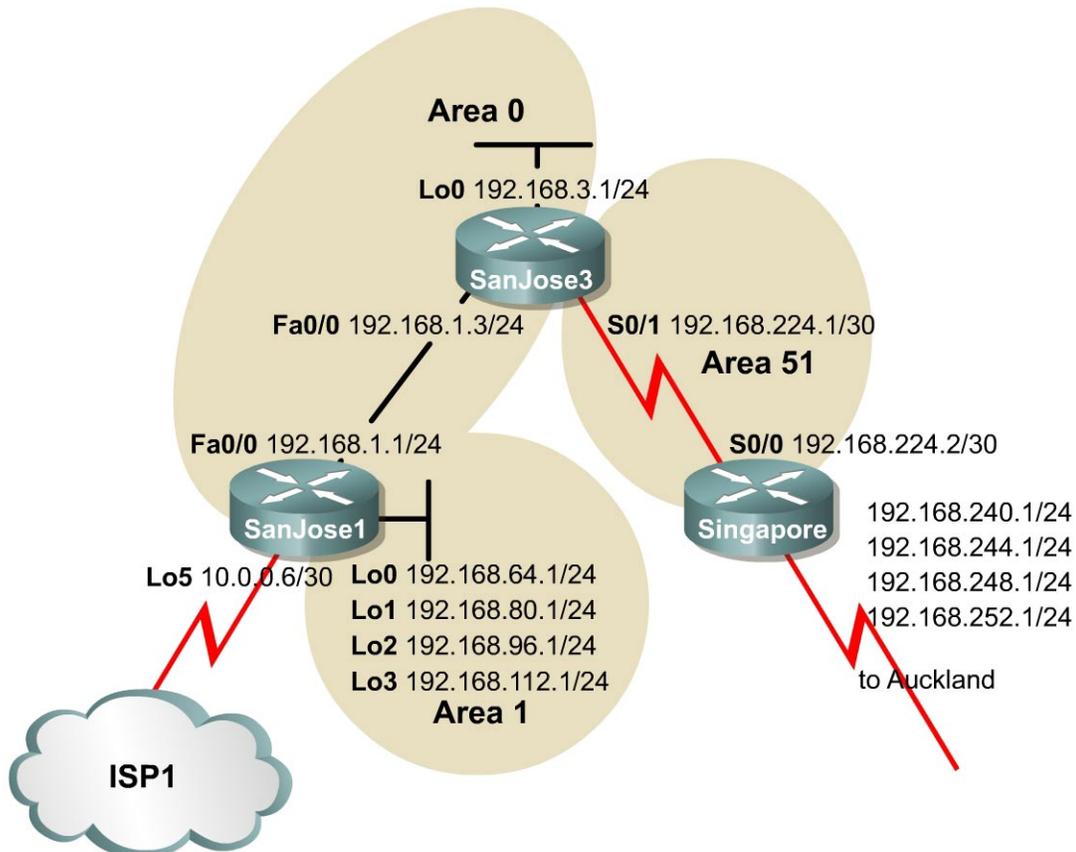


## Lab 6.9.3 Configuring Multiarea OSPF



### Objective

In this lab configure a multiarea OSPF operation, interarea summarization, external route summarization, and default routing.

### Scenario

International Travel Agency (ITA) maintains a complex OSPF environment. The task is to optimize OSPF routing, which creates the need to design and configure multiarea OSPF on the key routers connecting Asian regional headquarters to San Jose corporate headquarters and its local sites.

### Step 1

Build and configure the network according to the diagram, but do not configure a routing protocol yet.

**Note:** Ignore the ISP1 cloud for now. Also, the Singapore-to-Auckland networks 192.168.240.0/24, 192.168.244.0/24, 192.168.248.0/24, and 192.168.252.0/24 will be configured as static routes to Null0 in Steps 5 and 6, so should be deferred until then.

Configure each router with the loopback address indicated in the diagram. Be sure to configure SanJose1 with additional loopbacks of Lo0, Lo1, Lo2, and Lo3. These loopback interfaces simulate the serial links to local San Jose sites: Westasman, Baypointe, Vista, and Eastasman.

Use **ping** to test connectivity between all interfaces. Each router should be able to ping its link partner.

## Step 2

Configure multiarea OSPF. On SanJose1, configure FastEthernet 0/0 as a member of Area 0 and all other interfaces as members of Area 1 by using the following commands:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#network 192.168.1.0 0.0.0.255 area 0
SanJose1(config-router)#network 192.168.64.0 0.0.63.255 area 1
```

The last command conveniently enables all loopback interfaces on SanJose1 to participate in the OSPF process.

On SanJose3, configure E0 and Lo0 as members of Area 0, but configure Serial 0/0 as part of Area 51 as follows:

```
SanJose3(config)#router ospf 1
SanJose3(config-router)#network 192.168.1.0 0.0.0.255 area 0
SanJose3(config-router)#network 192.168.224.0 0.0.0.3 area 51
SanJose3(config-router)#network 192.168.3.0 0.0.0.255 area 0
```

Finally, on Singapore, configure Serial 0/0 to belong to Area 51 as follows:

```
Singapore(config)#router ospf 1
Singapore(config-router)#network 192.168.224.0 0.0.0.3 area 51
```

Issue the **show ip ospf** command as follows on all three routers:

```
SanJose3#show ip ospf
Routing Process "ospf 1" with ID 192.168.3.1
Supports only single TOS(TOS0) routes
It is an area border router
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x0
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 2
    Area has no authentication
    SPF algorithm executed 6 times
    Area ranges are
    Number of LSA 8. Checksum Sum 0x42B0C
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
  Area 51
    Number of interfaces in this area is 1
    Area has no authentication
    SPF algorithm executed 4 times
    Area ranges are
    Number of LSA 8. Checksum Sum 0x59B4F
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

1. According to the output of the `show ip ospf` command, which of these routers is an ABR?
- 

Area border routers connect one or more adjacent OSPF areas to the backbone area.

2. Are there any ASBRs?
- 

Autonomous system border routers connect external, non-OSPF, networks to the OSPF internetwork.

Issue the `show ip ospf neighbor detail` command on SanJose3:

```
SanJose3#show ip ospf neighbor detail
Neighbor 192.168.112.1, interface address 192.168.1.1
  In the area 0 via interface FastEthernet0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 192.168.1.1 BDR is 192.168.1.3
  Options 2
  Dead timer due in 00:00:33
  Index 1/1, retransmission queue length 0, number of retransmission 2
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
Neighbor 192.168.252.1, interface address 192.168.224.2
  In the area 51 via interface Serial0/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 0.0.0.0 BDR is 0.0.0.0
  Options 2
  Dead timer due in 00:00:32
  Index 1/2, retransmission queue length 0, number of retransmission 1
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 1, maximum is 1
  Last retransmission scan time is 0 msec, maximum is 0 msec
```

3. Is there a DR election on the 192.168.1.0/24 network? Why or why not?
- 
- 

4. Is there a DR election on the 192.168.224.0/30 network? Why or why not?
- 
- 

These are different types of OSPF networks. The Ethernet core network is designated as “broadcast”, and the WAN link between SanJose3 and Singapore is designated “point-to-point”. On a point-to-point link, there is no need to elect a DR to reduce the number of adjacencies, because only two routers exist in the network. The Ethernet segment has only two routers. However, a DR and BDR are elected because neighbor routers could join the area.

### Step 3

Check the routing table on each router. The output should show OSPF inter-area routes, which are denoted by an O and other routes denoted by an IA.

```
Singapore#show ip route
Codes: C - connected, S - static, I - IGRP, 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
 192.168.224.0/30 is subnetted, 1 subnets
C    192.168.224.0 is directly connected, Serial0/0
 192.168.64.0/32 is subnetted, 1 subnets
O IA 192.168.64.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
 192.168.80.0/32 is subnetted, 1 subnets
O IA 192.168.80.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
 192.168.96.0/32 is subnetted, 1 subnets
O IA 192.168.96.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
 192.168.112.0/32 is subnetted, 1 subnets
O IA 192.168.112.1 [110/783] via 192.168.224.1, 00:00:28, Serial0/0
O IA 192.168.1.0/24 [110/782] via 192.168.224.1, 00:01:31, Serial0/0
 192.168.3.0/32 is subnetted, 1 subnets
O IA 192.168.3.1 [110/782] via 192.168.224.1, 00:01:31, Serial0/0
```

5. What does IA stand for?

---

Check the codes listed with the routing table. Interarea routes point to networks in separate areas within the same OSPF autonomous system.

Verify that the routing tables are complete. Notice that SanJose1's loopback interfaces appear in the other routing tables of other routers that have a 32-bit mask. Any route with a 32-bit mask is called a 'host route', because it is a route to a host, not to a network. OSPF does not advertise loopback interfaces as if they were connected to a network.

6. How many host routes are in Singapore's table?

---

There should be a host route for every remote loopback advertised through OSPF.

Verify connectivity. From Singapore, ping SanJose3's Lo0 interface (192.168.3.1) and SanJose1's Lo2 interface (192.168.96.1).

### Step 4

To reduce routing table entries it is necessary to implement interarea route summarization throughout the internetwork. Start by configuring SanJose1 to summarize the networks for Area 1 and advertise this summary route to Area 0.

On SanJose1, enter the following commands to perform interarea summarization:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#area 1 range 192.168.64.0 255.255.192.0
```

When finished configuring the summary address, check the routing tables of SanJose3 and Singapore. If the expected changes do not occur, save and reload the routers.

```
Singapore#show ip route

<output omitted>

      192.168.224.0/30 is subnetted, 1 subnets
C       192.168.224.0 is directly connected, Serial0/0
O IA   192.168.1.0/24 [110/782] via 192.168.224.1, 00:01:38, Serial0/0
      192.168.3.0/32 is subnetted, 1 subnets
O IA   192.168.3.1 [110/782] via 192.168.224.1, 00:01:38, Serial0/0
O IA   192.168.64.0/18 [110/783] via 192.168.224.1, 00:00:02, Serial0/0
```

7. What happened to the host routes?

---

---

How many host routes does Singapore have?

---

8. Singapore should still be able to ping 192.168.96.1. Why?

---

9. What is the destination IP network of the ICMP request?

---

Singapore should have only one host route of 192.168.3.1/32 from SanJose3 Lo0. A host route points to one host. A network route points to multiple hosts in one broadcast domain. A summarized route points to a numerically contiguous series of networks.

## Step 5

Singapore must be configured to redistribute external routes from Auckland into the OSPF autonomous system. For the purposes of this lab, simulate the Auckland connection by configuring a static route in Singapore to the Auckland LAN (192.168.248.0/24). Use the following commands:

```
Singapore(config)#ip route 192.168.248.0 255.255.255.0 null0
Singapore(config)#router ospf 1
Singapore(config-router)#redistribute static
```

Because the route to 192.168.248.0/24 is imaginary, null0 is used as the exit interface. The **redistribute** command imports the static route into OSPF. Routes originated from anything but OSPF are considered external to the OSPF database. By default, when Singapore redistributes into Area 51, it creates and advertises Type 2 (E2) external routes using Type 5 LSAs.

The use of static routes to a null interface is a commonly used routing trick. Typically this technique is used to initialize or advertise a supernet route so that packets destined to an unknown subnet of a classful network are forwarded to 'this' router for handling. This technique is particularly useful when configuring Border Gateway Protocol (BGP).

Issue the `show ip ospf` command on Singapore.

10. According to the output of this command, what type of OSPF router is Singapore?

---

```
Singapore#show ip ospf
Routing Process "ospf 1" with ID 192.168.252.1
Supports only single TOS(TOS0) routes
It is an autonomous system boundary router
Redistributing External Routes from,
    static
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 1. Checksum Sum 0x8650
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 1. 1 normal 0 stub 0 nssa
External flood list length 0
  Area 51
    Number of interfaces in this area is 1
    Area has no authentication
    SPF algorithm executed 4 times
    Area ranges are
    Number of LSA 5. Checksum Sum 0x3A27A
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

Recall that ASBRs connect external networks to the OSPF autonomous system.

Now check the routing table of SanJose1. The routing table should have an E2 route to 192.168.248.0/24.

```
SanJose1#show ip route
<output omitted>
    192.168.224.0/30 is subnetted, 1 subnets
O IA   192.168.224.0 [110/782] via 192.168.1.3, 00:04:39, FastEthernet0/0
    192.168.64.0/30 is subnetted, 1 subnets
C      192.168.64.0 is directly connected, Loopback0
    192.168.80.0/30 is subnetted, 1 subnets
C      192.168.80.0 is directly connected, Loopback1
    192.168.96.0/30 is subnetted, 1 subnets
C      192.168.96.0 is directly connected, Loopback2
O E2 192.168.248.0/24 [110/20] via 192.168.1.3, 00:03:57, FastEthernet0/0
    192.168.112.0/30 is subnetted, 1 subnets
C      192.168.112.0 is directly connected, Loopback3
C      192.168.1.0/24 is directly connected, FastEthernet0/0
    192.168.3.0/32 is subnetted, 1 subnets
O      192.168.3.1 [110/2] via 192.168.1.3, 00:08:08, FastEthernet0/0
```

11. What is the metric, or OSPF cost, of this route?

---

Check the routing table of SanJose3. This router should also have the external route.

12. What is the metric of SanJose3's route to 192.168.248.0/24?

---

SanJose1 and SanJose3 should have the same cost. This might be surprising, because SanJose1 has an additional network to traverse.

A second link to the external network is about to come online. If the network is designed so that OSPF routers can have multiple external routes to the same destination, consider using Type 1 (E1) external routes. Type 2 (E2) external routes have static metrics throughout the OSPF autonomous system (AS). Type 1 routes consider metrics internal and external to the AS for accurate route selection when multiple external routes exist. The decision is made that Singapore should advertise external routes as Type 1 (E1). To configure Type 1, use the following commands on Singapore:

```
Singapore(config)#router ospf 1
Singapore(config-router)#redistribute static metric-type 1
```

After reconfiguring Singapore, check SanJose3's table again. SanJose3's route to 192.168.248.0/24 should now be Serial 0/1.

13. What is the metric of this route?

---

Check SanJose1's route to 192.168.248.0/24.

14. What is the metric of Singapore's route?

---

Typically, the cost of a route increases with every hop. Type2 (E2) routes ignore internal OSPF metrics. Type1 (E1) routes accumulate costs while being produced through the OSPF AS. With one exit point for the AS, Type2 (E2) routes might be adequate.

## Step 6

Over time, notice that as the Auckland office grows, many more Type 1, or FastEthernet 0/1, networks are propagated through the internetwork. To optimize the internetwork by reducing the routing table size, implement Classless Interdomain Routing (CIDR) to advertise all Auckland networks with one route. Create routes to these Auckland networks with three more static routes as follows:

```
Singapore(config)#ip route 192.168.240.0 255.255.255.0 null0
Singapore(config)#ip route 192.168.244.0 255.255.255.0 null0
Singapore(config)#ip route 192.168.252.0 255.255.255.0 null0
```

Configure Singapore to advertise all Auckland networks with a summary route:

```
Singapore(config)#router ospf 1
Singapore(config-router)#summary-address 192.168.240.0 255.255.240.0
```

After configuring the summary, check the routing tables on SanJose1 and SanJose3. Both routers should receive and install the supernet route, 192.168.240.0/20.

**Note:** On routers with very large routing tables the command `show ip route supernet` will show only aggregate routes.

```
SanJose3#show ip route
<output omitted>
 192.168.224.0/30 is subnetted, 1 subnets
C    192.168.224.0 is directly connected, Serial0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.3.0/24 is directly connected, Loopback0
O E1 192.168.240.0/20 [110/801] via 192.168.224.2, 00:00:05, Serial0/1
O IA 192.168.64.0/18 [110/2] via 192.168.1.1, 00:05:36, FastEthernet0/0
```

```
SanJose1#show ip route supernet
<output omitted>
O E1 192.168.240.0/20 [110/802] via 192.168.1.3, 00:01:08, FastEthernet0/0
```

15. Is 192.168.248.0/24 still in SanJose1 or SanJose3's routing table?

---

It should not be present because 192.168.248.0/24 is included in the range 192.168.240.0/20.

Internet connectivity is by way of ISP1 through SanJose1. The link is not active yet, but OSPF is configured in advance. Simulate the link with a loopback interface as follows:

```
SanJose1(config)#interface lo5
SanJose1(config-if)#ip address 10.0.0.6 255.255.255.252
```

Use the following commands to create and advertise a default route on SanJose1:

```
SanJose1(config)#router ospf 1
SanJose1(config-router)#default-information originate always
```

The **always** keyword instructs OSPF to advertise the default route whether or not the router has one in the routing table. In this case, the router will install a gateway of last resort as displayed in the output. Check the routing tables on SanJose3 and Singapore. Both should now have a default route of 0.0.0.0/0.

```
SanJose3#show ip route
<output omitted>
Gateway of last resort is 192.168.1.1 to network 0.0.0.0
 192.168.224.0/30 is subnetted, 1 subnets
C    192.168.224.0 is directly connected, Serial0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
C    192.168.3.0/24 is directly connected, Loopback0
O*E2 0.0.0.0/0 [110/1] via 192.168.1.1, 00:00:09, FastEthernet0/0
O E1 192.168.240.0/20 [110/801] via 192.168.224.2, 00:00:09, Serial0/1
O IA 192.168.64.0/18 [110/2] via 192.168.1.1, 00:00:09, FastEthernet0/0
```

16. What type of OSPF route is the default?

---

17. What is the metric of this route on SanJose3?

---

18. What is the metric of this route on Singapore?

---

The default route is considered External Type2 (E2). The default cost of one (1) will be retained throughout the autonomous system.

Verify that default routing is working by asking Singapore to ping a host that is not represented in its routing table. From Singapore, ping 10.0.0.6. If the default route is working, Singapore should receive replies. Troubleshoot, if necessary.

Save these configuration files for each router.