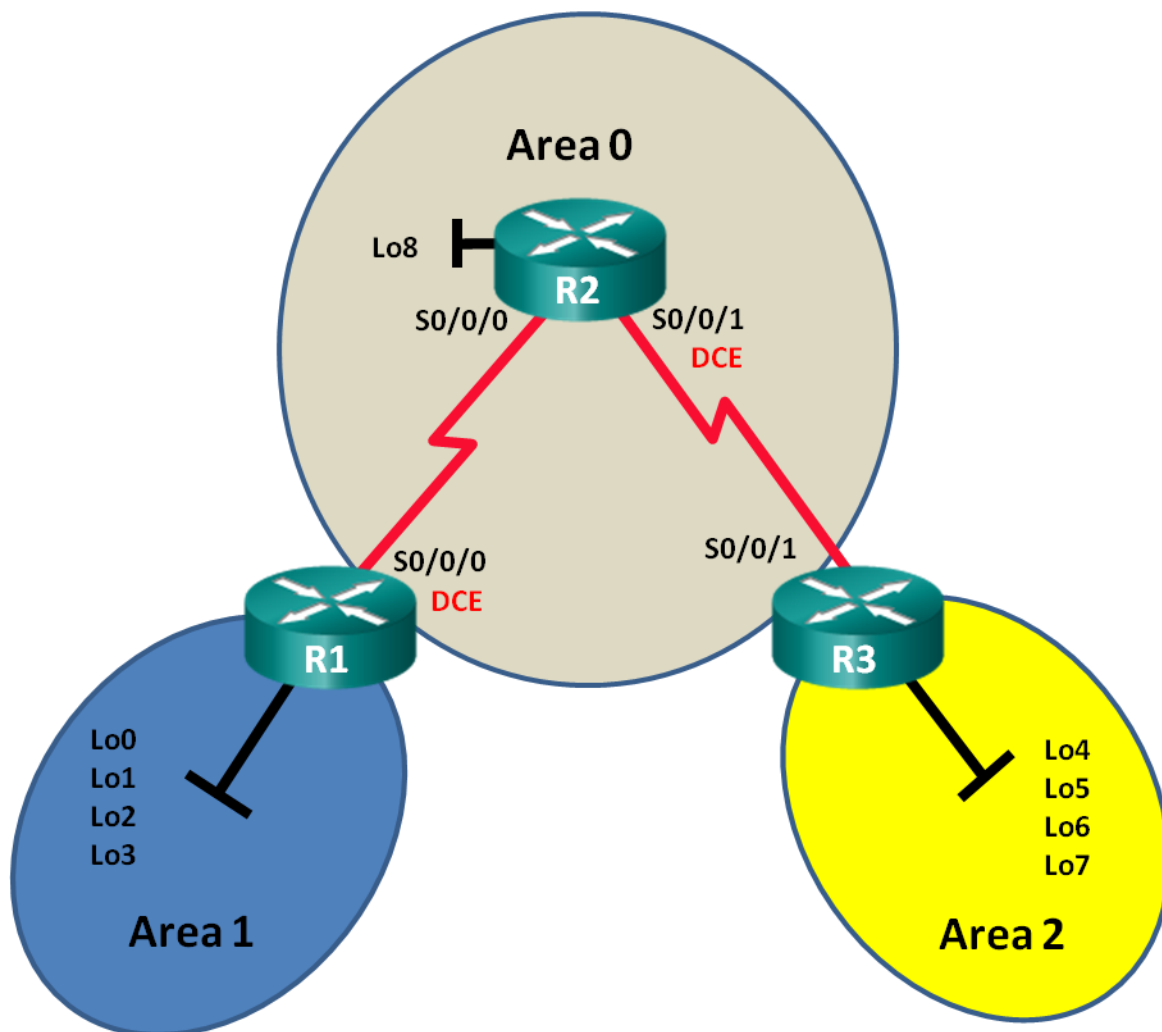


## Lab - Configuring Multiarea OSPFv3

### Topology



## Addressing Table

Device	Interface	IPv6 Address	Default Gateway
R1	S0/0/0 (DCE)	2001:DB8:ACAD:12::1/64 FE80::1 link-local	N/A
	Lo0	2001:DB8:ACAD::1/64	N/A
	Lo1	2001:DB8:ACAD:1::1/64	N/A
	Lo2	2001:DB8:ACAD:2::1/64	N/A
	Lo3	2001:DB8:ACAD:3::1/64	N/A
R2	S0/0/0	2001:DB8:ACAD:12::2/64 FE80::2 link-local	N/A
	S0/0/1 (DCE)	2001:DB8:ACAD:23::2/64 FE80::2 link-local	N/A
	Lo8	2001:DB8:ACAD:8::1/64	N/A
R3	S0/0/1	2001:DB8:ACAD:23::3/64 FE80::3 link-local	N/A
	Lo4	2001:DB8:ACAD:4::1/64	N/A
	Lo5	2001:DB8:ACAD:5::1/64	N/A
	Lo6	2001:DB8:ACAD:6::1/64	N/A
	Lo7	2001:DB8:ACAD:7::1/64	N/A

## Objectives

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

**Part 2: Configure Multiarea OSPFv3 Routing**

**Part 3: Configure Interarea Route Summarization**

## Background / Scenario

Using multiarea OSPFv3 in large IPv6 network deployments can reduce router processing by creating smaller routing tables and requiring less memory overhead. In multiarea OSPFv3, all areas are connected to the backbone area (area 0) through area border routers (ABRs).

In this lab, you will implement OSPFv3 routing for multiple areas and configure interarea route summarizations on the Area Border Routers (ABRs). You will also use a number of **show** commands to display and verify OSPFv3 routing information. This lab uses loopback addresses to simulate networks in multiple OSPFv3 areas.

**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 this 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)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- 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.

- Disable DNS lookup.
- Configure device name as shown in the topology.
- Assign **class** as the privileged EXEC password.
- Assign **cisco** as the vty password.
- Configure a MOTD banner to warn users that unauthorized access is prohibited.
- Configure **logging synchronous** for the console line.
- Encrypt plain text passwords.
- Configure the IPv6 unicast and link-local addresses listed in the Addressing Table for all interfaces.
- Enable IPv6 unicast routing on each router.
- Copy the running configuration to the startup configuration.

### Step 4: Test connectivity.

The routers should be able to ping one another. The routers are unable to ping distant loopbacks until OSPFv3 routing is configured. Verify and troubleshoot if necessary.

## Part 2: Configure Multiarea OSPFv3 Routing

In Part 2, you will configure OSPFv3 routing on all routers to separate the network domain into three distinct areas, and then verify that routing tables are updated correctly.

### Step 1: Assign router IDs.

- On R1, issue the **ipv6 router ospf** command to start an OSPFv3 process on the router.  

```
R1(config)# ipv6 router ospf 1
```

**Note:** The OSPF process ID is kept locally and has no meaning to other routers on the network.
- Assign the OSPFv3 router ID **1.1.1.1** to R1.  

```
R1(config-rtr)# router-id 1.1.1.1
```
- Assign a router ID of **2.2.2.2** to R2 and a router ID of **3.3.3.3** to R3.

- d. Issue the **show ipv6 ospf** command to verify the router IDs on all routers.

```
R2# show ipv6 ospf
Routing Process "ospfv3 1" with ID 2.2.2.2
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
Router is not originating router-LSAs with maximum metric
<output omitted>
```

### Step 2: Configure multiarea OSPFv3.

- a. Issue the **ipv6 ospf 1 area area-id** command for each interface on R1 that is to participate in OSPFv3 routing. The loopback interfaces are assigned to area 1 and the serial interface is assigned to area 0. You will change the network type on the loopback interfaces to ensure that the correct subnet is advertised.

```
R1(config)# interface lo0
R1(config-if)# ipv6 ospf 1 area 1
R1(config-if)# ipv6 ospf network point-to-point
R1(config-if)# interface lo1
R1(config-if)# ipv6 ospf 1 area 1
R1(config-if)# ipv6 ospf network point-to-point
R1(config-if)# interface lo2
R1(config-if)# ipv6 ospf 1 area 1
R1(config-if)# ipv6 ospf network point-to-point
R1(config-if)# interface lo3
R1(config-if)# ipv6 ospf 1 area 1
R1(config-if)# ipv6 ospf network point-to-point
R1(config-if)# interface s0/0/0
R1(config-if)# ipv6 ospf 1 area 0
```

- b. Use the **show ipv6 protocols** command to verify multiarea OSPFv3 status.

```
R1# show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 1"
  Router ID 1.1.1.1
  Area border router
  Number of areas: 2 normal, 0 stub, 0 nssa
  Interfaces (Area 0):
    Serial0/0/0
  Interfaces (Area 1):
    Loopback0
    Loopback1
    Loopback2
    Loopback3
  Redistribution:
    None
```

- c. Assign all interfaces on R2 to participate in OSPFv3 area 0. For the loopback interface, change the network type to point-to-point. Write the commands used in the space below.

- d. Use the **show ipv6 ospf interface brief** command to view OSPFv3 enabled interfaces.

```
R2# show ipv6 ospf interface brief
```

Interface	PID	Area	Intf ID	Cost	State	Nbrs	F/C
Lo8	1	0	13	1	P2P	0/0	
Se0/0/1	1	0	7	64	P2P	1/1	
Se0/0/0	1	0	6	64	P2P	1/1	

- e. Assign the loopback interfaces on R3 to participate in OSPFv3 area 2 and change the network type to point-to-point. Assign the serial interface to participate in OSPFv3 area 0. Write the commands used in the space below.

- f. Use the **show ipv6 ospf** command to verify configurations.

```
R3# show ipv6 ospf
```

```
Routing Process "ospfv3 1" with ID 3.3.3.3
```

```
Event-log enabled, Maximum number of events: 1000, Mode: cyclic
```

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

```
Router is not originating router-LSAs with maximum metric
```

```
Initial SPF schedule delay 5000 msec
```

```
Minimum hold time between two consecutive SPF's 10000 msec
```

```
Maximum wait time between two consecutive SPF's 10000 msec
```

```
Minimum LSA interval 5 secs
```

```
Minimum LSA arrival 1000 msec
```

```
LSA group pacing timer 240 secs
```

```
Interface flood pacing timer 33 msec
```

```
Retransmission pacing timer 66 msec
```

```
Number of external LSA 0. Checksum Sum 0x000000
```

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

```
Graceful restart helper support enabled
```

```
Reference bandwidth unit is 100 mbps
RFC1583 compatibility enabled
```

### Area BACKBONE (0)

```
Number of interfaces in this area is 1
SPF algorithm executed 2 times
Number of LSA 16. Checksum Sum 0x0929F8
Number of DCbitless LSA 0
Number of indication LSA 0
Number of DoNotAge LSA 0
Flood list length 0
```

### Area 2

```
Number of interfaces in this area is 4
SPF algorithm executed 2 times
Number of LSA 13. Checksum Sum 0x048E3C
Number of DCbitless LSA 0
Number of indication LSA 0
Number of DoNotAge LSA 0
Flood list length 0
```

## Step 3: Verify OSPFv3 neighbors and routing information.

- Issue the **show ipv6 ospf neighbor** command on all routers to verify that each router is listing the correct routers as neighbors.

```
R1# show ipv6 ospf neighbor
```

```
OSPFv3 Router with ID (1.1.1.1) (Process ID 1)
```

Neighbor ID	Pri	State	Dead Time	Interface ID	Interface
2.2.2.2	0	FULL/ -	00:00:39	6	Serial0/0/0

- Issue the **show ipv6 route ospf** command on all routers to verify that each router has learned routes to all networks in the Addressing Table.

```
R1# show ipv6 route ospf
```

```
IPv6 Routing Table - default - 16 entries
```

```
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
```

```
B - BGP, R - RIP, H - NHRP, I1 - ISIS L1
```

```
I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP
```

```
EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE - Destination
```

```
NDr - Redirect, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1
```

```
OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
```

```
OI 2001:DB8:ACAD:4::/64 [110/129]
```

```
via FE80::2, Serial0/0/0
```

```
OI 2001:DB8:ACAD:5::/64 [110/129]
```

```
via FE80::2, Serial0/0/0
```

```
OI 2001:DB8:ACAD:6::/64 [110/129]
```

```
via FE80::2, Serial0/0/0
```

```
OI 2001:DB8:ACAD:7::/64 [110/129]
```

```
via FE80::2, Serial0/0/0
```

```
O 2001:DB8:ACAD:8::/64 [110/65]
```

```
via FE80::2, Serial0/0/0
```

```
O 2001:DB8:ACAD:23::/64 [110/128]
```

```
via FE80::2, Serial0/0/0
```

What is the significance of an OI route?

- c. Issue the **show ipv6 ospf database** command on all routers.

```
R1# show ipv6 ospf database
```

```
OSPFv3 Router with ID (1.1.1.1) (Process ID 1)
```

### Router Link States (Area 0)

ADV Router	Age	Seq#	Fragment ID	Link count	Bits
1.1.1.1	908	0x80000001	0	1	B
2.2.2.2	898	0x80000003	0	2	None
3.3.3.3	899	0x80000001	0	1	B

### Inter Area Prefix Link States (Area 0)

ADV Router	Age	Seq#	Prefix
1.1.1.1	907	0x80000001	2001:DB8:ACAD::/62
3.3.3.3	898	0x80000001	2001:DB8:ACAD:4::/62

### Link (Type-8) Link States (Area 0)

ADV Router	Age	Seq#	Link ID	Interface
1.1.1.1	908	0x80000001	6	Se0/0/0
2.2.2.2	909	0x80000002	6	Se0/0/0

### Intra Area Prefix Link States (Area 0)

ADV Router	Age	Seq#	Link ID	Ref-lstyp	Ref-LSID
1.1.1.1	908	0x80000001	0	0x2001	0
2.2.2.2	898	0x80000003	0	0x2001	0
3.3.3.3	899	0x80000001	0	0x2001	0

### Router Link States (Area 1)

ADV Router	Age	Seq#	Fragment ID	Link count	Bits
1.1.1.1	908	0x80000001	0	0	B

### Inter Area Prefix Link States (Area 1)

ADV Router	Age	Seq#	Prefix
1.1.1.1	907	0x80000001	2001:DB8:ACAD:12::/64
1.1.1.1	907	0x80000001	2001:DB8:ACAD:8::/64
1.1.1.1	888	0x80000001	2001:DB8:ACAD:23::/64
1.1.1.1	888	0x80000001	2001:DB8:ACAD:4::/62

### Link (Type-8) Link States (Area 1)

ADV Router	Age	Seq#	Link ID	Interface
1.1.1.1	908	0x80000001	13	Lo0
1.1.1.1	908	0x80000001	14	Lo1
1.1.1.1	908	0x80000001	15	Lo2
1.1.1.1	908	0x80000001	16	Lo3

### Intra Area Prefix Link States (Area 1)

ADV Router	Age	Seq#	Link ID	Ref-lstype	Ref-LSID
1.1.1.1	908	0x80000001	0	0x2001	0

How many link state databases are found on R1?

How many link state databases are found on R2?

How many link state databases are found on R3?

## Part 3: Configure Interarea Route Summarization

In Part 3, you will manually configure interarea route summarization on the ABRs.

### Step 1: Summarize networks on R1.

- List the network addresses for the loopback interfaces and identify the hexet section where the addresses differ.

2001:DB8:ACAD:0000::1/64

2001:DB8:ACAD:0001::1/64

2001:DB8:ACAD:0002::1/64

2001:DB8:ACAD:0003::1/64

- Convert the differing section from hex to binary.

2001:DB8:ACAD: 0000 0000 0000 0000::1/64

2001:DB8:ACAD: 0000 0000 0000 0001::1/64

2001:DB8:ACAD: 0000 0000 0000 0010::1/64

2001:DB8:ACAD: 0000 0000 0000 0011::1/64

- Count the number of leftmost matching bits to determine the prefix for the summary route.

2001:DB8:ACAD: 0000 0000 0000 0000::1/64

2001:DB8:ACAD: 0000 0000 0000 0001::1/64

2001:DB8:ACAD: 0000 0000 0000 0010::1/64

2001:DB8:ACAD: 0000 0000 0000 0011::1/64

How many bits match?

- Copy the matching bits and then add zero bits to determine the summarized network address.

2001:DB8:ACAD: 0000 0000 0000 0000::0



- e. Convert the binary section back to hex.

**2001:DB8:ACAD::**

- f. Append the prefix of the summary route (result of Step 1c).

**2001:DB8:ACAD::/62**

### Step 2: Configure interarea route summarization on R1.

- a. To manually configure interarea route summarization on R1, use the **area area-id range address mask** command.

```
R1(config)# ipv6 router ospf 1
```

```
R1(config-rtr)# area 1 range 2001:DB8:ACAD::/62
```

- b. View the OSPFv3 routes on R3.

```
R3# show ipv6 route ospf
```

IPv6 Routing Table - default - 14 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, R - RIP, H - NHRP, I1 - ISIS L1

I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP

EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE - Destination

NDR - Redirect, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1

OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

**OI 2001:DB8:ACAD::/62 [110/129]**

**via FE80::2, Serial0/0/1**

O 2001:DB8:ACAD:8::/64 [110/65]

via FE80::2, Serial0/0/1

O 2001:DB8:ACAD:12::/64 [110/128]

via FE80::2, Serial0/0/1

Compare this output to the output from Part 2, Step 3b. How are the networks in area 1 now expressed in the routing table on R3?

- c. View the OSPFv3 routes on R1.

```
R1# show ipv6 route ospf
```

IPv6 Routing Table - default - 18 entries

Codes: C - Connected, L - Local, S - Static, U - Per-user Static route

B - BGP, R - RIP, H - NHRP, I1 - ISIS L1

I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP

EX - EIGRP external, ND - ND Default, NDp - ND Prefix, DCE - Destination

NDR - Redirect, O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1

OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2

**O 2001:DB8:ACAD::/62 [110/1]**

**via Null0, directly connected**

OI 2001:DB8:ACAD:4::/64 [110/129]

via FE80::2, Serial0/0/0

OI 2001:DB8:ACAD:5::/64 [110/129]

via FE80::2, Serial0/0/0

OI 2001:DB8:ACAD:6::/64 [110/129]

via FE80::2, Serial0/0/0

```
OI 2001:DB8:ACAD:7::/64 [110/129]
   via FE80::2, Serial0/0/0
O  2001:DB8:ACAD:8::/64 [110/65]
   via FE80::2, Serial0/0/0
O  2001:DB8:ACAD:23::/64 [110/128]
   via FE80::2, Serial0/0/0
```

Compare this output to the output from Part 2, Step 3b. How are the summarized networks expressed in the routing table on R1?

### Step 3: Summarize networks and configure interarea route summarization on R3.

- a. Summarize the loopback interfaces on R3.
  - 1) List the network addresses and identify the hextet section where the addresses differ.
  - 2) Convert the differing section from hex to binary.
  - 3) Count the number of left-most matching bits to determine the prefix for the summary route.
  - 4) Copy the matching bits and then add zero bits to determine the summarized network address.
  - 5) Convert the binary section back to hex.
  - 6) Append the prefix of the summary route.Write the summary address in the space provided.
- b. Manually configure interarea route summarization on R3. Write the commands in the space provided.
- c. Verify that area 2 routes are summarized on R1. What command was used?
- d. Record the routing table entry on R1 for the summarized route advertised from R3.

### Reflection

1. Why would multiarea OSPFv3 be used?
2. What is the benefit of configuring interarea route summarization?

## 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)
<p><b>Note:</b> 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.</p>				