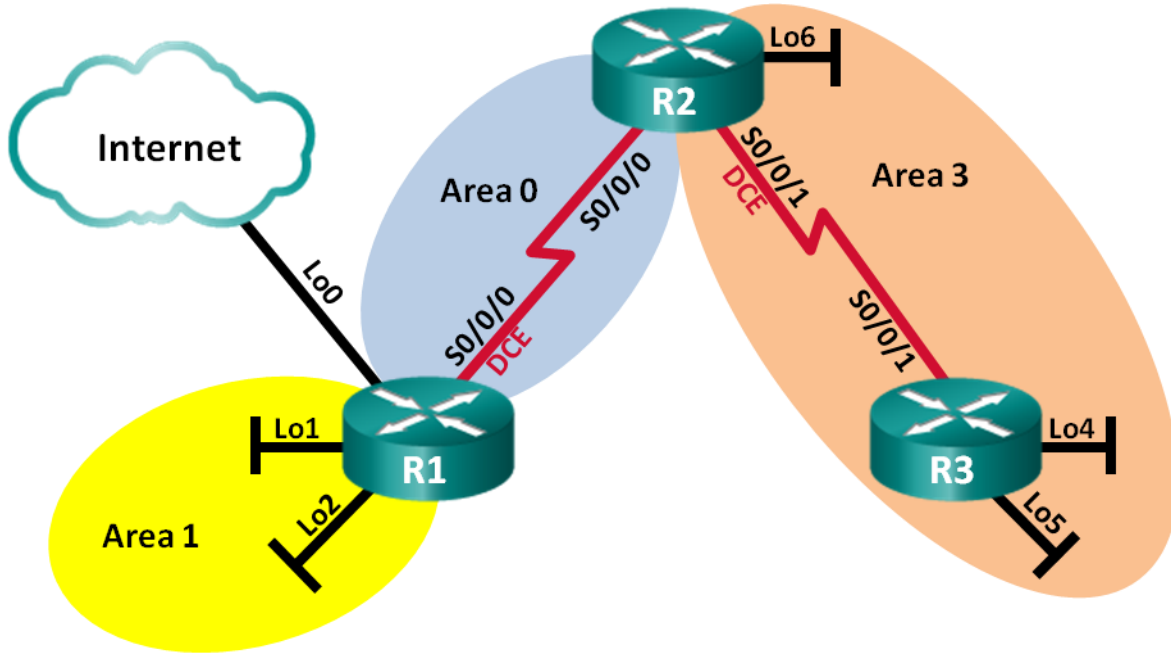


# Lab - Configuring Multiarea OSPFv2

## Topology



## Addressing Table

Device	Interface	IP Address	Subnet Mask
R1	Lo0	209.165.200.225	255.255.255.252
	Lo1	192.168.1.1	255.255.255.0
	Lo2	192.168.2.1	255.255.255.0
	S0/0/0 (DCE)	192.168.12.1	255.255.255.252
R2	Lo6	192.168.6.1	255.255.255.0
	S0/0/0	192.168.12.2	255.255.255.252
	S0/0/1 (DCE)	192.168.23.1	255.255.255.252
R3	Lo4	192.168.4.1	255.255.255.0
	Lo5	192.168.5.1	255.255.255.0
	S0/0/1	192.168.23.2	255.255.255.252

## Objectives

**Part 1: Build the Network and Configure Basic Device Settings**

**Part 2: Configure a Multiarea OSPFv2 Network**

**Part 3: Configure Interarea Summary Routes**

### Background / Scenario

To make OSPF more efficient and scalable, OSPF supports hierarchical routing using the concept of areas. An OSPF area is a group of routers that share the same link-state information in their link-state databases (LSDBs). When a large OSPF area is divided into smaller areas, it is called multiarea OSPF. Multiarea OSPF is useful in larger network deployments to reduce processing and memory overhead.

In the lab, you will configure a multiarea OSPFv2 network with interarea summary routes.

**Note:** The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). Other routers and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

**Note:** Make sure that the routers have been erased and have no startup configurations. If you are unsure, contact your instructor.

### Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- Console cables to configure the Cisco IOS devices via the console ports
- Serial cables as shown in the topology

### Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the routers.

**Step 1: Cable the network as shown in the topology.**

**Step 2: Initialize and reload the routers as necessary.**

**Step 3: Configure basic settings for each router.**

- a. Disable DNS lookup.
- b. Configure device name, as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the console and vty passwords.
- e. Configure **logging synchronous** for the console line.
- f. Configure an MOTD banner to warn users that unauthorized access is prohibited.
- g. Configure the IP addresses listed in the Addressing Table for all interfaces. DCE interfaces should be configured with a clock rate of 128000. Bandwidth should be set to 128 Kb/s on all serial interfaces.
- h. Copy the running configuration to the startup configuration.

**Step 4: Verify Layer 3 connectivity.**

Use the **show ip interface brief** command to verify that the IP addressing is correct and that the interfaces are active. Verify that each router can ping their neighbor's serial interface.

## Part 2: Configure a Multiarea OSPFv2 Network

In Part 2, you will configure a multiarea OSPFv2 network with process ID of 1. All LAN loopback interfaces should be passive, and all serial interfaces should be configured with MD5 authentication using **Cisco123** as the key.

### Step 1: Identify the OSPF router types in the topology.

Identify the Backbone router(s):

Identify the Autonomous System Boundary Router(s) (ASBR):

Identify the Area Border Router(s) (ABR):

Identify the Internal router(s):

### Step 2: Configure OSPF on R1.

a. Configure a router ID of 1.1.1.1 with OSPF process ID of 1.

b. Add the networks for R1 to OSPF.

```
R1(config-router)# network 192.168.1.0 0.0.0.255 area 1
```

```
R1(config-router)# network 192.168.2.0 0.0.0.255 area 1
```

```
R1(config-router)# network 192.168.12.0 0.0.0.3 area 0
```

c. Set all LAN loopback interfaces, Lo1 and Lo2, as passive.

d. Create a default route to the Internet using exit interface Lo0.

**Note:** You may see the “%Default route without gateway, if not a point-to-point interface, may impact performance” message. This is normal behavior if using a Loopback interface to simulate a default route.

e. Configure OSPF to propagate the routes throughout the OSPF areas.

### Step 3: Configure OSPF on R2.

a. Configure a router ID of 2.2.2.2 with OSPF process ID of 1.

b. Add the networks for R2 to OSPF. Add the networks to the correct area. Write the commands used in the space below.

c. Set all LAN loopback interfaces as passive.

### Step 4: Configure OSPF on R3.

a. Configure a router ID of 3.3.3.3 with OSPF process ID of 1.

b. Add the networks for R3 to OSPF. Write the commands used in the space below.

c. Set all LAN loopback interfaces as passive.

### Step 5: Verify that OSPF settings are correct and adjacencies have been established between routers.

- Issue the `show ip protocols` command to verify OSPF settings on each router. Use this command to identify the OSPF router types and to determine the networks assigned to each area.

```
R1# show ip protocols
```

```
*** IP Routing is NSF aware ***
```

```
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
```

```
It is an area border and autonomous system boundary router
```

```
Redistributing External Routes from,
```

```
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
```

```
Maximum path: 4
```

```
Routing for Networks:
```

```
192.168.1.0 0.0.0.255 area 1
```

```
192.168.2.0 0.0.0.255 area 1
```

```
192.168.12.0 0.0.0.3 area 0
```

```
Passive Interface(s):
```

```
Loopback1
```

```
Loopback2
```

```
Routing Information Sources:
```

```
Gateway Distance Last Update
```

```
2.2.2.2 110 00:01:45
```

```
Distance: (default is 110)
```

```
R2# show ip protocols
```

```
*** IP Routing is NSF aware ***
```

```
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
```

```
It is an area border router
```

```
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
```

```
Maximum path: 4
```

```
Routing for Networks:
```

```
192.168.6.0 0.0.0.255 area 3
```

```
192.168.12.0 0.0.0.3 area 0
```

```
192.168.23.0 0.0.0.3 area 3
```

```
Passive Interface(s):
```

```
Loopback6
```

```
Routing Information Sources:
```

```
Gateway Distance Last Update
```

```
3.3.3.3 110 00:01:20
```

```
1.1.1.1 110 00:10:12
```

```
Distance: (default is 110)
```

## Lab - Configuring Multiarea OSPFv2

```
R3# show ip protocols
*** IP Routing is NSF aware ***

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 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.4.0 0.0.0.255 area 3
    192.168.5.0 0.0.0.255 area 3
    192.168.23.0 0.0.0.3 area 3
  Passive Interface(s):
    Loopback4
    Loopback5
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1          110           00:07:46
    2.2.2.2          110           00:07:46
  Distance: (default is 110)
```

What is the OSPF router type for each router?

R1:

R2:

R3:

- b. Issue the **show ip ospf neighbor** command to verify that OSPF adjacencies have been established between routers.

```
R1# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	0	FULL/ -	00:00:34	192.168.12.2	Serial0/0/0

```
R2# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	0	FULL/ -	00:00:36	192.168.12.1	Serial0/0/0
3.3.3.3	0	FULL/ -	00:00:36	192.168.23.2	Serial0/0/1

```
R3# show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	0	FULL/ -	00:00:38	192.168.23.1	Serial0/0/1

- c. Issue the **show ip ospf interface brief** command to display a summary of interface route costs.

```
R1# show ip ospf interface brief
```

Interface	PID	Area	IP Address/Mask	Cost	State	Nbrs	F/C
Se0/0/0	1	0	192.168.12.1/30	781	P2P	1/1	

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```
Lo1          1      1          192.168.1.1/24      1      LOOP  0/0
Lo2          1      1          192.168.2.1/24      1      LOOP  0/0
```

```
R2# show ip ospf interface brief
```

```
Interface    PID  Area          IP Address/Mask    Cost  State Nbrs F/C
Se0/0/0      1    0             192.168.12.2/30    781   P2P   1/1
Lo6          1    3             192.168.6.1/24     1     LOOP  0/0
Se0/0/1      1    3             192.168.23.1/30    781   P2P   1/1
```

```
R3# show ip ospf interface brief
```

```
Interface    PID  Area          IP Address/Mask    Cost  State Nbrs F/C
Lo4          1    3             192.168.4.1/24     1     LOOP  0/0
Lo5          1    3             192.168.5.1/24     1     LOOP  0/0
Se0/0/1      1    3             192.168.23.2/30    781   P2P   1/1
```

### Step 6: Configure MD5 authentication on all serial interfaces.

Configure OSPF MD5 authentication at the interface level with an authentication key of **Cisco123**.

Why is it a good idea to verify that OSPF is functioning correctly before configuring OSPF authentication?

### Step 7: Verify OSPF adjacencies have been re-established.

Issue the **show ip ospf neighbor** command again to verify that adjacencies have been re-established after MD5 authentication was implemented. Troubleshoot any issues found before moving on to Part 3.

## Part 3: Configure Interarea Summary Routes

OSPF does not perform automatic summarization. Interarea summarization must be manually configured on ABRs. In Part 3, you will apply interarea summary routes on the ABRs. Using **show** commands, you will be able to observe how summarization affects the routing table and LSDBs.

### Step 1: Display the OSPF routing tables on all routers.

- Issue the **show ip route ospf** command on R1. OSPF routes that originate from a different area have a descriptor (O IA) indicating that these are interarea routes.

```
R1# show ip route ospf
```

```
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
       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, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

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Gateway of last resort is 0.0.0.0 to network 0.0.0.0

```
192.168.4.0/32 is subnetted, 1 subnets
O IA 192.168.4.1 [110/1563] via 192.168.12.2, 00:23:49, Serial10/0/0
192.168.5.0/32 is subnetted, 1 subnets
O IA 192.168.5.1 [110/1563] via 192.168.12.2, 00:23:49, Serial10/0/0
192.168.23.0/30 is subnetted, 1 subnets
O IA 192.168.6.1 [110/782] via 192.168.12.2, 00:02:01, Serial10/0/0
192.168.23.0/30 is subnetted, 1 subnets
O IA 192.168.23.0 [110/1562] via 192.168.12.2, 00:23:49, Serial10/0/0
```

- b. Repeat the **show ip route ospf** command for R2 and R3. Record the OSPF interarea routes for each router.

R2:

R3:

### Step 2: Display the LSDB on all routers.

- a. Issue the **show ip ospf database** command on R1. A router maintains a separate LSDB for every area that it is a member.

R1# **show ip ospf 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	1295	0x80000003	0x0039CD	2
2.2.2.2	2.2.2.2	1282	0x80000002	0x00D430	2

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.1	1.1.1.1	1387	0x80000002	0x00AC1F
192.168.2.1	1.1.1.1	1387	0x80000002	0x00A129
192.168.4.1	2.2.2.2	761	0x80000001	0x000DA8
192.168.5.1	2.2.2.2	751	0x80000001	0x0002B2
192.168.6.1	2.2.2.2	1263	0x80000001	0x00596A
192.168.23.0	2.2.2.2	1273	0x80000001	0x00297E

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### Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
1.1.1.1	1.1.1.1	1342	0x80000006	0x0094A4	2

### Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.4.1	1.1.1.1	760	0x80000001	0x00C8E0
192.168.5.1	1.1.1.1	750	0x80000001	0x00BDEA
192.168.6.1	1.1.1.1	1262	0x80000001	0x0015A2
192.168.12.0	1.1.1.1	1387	0x80000001	0x00C0F5
192.168.23.0	1.1.1.1	1272	0x80000001	0x00E4B6

### Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
0.0.0.0	1.1.1.1	1343	0x80000001	0x001D91	1

- b. Repeat the **show ip ospf database** command for R2 and R3. Record the Link IDs for the Summary Net Link States for each area.

R2:

R3:

### Step 3: Configure the interarea summary routes.

- Calculate the summary route for the networks in area 1.
- Configure the summary route for area 1 on R1.  
R1(config)# **router ospf 1**  
R1(config-router)# **area 1 range 192.168.0.0 255.255.252.0**
- Calculate the summary route for the networks in area 3. Record your results.
- Configure the summary route for area 3 on R2. Write the commands you used in the space below.

### Step 4: Re-display the OSPF routing tables on all routers.

Issue the **show ip route ospf** command on each router. Record the results for the summary and interarea routes.

R1:



R2:

R3:

**Step 5: Display the LSDB on all routers.**

Issue the **show ip ospf database** command again on each router. Record the Link IDs for the Summary Net Link States for each area.

R1:

R2:

R3:

What type of LSA is injected into the backbone by the ABR when interarea summarization is enabled?

**Step 6: Verify end-to-end connectivity.**

Verify that all networks can be reached from each router. If any issues exist, troubleshoot until they have been resolved.

**Reflection**

What are three advantages for designing a network with multiarea OSPF?

### Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

**Note:** To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.