Student notes for

David Bombal's

Packet Tracer
Labs Course

David Bombal

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Remember: You will probably learn more by making notes like these and sharing them for the benefit of others.

All the best!

David Bombal

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Contents

Brief

This lab is for configuring OSPF and reviewing how you can advertise specific networks or subnets or everything with one command.

Lab requirements

OSPF Single Area

1. Configure OSPF in a single area as follows:
   a. Use OSPF process ID 1
   b. R1 - enable OSPF using the network command with exact IP match
   c. R2 - enable OSPF using the network command based on subnet mask
   d. R3 - enable OSPF using the interface command
   e. R4 - enble OSPF on all interfaces with a single network command

OSPF Multi-Area

1. Configure OSPF in a multiple areas as follows:
   a. Use OSPF process ID 1
   b. R1 - enable OSPF using the network command with exact IP match Area 2
   c. R2 - enable OSPF using the network command based on subnet mask area0 and area 2
   d. R3 - enable OSPF using the interface command ABR area 0 and area 3
   e. R4 - enable OSPF on all interfaces with a single network command area 3
   f. Loopbacks in R2 and R3 belong in area 0

OSPF (Open Shortest Path First)

Key Points

- Router ID in OSPF is the highest IP physical interface address configured on the interfaces. Unless you have a loopback configured and it uses the highest loopback ID.

- OSPF is a link state routing protocol

- OSPF Routes use an administrative distance of 110

- OSPF Routes come up as O

- OSPF elects a dedicated router (DR) with highest priority on that segment it also elects a (BDR) backup designated router

Open shortest path first (OSPF) is a link-state routing protocol that creates a link-state database for all routers in a certain area inside a network. There can be multiple areas to reduce the database size which helps reduce router memory allocation and utilisation. Passive interfaces are configured at network edges that do not forward OSPF routing information.

OSPF has 8 LSA's which stand for Link State Advertisements this is important for OSPF as it shares its networks within an area. The types are as follows.

- LSA Type 1:   Router LSA – (Generated after OSPF is run)
- LSA Type 2:   Network LSA – (Multi access networks with 2 OSPF routers DR election)
- LSA Type 3:   Summary LSA – (Summarise inter-area routes)
- LSA Type 4:   Summary ASBR LSA – (Autonomous system border router between ospf and another routing protocol)
- LSA Type 5:   Autonomous system external LSA (External LSA for separate areas)
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Note:

- OSPF MTU maximum transmission units must be matched if not OSPF does not work.
- Authentication mechanism between the IGP routers should be same for IGP to be established in Full state.
- Hello and dead internal between the 2 OSPF speaking routers should be the same.
- OSPF network types should be same.

OSPF Authentication Configuration

OSPF MD5 Authentication Configuration

R1
!
Router ospf 1
area 0 authentication message-digest
!
Interface serial 0/0/0
ipospf message-digest-key 7 md5 AUT

OSPF Network Types

- Broadcast to Broadcast

- Non-Broadcast to Non-Broadcast (NBMA Non-broadcast multi-access e.g. Frame Relay and ATM
  interfaces)

- Point-to-Point to Point-to-Point

- Point-to-Multipoint to Point-to-Multipoint

OSPF Neighbor States

Before reaching to full state routers speaking OSPF goes to different intermediate states which are
mentioned below.

- Down

- Init

- 2-way

- Exstart

- Exchange

- Loading

- Full

OSPF Metric

Metric of OSPF is bandwidth inversely proportional to cost. As the bandwidth of interface increases the cost of the interface decreases.

$$Cost = 10^8/\text{interface bandwidth in bps}$$

Bandwidth	OSPF Cost
100 Gbps	1
40 Gbps	1
10 Gbps	1
1 Gbps	1
100 Mbps	1
10 Mbps	10
1.544 Mbps	64

OSPF Area Information and division.

- ### Backbone area A0

OSPF backbone area usually defined as area 0, all other areas must connect to the backbone area for OSPF to work.
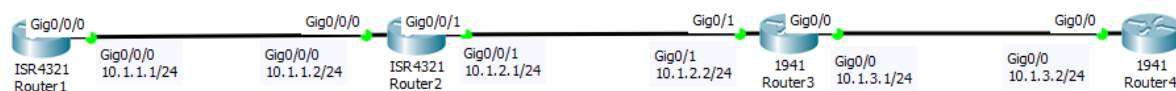
- ### Area Border Router (ABR)

Router that is connected to multiple areas is called ABR.

- ### ASBR

A router redistributing other protocols information within OSPF is called ASBR.

Lab Topology

Here we have four routers that we will configure to advertise their networks with OSPF AS 1 in a single area.

Configurations and Verification

OSPF Single area

Router1
```
!
R1(config)#router ospf 1
R1(config-router)#network 10.1.1.1 0.0.0.0 area 0
R1(config-router)#network 1.1.1.1 0.0.0.0 area 0
!
```

Router2
```
!
R2(config)#router ospf 1
R2(config-router)#network 10.1.1.0 0.0.0.255 area 0
R2(config-router)#network 10.1.2.0 0.0.0.255 area 0
R2(config-router)#network 2.2.2.2 0.0.0.0 area 0
!
```

Router3
```
!
R3(config)#interface Loopback0
R3(config-if)#ip address 3.3.3.3 255.255.255.255
R3(config-if)#ipospf 1 area 0
!
R3(config)#interface GigabitEthernet0/0
R3(config-if)#ip address 10.1.3.1 255.255.255.0
R3(config-if)#ipospf 1 area 0
!
R3(config)#interface GigabitEthernet0/1
R3(config-if)#ip address 10.1.2.2 255.255.255.0
R3(config-if)#ipospf 1 area 0
!
```

Router4
```
!
R4(config)# router ospf 1
R4(config-router)#network 0.0.0.0 255.255.255.255 area 0
!
```

Verification commands and outputs

R4#show ip route
```
Codes: L - local, 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, E - EGP
i - IS-IS, 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

1.0.0.0/32 is subnetted, 1 subnets
```

O 1.1.1.1/32 [110/4] via 10.1.3.1, 00:01:29, GigabitEthernet0/0
2.0.0.0/32 is subnetted, 1 subnets
O 2.2.2.2/32 [110/3] via 10.1.3.1, 00:01:29, GigabitEthernet0/0
3.0.0.0/32 is subnetted, 1 subnets
O 3.3.3.3/32 [110/2] via 10.1.3.1, 00:11:52, GigabitEthernet0/0
4.0.0.0/32 is subnetted, 1 subnets
C 4.4.4.4/32 is directly connected, Loopback0
10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
O 10.1.1.0/24 [110/3] via 10.1.3.1, 00:01:29, GigabitEthernet0/0
O 10.1.2.0/24 [110/2] via 10.1.3.1, 00:01:29, GigabitEthernet0/0
C 10.1.3.0/24 is directly connected, GigabitEthernet0/0
L 10.1.3.2/32 is directly connected, GigabitEthernet0/0

R1#show ip protocols

Routing Protocol is "ospf 1"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 1.1.1.1
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
10.1.1.1 0.0.0.0 area 0
1.1.1.1 0.0.0.0 area 0
Routing Information Sources:
Gateway Distance Last Update
1.1.1.1 110 00:14:25
2.2.2.2 110 00:05:47
3.3.3.3 110 00:05:47
4.4.4.4 110 00:16:09
Distance: (default is 110)

R1#show ipospf database
OSPF Router with ID (1.1.1.1) (Process ID 1)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count
1.1.1.1 1.1.1.1 843 0x80000003 0x008595 2
4.4.4.4 4.4.4.4 947 0x80000003 0x007d74 2
3.3.3.3 3.3.3.3 325 0x80000008 0x00efdc 3
2.2.2.2 2.2.2.2 325 0x80000007 0x00b32a 3

Net Link States (Area 0)
Link ID ADV Router Age Seq# Checksum
10.1.1.2 2.2.2.2 843 0x80000001 0x005e55
10.1.3.2 4.4.4.4 947 0x80000001 0x0022fd
10.1.2.1 2.2.2.2 325 0x80000002 0x0061ec

R3#show ipospf interface

Loopback0 is up, line protocol is up
Internet address is 3.3.3.3/32, Area 0
Process ID 1, Router ID 3.3.3.3, Network Type LOOPBACK, Cost: 1
Loopback interface is treated as a stub Host
GigabitEthernet0/0 is up, line protocol is up
Internet address is 10.1.3.1/24, Area 0
Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 1

```
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 4.4.4.4, Interface address 10.1.3.2
Backup Designated Router (ID) 3.3.3.3, Interface address 10.1.3.1
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:07
Index 2/2, 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 4.4.4.4 (Designated Router)
Suppress hello for 0 neighbor(s)
GigabitEthernet0/1 is up, line protocol is up
Internet address is 10.1.2.2/24, Area 0
Process ID 1, Router ID 3.3.3.3, Network Type BROADCAST, Cost: 1
Transmit Delay is 1 sec, State BDR, Priority 1
Designated Router (ID) 2.2.2.2, Interface address 10.1.2.1
Backup Designated Router (ID) 3.3.3.3, Interface address 10.1.2.2
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
Hello due in 00:00:03
Index 3/3, 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 2.2.2.2 (Designated Router)
Suppress hello for 0 neighbor(s)
```

```
R4#traceroute 1.1.1.1
Type escape sequence to abort.
Tracing the route to 1.1.1.1

1 10.1.3.1 14 msec 0 msec 0 msec
2 10.1.2.1 0 msec 1 msec 0 msec
3 10.1.1.1 0 msec 0 msec 0 msec
```

```
R2#show ipospfneighbor

Neighbor ID Pri State Dead Time Address Interface
3.3.3.3 1 FULL/BDR 00:00:33 10.1.2.2 GigabitEthernet0/0/1
1.1.1.1 1 FULL/BDR 00:00:39 10.1.1.1 GigabitEthernet0/0/0
```

Lab Topology

Here we have four routers that we will configure to advertise their networks with OSPF AS 1 in separate areas as shown by circles. This is normal format to show separation of areas or routing protocols. The main difference between single area and multi area is the interarea routes.

OSPF Multi Area Configuration

Router1
```
!
R1(config)#router ospf 1
R1(config-router)#network 10.1.1.1 0.0.0.0 area 2
R1(config-router)#network 1.1.1.1 0.0.0.0 area 2
!
```

Router2
```
!
R2(config)#router ospf 1
R2(config-router)#network 10.1.1.0 0.0.0.255 area 2
R2(config-router)#network 10.1.2.0 0.0.0.255 area 0
R2(config-router)#network 2.2.2.2 0.0.0.0 area 0
!
```

Router3
```
!
R3(config)#router ospf 1
R3(config-router)#int g0/1
R3(config-if)#ipospf 1 area 0
R3(config-if)#int lo0
R3(config-if)#ipospf 1 area 0
R3(config-if)#int g0/0
R3(config-if)#ipospf 1 area 3
!
```

Router4
```
!
R4(config-router)#network 0.0.0.0 255.255.255.255 area 3
!
```

Verification commands and outputs

R2#show ipospfneighbor

```
Neighbor ID Pri State Dead Time Address Interface
3.3.3.3 1 FULL/DR 00:00:38 10.1.2.2 GigabitEthernet0/0/1
1.1.1.1 1 FULL/BDR 00:00:38 10.1.1.1 GigabitEthernet0/0/0
```

R2#show ip protocols

```
Routing Protocol is "ospf 1"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 2.2.2.2
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
2.2.2.2 0.0.0.0 area 0
10.1.2.0 0.0.0.255 area 0
10.1.1.0 0.0.0.255 area 1
Routing Information Sources:
Gateway Distance Last Update
```

1.1.1.1 110 00:02:12
2.2.2.2 110 00:02:12
3.3.3.3 110 00:02:12
Distance: (default is 110)

R3#show ip protocols

Routing Protocol is "ospf 1"
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Router ID 3.3.3.3
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
Maximum path: 4
Routing for Networks:
Routing Information Sources:
Gateway Distance Last Update
2.2.2.2 110 00:02:46
3.3.3.3 110 00:02:46
4.4.4.4 110 00:02:46
Distance: (default is 110)

R3#show ipospfneighbor

Neighbor ID Pri State Dead Time Address Interface
2.2.2.2 1 FULL/BDR 00:00:30 10.1.2.1 GigabitEthernet0/1

4.4.4.4 1 FULL/DR 00:00:30 10.1.3.2 GigabitEthernet0/0

R2#show ipospf 1 border-routers
OSPF Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 3.3.3.3 [1] via 10.1.2.2, GigabitEthernet0/0/1, ABR, Area 0, SPF 1

R3#show ipospf border-routers
OSPF Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [1] via 10.1.2.1, GigabitEthernet0/1, ABR, Area 0, SPF 1

R1#show ipospf border-routers
OSPF Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 2.2.2.2 [1] via 10.1.1.2, GigabitEthernet0/0/0, ABR, Area 1, SPF 1

R1#show ip route
Codes: L - local, 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, E - EGP
i - IS-IS, 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

1.0.0.0/32 is subnetted, 1 subnets
C 1.1.1.1/32 is directly connected, Loopback0
2.0.0.0/32 is subnetted, 1 subnets
O IA 2.2.2.2/32 [110/2] via 10.1.1.2, 00:04:26, GigabitEthernet0/0/0
3.0.0.0/32 is subnetted, 1 subnets
O IA 3.3.3.3/32 [110/3] via 10.1.1.2, 00:04:26, GigabitEthernet0/0/0
4.0.0.0/32 is subnetted, 1 subnets
O IA 4.4.4.4/32 [110/4] via 10.1.1.2, 00:04:16, GigabitEthernet0/0/0
10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C 10.1.1.0/24 is directly connected, GigabitEthernet0/0/0
L 10.1.1.1/32 is directly connected, GigabitEthernet0/0/0
O IA 10.1.2.0/24 [110/2] via 10.1.1.2, 00:04:26, GigabitEthernet0/0/0
O IA 10.1.3.0/24 [110/3] via 10.1.1.2, 00:04:16, GigabitEthernet0/0/0

R1#traceroute 4.4.4.4
Type escape sequence to abort.
Tracing the route to 4.4.4.4

1 10.1.1.2 1 msec 0 msec 0 msec
2 10.1.2.2 0 msec 0 msec 0 msec
3 10.1.3.2 0 msec 0 msec 0 msec

R1#show ipospf database
OSPF Router with ID (1.1.1.1) (Process ID 1)

Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count
1.1.1.1 1.1.1.1 368 0x80000003 0x008595 2
2.2.2.2 2.2.2.2 368 0x80000002 0x0063c3 1

Net Link States (Area 1)
Link ID ADV Router Age Seq# Checksum
10.1.1.2 2.2.2.2 368 0x80000001 0x006d58

Summary Net Link States (Area 1)
Link ID ADV Router Age Seq# Checksum
10.1.2.0 2.2.2.2 363 0x80000001 0x00b296
2.2.2.2 2.2.2.2 363 0x80000002 0x00f854
3.3.3.3 2.2.2.2 363 0x80000003 0x00d274
10.1.3.0 2.2.2.2 353 0x80000004 0x00ab98
4.4.4.4 2.2.2.2 353 0x80000005 0x00aa95

R3#show ipospf database
OSPF Router with ID (3.3.3.3) (Process ID 1)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count
3.3.3.3 3.3.3.3 738 0x80000003 0x007d81 2
2.2.2.2 2.2.2.2 738 0x80000004 0x008a80 2

Net Link States (Area 0)
Link ID ADV Router Age Seq# Checksum
10.1.2.2 3.3.3.3 738 0x80000001 0x0007bc

Summary Net Link States (Area 0)
Link ID ADV Router Age Seq# Checksum
10.1.1.0 2.2.2.2 733 0x80000001 0x00bd8c
10.1.3.0 3.3.3.3 733 0x80000001 0x0089ba
4.4.4.4 3.3.3.3 733 0x80000002 0x0088b7
1.1.1.1 2.2.2.2 728 0x80000002 0x00311f

Router Link States (Area 2)

Link ID ADV Router Age Seq# Checksum Link count
3.3.3.3 3.3.3.3 739 0x80000002 0x0035e6 1
4.4.4.4 4.4.4.4 739 0x80000003 0x007d74 2

Net Link States (Area 2)
Link ID ADV Router Age Seq# Checksum
10.1.3.2 4.4.4.4 739 0x80000001 0x00c0fc

Summary Net Link States (Area 2)
Link ID ADV Router Age Seq# Checksum
3.3.3.3 3.3.3.3 734 0x80000001 0x00ae97
10.1.2.0 3.3.3.3 734 0x80000002 0x0092b1
2.2.2.2 3.3.3.3 724 0x80000003 0x00e264
10.1.1.0 3.3.3.3 724 0x80000004 0x00a39e
1.1.1.1 3.3.3.3 724 0x80000005 0x001731

R2#show ipospf database
OSPF Router with ID (2.2.2.2) (Process ID 1)

Router Link States (Area 0)

Link ID ADV Router Age Seq# Checksum Link count
2.2.2.2 2.2.2.2 801 0x80000004 0x008a80 2
3.3.3.3 3.3.3.3 801 0x80000003 0x007d81 2

Net Link States (Area 0)
Link ID ADV Router Age Seq# Checksum
10.1.2.2 3.3.3.3 801 0x80000001 0x0007bc

Summary Net Link States (Area 0)
Link ID ADV Router Age Seq# Checksum
10.1.1.0 2.2.2.2 796 0x80000001 0x00bd8c

```
10.1.3.0 3.3.3.3 796 0x80000001 0x0089ba
4.4.4.4 3.3.3.3 796 0x80000002 0x0088b7
1.1.1.1 2.2.2.2 791 0x80000002 0x00311f

Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count
2.2.2.2 2.2.2.2 801 0x80000002 0x0063c3 1
1.1.1.1 1.1.1.1 801 0x80000003 0x008595 2

Net Link States (Area 1)
Link ID ADV Router Age Seq# Checksum
10.1.1.2 2.2.2.2 801 0x80000001 0x006d58

Summary Net Link States (Area 1)
Link ID ADV Router Age Seq# Checksum
10.1.2.0 2.2.2.2 796 0x80000001 0x00b296
2.2.2.2 2.2.2.2 796 0x80000002 0x00f854
3.3.3.3 2.2.2.2 796 0x80000003 0x00d274
10.1.3.0 2.2.2.2 786 0x80000004 0x00ab98
4.4.4.4 2.2.2.2 786 0x80000005 0x00aa95
```

Note: if you have problems save all configurations save the topology and reopen it this helped me with this lab and the EIGRP lab.

Note 2: don't be confused by the completed lab it does use a different area instead of area 1 it uses area 2.

Note 3: run these commands for each router and observe the results

Note 4: databases are the same for routers inside the same area

Extra Examples and Resources
Cisco OSPF

https://www.cisco.com/c/en/us/td/docs/security/asa/asa82/configuration/guide/config/route_ospf.html

https://www.cisco.com/c/en/us/support/docs/ip/open-shortest-path-first-ospf/7039-1.html