.0.5/29

#### IP Routes:

```
R1#sh 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, FastEthernet0/0

192.168.0.0/29 is subnetted, 1 subnets

C 192.168.0.0 is directly connected, Loopback0
```

Figure 2 Router 1

```
R2#sh 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
        192.168.10.0 is directly connected, FastEthernet2/0
        192.168.10.4 is directly connected, FastEthernet0/1
     192.168.11.0/30 is subnetted, 1 subnets
        192.168.11.0 is directly connected, FastEthernet0/0
     192.168.0.0/29 is subnetted, 1 subnets
        192.168.0.0 is directly connected, Loopback0
```

Figure 3 Router 2

```
R3#sh 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, FastEthernet2/0
C 192.168.10.12 is directly connected, FastEthernet3/0
C 192.168.0.0/29 is subnetted, 1 subnets
C 192.168.0.0 is directly connected, Loopback0
```

#### Figure 4 Router 3

```
R4#sh 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, FastEthernet0/1

C 192.168.10.8 is directly connected, FastEthernet3/0

192.168.0.0/29 is subnetted, 1 subnets

C 192.168.0.0 is directly connected, Loopback0
```

#### Figure 5 Router 4

```
R5#sh 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 192.168.10.12 is directly connected, FastEthernet0/0

192.168.0.0/29 is subnetted, 1 subnets

C 192.168.0.0 is directly connected, Loopback0
```

Figure 6 Router 5

As can be seen, every router has been setup correctly. There are active connections between every device and they are subnetted properly. On the 5 screens above we can see that depicted addresses are the ones to which the router has a direct connection. That is due to the fact that we have not yet enabled the routing protocol on the network.

## Task 2

```
R1#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

192.168.10.0 [110/11] via 192.168.11.2, 00:03:27, FastEthernet0/0

192.168.10.4 [110/20] via 192.168.11.2, 00:03:27, FastEthernet0/0

192.168.10.8 [110/12] via 192.168.11.2, 00:03:27, FastEthernet0/0

192.168.10.12 [110/13] via 192.168.11.2, 00:03:27, FastEthernet0/0

192.168.11.0/30 is subnetted, 1 subnets

C 192.168.11.0 is directly connected, FastEthernet0/0

192.168.0.0/29 is subnetted, 1 subnets

C 192.168.0.0 is directly connected, Loopback0
```

Figure 7 IP route for router 1

```
R2#sh 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
        192.168.10.0 is directly connected, FastEthernet2/0
        192.168.10.4 is directly connected, FastEthernet0/1
        192.168.10.8 [110/2] via 192.168.10.2, 00:03:34, FastEthernet2/0
0
0
        192.168.10.12 [110/11] via 192.168.10.2, 00:03:34, FastEthernet2/0
0
        192.168.10.16 [110/3] via 192.168.10.2, 00:03:34, FastEthernet2/0
     192.168.11.0/30 is subnetted, 1 subnets
        192.168.11.0 is directly connected, FastEthernet0/0
     192.168.0.0/29 is subnetted, 1 subnets
        192.168.0.0 is directly connected, Loopback0
```

Figure 8 IP route for router 2

```
R3#sh 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
        192.168.10.0 is directly connected, FastEthernet2/0
        192.168.10.4 [110/11] via 192.168.10.10, 00:00:19, FastEthernet3/0
0
                     [110/11] via 192.168.10.1, 00:00:19, FastEthernet2/0
        192.168.10.8 is directly connected, FastEthernet3/0
        192.168.10.12 is directly connected, FastEthernet0/0
        192.168.10.16 [110/2] via 192.168.10.10, 00:00:19, FastEthernet3/0
0
     192.168.11.0/30 is subnetted, 1 subnets
        192.168.11.0 [110/11] via 192.168.10.1, 00:00:21, FastEthernet2/0
     192.168.0.0/29 is subnetted, 1 subnets
        192.168.0.0 is directly connected, Loopback0
```

#### Figure 9 IP route for router 3

```
R4#sh 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
        192.168.10.0 [110/2] via 192.168.10.9, 00:03:42, FastEthernet3/0
        192.168.10.4 is directly connected, FastEthernet0/1
        192.168.10.8 is directly connected, FastEthernet3/0
        192.168.10.12 [110/11] via 192.168.10.18, 00:03:42, FastEthernet2/0
0
                       [110/11] via 192.168.10.9, 00:03:41, FastEthernet3/0
        192.168.10.16 is directly connected, FastEthernet2/0
     192.168.11.0/30 is subnetted, 1 subnets
192.168.11.0 [110/12] via 192.168.10.9, 00:03:43, FastEthernet3/0
     192.168.0.0/29 is subnetted, 1 subnets
        192.168.0.0 is directly connected, Loopback0
```

Figure 10 IP Route for router 4

```
R5#sh 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
        192.168.10.0 [110/3] via 192.168.10.17, 00:03:50, FastEthernet2/0
0
        192.168.10.4 [110/11] via 192.168.10.17, 00:03:50, FastEthernet2/0
0
0
        192.168.10.8 [110/2] via 192.168.10.17, 00:03:50, FastEthernet2/0
        192.168.10.12 is directly connected, FastEthernet0/0
        192.168.10.16 is directly connected, FastEthernet2/0
     192.168.11.0/30 is subnetted, 1 subnets
0
        192.168.11.0 [110/13] via 192.168.10.17, 00:03:50, FastEthernet2/0
     192.168.0.0/29 is subnetted, 1 subnets
        192.168.0.0 is directly connected, Loopback0
```

Figure 11 IP route for router 5

```
R1#sh ip ospf
Routing Process "ospf 1" with ID 192.168.0.1
 Start time: 01:33:01.452, Time elapsed: 00:21:03.976
 Supports only single TOS(TOSO) 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 O. 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 1
        Area has no authentication
        SPF algorithm last executed 00:06:57.064 ago
        SPF algorithm executed 14 times
        Area ranges are
       Number of LSA 11. Checksum Sum 0x05005C
       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
```

Figure 12 OSPF configuration for router 1

```
R2#sh ip ospf
Routing Process "ospf 2" with ID 192.168.0.2
Start time: 01:33:03.760, Time elapsed: 00:20:07.592
Supports only single TOS(TOSO) 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
           Area has no authentication
           SPF algorithm last executed 00:07:01.460 ago
           SPF algorithm executed 14 times
           Area ranges are
Number of LSA 11. Checksum Sum 0x05005C
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
```

Figure 13 OSPF configuration for router 2

```
Routing Process "ospf 3" with ID 192.168.0.3
Routing Process "ospf 3" with ID 192.168.0.3
Start time: 01:24:30.908, Time elapsed: 00:19:15.644
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
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
Interface flood 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
                  Area has no authentication
                  SPF algorithm last executed 00:07:04.736 ago
                  SPF algorithm executed 11 times
                  Area ranges are
                  Number of LSA 11. Checksum Sum 0x05005C
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
```

Figure 14 OSPF configuration for router 3

```
R4#sh ip ospf
Routing Process "ospf 4" with ID 192.168.0.4
Start time: 01:12:46.712, Time elapsed: 00:19:04.920
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports opaque com
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
            Area has no authentication
            SPF algorithm last executed 00:07:07.600 ago
            SPF algorithm executed 7 times
            Area ranges are
            Number of LSA 11. Checksum Sum 0x05005C
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
```

Figure 15 OSPF configuration for router 4

```
Routing Process "ospf 5" with ID 192.168.0.5
Start time: 01:12:06.608, Time elapsed: 00:18:21.380
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
          Area has no authentication
          SPF algorithm last executed 00:07:12.864 ago
          SPF algorithm executed 3 times
          Area ranges are
          Number of LSA 11. Checksum Sum 0x05005C
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
```

Figure 16 OSPF configuration for router 5

As can be seen on the above screens, now, all routers are connected to every router in the network (not only to it's neighbours) via OSPF protocol. Also from the OSPF configuration we can tell different parameters of the protocol for each device, like start time, elapsed time or ID to name a few. Everything seems to be set-up correctly.

## Task 3

```
R5#sh ip ospf database
           OSPF Router with ID (192.168.0.5) (Process ID 5)
               Router Link States (Area 0)
                                                     Checksum Link count
Link ID
               ADV Router
                               Age
                                           Seq#
                               158
192.168.0.1
               192.168.0.1
                                          0x80000003 0x0082E5 1
192.168.0.2
               192.168.0.2
                               34
                                          0x80000009 0x00DB85 5
192.168.0.3
                                          0x80000009 0x002E1C 5
               192.168.0.3
                               281
192.168.0.4
                               222
               192.168.0.4
                                          0x8000000A 0x000F27 5
               192.168.0.5
192.168.0.5
                              151
                                          0x80000008 0x00F539 4
               Net Link States (Area 0)
Link ID
               ADV Router
                               Age
                                                     Checksum
                                           Seq#
192.168.10.9
               192.168.0.3
                               18
                                           0x80000002 0x000475
192.168.11.1 192.168.0.1
                               158
                                           0x80000002 0x002561
```

Figure 17 OSPF Database for Router 5

```
LS age: 187
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: 0x82E5
Length: 36
Number of Links: 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
```

Figure 18 Advertising Router: 192.168.0.1

```
LS age: 63
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: 0xDB85
Length: 84
Number of Links: 5
  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.4
   (Link Data) Router Interface address: 192.168.10.5
    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: 192.168.0.3
   (Link Data) Router Interface address: 192.168.10.1
    Number of TOS metrics: 0
     TOS 0 Metrics: 1
  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: 1
  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
```

Figure 19 Advertising Router: 192.168.0.2

```
LS age: 314
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: 80000009
Checksum: 0x2E1C
Length: 84
Number of Links: 5
  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.5
   (Link Data) Router Interface address: 192.168.10.13
   Number of TOS metrics: 0
     TOS 0 Metrics: 10
  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.10.12
   (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: 192.168.10.9
   (Link Data) Router Interface address: 192.168.10.9
   Number of TOS metrics: 0
     TOS 0 Metrics: 1
  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.2
   (Link Data) Router Interface address: 192.168.10.2
   Number of TOS metrics: 0
     TOS 0 Metrics: 1
  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: 1
```

Figure 20 Advertising Router: 192.168.0.3

```
LS age: 257
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: 0xF27
Length: 84
Number of Links: 5
  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: 1
  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: 1
  Link connected to: a Transit Network
   (Link ID) Designated Router address: 192.168.10.9
   (Link Data) Router Interface address: 192.168.10.10
    Number of TOS metrics: 0
     TOS 0 Metrics: 1
  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.2
   (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
```

Figure 21 Advertising Router: 192.168.0.4

```
LS age: 190
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: 80000008
Checksum: 0xF539
Length: 72
Number of Links: 4
  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: 1
  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: 1
  Link connected to: another Router (point-to-point)
   (Link ID) Neighboring Router ID: 192.168.0.3
   (Link Data) Router Interface address: 192.168.10.14
    Number of TOS metrics: 0
     TOS 0 Metrics: 10
  Link connected to: a Stub Network
   (Link ID) Network/subnet number: 192.168.10.12
   (Link Data) Network Mask: 255.255.255.252
    Number of TOS metrics: 0
     TOS 0 Metrics: 10
```

Figure 22 Advertising Router: 192.168.0.5

```
R5#sh ip ospf database network
            OSPF Router with ID (192.168.0.5) (Process ID 5)
                Net Link States (Area 0)
  Routing Bit Set on this LSA
  LS age: 272
  Options: (No TOS-capability, DC)
 LS Type: Network Links
  Link State ID: 192.168.10.9 (address of Designated Router)
  Advertising Router: 192.168.0.3
  LS Seq Number: 80000002
  Checksum: 0x475
  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: 413
  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 Seg Number: 80000002
  Checksum: 0x2561
  Length: 32
  Network Mask: /30
        Attached Router: 192.168.0.1
        Attached Router: 192.168.0.2
```

Figure 23 OSPF database for router 5

- There are 2 network LSAs in OSPF database because in the whole network there are 2 subnetworks: one for R1 and R2 routers and second one for R2, R3, R4 and R5. There are 5 router LSAs because there are 5 router loopback addresses in the network.
- In Figure 20 we can find information about the R5 LSA when the router 3 is advertising. Analysing that table from top to bottom we can see:
  - First record is labeled as another Router and by the link ID we can identify that it's the R5 with point-to-point connection which we setup correctly
  - Second and fifth records are stub networks which represent the connections R3-R2 and R3-R5 on their respective interfaces

- Third record is a *Transit Network* which has the link ID of 192.168.10.9, which is the id of interface f3/0 connecting R3 and R4, which we have not set as point-to-point
- Fourth record is again labeled as another router and ID'd as 192.168.0.2 which is the loopback address of Router 2 which is also indentified as point-to-point, since we set it up manually

All of these results make sense in terms of our topology and subnetting done in Task 1.

- Doing a similar analysis in terms of the network LSA we can conclude that the network works correctly.
- As can be seen on Figure 22, the DRs are Router 1 and 3. We can see this based on the Link State ID and compare it to the routing table from Task 1.
- Router 5 can gather information about the network topology by connecting to the advertising routers which would provide the information about their neighbours.

# Task 4

```
R1#sh 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
                                            0x800000002 0x0084E4 1
                192.168.0.1
                                117
192.168.0.2
                192.168.0.2
                                118
                                            0x80000001 0x0087DE 1
                Net Link States (Area 1)
                                Age
Link ID
                ADV Router
                                            Seq#
                                                       Checksum
192.168.11.1
                                            0x80000001 0x002760
                192.168.0.1
                                116
                Summary Net Link States (Area 1)
Link ID
                ADV Router
                                Age
                                            Seq#
                                                       Checksum
192.168.10.0
                192.168.0.2
                                118
                                            0x80000001 0x004917
192.168.10.4
                192.168.0.2
                                118
                                            0x80000001 0x007BD7
192.168.10.8
                192.168.0.2
                                118
                                            0x80000001 0x000354
                192.168.0.2
                                118
                                            0x80000001 0x003515
192.168.10.12
                                118
                                            0x80000001 0x00BC91
192.168.10.16
                192.168.0.2
```

Figure 24 OSPF Database for router 1

```
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: 301
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: 0x4917
Length: 28
Network Mask: /30
TOS: 0 Metric: 1
```

Figure 25 LSA 301 metric 1 R1

```
Routing Bit Set on this LSA
LS age: 301
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
```

Figure 26 LSA 301 metric 10 R1

```
Routing Bit Set on this LSA
LS age: 302
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: 0x354
Length: 28
Network Mask: /30
TOS: 0 Metric: 2
```

Figure 27 LSA 302 metric 2 R1

```
Routing Bit Set on this LSA
LS age: 303
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: 0x3515
Length: 28
Network Mask: /30
TOS: 0 Metric: 11
```

Figure 28 LSA 303 metric 11 R1

```
Routing Bit Set on this LSA
LS age: 304
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: 0xBC91
Length: 28
Network Mask: /30
TOS: 0 Metric: 3
```

Figure 29 LSA 304 metric 3 R1

```
R1# sh 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
        192.168.10.0 [110/11] via 192.168.11.2, 00:06:43, FastEthernet0/0
O IA
        192.168.10.4 [110/20] via 192.168.11.2, 00:06:43, FastEthernet0/0
O IA
        192.168.10.8 [110/12] via 192.168.11.2, 00:06:43, FastEthernet0/0
O IA
        192.168.10.12 [110/21] via 192.168.11.2, 00:06:43, FastEthernet0/0
O IA
        192.168.10.16 [110/13] via 192.168.11.2, 00:06:43, FastEthernet0/0
O IA
     192.168.11.0/30 is subnetted, 1 subnets
        192.168.11.0 is directly connected, FastEthernet0/0
     192.168.0.0/29 is subnetted, 1 subnets
        192.168.0.0 is directly connected, Loopback0
```

Figure 30 IP routing table for router 1

```
R5# sh ip ospf database
            OSPF Router with ID (192.168.0.5) (Process ID 5)
                Router Link States (Area 0)
Link ID
               ADV Router
                                           Seq#
                                                       Checksum Link count
                               Age
                               1172
                                           0x80000003 0x0082E5 1
192.168.0.1
                192.168.0.1
                               465
192.168.0.2
                192.168.0.2
                                           0x8000000B 0x0097CB 4
192.168.0.3
                192.168.0.3
                               772
                                           0x8000000A 0x002C1D 5
192.168.0.4
                192.168.0.4
                               764
                                           0x8000000B 0x000D28 5
192.168.0.5
               192.168.0.5
                               1165
                                           0x80000008 0x00F539 4
               Net Link States (Area 0)
Link ID
               ADV Router
                               Age
                                           Seq#
                                                      Checksum
192.168.10.9
                192.168.0.3
                               1031
                                           0x80000002 0x000475
192.168.11.1
               192.168.0.1
                               1172
                                           0x80000002 0x002561
                Summary Net Link States (Area 0)
Link ID
                ADV Router
                                            Seq#
                                                       Checksum
                               Age
               192.168.0.2
                               460
                                            0x80000001 0x0098BD
192.168.11.0
```

Figure 31 OSPF Database for router 5

```
R5#sh ip ospf database summary

OSPF Router with ID (192.168.0.5) (Process ID 5)

Summary Net Link States (Area 0)

Routing Bit Set on this LSA
LS age: 490
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: 800000001
Checksum: 0x98BD
Length: 28
Network Mask: /30
TOS: 0 Metric: 10
```

Figure 32 LSA 490 R5

```
R5# sh 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
       192.168.10.0 [110/3] via 192.168.10.17, 00:09:33, FastEthernet2/0
0
        192.168.10.4 [110/11] via 192.168.10.17, 00:09:33, FastEthernet2/0
        192.168.10.8 [110/2] via 192.168.10.17, 00:09:33, FastEthernet2/0
        192.168.10.12 is directly connected, FastEthernet0/0
        192.168.10.16 is directly connected, FastEthernet2/0
     192.168.11.0/30 is subnetted, 1 subnets
      192.168.11.0 [110/13] via 192.168.10.17, 00:09:33, FastEthernet2/0
     192.168.0.0/29 is subnetted, 1 subnets
       192.168.0.0 is directly connected, Loopback0
```

Figure 33 ip routing table for router 5

When running *sh ip ospf database* now, there is a new category: Summary Net Link. This category contains information that R2 advertised to R1 about every other device in area 0. For R5 we have the opposite situation, summary net link shows only one address since there is only 1 device exclusively in area 1. As for *sh ip ospf database summary*, on R1 we can see that R1 can identify all devices in the network via R2 advertisment. Vice versa R5 has the information about the whole network but this time R2 advertises once since there is only one device in area 1.

# Task 5

```
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 = 44/63/84 ms
```

Figure 34 ping from R4 to R1

After pinging 192.168.11.1 we can see that out of 5 packets sent, 5 have been received with average RTT of 63 ms.

```
R4#traceroute 192.168.11.1

Type escape sequence to abort.

Tracing the route to 192.168.11.1

1 192.168.10.9 16 msec 16 msec 20 msec 2 192.168.10.1 32 msec 48 msec 40 msec 3 192.168.11.1 80 msec 52 msec 76 msec
```

Figure 35 Tracert from R4 to R1

Tracert to 192.168.11.1 tells us the exact path the packet was sent through.

```
R1#sh ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet Address 192.168.11.1/30, Area 1
  Process ID 1, Router ID 192.168.0.1, Network Type BROADCAST, Cost: 10
  Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 192.168.0.1, Interface address 192.168.11.1
  Backup Designated router (ID) 192.168.0.2, Interface address 192.168.11.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:08
  Supports Link-local Signaling (LLS)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 192.168.0.2 (Backup Designated Router)
  Suppress hello for 0 neighbor(s)
```

Figure 36 OSPF ip interface for router 1

```
R1#sh ip ospf interface brief
Interface PID Area IP Address/Mask Cost State Nbrs F/C
Fa0/0 1 1 192.168.11.1/30 10 DR 1/1
```

Figure 37 R1 cost 10

R2#sh ip ospf interface brief							
Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs F/C	
Fa0/1	2	0	192.168.10.5/30	10	P2P	1/1	
Fa2/0	2	0	192.168.10.1/30	1	P2P	1/1	
Fa0/0	2	1	192.168.11.2/30	10	BDR	1/1	

Figure 38 R2 costs

The costs define how optimal is a certain interface. This is used by the OSPF to define the path for a connection that would lead to the lowest delay and congestion.

```
FastEthernet0/1 is up, line protocol is up
 Hardware is Gt96k FE, address is c402.6504.0001 (bia c402.6504.0001)
 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)
 Half-duplex, 10Mb/s, 100BaseTX/FX
ARP type: ARPA, ARP Timeout 04:00:00
 Last input 00:00:09, 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
    859 packets input, 117111 bytes
    Received 848 broadcasts, 0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
    0 watchdog
    O input packets with dribble condition detected
    1917 packets output, 191034 bytes, 0 underruns
    O output errors, O collisions, 2 interface resets
    0 unknown protocol drops
    0 babbles, 0 late collision, 0 deferred
    0 lost carrier, 0 no carrier
    O output buffer failures, O output buffers swapped out
```

Figure 39 BW 10Mb/s

The bandwidth between R2 and R4 is 10 Mb/s. The link cost on the connection between R2 and R4 is 10.

R3#sh ip osp	f inte	rface brief					
Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Fa0/0	3	0	192.168.10.13/30	10	P2P	1/1	
Fa3/0	3	0	192.168.10.9/30	100	DR	1/1	
Fa2/0	3	0	192.168.10.2/30	1	P2P	1/1	

Figure 40 R3 costs

R4#sh ip ospf interface brief							
Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs F/C	
Fa2/0	4	0	192.168.10.17/30	1	P2P	1/1	
Fa3/0	4	0	192.168.10.10/30	100	BDR	1/1	
Fa0/1	4	0	192.168.10.6/30	10	P2P	1/1	

Figure 41 R4 costs

On above figures we can see that the cost of the interface f3/0 has been changed to 100.

```
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 = 28/36/44 ms
```

Figure 42 ping from R4 to R1

```
R4#traceroute 192.168.11.1

Type escape sequence to abort.

Tracing the route to 192.168.11.1

1 192.168.10.5 32 msec 20 msec 20 msec
2 192.168.11.1 48 msec 40 msec 44 msec
```

Figure 43 tracert to R1

Doing the ping and tracert operations again we can see that this time the average RTT is lower and the path taken is different. Since the costs were the same last time the protocol probably chose the path at random. Now since we've manually set the cost on one link to be huge compared to others, the protocol choses a different, more optimal path which is in fact better.