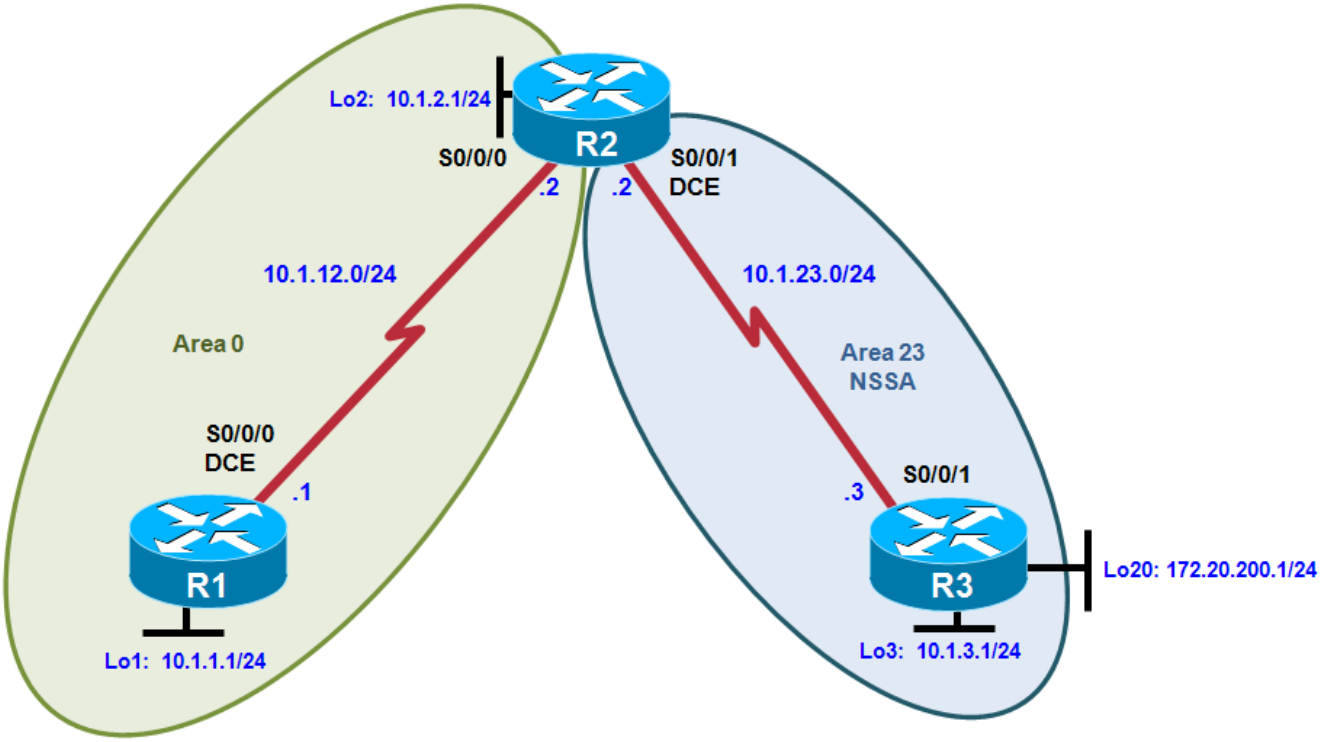
Chapter 3 Lab 3-2, Multi-Area OSPF with Stub Areas and Authentication

Topology



Objectives

- Configure multiple-area OSPF on a router.
- Verify multiple-area behavior.
- Configure OSPF stub, totally stubby, and not-so-stubby areas.
- Configure OSPF authentication.

Background

You are responsible for configuring the new network to connect your company's engineering, marketing, and accounting departments, represented by loopback interfaces on each of the three routers. The physical devices have just been installed and connected by serial cables. Configure multiple-area OSPF to allow full connectivity between all departments.

R3 also has a loopback representing a connection to another autonomous system that is not part of OSPF.

Note: This lab uses Cisco 1841 routers with Cisco IOS Release 12.4(24)T1 and the Advanced IP Services image c1841-advipservicesk9-mz.124-24.T1.bin. You can use other routers (such as a 2801 or 2811) and Cisco IOS Software versions if they have comparable capabilities and features. Depending on the router

model and Cisco IOS Software version, the commands available and output produced might vary from what is shown in this lab.

Required Resources

- 3 routers (Cisco 1841 with Cisco IOS Release 12.4(24)T1 Advanced IP Services or comparable)
- Serial and console cables

Step 1: Configure addressing and loopbacks.

a. Using the addressing scheme in the diagram, apply IP addresses to the serial interfaces on R1, R2, and R3. Create loopbacks on R1, R2, and R3, and address them according to the diagram.

Note: Depending on the router models you have, you might need to add clock rates to the DCE end of each connection (newer equipment adds this automatically). Verify connectivity across each serial link.

```
R1# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# interface loopback 1
R1(config-if)# description Engineering Department
R1(config-if)# ip address 10.1.1.1 255.255.255.0
R1(config-if)# interface serial 0/0/0
R1(config-if)# ip address 10.1.12.1 255.255.255.0
R1(config-if)# clockrate 64000
R1(config-if)# no shutdown

R2# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# interface loopback 2
R2(config-if)# description Marketing Department
R2(config-if)# ip address 10.1.2.1 255.255.255.0
R2(config-if)# interface serial 0/0/0
R2(config-if)# ip address 10.1.12.2 255.255.255.0
R2(config-if)# no shutdown
R2(config-if)# interface serial 0/0/1
R2(config-if)# ip address 10.1.23.2 255.255.255.0
R2(config-if)# clockrate 64000
R2(config-if)# no shutdown

R3# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# interface loopback 3
R3(config-if)# description Accounting Department
R3(config-if)# ip address 10.1.3.1 255.255.255.0
R3(config-if)# interface loopback 20
R3(config-if)# description Connection to another AS
R3(config-if)# ip address 172.20.200.1 255.255.255.0
R3(config-if)# interface serial 0/0/1
R3(config-if)# ip address 10.1.23.3 255.255.255.0
R3(config-if)# no shutdown
```

Step 2: Add interfaces into OSPF.

a. Create OSPF process 1 on routers R1 and R2. Configure the subnet of the serial link between R1 and R2 to be in OSPF area 0 using the **network** command. Add loopback 1 on R1 and loopback 2 on R2 into OSPF area 0. Change the network type on the loopback interfaces so that they are advertised with the correct subnet.


```
R1(config)# router ospf 1
R1(config-router)# network 10.1.12.0 0.0.0.255 area 0
R1(config-router)# network 10.1.1.0 0.0.0.255 area 0
R1(config-router)# exit
R1(config)# interface loopback 1
R1(config-if)# ip ospf network point-to-point

R2(config)# router ospf 1
R2(config-router)# network 10.1.12.0 0.0.0.255 area 0
R2(config-router)# network 10.1.2.0 0.0.0.255 area 0
R2(config-router)# exit
R2(config)# interface loopback 2
R2(config-if)# ip ospf network point-to-point
```

Note: Another option for adding individual directly connected networks into the OSPF process is to use the **ip ospf** *process-id* **area** *area-id* interface command that is available with Cisco IOS version 12.3(11)T and later.

b. Verify that both routers have OSPF neighbors using the **show ip ospf neighbors** command.

```
R1# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.1.2.1          0   FULL/  -        00:00:38    10.1.12.2       Serial0/0/0

R2# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.1.1.1          0   FULL/  -        00:00:35    10.1.12.1       Serial0/0/0
```

c. Verify that the routers can see each other's loopback with the **show ip route** command.

```
R1# show ip route
Codes: 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

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 3 subnets
C       10.1.12.0 is directly connected, Serial0/0/0
O       10.1.2.0 [110/65] via 10.1.12.2, 00:00:10, Serial0/0/0
C       10.1.1.0 is directly connected, Loopback1

R2# show ip route
Codes: 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

Gateway of last resort is not set
```

```
     10.0.0.0/24 is subnetted, 4 subnets
C       10.1.12.0 is directly connected, Serial0/0/0
C       10.1.2.0 is directly connected, Loopback2
O       10.1.1.0 [110/65] via 10.1.12.1, 00:00:30, Serial0/0/0
C       10.1.23.0 is directly connected, Serial0/0/1
```

d. Add the subnet between R2 and R3 into OSPF area 23 using the **network** command. Add loopback 3 on R3 into area 23.

```
R2(config)# router ospf 1
R2(config-router)# network 10.1.23.0 0.0.0.255 area 23

R3(config)# router ospf 1
R3(config-router)# network 10.1.23.0 0.0.0.255 area 23
R3(config-router)# network 10.1.3.0 0.0.0.255 area 23
R3(config-router)# exit
R3(config)# interface loopback 3
R3(config-if)# ip ospf network point-to-point
```

e. Verify that this neighbor relationship comes up using the **show ip ospf neighbors** command.

```
R2# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.1.1.1          0   FULL/  -        00:00:36    10.1.12.1       Serial0/0/0
10.1.3.1          0   FULL/  -        00:00:36    10.1.23.3       Serial0/0/1
```

f. If you look at the output of the **show ip route** command on R1, you see a route to the R3 loopback. Notice that it is identified as an inter-area route.

```
R1# show ip route
Codes: 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

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 5 subnets
C       10.1.12.0 is directly connected, Serial0/0/0
O IA    10.1.3.0 [110/129] via 10.1.12.2, 00:00:28, Serial0/0/0
O       10.1.2.0 [110/65] via 10.1.12.2, 00:01:38, Serial0/0/0
C       10.1.1.0 is directly connected, Loopback1
O IA    10.1.23.0 [110/128] via 10.1.12.2, 00:01:38, Serial0/0/0
```

g. Issue the **show ip route** command on R2. Notice that R2 has no inter-area routes because R2 is in both areas. It is an ABR, or area border router.

```
R2# show ip route
Codes: 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

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 5 subnets
C       10.1.12.0 is directly connected, Serial0/0/0
O       10.1.3.0 [110/65] via 10.1.23.3, 00:00:50, Serial0/0/1
C       10.1.2.0 is directly connected, Loopback2
O       10.1.1.0 [110/65] via 10.1.12.1, 00:02:00, Serial0/0/0
C       10.1.23.0 is directly connected, Serial0/0/1
```

h. Using a Tcl script, verify connectivity to all interfaces from any router, with the exception of loopback 20 on R3 (172.20.200.1), which has not yet been configured as part of OSPF.

i. Use the following Tcl script to verify that you can ping all addresses in the topology.

```
R1# tclsh
R1(tcl)#

foreach address {
10.1.1.1
10.1.2.1
10.1.3.1
10.1.12.1
10.1.12.2
10.1.23.2
10.1.23.3
172.20.200.1
} {
ping $address }
```

Step 3: Configure a stub area.

a. Under the OSPF process on R2 and R3, make area 23 the stub area using the **area** *area* **stub** command. The adjacency between the two routers might go down during the transition period, but it should come back up afterwards.

```
R2(config)# router ospf 1
R2(config-router)# area 23 stub

R3(config)# router ospf 1
R3(config-router)# area 23 stub
```

b. Confirm that it comes up by using the **show ip ospf neighbors** command.

```
R2# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.1.1.1          0   FULL/  -        00:00:36    10.1.12.1       Serial0/0/0
10.1.3.1          0   FULL/  -        00:00:36    10.1.23.3       Serial0/0/1

R3# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.1.2.1          0   FULL/  -        00:00:31    10.1.23.2       Serial0/0/1
```

c. Using the **show ip route** command, you can see that R3 now has a default route pointing toward R2. A stub area does not receive any external routes. It receives a default route and OSPF inter-area routes.

```
R3# show ip route
Codes: 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

Gateway of last resort is 10.1.23.2 to network 0.0.0.0

     172.20.0.0/24 is subnetted, 1 subnets
C       172.20.200.0 is directly connected, Loopback20
     10.0.0.0/24 is subnetted, 5 subnets
O IA    10.1.12.0 [110/128] via 10.1.23.2, 00:00:56, Serial0/0/1
C       10.1.3.0 is directly connected, Loopback3
O IA    10.1.2.0 [110/65] via 10.1.23.2, 00:00:56, Serial0/0/1
O IA    10.1.1.0 [110/129] via 10.1.23.2, 00:00:56, Serial0/0/1
C       10.1.23.0 is directly connected, Serial0/0/1
O*IA 0.0.0.0/0 [110/65] via 10.1.23.2, 00:00:56, Serial0/0/1
```

d. Look at the output of the **show ip ospf** command to see what type each area is.

```
R2# show ip ospf
 Routing Process "ospf 1" with ID 10.1.2.1
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 It is an area border router
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 2. 1 normal 1 stub 0 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 2
        Area has no authentication
        SPF algorithm last executed 00:02:11.680 ago
        SPF algorithm executed 5 times
        Area ranges are
        Number of LSA 4. Checksum Sum 0x01A85A
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
    Area 23
        Number of interfaces in this area is 1
```



```
        It is a stub area
          generates stub default route with cost 1
        Area has no authentication
        SPF algorithm last executed 00:01:38.276 ago
        SPF algorithm executed 8 times
        Area ranges are
        Number of LSA 6. Checksum Sum 0x027269
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

What are the advantages of having a router receive a default route rather than a more specific route?

Why do all routers in a stub area need to know that the area is a stub?

Step 4: Configure a totally stubby area.

A modified version of a stubby area is a totally stubby area. A totally stubby area ABR only allows in a single, default route from the backbone. To configure a totally stubby area, you only need to change a command at the ABR, R2 in this scenario. Under the router OSPF process, you will enter the **area 23 stub no-summary** command to replace the existing stub command for area 23. The **no-summary** option tells the router that this area will not receive summary (inter-area) routes.

a. To see how this works, issue the **show ip route** command on R3. Notice the inter-area routes, in addition to the default route generated by R2.

```
R3# show ip route
Codes: 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

Gateway of last resort is 10.1.23.2 to network 0.0.0.0

     172.20.0.0/24 is subnetted, 1 subnets
C       172.20.200.0 is directly connected, Loopback20
     10.0.0.0/24 is subnetted, 5 subnets
O IA    10.1.12.0 [110/128] via 10.1.23.2, 00:00:56, Serial0/0/1
C       10.1.3.0 is directly connected, Loopback3
O IA    10.1.2.0 [110/65] via 10.1.23.2, 00:00:56, Serial0/0/1
O IA    10.1.1.0 [110/129] via 10.1.23.2, 00:00:56, Serial0/0/1
```

```
C       10.1.23.0 is directly connected, Serial0/0/1
O*IA 0.0.0.0/0 [110/65] via 10.1.23.2, 00:00:56, Serial0/0/1
```

b. Look at the output of the **show ip ospf database** command on R2 to see which LSAs are in its OSPF database.

```
R2# show ip ospf database

            OSPF Router with ID (10.1.2.1) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
10.1.1.1        10.1.1.1        435         0x80000004 0x0056D6 3
10.1.2.1        10.1.2.1        358         0x80000003 0x0057D2 3

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.3.0        10.1.2.1        174         0x80000001 0x00EFEF
10.1.23.0       10.1.2.1        354         0x80000001 0x0009C3

                Router Link States (Area 23)

Link ID         ADV Router      Age         Seq#       Checksum Link count
10.1.2.1        10.1.2.1        188         0x80000004 0x00298C 2
10.1.3.1        10.1.3.1        188         0x80000004 0x00B762 3

                Summary Net Link States (Area 23)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         10.1.2.1        207         0x80000001 0x003BF4
10.1.1.0        10.1.2.1        209         0x80000002 0x0022C0
10.1.2.0        10.1.2.1        209         0x80000002 0x00948D
10.1.12.0       10.1.2.1        209         0x80000002 0x009E3A
```

c. Enter the **stub no-summary** command on R2 (the ABR) under the OSPF process.

```
R2(config)# router ospf 1
R2(config-router)# area 23 stub no-summary
```

d. Go back to R3 and issue the **show ip route** command again. Notice that it shows only one incoming route from OSPF.

```
R3# show ip route
Codes: 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

Gateway of last resort is 10.1.23.2 to network 0.0.0.0

     172.20.0.0/24 is subnetted, 1 subnets
C       172.20.200.0 is directly connected, Loopback20
     10.0.0.0/24 is subnetted, 2 subnets
C       10.1.3.0 is directly connected, Loopback3
```

```
C       10.1.23.0 is directly connected, Serial0/0/1
O*IA 0.0.0.0/0 [110/65] via 10.1.23.2, 00:00:10, Serial0/0/1
```

e. Look at the **show ip ospf database** output to see which routes are in area 23.

```
R3# show ip ospf database

            OSPF Router with ID (10.1.3.1) (Process ID 1)

                Router Link States (Area 23)

Link ID         ADV Router      Age         Seq#       Checksum Link count
10.1.2.1        10.1.2.1        275         0x80000004 0x00298C 2
10.1.3.1        10.1.3.1        276         0x80000004 0x00B762 3

                Summary Net Link States (Area 23)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         10.1.2.1        68          0x80000002 0x0039F5
```

What are the advantages of making an area totally stubby instead of a regular stub area? What are the disadvantages?

Why did only the ABR need to know that the area was totally stubby rather than all routers in the area?

Step 5: Configure a not-so-stubby area.

Not-so-stubby areas (NSSAs) are similar to regular stub areas, except that they allow routes to be redistributed from an ASBR into that area with a special LSA type, which gets converted to a normal external route at the ABR.

a. Change area 23 into an NSSA. NSSAs are not compatible with stub areas, so the first thing to do is issue the **no area 23 stub** command on routers R2 and R3. Next, issue the **area** *area* **nssa** command on routers R2 and R3 to change area 23 to an NSSA. To generate an external route into the NSSA, use the **redistribute connected subnets** command on R3. This adds the previously unreachable loopback 20 into OSPF. Be sure to include the **subnets** keyword; otherwise, only classful networks are redistributed.

```
R2(config)# router ospf 1
R2(config-router)# no area 23 stub
R2(config-router)# area 23 nssa

R3(config)# router ospf 1
R3(config-router)# no area 23 stub
R3(config-router)# area 23 nssa
R3(config-router)# redistribute connected subnets
```

b. In the output of the **show ip ospf** command on R2, notice that area 23 is an NSSA and that R2 is performing the LSA type 7 to type 5 translation. If there are multiple ABRs to an NSSA, the ABR with the highest router ID performs the translation.

```
R2# show ip ospf
 Routing Process "ospf 1" with ID 10.1.2.1
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Link-local Signaling (LLS)
 Supports area transit capability
 It is an area border and autonomous system boundary router
 Redistributing External Routes from,
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Incremental-SPF disabled
 Minimum LSA interval 5 secs
 Minimum LSA arrival 1000 msecs
 LSA group pacing timer 240 secs
 Interface flood pacing timer 33 msecs
 Retransmission pacing timer 66 msecs
 Number of external LSA 1. Checksum Sum 0x00CA2F
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of DCbitless external and opaque AS LSA 0
 Number of DoNotAge external and opaque AS LSA 0
 Number of areas in this router is 2. 1 normal 0 stub 1 nssa
 Number of areas transit capable is 0
 External flood list length 0
    Area BACKBONE(0)
        Number of interfaces in this area is 2
        Area has no authentication
        SPF algorithm last executed 00:03:11.636 ago
        SPF algorithm executed 9 times
        Area ranges are
        Number of LSA 4. Checksum Sum 0x01AC53
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
    Area 23
        Number of interfaces in this area is 1
        It is a NSSA area
        Perform type-7/type-5 LSA translation
        Area has no authentication
        SPF algorithm last executed 00:00:16.408 ago
        SPF algorithm executed 16 times
        Area ranges are
        Number of LSA 6. Checksum Sum 0x025498
        Number of opaque link LSA 0. Checksum Sum 0x000000
        Number of DCbitless LSA 0
        Number of indication LSA 0
        Number of DoNotAge LSA 0
        Flood list length 0
```

c. Look at the **show ip route** output on R2. Notice that the external route comes in as type N2 from R3. This is because it is a special NSSA external route.

```
R2# show ip route
```



```
Codes: 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

Gateway of last resort is not set

     172.20.0.0/24 is subnetted, 1 subnets
O N2    172.20.200.0 [110/20] via 10.1.23.3, 00:00:41, Serial0/0/1
     10.0.0.0/24 is subnetted, 5 subnets
C       10.1.12.0 is directly connected, Serial0/0/0
O       10.1.3.0 [110/65] via 10.1.23.3, 00:00:47, Serial0/0/1
C       10.1.2.0 is directly connected, Loopback2
O       10.1.1.0 [110/65] via 10.1.12.1, 00:03:42, Serial0/0/0
C       10.1.23.0 is directly connected, Serial0/0/1
```

d. Look at the **show ip route** output on R1. Notice that the route is now a regular E2 external route, because R2 has performed the type 7 to type 5 translation.

```
R1# show ip route
Codes: 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

Gateway of last resort is not set

     172.20.0.0/24 is subnetted, 1 subnets
O E2    172.20.200.0 [110/20] via 10.1.12.2, 00:01:22, Serial0/0/0
     10.0.0.0/24 is subnetted, 5 subnets
C       10.1.12.0 is directly connected, Serial0/0/0
O IA    10.1.3.0 [110/129] via 10.1.12.2, 00:02:06, Serial0/0/0
O       10.1.2.0 [110/65] via 10.1.12.2, 00:04:22, Serial0/0/0
C       10.1.1.0 is directly connected, Loopback1
O IA    10.1.23.0 [110/128] via 10.1.12.2, 00:04:22, Serial0/0/0
```

e. Look at the **show ip route** output on R3. Notice that it no longer has a default route in it, but inter-area routes are coming in.

Note: An NSSA does not have the default route injected by the ABR (R2) automatically. It is possible to make the ABR inject the default route into the NSSA using the **area 23 nssa default-information-originate** command on R2.

```
R3# show ip route
Codes: 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

Gateway of last resort is not set

     172.20.0.0/24 is subnetted, 1 subnets
C       172.20.200.0 is directly connected, Loopback20
     10.0.0.0/24 is subnetted, 5 subnets
O IA    10.1.12.0 [110/128] via 10.1.23.2, 00:02:11, Serial0/0/1
C       10.1.3.0 is directly connected, Loopback3
O IA    10.1.2.0 [110/65] via 10.1.23.2, 00:02:11, Serial0/0/1
O IA    10.1.1.0 [110/129] via 10.1.23.2, 00:02:11, Serial0/0/1
C       10.1.23.0 is directly connected, Serial0/0/1
```

f. Yet another type of area is a totally-stubby NSSA that combines the property of an NSSA area (injecting external routing information into OSPF) with a totally stubby behavior (accepting only default route from the backbone). Issue the **area 23 nssa no-summary** command on R2, similar to converting a stub area into a totally stubby area.

```
R2(config)# router ospf 1
R2(config-router)# area 23 nssa no-summary
```

g. Check the routing table on R3. Notice that the inter-area routes have been replaced by a single default route.

```
R3# show ip route
Codes: 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

Gateway of last resort is 10.1.23.2 to network 0.0.0.0

     172.20.0.0/24 is subnetted, 1 subnets
C       172.20.200.0 is directly connected, Loopback20
     10.0.0.0/24 is subnetted, 2 subnets
C       10.1.3.0 is directly connected, Loopback3
C       10.1.23.0 is directly connected, Serial0/0/1
O*IA 0.0.0.0/0 [110/65] via 10.1.23.2, 00:00:20, Serial0/0/1
```

h. On R2, look at the **show ip ospf database** output to see the various LSA types.

```
R2# show ip ospf database

            OSPF Router with ID (10.1.2.1) (Process ID 1)

                Router Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum Link count
10.1.1.1        10.1.1.1        944         0x80000004 0x0056D6 3
10.1.2.1        10.1.2.1        383         0x80000004 0x005BCB 3

                Summary Net Link States (Area 0)

Link ID         ADV Router      Age         Seq#       Checksum
10.1.3.0        10.1.2.1        242         0x80000001 0x00EFEF
10.1.23.0       10.1.2.1        862         0x80000001 0x0009C3
```

```
                Router Link States (Area 23)

Link ID         ADV Router      Age         Seq#       Checksum Link count
10.1.2.1        10.1.2.1        257         0x80000007 0x00B0F7 2
10.1.3.1        10.1.3.1        209         0x80000007 0x003FCD 3

                Summary Net Link States (Area 23)

Link ID         ADV Router      Age         Seq#       Checksum
0.0.0.0         10.1.2.1        34          0x80000001 0x00C265

                Type-7 AS External Link States (Area 23)

Link ID         ADV Router      Age         Seq#       Checksum Tag
10.1.3.0        10.1.3.1        200         0x80000001 0x0076FC 0

                Type-5 AS External Link States

Link ID         ADV Router      Age         Seq#       Checksum Tag
10.1.3.0        10.1.2.1        199         0x80000001 0x00CA2F 0
```

Where would it be useful to make an area into an NSSA?

Step 6: Configure OSPF interface authentication.

For security purposes, you can configure OSPF interfaces to use authentication.

a. Configure the link between R2 and R3 for plaintext authentication. To set up plaintext authentication on an interface, type **ip ospf authentication** at the interface command prompt. Then set the password to **cisco** with the **ip ospf authentication-key** *key-string* command.

```
R2(config)# interface serial 0/0/1
R2(config-if)# ip ospf authentication
R2(config-if)# ip ospf authentication-key cisco

R3(config)# interface serial 0/0/1
R3(config-if)# ip ospf authentication
R3(config-if)# ip ospf authentication-key cisco
```

Note: While configuring the authentication, the adjacency might go down if the dead timer expires on one of the routers. The relationship should be reestablished once authentication is configured on both sides.

b. Verify the authentication using the **show ip ospf interface** *interface* command.

```
R2# show ip ospf interface serial 0/0/1
Serial0/0/1 is up, line protocol is up
  Internet Address 10.1.23.2/24, Area 23
  Process ID 1, Router ID 10.1.2.1, Network Type POINT_TO_POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
```



```
    Hello due in 00:00:09
  Supports Link-local Signaling (LLS)
  Index 1/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 4
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.3.1
  Suppress hello for 0 neighbor(s)
  Simple password authentication enabled
```

c. MD5 authentication encrypts the password for stronger security. Configure the link between R1 and R2 for MD5 authentication using the **ip ospf authentication message-digest** interface command. Then set the password to **cisco** with the **ip ospf message-digest-key** *key_number* **md5** *key-string* command. Make sure that the key number is the same on both routers. In this case, use 1 for simplicity.

```
R1(config)# interface serial 0/0/0
R1(config-if)# ip ospf authentication message-digest
R1(config-if)# ip ospf message-digest-key 1 md5 cisco

R2(config)# interface serial 0/0/0
R2(config-if)# ip ospf authentication message-digest
R2(config-if)# ip ospf message-digest-key 1 md5 cisco
```

Note: The MD5 key number works differently than key chains. The router uses the most recently added key for authenticating sent packets. The key number does not have a direct influence on this behavior, that is, if the interface was configured with the MD5 key number 10 and later the key with number 5 was added, the router would use the key number 5 to digitally sign outbound sent packets. If a router having several MD5 keys on an interface detects that at least one of its neighbors has not yet started using the most recently added key, it engages in a simple key migration procedure: it sends each OSPF packet multiple times, with each instance of the packet authenticated by a particular MD5 key configured on the interface, one instance for each key. This ensures a smooth, gradual migration.

d. Verify the configuration using the **show ip ospf interface** *interface* command.

```
R1# show ip ospf interface serial 0/0/0
Serial0/0/0 is up, line protocol is up
  Internet Address 10.1.12.1/24, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT_TO_POINT, Cost: 64
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    oob-resync timeout 40
    Hello due in 00:00:08
  Supports Link-local Signaling (LLS)
  Index 1/1, 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 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
  Message digest authentication enabled
    Youngest key id is 1
```

Why is configuring authentication for OSPF, or any routing protocol, a good idea?

e. Use the following Tcl script to verify connectivity to all addresses in the topology.

```
R1# tclsh
R1(tcl)#

foreach address {
10.1.1.1
10.1.2.1
10.1.3.1
10.1.12.1
10.1.12.2
10.1.23.2
10.1.23.3
172.20.200.1
} {
ping $address }
```

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1700	Fast Ethernet 0 (FA0)	Fast Ethernet 1 (FA1)	Serial 0 (S0)	Serial 1 (S1)
1800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2600	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0 (S0/0)	Serial 0/1 (S0/1)
2800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	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. Rather than list all 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 might contain one. For example, for an ISDN BRI interface, the string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.				