Lab - Configuring Multiarea OSPFv2 (Instructor Version)

**Instructor Note**: Red font color or Gray highlights indicate text that appears in the instructor copy only.

1. Topology

1. 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 |

1. Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure a Multiarea OSPFv2 Network

Part 3: Configure Interarea Summary Routes

1. 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.

**Instructor Note**: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

1. 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
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.

* 1. Cable the network as shown in the topology.
	2. Initialize and reload the routers as necessary.
	3. Configure basic settings for each router.
		1. Disable DNS lookup.
		2. Configure device name, as shown in the topology.
		3. Assign **class** as the privileged EXEC password.
		4. Assign **cisco** as the console and vty passwords.
		5. Configure **logging synchronous** for the console line.
		6. Configure an MOTD banner to warn users that unauthorized access is prohibited.
		7. 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.
		8. Copy the running configuration to the startup configuration.
	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.

1. 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.

* 1. Identify the OSPF router types in the topology.

Identify the Backbone router(s): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ R1 and R2

Identify the Autonomous System Boundary Router(s) (ASBR): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ R1

Identify the Area Border Router(s) (ABR): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ R1 and R2

Identify the Internal router(s): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ R3

* 1. Configure OSPF on R1.
		1. Configure a router ID of 1.1.1.1 with OSPF process ID of 1.

R1(config)# **router ospf 1**

R1(config-router)# **router-id 1.1.1.1**

* + 1. 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**

* + 1. Set all LAN loopback interfaces, Lo1 and Lo2, as passive.

R1(config-router)# **passive-interface lo1**

R1(config-router)# **passive-interface lo2**

R1(config-router)# **exit**

* + 1. Create a default route to the Internet using exit interface Lo0.

R1(config)# **ip route 0.0.0.0 0.0.0.0 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.

* + 1. Configure OSPF to propagate the routes throughout the OSPF areas.

R1(config)# **router ospf 1**

R1(config-router)# **default-information originate**

* 1. Configure OSPF on R2.
		1. Configure a router ID of 2.2.2.2 with OSPF process ID of 1.

R2(config)# **router ospf 1**

R2(config-router)# **router-id 2.2.2.2**

* + 1. Add the networks for R2 to OSPF. Add the networks to the correct area. Write the commands used in the space below.

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R2(config-router)# **network 192.168.12.0 0.0.0.3 area 0**

R2(config-router)# **network 192.168.23.0 0.0.0.3 area 3**

R2(config-router)# **network 192.168.6.0 0.0.0.255 area 3**

* + 1. Set all LAN loopback interfaces as passive.

R2(config-router)# **passive-interface lo6**

* 1. Configure OSPF on R3.
		1. Configure a router ID of 3.3.3.3 with OSPF process ID of 1.

R3(config)# **router ospf 1**

R3(config-router)# **router-id 3.3.3.3**

* + 1. Add the networks for R3 to OSPF. Write the commands used in the space below.

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R3(config-router)# **network 192.168.23.0 0.0.0.3 area 3**

R3(config-router)# **network 192.168.4.0 0.0.0.255 area 3**

R3(config-router)# **network 192.168.5.0 0.0.0.255 area 3**

* + 1. Set all LAN loopback interfaces as passive.

R3(config-router)# **passive-interface lo4**

R3(config-router)# **passive-interface l05**

* 1. Verify that OSPF settings are correct and adjacencies have been established between routers.
		1. 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)

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: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

R1 - ABR and ASBR

R2 - ABR

R3 - No special OSPF router type

* + 1. 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

* + 1. 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

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

* 1. Configure MD5 authentication on all serial interfaces.

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

R1(config)# **interface s0/0/0**

R1(config-if)# **ip ospf message-digest-key 1 md5 Cisco123**

R1(config-if)# **ip ospf authentication message-digest**

R2(config)# **int s0/0/0**

R2(config-if)# **ip ospf message-digest-key 1 md5 Cisco123**

R2(config-if)# **ip ospf authentication message-digest**

R2(config-if)# **interface s0/0/1**

R2(config-if)# **ip ospf message-digest-key 1 md5 Cisco123**

R2(config-if)# **ip ospf authentication message-digest**

R3(config)# **interface s0/0/1**

R3(config-if)# **ip ospf message-digest-key 1 md5 Cisco123**

R3(config-if)# **ip ospf authentication message-digest**

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

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Troubleshooting OSPF problems is much easier if OSPF adjacencies have been established and verified before implementing authentication. You then know that your authentication implementation is flawed, as adjacencies do not re-establish.

* 1. 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.

1. 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.

* 1. Display the OSPF routing tables on all routers.
1. 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

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, Serial0/0/0

 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, Serial0/0/0

 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, Serial0/0/0

 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, Serial0/0/0

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

R2:

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O IA 192.168.1.1 [110/782] via 192.168.12.1, 00:25:22, Serial0/0/0

O IA 192.168.2.1 [110/782] via 192.168.12.1, 00:25:22, Serial0/0/0

R3:

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O IA 192.168.1.1 [110/1563] via 192.168.23.1, 00:30:41, Serial0/0/1

O IA 192.168.2.1 [110/1563] via 192.168.23.1, 00:30:41, Serial0/0/1

O IA 192.168.12.0 [110/1562] via 192.168.23.1, 01:40:46, Serial0/0/1

R2# **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

Gateway of last resort is 192.168.12.1 to network 0.0.0.0

O\*E2 0.0.0.0/0 [110/1] via 192.168.12.1, 00:25:22, Serial0/0/0

 192.168.1.0/32 is subnetted, 1 subnets

O IA 192.168.1.1 [110/782] via 192.168.12.1, 00:25:22, Serial0/0/0

 192.168.2.0/32 is subnetted, 1 subnets

O IA 192.168.2.1 [110/782] via 192.168.12.1, 00:25:22, Serial0/0/0

 192.168.4.0/32 is subnetted, 1 subnets

O 192.168.4.1 [110/782] via 192.168.23.2, 01:35:23, Serial0/0/1

 192.168.5.0/32 is subnetted, 1 subnets

O 192.168.5.1 [110/782] via 192.168.23.2, 01:35:23, Serial0/0/1

R3# **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

Gateway of last resort is 192.168.23.1 to network 0.0.0.0

O\*E2 0.0.0.0/0 [110/1] via 192.168.23.1, 00:30:36, Serial0/0/1

 192.168.1.0/32 is subnetted, 1 subnets

O IA 192.168.1.1 [110/1563] via 192.168.23.1, 00:30:41, Serial0/0/1

 192.168.2.0/32 is subnetted, 1 subnets

O IA 192.168.2.1 [110/1563] via 192.168.23.1, 00:30:41, Serial0/0/1

 192.168.12.0/30 is subnetted, 1 subnets

O 192.168.6.1 [110/782] via 192.168.23.1, 00:00:38, Serial0/0/1

 192.168.12.0/30 is subnetted, 1 subnets

O IA 192.168.12.0 [110/1562] via 192.168.23.1, 01:40:46, Serial0/0/1

* 1. Display the LSDB on all routers.
1. 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

 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

1. 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:

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Area 0 - 192.168.1.1, 192.168.2.1, 192.168.4.1, 192.168.5.1, 192.168.6.1, 192.168.23.0

Area 3 – 192.168.1.1, 192.168.2.1, 192.168.12.0

R3:

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Area 3 - 192.168.1.1, 192.168.2.1, 192.168.12.0

R2# **show ip ospf 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

1.1.1.1 1.1.1.1 1444 0x80000003 0x0039CD 2

2.2.2.2 2.2.2.2 1429 0x80000002 0x00D430 2

 Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.1.1 1.1.1.1 1535 0x80000002 0x00AC1F

192.168.2.1 1.1.1.1 1535 0x80000002 0x00A129

192.168.4.1 2.2.2.2 908 0x80000001 0x000DA8

192.168.5.1 2.2.2.2 898 0x80000001 0x0002B2

192.168.6.1 2.2.2.2 1410 0x80000001 0x00596A

192.168.23.0 2.2.2.2 1420 0x80000001 0x00297E

 Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 1212 0x80000003 0x00DE86 3

3.3.3.3 3.3.3.3 892 0x80000005 0x00DB05 4

 Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.1.1 2.2.2.2 1420 0x80000002 0x002C8B

192.168.2.1 2.2.2.2 1420 0x80000002 0x002195

192.168.12.0 2.2.2.2 1420 0x80000002 0x00A011

 Summary ASB Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

1.1.1.1 2.2.2.2 1420 0x80000002 0x00AC72

 Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

0.0.0.0 1.1.1.1 1492 0x80000001 0x001D91 1

R3# **show ip ospf database**

 OSPF Router with ID (3.3.3.3) (Process ID 1)

 Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 1251 0x80000003 0x00DE86 3

3.3.3.3 3.3.3.3 930 0x80000005 0x00DB05 4

 Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.1.1 2.2.2.2 1459 0x80000002 0x002C8B

192.168.2.1 2.2.2.2 1459 0x80000002 0x002195

192.168.12.0 2.2.2.2 1459 0x80000002 0x00A011

 Summary ASB Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

1.1.1.1 2.2.2.2 1459 0x80000002 0x00AC72

 Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

0.0.0.0 1.1.1.1 1531 0x80000001 0x001D91 1

* 1. Configure the interarea summary routes.
		1. Calculate the summary route for the networks in area 1.

Networks 192.168.1.0 and 192.168.2.0 can be summarized as 192.168.0.0/22.

* + 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**

* + 1. Calculate the summary route for the networks in area 3. Record your results.

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Networks 192.168.4.0, 192.168.5.0, and 192.168.6.0 can be summarized as 192.168.4.0/22.

* + 1. Configure the summary route for area 3 on R2. Write the commands you used in the space below.

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R2(config)# **router ospf 1**

R2(config-router)# **area 3 range 192.168.4.0 255.255.252.0**

* 1. 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:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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O IA 192.168.4.0/22 [110/782] via 192.168.12.2, 00:04:04, Serial0/0/0

O IA 192.168.23.0 [110/1562] via 192.168.12.2, 00:06:31, Serial0/0/0

R2:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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O IA 192.168.0.0/22 [110/782] via 192.168.12.1, 00:04:42, Serial0/0/0

O 192.168.4.0/22 is a summary, 00:04:42, Null0

R3:

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O IA 192.168.0.0/22 [110/1563] via 192.168.23.1, 00:08:01, Serial0/0/1

O IA 192.168.12.0 [110/1562] via 192.168.23.1, 00:53:17, Serial0/0/1

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

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

O 192.168.0.0/22 is a summary, 00:06:31, Null0

O IA 192.168.4.0/22 [110/782] via 192.168.12.2, 00:04:04, Serial0/0/0

 192.168.23.0/30 is subnetted, 1 subnets

O IA 192.168.23.0 [110/1562] via 192.168.12.2, 00:06:31, Serial0/0/0

R2# **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

Gateway of last resort is 192.168.12.1 to network 0.0.0.0

O\*E2 0.0.0.0/0 [110/1] via 192.168.12.1, 00:04:42, Serial0/0/0

O IA 192.168.0.0/22 [110/782] via 192.168.12.1, 00:04:42, Serial0/0/0

O 192.168.4.0/22 is a summary, 00:04:42, Null0

 192.168.4.0/32 is subnetted, 1 subnets

O 192.168.4.1 [110/782] via 192.168.23.2, 00:04:42, Serial0/0/1

 192.168.5.0/32 is subnetted, 1 subnets

O 192.168.5.1 [110/782] via 192.168.23.2, 00:04:42, Serial0/0/1

R3# **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

Gateway of last resort is 192.168.23.1 to network 0.0.0.0

O\*E2 0.0.0.0/0 [110/1] via 192.168.23.1, 00:53:17, Serial0/0/1

O IA 192.168.0.0/22 [110/1563] via 192.168.23.1, 00:08:01, Serial0/0/1

 192.168.6.0/32 is subnetted, 1 subnets

O 192.168.6.1 [110/782] via 192.168.23.1, 00:53:17, Serial0/0/1

 192.168.12.0/30 is subnetted, 1 subnets

O IA 192.168.12.0 [110/1562] via 192.168.23.1, 00:53:17, Serial0/0/1

* 1. 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:

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Area 0 - 192.168.0.0, 192.168.4.0, 192.168.23.0

Area 1 – 192.168.4.0, 192.168.12.0, 192.168.23.0

R2:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Area 0 - 192.168.0.0, 192.168.4.0, 192.168.23.0

Area 3 - 192.168.0.0, 192.168.12.0

R3:

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Area 3 - 192.168.0.0, 192.168.12.0

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 1452 0x80000006 0x0033D0 2

2.2.2.2 2.2.2.2 1451 0x80000005 0x00CE33 2

 Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.0.0 1.1.1.1 807 0x80000001 0x00B41D

192.168.4.0 2.2.2.2 660 0x80000001 0x006A5F

192.168.23.0 2.2.2.2 1753 0x80000002 0x00277F

 Router Link States (Area 1)

Link ID ADV Router Age Seq# Checksum Link count

1.1.1.1 1.1.1.1 1871 0x80000007 0x0092A5 2

 Summary Net Link States (Area 1)

Link ID ADV Router Age Seq# Checksum

192.168.4.0 1.1.1.1 659 0x80000001 0x002697

192.168.12.0 1.1.1.1 1871 0x80000002 0x00BEF6

192.168.23.0 1.1.1.1 1449 0x80000004 0x00DEB9

 Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

0.0.0.0 1.1.1.1 1871 0x80000002 0x001B92 1

R2# **show ip ospf 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

1.1.1.1 1.1.1.1 1467 0x80000006 0x0033D0 2

2.2.2.2 2.2.2.2 1464 0x80000005 0x00CE33 2

 Summary Net Link States (Area 0)

Link ID ADV Router Age Seq# Checksum

192.168.0.0 1.1.1.1 821 0x80000001 0x00B41D

192.168.4.0 2.2.2.2 673 0x80000001 0x006A5F

192.168.23.0 2.2.2.2 1766 0x80000002 0x00277F

 Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 1521 0x80000004 0x00DC87 3

3.3.3.3 3.3.3.3 1295 0x80000006 0x00D906 4

 Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.0.0 2.2.2.2 820 0x80000001 0x003489

192.168.12.0 2.2.2.2 1766 0x80000003 0x009E12

 Summary ASB Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

1.1.1.1 2.2.2.2 1766 0x80000003 0x00AA73

 Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

0.0.0.0 1.1.1.1 1886 0x80000002 0x001B92 1

R3# **show ip ospf database**

 OSPF Router with ID (3.3.3.3) (Process ID 1)

 Router Link States (Area 3)

Link ID ADV Router Age Seq# Checksum Link count

2.2.2.2 2.2.2.2 1548 0x80000004 0x00DC87 3

3.3.3.3 3.3.3.3 1320 0x80000006 0x00D906 4

 Summary Net Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

192.168.0.0 2.2.2.2 847 0x80000001 0x003489

192.168.12.0 2.2.2.2 1793 0x80000003 0x009E12

 Summary ASB Link States (Area 3)

Link ID ADV Router Age Seq# Checksum

1.1.1.1 2.2.2.2 1793 0x80000003 0x00AA73

 Type-5 AS External Link States

Link ID ADV Router Age Seq# Checksum Tag

0.0.0.0 1.1.1.1 1913 0x80000002 0x001B92 1

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

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A type-3 LSA or an interarea summary route.

* 1. 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.

1. Reflection

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

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1. Smaller routing tables. 2. Reduced link-state update overhead. 3. Reduced frequency of SPF calculations.

1. 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. |

1. Device Configs - Final
2. Router R1

R1# show run

Building configuration...

Current configuration : 2062 bytes

!

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname R1

!

boot-start-marker

boot-end-marker

!

enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2

!

no aaa new-model

memory-size iomem 15

!

ip cef

!

no ip domain lookup

no ipv6 cef

multilink bundle-name authenticated

!

interface Loopback0

 ip address 209.165.200.225 255.255.255.252

!

interface Loopback1

 ip address 192.168.1.1 255.255.255.0

!

interface Loopback2

 ip address 192.168.2.1 255.255.255.0

!

interface Embedded-Service-Engine0/0

 no ip address

 shutdown

!

interface GigabitEthernet0/0

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface GigabitEthernet0/1

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface Serial0/0/0

 bandwidth 128

 ip address 192.168.12.1 255.255.255.252

 ip ospf authentication message-digest

 ip ospf message-digest-key 1 md5 Cisco123

 clock rate 128000

!

interface Serial0/0/1

 no ip address

 shutdown

!

router ospf 1

 router-id 1.1.1.1

 area 1 range 192.168.0.0 255.255.252.0

 passive-interface Loopback1

 passive-interface Loopback2

 network 192.168.1.0 0.0.0.255 area 1

 network 192.168.2.0 0.0.0.255 area 1

 network 192.168.12.0 0.0.0.3 area 0

 default-information originate

!

ip forward-protocol nd

!

no ip http server

no ip http secure-server

!

ip route 0.0.0.0 0.0.0.0 Loopback0

!

control-plane

!

!

banner motd @

 Unauthorized Access is Prohibited! @

!

line con 0

 password cisco

 logging synchronous

 login

line aux 0

line 2

 no activation-character

 no exec

 transport preferred none

 transport input all

 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh

 stopbits 1

line vty 0 4

 password cisco

 login

 transport input all

!

scheduler allocate 20000 1000

!

end

1. Router R2

R2# show run

Building configuration...

Current configuration : 1905 bytes

!

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname R2

!

boot-start-marker

boot-end-marker

!

enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2

!

no aaa new-model

memory-size iomem 15

!

ip cef

!

no ip domain lookup

no ipv6 cef

multilink bundle-name authenticated

!

interface Loopback6

 ip address 192.168.6.1 255.255.255.0

!

interface Embedded-Service-Engine0/0

 no ip address

 shutdown

!

interface GigabitEthernet0/0

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface GigabitEthernet0/1

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface Serial0/0/0

 bandwidth 128

 ip address 192.168.12.2 255.255.255.252

 ip ospf authentication message-digest

 ip ospf message-digest-key 1 md5 Cisco123

!

interface Serial0/0/1

 bandwidth 128

 ip address 192.168.23.1 255.255.255.252

 ip ospf authentication message-digest

 ip ospf message-digest-key 1 md5 Cisco123

clock rate 128000

!

router ospf 1

 router-id 2.2.2.2

 area 3 range 192.168.4.0 255.255.252.0

 passive-interface Loopback6

 network 192.168.6.0 0.0.0.255 area 3

 network 192.168.12.0 0.0.0.3 area 0

 network 192.168.23.0 0.0.0.3 area 3

!

ip forward-protocol nd

!

no ip http server

no ip http secure-server

!

control-plane

!

banner motd @

 Unauthorized Access is Prohibited! @

!

line con 0

 password cisco

 logging synchronous

 login

line aux 0

line 2

 no activation-character

 no exec

 transport preferred none

 transport input all

 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh

 stopbits 1

line vty 0 4

 password cisco

 login

 transport input all

!

scheduler allocate 20000 1000

!

end

1. Router R3

R3# show run

Building configuration...

Current configuration : 1958 bytes

!

version 15.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname R3

!

boot-start-marker

boot-end-marker

!

enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2

!

no aaa new-model

memory-size iomem 15

!

ip cef

!

no ip domain lookup

no ipv6 cef

!

multilink bundle-name authenticated

!

interface Loopback4

 ip address 192.168.4.1 255.255.255.0

!

interface Loopback5

 ip address 192.168.5.1 255.255.255.0

!

interface Embedded-Service-Engine0/0

 no ip address

 shutdown

!

interface GigabitEthernet0/0

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface GigabitEthernet0/1

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface Serial0/0/0

 no ip address

 shutdown

 clock rate 2000000

!

interface Serial0/0/1

 bandwidth 128

 ip address 192.168.23.2 255.255.255.252

 ip ospf authentication message-digest

 ip ospf message-digest-key 1 md5 Cisco123

!

router ospf 1

 router-id 3.3.3.3

 passive-interface Loopback4

 passive-interface Loopback5

 network 192.168.4.0 0.0.0.255 area 3

 network 192.168.5.0 0.0.0.255 area 3

 network 192.168.23.0 0.0.0.3 area 3

!

ip forward-protocol nd

!

no ip http server

no ip http secure-server

!

control-plane

!

banner motd @

 Unauthorized Access is Prohibited! @

!

line con 0

 password cisco

 logging synchronous

 login

line aux 0

line 2

 no activation-character

 no exec

 transport preferred none

 transport input all

 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh

 stopbits 1

line vty 0 4

 password cisco

 login

 transport input all

!

scheduler allocate 20000 1000

!

end