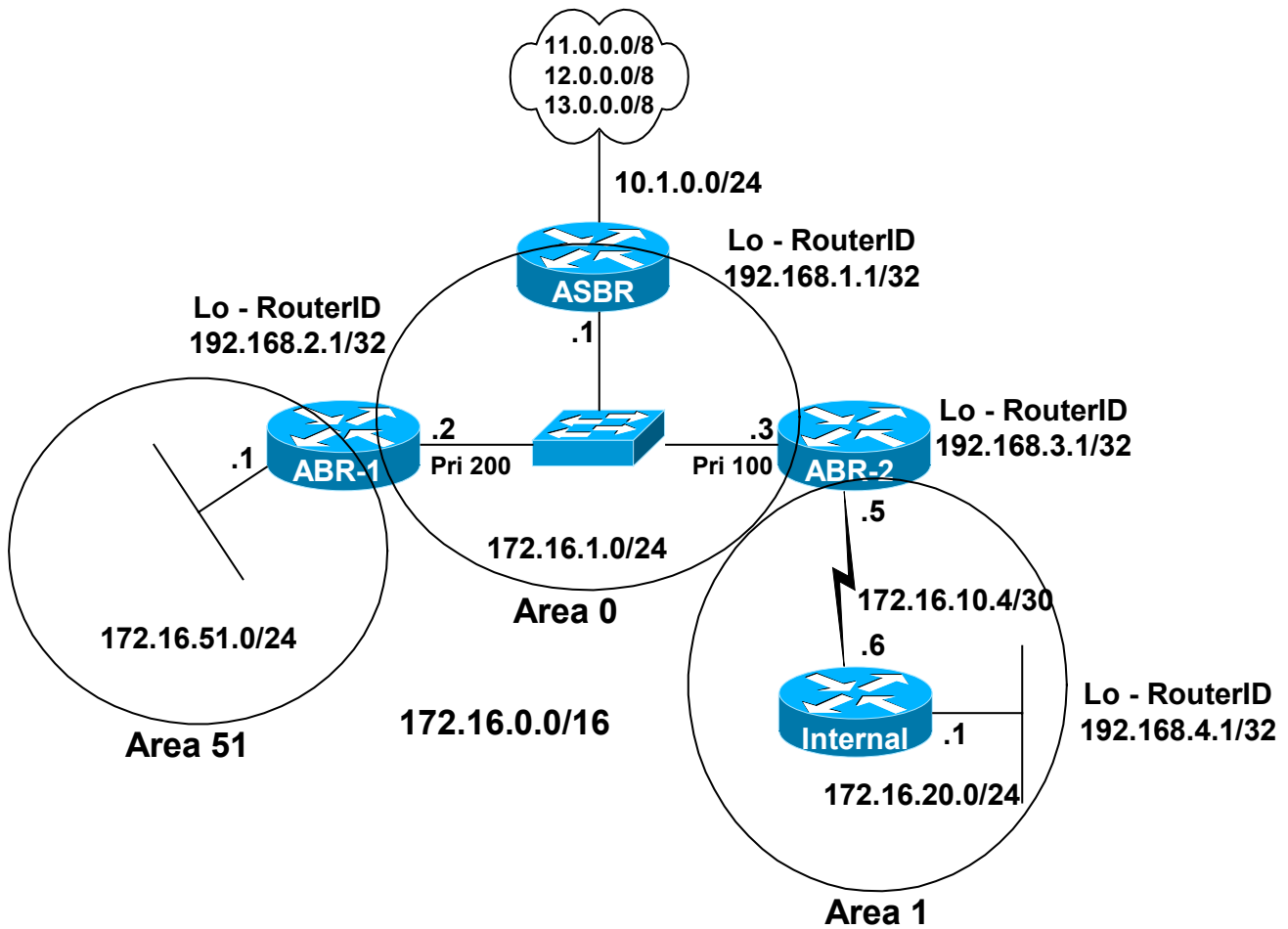


# Multi-Area OSPF Labs



## Labs

1. OSPF Normal Areas
2. OSPF Stub Area
3. OSPF Totally Stubby Area
4. OSPF SPF Calculation
5. OSPF Default Route

## Notes:

**Instructors:** Although there are some explanation contained in this lab, it is designed to coincide with the Multi-area OSPF PowerPoint lesson. The information in the PowerPoint explains much of the information and output in this lab. If you need access to this PowerPoint, please email me at [graziani@cabrillo.edu](mailto:graziani@cabrillo.edu).

Verification commands used in this lab:

- show ip ospf
- show ip ospf neighbor
- show ip ospf data
- show ip ospf border
- show ip ospf route

A command that was not included, but is highly recommended, is **show ip ospf interface**.

Equipment used:

- ASBR: Cisco 2622
- ABR-1: Cisco 2621
- ABR-2: Cisco 1720
- Internal: Cisco 1720

Notes:

- Loopback1 is used to simulate 172.16.51.1/24 interface.
- Interfaces with clock rate may vary upon your configuration.
- I would suggest using the following commands to keep debug information from interfering with other output and to keep the router from timing out.

```
line con 0
logging synchronous
exec-timeout 0 0
```

# Lab 1: OSPF Normal Areas

## Objective

In this lab, students will configure a multiarea OSPF operation. There are no default routes on the ASBR. Students will learn how to configure routers for multiarea OSPF. Students will also become familiar with the output associated with show ip ospf database and other commands, knowing what they should expect to see when the routers are properly configured.

## Router Configs

### ASBR

Current configuration:

```
version 12.0
!
hostname ASBR
!
interface Loopback0
  ip address 192.168.1.1 255.255.255.255
!
interface FastEthernet0/0
  ip address 172.16.1.1 255.255.255.0
!
interface FastEthernet0/1
  ip address 10.1.0.1 255.255.255.0
!
router ospf 1
  redistribute static
  network 172.16.1.0 0.0.0.255 area 0
!
ip classless
ip route 11.0.0.0 255.0.0.0 Null0
ip route 12.0.0.0 255.0.0.0 Null0
ip route 13.0.0.0 255.0.0.0 Null0
!
```

### ABR-1

Current configuration:

```
version 12.0
!
hostname ABR-1
!
interface Loopback0
  ip address 192.168.2.1 255.255.255.255
!
interface Loopback1
  ip address 172.16.51.1 255.255.255.0
!
interface FastEthernet0/0
  ip address 172.16.1.2 255.255.255.0
  ip ospf priority 200
!
router ospf 1
  network 172.16.1.0 0.0.0.255 area 0
  network 172.16.51.0 0.0.0.255 area 51
!
ip classless
!
```

## ABR-2

Current configuration:

```
version 12.0
!  
hostname ABR-2
!  
interface Loopback1  
  ip address 192.168.3.1 255.255.255.255  
!  
interface Serial0  
  ip address 172.16.10.5 255.255.255.252  
!  
interface FastEthernet0  
  ip address 172.16.1.3 255.255.255.0  
  ip ospf priority 100  
!  
router ospf 1  
  network 172.16.1.0 0.0.0.255 area 0  
  network 172.16.10.4 0.0.0.3 area 1  
!  
ip classless  
!
```

## Internal

Current configuration:

```
version 12.0
!  
hostname Internal
!  
interface Loopback0  
  ip address 192.168.4.1 255.255.255.255  
!  
interface Serial0  
  ip address 172.16.10.6 255.255.255.252  
  clockrate 64000  
!  
interface FastEthernet0  
  ip address 172.16.20.1 255.255.255.0  
!  
router ospf 1  
  network 172.16.0.0 0.0.255.255 area 1  
!  
ip classless  
!
```

## ASBR: Normal Area Outputs

ASBR#**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

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/2] via 172.16.1.2, 00:02:54, FastEthernet0/0
O IA 172.16.20.0/24 [110/783] via 172.16.1.3, 00:02:54, FastEthernet0/0
O IA 172.16.10.4/30 [110/782] via 172.16.1.3, 00:02:54, FastEthernet0/0
C 172.16.1.0/24 is directly connected, FastEthernet0/0
10.0.0.0/24 is subnetted, 1 subnets
C 10.1.0.0 is directly connected, FastEthernet0/1
S 11.0.0.0/8 is directly connected, Null0
S 12.0.0.0/8 is directly connected, Null0
192.168.1.0/32 is subnetted, 1 subnets
C 192.168.1.1 is directly connected, Loopback0
S 13.0.0.0/8 is directly connected, Null0
ASBR#
```

- Notice which routes are OSPF inter area routes.
- The three static routes are redistributed to other routers via the ASBR using the command:  

```
router ospf 1
 redistribute static
```

  - This command is discussed later in the chapter on Route Optimization.
- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

```
ASBR#show ip ospf nei
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.3.1	100	FULL/BDR	00:00:37	172.16.1.3	FastEthernet0/0
192.168.2.1	200	FULL/DR	00:00:33	172.16.1.2	FastEthernet0/0

- Notice that the router with the highest ip ospf priority is the DR and the second highest is the BDR.

```
ASBR#show ip ospf
```

```
Routing Process "ospf 1" with ID 192.168.1.1
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 SPF's 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 3. Checksum Sum 0x97E3
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 BACKBONE(0)
  Number of interfaces in this area is 1
  Area has no authentication
  SPF algorithm executed 36 times
  Area ranges are
  Number of LSA 8. Checksum Sum 0x507DB
  Number of DCbitless LSA 0
  Number of indication LSA 0
  Number of DoNotAge LSA 0
  Flood list length 0
```

- Besides the information this command provides that we saw in single area OSPF, this command also includes information regarding:
  - The type of router it is.
  - If any routes are being redistributed by this router.
  - Number of areas in this router, including number of normal, stub and nssa areas.
  - Specific OSPF information per area.

```
ASBR#show ip ospf border
```

```
OSPF Process 1 internal Routing Table
```

```
Codes: i - Intra-area route, I - Inter-area route
```

```
i 192.168.2.1 [1] via 172.16.1.2, FastEthernet0/0, ABR, Area 0, SPF 36
i 192.168.3.1 [1] via 172.16.1.3, FastEthernet0/0, ABR, Area 0, SPF 36
ASBR#
```

- This command will displays any ABRs in the area or any ASBRs in the OSPF routing domain.

## ASBR: Normal Area Outputs

ASBR#show ip ospf data

OSPF Router with ID (192.168.1.1) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
172.16.10.5	172.16.10.5	412	0x8000000F	0x6F9C	1
192.168.1.1	192.168.1.1	201	0x80000012	0x8D3D	1
192.168.2.1	192.168.2.1	205	0x80000016	0x7E46	1
192.168.3.1	192.168.3.1	205	0x80000005	0x9C36	1

Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.2	192.168.2.1	201	0x8000000D	0xCFE8

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.10.4	192.168.3.1	278	0x80000001	0xD126
172.16.20.0	192.168.3.1	278	0x80000001	0xA746
172.16.51.1	192.168.2.1	206	0x80000005	0xA832

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	648	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	649	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	649	0x80000001	0x2503	0

ASBR#

Understanding the output: (Use the information below when viewing output for show ip ospf database output from the other routers and with the other labs.)

- **Router Link States (LSA 1)**
  - Router Link States (LSA1's) should display all the RouterIDs of routers in that area, including its own.
  - Link State ID is always the same as the Advertising Router.
  - ADV Router is the Router ID of the router that created this LSA 1.
- **Net Link States (LSA 2)**
  - Net Link States (LSA2's) should display the RouterIDs of the DRs on all multi-access networks in the area and their IP addresses.
  - Link ID is the IP address of DR on MultiAccess Network.
  - ADV Router is the Router ID of the DR.
- **Summary Link States (LSA 3)**
  - Should see networks in other areas and the ABR advertising that route.
  - Link ID is the IP network addresses of networks in other areas
  - ADV Router is the ABR Router ID sending the LSA-3.
- **Summary ASB Link States (LSA 4)**
  - Routers in non-area 0, should see Router ID of ASBR and its ABR to get there.
  - Link ID is the Router ID of ASBR
  - ADV Router is the Router ID of the ABR advertising route
- **Type-5 AS External Link States (LSA 5)**
  - All Routers should see External networks and the Router ID of ASBR to get there
  - Link ID is the External Network
  - ADV Router is the Router ID of ASBR advertising the LSA 5.

## ABR-1: Normal Area Outputs

ABR-1#**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  
<text omitted>

Gateway of last resort is not set

```
172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.51.0/24 is directly connected, Loopback1
O IA    172.16.20.0/24 [110/783] via 172.16.1.3, 00:08:17, FastEthernet0/0
O IA    172.16.10.4/30 [110/782] via 172.16.1.3, 00:08:17, FastEthernet0/0
C       172.16.1.0/24 is directly connected, FastEthernet0/0
O E2 11.0.0.0/8 [110/20] via 172.16.1.1, 00:08:17, FastEthernet0/0
O E2 12.0.0.0/8 [110/20] via 172.16.1.1, 00:08:17, FastEthernet0/0
O E2 13.0.0.0/8 [110/20] via 172.16.1.1, 00:08:17, FastEthernet0/0
192.168.2.0/32 is subnetted, 1 subnets
C       192.168.2.1 is directly connected, Loopback0
ABR-1#
```

- Notice the external routes, received from the ASBR.
- LSA 1 and LSA 2: Denoted by “O” or “C”
- LSA 3: Denoted by “IA”
- LSA 5: Denoted by “E1” or “E2” (default)

ABR-1#**show ip ospf nei**

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.3.1	100	FULL/BDR	00:00:35	172.16.1.3	FastEthernet0/0
192.168.1.1	1	FULL/DROTHER	00:00:32	172.16.1.1	FastEthernet0/0

ABR-1#



ABR-1#**show ip ospf**

```
Routing Process "ospf 1" with ID 192.168.2.1
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 3. Checksum Sum 0x97E3
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 1
    Area has no authentication
    SPF algorithm executed 38 times
    Area ranges are
    Number of LSA 11. Checksum Sum 0x752B2
    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 17 times
    Area ranges are
    Number of LSA 5. Checksum Sum 0x32392
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

ABR-1#

- o Notice the information for multiple areas for this ABR.

ABR-1#**show ip ospf border**

OSPF Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

```
i 192.168.1.1 [1] via 172.16.1.1, FastEthernet0/0, ASBR, Area 0, SPF 38
i 192.168.3.1 [1] via 172.16.1.3, FastEthernet0/0, ABR, Area 0, SPF 38
ABR-1#
```

- o This command will displays any ABRs in the area or any ASBRs in the OSPF routing domain.

## ABR-1: Normal Area Outputs

ABR-1#show ip ospf data

OSPF Router with ID (192.168.2.1) (Process ID 1)

### Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
172.16.10.5	172.16.10.5	751	0x8000000F	0x6F9C	1
192.168.1.1	192.168.1.1	540	0x80000012	0x8D3D	1
192.168.2.1	192.168.2.1	543	0x80000016	0x7E46	1
192.168.3.1	192.168.3.1	543	0x80000005	0x9C36	1

### Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.2	192.168.2.1	539	0x8000000D	0xCFE8

### Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.10.4	192.168.3.1	617	0x80000001	0xD126
172.16.20.0	192.168.3.1	617	0x80000001	0xA746
172.16.51.1	192.168.2.1	544	0x80000005	0xA832

### Router Link States (Area 51)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.2.1	192.168.2.1	585	0x8000000B	0x855	1

### Summary Net Link States (Area 51)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.0	192.168.2.1	531	0x80000001	0xE22F
172.16.10.4	192.168.2.1	531	0x80000001	0xE215
172.16.20.0	192.168.2.1	531	0x80000001	0xB835

### Summary ASB Link States (Area 51)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.1	192.168.2.1	531	0x80000001	0x9EC4

### Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	988	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	988	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	988	0x80000001	0x2503	0

ABR-1#

- o Notice the output for multiple areas.
- o LSA 5s(Type-5 AS External Link States) are not listed per area, but one set per router.

## ABR-2: Normal Area Outputs

ABR-2#**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  
<text omitted>

Gateway of last resort is not set

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/2] via 172.16.1.2, 00:11:44, FastEthernet0
O    172.16.20.0/24 [110/782] via 172.16.10.6, 00:12:29, Serial0
C    172.16.10.4/30 is directly connected, Serial0
C    172.16.1.0/24 is directly connected, FastEthernet0
O E2 11.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
O E2 12.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
O E2 13.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
    192.168.3.0/32 is subnetted, 1 subnets
C    192.168.3.1 is directly connected, Loopback1
ABR-2#
```

- LSA 1 and LSA 2: Denoted by “O” or “C”
- LSA 3: Denoted by “IA”
- LSA 5: Denoted by “E1” or “E2” (default)

ABR-2#**show ip ospf nei**

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.1.1	1	FULL/DROTHER	00:00:34	172.16.1.1	FastEthernet0
192.168.2.1	200	FULL/DR	00:00:33	172.16.1.2	FastEthernet0
192.168.4.1	1	FULL/ -	00:00:37	172.16.10.6	Serial0

ABR-2#

ABR-2#**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 3. Checksum Sum 0x97E3

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 1

Area has no authentication

SPF algorithm executed 8 times

Area ranges are

Number of LSA 8. Checksum Sum 0x507DB

Number of DCbitless LSA 0

Number of indication LSA 0

Number of DoNotAge LSA 0

Flood list length 0

**Area 1**

Number of interfaces in this area is 1

Area has no authentication

SPF algorithm executed 5 times

Area ranges are

Number of LSA 5. Checksum Sum 0x3E5C8

Number of DCbitless LSA 0

Number of indication LSA 0

Number of DoNotAge LSA 0

Flood list length 0

## ABR-2: Normal Area Outputs

ABR-2#**show ip ospf data**

OSPF Router with ID (192.168.3.1) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
172.16.10.5	172.16.10.5	954	0x8000000F	0x6F9C	1
192.168.1.1	192.168.1.1	743	0x80000012	0x8D3D	1
192.168.2.1	192.168.2.1	746	0x80000016	0x7E46	1
192.168.3.1	192.168.3.1	746	0x80000005	0x9C36	1

Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.2	192.168.2.1	743	0x8000000D	0xCFE8

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.10.4	192.168.3.1	787	0x80000001	0xD126
172.16.20.0	192.168.3.1	787	0x80000001	0xA746
172.16.51.1	192.168.2.1	748	0x80000005	0xA832

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	786	0x80000003	0xCE56	2
192.168.4.1	192.168.4.1	828	0x80000003	0xFD44	3

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.0	192.168.3.1	737	0x80000005	0xD339
172.16.51.1	192.168.3.1	733	0x80000001	0xB329

Summary ASB Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.1	192.168.3.1	801	0x80000003	0x93CC

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	1191	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	1191	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	1191	0x80000001	0x2503	0

ABR-2#

ABR-2#**show ip ospf border**

OSPF Process 1 internal Routing Table

Codes: i - Intra-area route, I - Inter-area route

i 192.168.1.1 [1] via 172.16.1.1, FastEthernet0, ASBR, Area 0, SPF 8  
i 192.168.2.1 [1] via 172.16.1.2, FastEthernet0, ABR, Area 0, SPF 8

ABR-2#

- o This command will displays any ABRs in the area or any ASBRs in the OSPF routing domain.

## Internal: Normal Area Outputs

Internal#**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

172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks

O IA 172.16.51.1/32 [110/783] via 172.16.10.5, 00:13:48, Serial0

C 172.16.20.0/24 is directly connected, FastEthernet0

C 172.16.10.4/30 is directly connected, Serial0

O IA 172.16.1.0/24 [110/782] via 172.16.10.5, 00:13:53, Serial0

192.168.4.0/32 is subnetted, 1 subnets

C 192.168.4.1 is directly connected, Loopback0

O E2 11.0.0.0/8 [110/20] via 172.16.10.5, 00:14:41, Serial0

O E2 12.0.0.0/8 [110/20] via 172.16.10.5, 00:14:41, Serial0

O E2 13.0.0.0/8 [110/20] via 172.16.10.5, 00:14:42, Serial0

Internal#

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

Internal#**show ip ospf nei**

Neighbor ID	Pri	State	Dead Time	Address	Interface
192.168.3.1	1	FULL/ -	00:00:39	172.16.10.5	Serial0

Internal#

Internal#**show ip ospf**

Routing Process "ospf 1" with ID 192.168.4.1

Supports only single TOS(TOS0) routes

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 3. Checksum Sum 0x97E3

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 1

Number of interfaces in this area is 2

Area has no authentication

SPF algorithm executed 5 times

Area ranges are

Number of LSA 5. Checksum Sum 0x3E5C8

Number of DCbitless LSA 0

Number of indication LSA 0

Number of DoNotAge LSA 0

Flood list length 0

Internal#

## Internal: Normal Area Outputs

Internal#**show ip ospf data**

OSPF Router with ID (192.168.4.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	898	0x80000003	0xCE56	2
192.168.4.1	192.168.4.1	937	0x80000003	0xFD44	3

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.0	192.168.3.1	848	0x80000005	0xD339
172.16.51.1	192.168.3.1	843	0x80000001	0xB329

Summary ASB Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.1	192.168.3.1	912	0x80000003	0x93CC

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	1302	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	1303	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	1303	0x80000001	0x2503	0

Internal#

Internal#**show ip ospf border**

OSPF Process 1 internal Routing Table

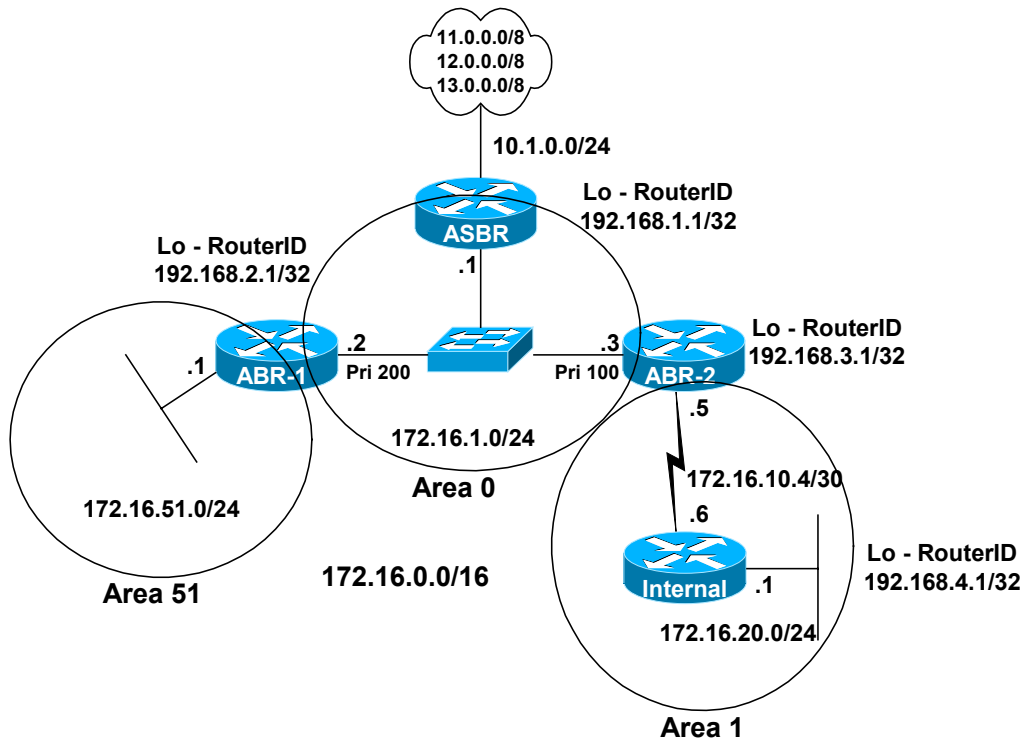
Codes: i - Intra-area route, I - Inter-area route

I 192.168.1.1 [782] via 172.16.10.5, Serial0, ASBR, Area 1, SPF 5  
i 192.168.3.1 [781] via 172.16.10.5, Serial0, ABR, Area 1, SPF 5  
Internal#

- o This command will displays any ABRs in the area or any ASBRs in the OSPF routing domain.

## Lab 2: OSPF Stub Area 1

- No default route on ASBR
- No default-information originate on ASBR



### Changes in configs

#### ABR-2 (Add this command)

```
router ospf 1
network 172.16.1.0 0.0.0.255 area 0
network 172.16.10.4 0.0.0.3 area 1
area 1 stub
!
```

#### Internal (Add this command)

```
router ospf 1
network 172.16.0.0 0.0.255.255 area 1
area 1 stub
!
```

*Changes in outputs follow...*



## ABR-2: Area 1 Stub

ABR-2#**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

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/2] via 172.16.1.2, 00:01:59, FastEthernet0
O    172.16.20.0/24 [110/782] via 172.16.10.6, 00:01:59, Serial0
C    172.16.10.4/30 is directly connected, Serial0
C    172.16.1.0/24 is directly connected, FastEthernet0
O E2 11.0.0.0/8 [110/20] via 172.16.1.1, 00:01:59, FastEthernet0
O E2 12.0.0.0/8 [110/20] via 172.16.1.1, 00:01:59, FastEthernet0
O E2 13.0.0.0/8 [110/20] via 172.16.1.1, 00:01:59, FastEthernet0
192.168.3.0/32 is subnetted, 1 subnets
C    192.168.3.1 is directly connected, Loopback1
ABR-2#
```

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

ABR-2#**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 3. Checksum Sum 0x97E3
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 2. 1 normal 1 stub 0 nssa
External flood list length 0
Area BACKBONE(0)
  Number of interfaces in this area is 1
  Area has no authentication
  SPF algorithm executed 9 times
  Area ranges are
  Number of LSA 8. Checksum Sum 0x507DB
  Number of DCbitless LSA 0
  Number of indication LSA 0
  Number of DoNotAge LSA 0
  Flood list length 0
Area 1
  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 executed 8 times
  Area ranges are
  Number of LSA 5. Checksum Sum 0x348D8
  Number of DCbitless LSA 0
  Number of indication LSA 0
  Number of DoNotAge LSA 0
  Flood list length 0
```

**ABR-2: Area 1 Stub**

ABR-2#show ip ospf data

OSPF Router with ID (192.168.3.1) (Process ID 1)

Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
172.16.10.5	172.16.10.5	1609	0x8000000F	0x6F9C	1
192.168.1.1	192.168.1.1	1398	0x80000012	0x8D3D	1
192.168.2.1	192.168.2.1	1401	0x80000016	0x7E46	1
192.168.3.1	192.168.3.1	1400	0x80000005	0x9C36	1

Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.2	192.168.2.1	1397	0x8000000D	0xCFE8

Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.10.4	192.168.3.1	1441	0x80000001	0xD126
172.16.20.0	192.168.3.1	139	0x80000001	0xA746
172.16.51.1	192.168.2.1	1402	0x80000005	0xA832

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	144	0x80000005	0xE83C	2
192.168.4.1	192.168.4.1	144	0x80000005	0x182A	3

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.0	192.168.3.1	176	0x80000001	0x8A46
172.16.1.0	192.168.3.1	176	0x80000006	0xEF1E
172.16.51.1	192.168.3.1	176	0x80000002	0xCF0E

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	1846	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	1846	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	1846	0x80000001	0x2503	0

ABR-2#

## Internal: Area 1 Stub

Internal#**show ip ospf data**

OSPF Router with ID (192.168.4.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	211	0x80000005	0xE83C	2
192.168.4.1	192.168.4.1	209	0x80000005	0x182A	3

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.0	192.168.3.1	243	0x80000001	0x8A46
172.16.1.0	192.168.3.1	243	0x80000006	0xEF1E
172.16.51.1	192.168.3.1	243	0x80000002	0xCF0E

Internal#

- o Notice there are no External LSA 5s, only the LSA 3's including one for a default route injected by the ABR.

Internal#**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 172.16.10.5 to network 0.0.0.0

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/783] via 172.16.10.5, 00:03:08, Serial0
C 172.16.20.0/24 is directly connected, FastEthernet0
C 172.16.10.4/30 is directly connected, Serial0
O IA 172.16.1.0/24 [110/782] via 172.16.10.5, 00:03:08, Serial0
192.168.4.0/32 is subnetted, 1 subnets
C 192.168.4.1 is directly connected, Loopback0
O*IA 0.0.0.0/0 [110/782] via 172.16.10.5, 00:03:08, Serial0
Internal#
```

- Notice there are no External routes, only a default route injected by the ABR.
- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

**Internal: Area 1 Stub**

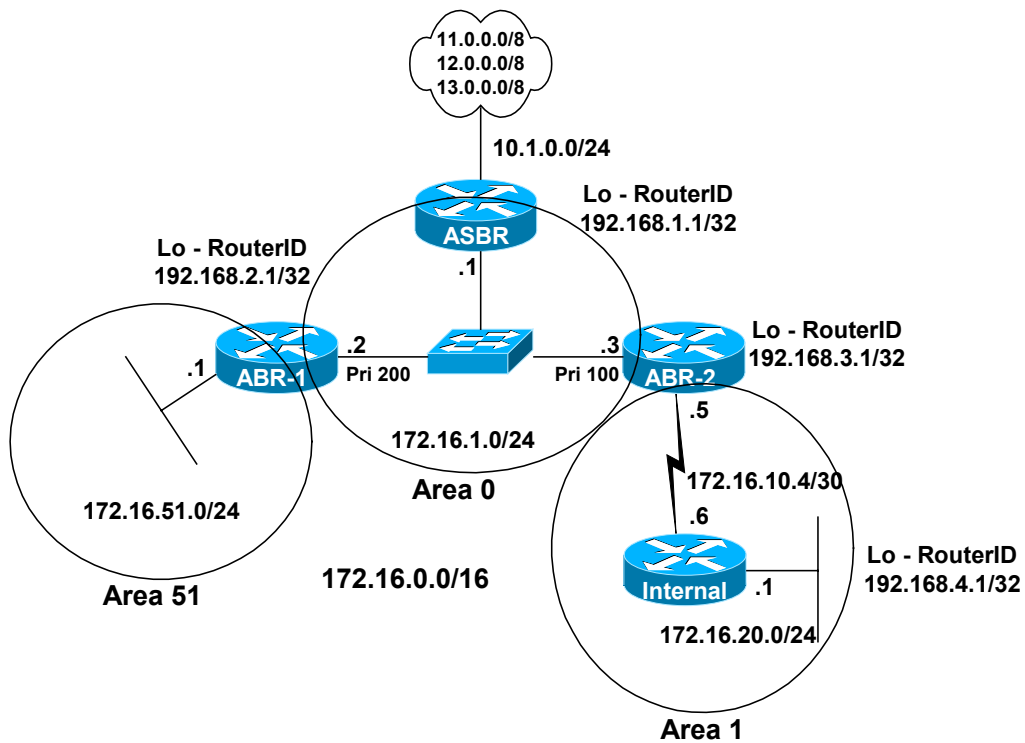
Internal#**show ip ospf**

```
Routing Process "ospf 1" with ID 192.168.4.1
Supports only single TOS(TOS0) routes
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 1. 0 normal 1 stub 0 nssa
External flood list length 0
  Area 1
    Number of interfaces in this area is 2
    It is a stub area
    Area has no authentication
    SPF algorithm executed 7 times
    Area ranges are
    Number of LSA 5. Checksum Sum 0x348D8
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

Internal#

## Lab 3: OSPF Totally Stubby Area 1

- No default route on ASBR
- No default-information originate on ASBR



### Changes in configs

#### ABR-2 (Modify the previous command)

```
router ospf 1
 network 172.16.1.0 0.0.0.255 area 0
 network 172.16.10.4 0.0.0.3 area 1
 area 1 stub no-summary
!
```

#### Internal (No Change)

```
router ospf 1
 network 172.16.0.0 0.0.255.255 area 1
 area 1 stub
!
```

*Changes in outputs follow...*

## ABR-2: Area 1 Totally Stubby

ABR-2#**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

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/2] via 172.16.1.2, 00:02:35, FastEthernet0
O    172.16.20.0/24 [110/782] via 172.16.10.6, 00:02:35, Serial0
C    172.16.10.4/30 is directly connected, Serial0
C    172.16.1.0/24 is directly connected, FastEthernet0
O E2 11.0.0.0/8 [110/20] via 172.16.1.1, 00:02:35, FastEthernet0
O E2 12.0.0.0/8 [110/20] via 172.16.1.1, 00:02:35, FastEthernet0
O E2 13.0.0.0/8 [110/20] via 172.16.1.1, 00:02:35, FastEthernet0
    192.168.3.0/32 is subnetted, 1 subnets
C    192.168.3.1 is directly connected, Loopback1
```

ABR-2#

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

ABR-2#**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 3. Checksum Sum 0x91E6
Number of DCbitless external LSA 0
Number of DoNotAge external LSA 0
Number of areas in this router is 2. 1 normal 1 stub 0 nssa
External flood list length 0
```

Area BACKBONE(0)

```
Number of interfaces in this area is 1
Area has no authentication
SPF algorithm executed 10 times
Area ranges are
Number of LSA 8. Checksum Sum 0x4FFDF
Number of DCbitless LSA 0
Number of indication LSA 0
Number of DoNotAge LSA 0
Flood list length 0
```

Area 1

```
Number of interfaces in this area is 1
It is a stub area, no summary LSA in this area
generates stub default route with cost 1
Area has no authentication
SPF algorithm executed 10 times
Area ranges are
Number of LSA 3. Checksum Sum 0x182B0
Number of DCbitless LSA 0
Number of indication LSA 0
Number of DoNotAge LSA 0
Flood list length 0
```

## ABR-2: Area 1 Totally Stubby

ABR-2#show ip ospf data

OSPF Router with ID (192.168.3.1) (Process ID 1)

### Router Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
172.16.10.5	172.16.10.5	2177	0x8000000F	0x6F9C	1
192.168.1.1	192.168.1.1	1966	0x80000012	0x8D3D	1
192.168.2.1	192.168.2.1	168	0x80000017	0x7C47	1
192.168.3.1	192.168.3.1	77	0x80000006	0x9A37	1

### Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.2	192.168.2.1	1966	0x8000000D	0xCFE8

### Summary Net Link States (Area 0)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.10.4	192.168.3.1	77	0x80000002	0xCF27
172.16.20.0	192.168.3.1	166	0x80000001	0xA746
172.16.51.1	192.168.2.1	168	0x80000006	0xA633

### Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	170	0x80000007	0xE43E	2
192.168.4.1	192.168.4.1	712	0x80000005	0x182A	3

### Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.0	192.168.3.1	171	0x80000003	0x8648

### Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	465	0x80000002	0x3DEB	0
12.0.0.0	192.168.1.1	466	0x80000002	0x30F7	0
13.0.0.0	192.168.1.1	466	0x80000002	0x2304	0

ABR-2#

## Internal: Area 1 Totally Stubby

Internal#**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 172.16.10.5 to network 0.0.0.0

```
172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.20.0/24 is directly connected, FastEthernet0
C       172.16.10.4/30 is directly connected, Serial0
192.168.4.0/32 is subnetted, 1 subnets
C       192.168.4.1 is directly connected, Loopback0
O*IA 0.0.0.0/0 [110/782] via 172.16.10.5, 00:03:09, Serial0
```

Internal#

- Notice there are no External routes or Inter Area routes except the one for a default route injected by the ABR
- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

Internal#**show ip ospf data**

OSPF Router with ID (192.168.4.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	204	0x80000007	0xE43E	2
192.168.4.1	192.168.4.1	743	0x80000005	0x182A	3

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
0.0.0.0	192.168.3.1	205	0x80000003	0x8648

Internal#

- Notice there are no External LSA 5s or LSA 3's except the one for a default route injected by the ABR.



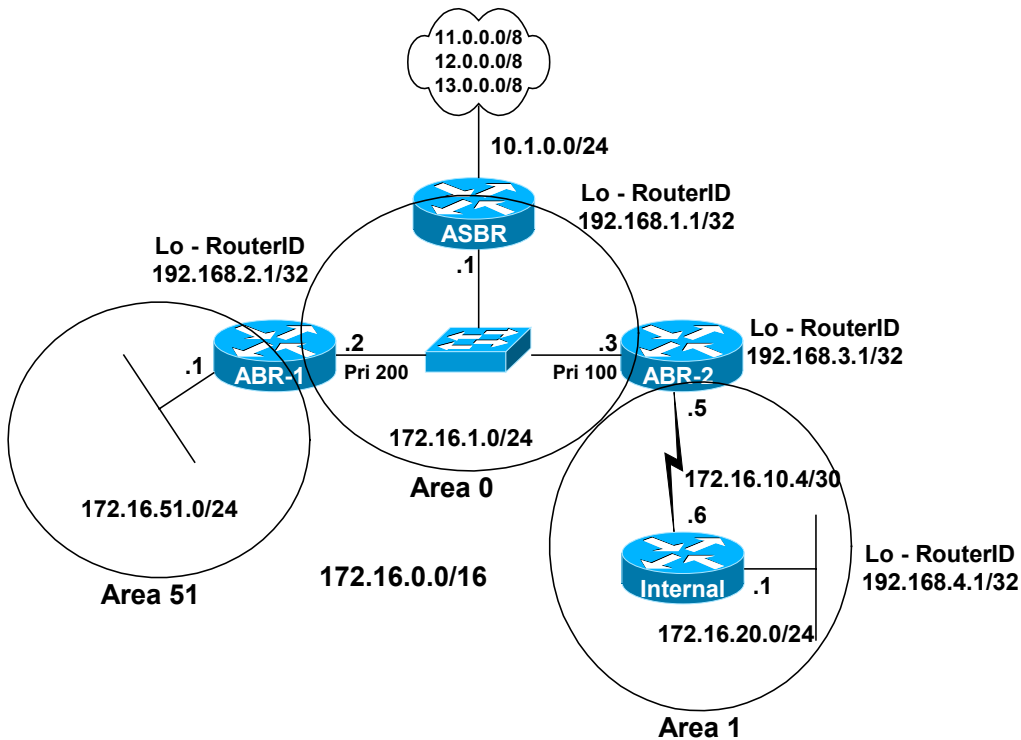
Internal#**show ip ospf**

```
Routing Process "ospf 1" with ID 192.168.4.1
Supports only single TOS(TOS0) routes
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 1. 0 normal 1 stub 0 nssa
External flood list length 0
  Area 1
    Number of interfaces in this area is 2
    It is a stub area
    Area has no authentication
    SPF algorithm executed 8 times
    Area ranges are
    Number of LSA 3. Checksum Sum 0x182B0
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

Internal#

## Lab 4: OSPF SPF Calculation

- On ABR1, the Ethernet 172.16.1.2 port will be disconnected from the switch.
- SPF runs on area0 but not for Internal router on area 1.
- All areas normal in this scenario, but it does not matter.
- Outputs show results for Internal and ABR-1 routers before and after the disconnected network.



### Changes in configs

#### ABR-2

```
ABR-2#(config)#router ospf 1
ABR-2(config-router)#no area 1 stub no-summary
```

#### Internal (No Change)

```
Internal#(config)#router ospf 1
Internal#(config-router)#no area 1 stub
```

## Internal: OSPF SPF Calculation

Internal#**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

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/783] via 172.16.10.5, 00:02:51, Serial0
C    172.16.20.0/24 is directly connected, FastEthernet0
C    172.16.10.4/30 is directly connected, Serial0
O IA 172.16.1.0/24 [110/782] via 172.16.10.5, 00:02:51, Serial0
    192.168.4.0/32 is subnetted, 1 subnets
C    192.168.4.1 is directly connected, Loopback0
O E2 11.0.0.0/8 [110/20] via 172.16.10.5, 00:02:51, Serial0
O E2 12.0.0.0/8 [110/20] via 172.16.10.5, 00:02:51, Serial0
O E2 13.0.0.0/8 [110/20] via 172.16.10.5, 00:02:51, Serial0
Internal#
```

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

Internal#**show ip ospf**

```
Routing Process "ospf 1" with ID 192.168.4.1
Supports only single TOS(TOS0) routes
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 3. Checksum Sum 0x91E6
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 1
  Number of interfaces in this area is 2
  Area has no authentication
  SPF algorithm executed 17 times
  Area ranges are
  Number of LSA 5. Checksum Sum 0x3CDD4
  Number of DCbitless LSA 0
  Number of indication LSA 0
  Number of DoNotAge LSA 0
  Flood list length 0
```

Internal#

Internal#**debug ip ospf spf**

```
OSPF spf intra events debugging is on
OSPF spf inter events debugging is on
OSPF spf external events debugging is on
Internal#
```

**Internal: OSPF SPF Calculation**

***Disconnect Ethernet 172.16.1.2 port from the switch***

Internal#

```
00:57:00: OSPF: Detect change in LSA type 3, LSID 172.16.1.0, from 192.168.3.1
area 1
00:57:00: OSPF: Schedule partial SPF - type 3 id 172.16.1.0 adv rtr 192.168.3.1
00:57:00: OSPF: Detect change in LSA type 3, LSID 172.16.51.1, from 192.168.3.1
area 1
00:57:00: OSPF: Schedule partial SPF - type 3 id 172.16.51.1 adv rtr 192.168.3.1
00:57:00: OSPF: Service partial SPF 2/0/0
00:57:00: OSPF: Start partial processing Summary LSA 172.16.1.0, mask
255.255.255.0, adv 192.168.3.1, age 3600, seq 0x80000003 (Area 1)
00:57:00: OSPF: delete lsa id 172.16.1.0, type 3, adv rtr 192.168.3.1 from delete
list
00:57:00: OSPF: inter route to 172.16.1.0/24 became unreachable, check externals
00:57:00: OSPF: Start partial processing Summary LSA 172.16.51.1, mask
255.255.255.255, adv 192.168.3.1, age 3600, seq 0x80000003 (Area 1)
00:57:00: OSPF: delete lsa id 172.16.51.1, type 3, adv rtr 192.168.3.1 from delete
list
00:57:00: OSPF: inter route to 172.16.51.1/32 became unreachable, check externals
00:57:05: OSPF: Detect change in LSA type 3, LSID 172.16.1.0, from 192.168.3.1
area 1
00:57:05: OSPF: SPF due to NON-MAXAGE in lsa 3 from 192.168.3.1
00:57:05: OSPF: Schedule partial SPF - type 3 id 172.16.1.0 adv rtr 192.168.3.1
00:57:05: OSPF: Service partial SPF 1/0/0
00:57:05: OSPF: Start partial processing Summary LSA 172.16.1.0, mask
255.255.255.0, adv 192.168.3.1, age 1, seq 0x80000004 (Area 1)
00:57:05:   Add better path to LSA ID 172.16.1.0, gateway 0.0.0.0, dist 782
00:57:05:   Add path: next-hop 172.16.10.5, interface Serial0
00:57:05:   Add Summary Route to 172.16.1.0. Metric: 782, Next Hop: 172.16.10.5
00:57:05: OSPF: insert route list LS ID 172.16.1.0, type 3, adv rtr 192.168.3.1
00:57:05: OSPF: delete lsa id 172.16.1.0, type 3, adv rtr 192.168.3.1 from delete
list
00:57:05: OSPF: insert route list LS ID 172.16.1.0, type 3, adv rtr 192.168.3.1
```

Internal#**un all**

All possible debugging has been turned off

Internal#**show ip ospf**

```
Routing Process "ospf 1" with ID 192.168.4.1
Supports only single TOS(TOS0) routes
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 3. Checksum Sum 0x91E6
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 1
  Number of interfaces in this area is 2
  Area has no authentication
  SPF algorithm executed 17 times
  Area ranges are
  Number of LSA 4. Checksum Sum 0x318AC
  Number of DCbitless LSA 0
  Number of indication LSA 0
  Number of DoNotAge LSA 0
  Flood list length 0
```

Internal#

## Internal: OSPF SPF Calculation

Internal#**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

```
    172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C       172.16.20.0/24 is directly connected, FastEthernet0
C       172.16.10.4/30 is directly connected, Serial0
O IA    172.16.1.0/24 [110/782] via 172.16.10.5, 00:00:14, Serial0
        192.168.4.0/32 is subnetted, 1 subnets
C       192.168.4.1 is directly connected, Loopback0
O E2   11.0.0.0/8 [110/20] via 172.16.10.5, 00:04:16, Serial0
O E2   12.0.0.0/8 [110/20] via 172.16.10.5, 00:04:16, Serial0
O E2   13.0.0.0/8 [110/20] via 172.16.10.5, 00:04:16, Serial0
Internal#
```

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

## ABR-1: OSPF SPF Calculation

ABR-1#**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

```
172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.51.0/24 is directly connected, Loopback1
O IA    172.16.20.0/24 [110/783] via 172.16.1.3, 00:00:49, FastEthernet0/0
O IA    172.16.10.4/30 [110/782] via 172.16.1.3, 00:00:49, FastEthernet0/0
C       172.16.1.0/24 is directly connected, FastEthernet0/0
O E2    11.0.0.0/8 [110/20] via 172.16.1.1, 00:00:49, FastEthernet0/0
O E2    12.0.0.0/8 [110/20] via 172.16.1.1, 00:00:49, FastEthernet0/0
O E2    13.0.0.0/8 [110/20] via 172.16.1.1, 00:00:49, FastEthernet0/0
        192.168.2.0/32 is subnetted, 1 subnets
C       192.168.2.1 is directly connected, Loopback0
ABR-1#
```

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

ABR-1#**show ip ospf**

```
Routing Process "ospf 1" with ID 192.168.2.1
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 3. Checksum Sum 0x91E6
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 1
  Area has no authentication
  SPF algorithm executed 47 times
  Area ranges are
  Number of LSA 12. Checksum Sum 0x706AE
  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 20 times
  Area ranges are
  Number of LSA 5. Checksum Sum 0x31997
  Number of DCbitless LSA 0
  Number of indication LSA 0
  Number of DoNotAge LSA 0
  Flood list length 0
```

ABR-1#

## **ABR-1: OSPF SPF Calculation**

```
ABR-1#debug ip ospf spf
OSPF spf intra events debugging is on
OSPF spf inter events debugging is on
OSPF spf external events debugging is on
ABR-1#
```

### ***Disconnect Ethernet 172.16.1.2 port from the switch***

```
ABR-1#
01:49:07: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed
state to down
ABR-1#
01:49:13: OSPF: running SPF for area 0
01:49:13: OSPF: Initializing to run spf
01:49:13: It is a router LSA 192.168.2.1. Link Count 0
01:49:13: OSPF: Adding Stub nets
01:49:13: OSPF: Entered old delete routine
01:49:13: OSPF: Delete path to router 192.168.1.1 via 172.16.1.1 spf 47
01:49:13: OSPF: Delete path to router 192.168.3.1 via 172.16.1.3 spf 47
01:49:13: OSPF: No ndb for NET old route 172.16.1.0, mask /24, next hop 172.16.1.2
01:49:13: OSPF: delete lsa id 192.168.1.1, type 1, adv rtr 192.168.1.1 from delete
list
01:49:13: OSPF: delete lsa id 192.168.3.1, type 1, adv rtr 192.168.3.1 from delete
list
01:49:13: OSPF: delete lsa id 172.16.1.1, type 2, adv rtr 192.168.1.1 from delete
list
01:49:13: OSPF: running SPF for area 51
01:49:13: OSPF: Initializing to run spf
01:49:13: It is a router LSA 192.168.2.1. Link Count 1
01:49:13: Processing link 0, id 172.16.51.1, link data 255.255.255.255, type 3
01:49:13: Add better path to LSA ID 172.16.51.1, gateway 172.16.51.1, dist 1
01:49:13: Add path: next-hop 172.16.51.1, interface Loopback1
01:49:13: OSPF: Adding Stub nets
01:49:13: OSPF: delete lsa id 172.16.51.1, type 0, adv rtr 192.168.2.1 from delete
list
01:49:13: OSPF: insert route list LS ID 172.16.51.1, type 0, adv rtr 192.168.2.1
01:49:13: OSPF: Entered old delete routine
01:49:13: OSPF: running spf for summaries area 0
01:49:13: OSPF: Start processing Summary LSA 172.16.10.4, mask 255.255.255.252,
adv 192.168.3.1, age 1172, seq 0x80000003 (Area 0)
01:49:13: OSPF: ABR not reachable 192.168.3.1
01:49:13: OSPF: Start processing Summary LSA 172.16.20.0, mask 255.255.255.0, adv
192.168.3.1, age 435, seq 0x80000001 (Area 0)
01:49:13: OSPF: ABR not reachable 192.168.3.1
01:49:13: OSPF: sum_delete_old_routes area 0
01:49:13: OSPF: sum-Deleting old route 172.16.20.0
01:49:13: OSPF: sum-Deleting old route 172.16.10.4
01:49:13: OSPF: delete lsa id 172.16.20.0, type 3, adv rtr 192.168.3.1 from delete
list
01:49:13: OSPF: delete lsa id 172.16.10.4, type 3, adv rtr 192.168.3.1 from delete
list
01:49:13: OSPF: running spf for summaries area 51
01:49:13: OSPF: sum_delete_old_routes area 51
01:49:13: OSPF: Started Building Type 5 External Routes
01:49:13: OSPF: Start processing Type 5 External LSA 11.0.0.0, mask 255.0.0.0, adv
192.168.1.1, age 10, seq 0x80000003, metric 20, metric-type 2
01:49:13: OSPF: Did not find route to ASBR 192.168.1.1
01:49:13: OSPF: Start processing Type 5 External LSA 12.0.0.0, mask 255.0.0.0, adv
192.168.1.1, age 10, seq 0x80000003, metric 20, metric-type 2
```

## ABR-1: OSPF SPF Calculation

```
01:49:13: OSPF: Did not find route to ASBR 192.168.1.1
01:49:13: OSPF: Start processing Type 5 External LSA 13.0.0.0, mask 255.0.0.0, adv
192.168.1.1, age 10, seq 0x80000003, metric 20, metric-type 2
01:49:13: OSPF: Did not find route to ASBR 192.168.1.1
01:49:13: OSPF: ex_delete_old_routes
01:49:13: OSPF: ex-Deleting old route 13.0.0.0
01:49:13: OSPF: Remove 13.0.0.0 255.0.0.0 172.16.1.1 192.168.1.1 FastEthernet0/0
10 80000014
01:49:13: OSPF: ex-Deleting old route 12.0.0.0
01:49:13: OSPF: Remove 12.0.0.0 255.0.0.0 172.16.1.1 192.168.1.1 FastEthernet0/0
10 80000014
01:49:13: OSPF: ex-Deleting old route 11.0.0.0
01:49:13: OSPF: Remove 11.0.0.0 255.0.0.0 172.16.1.1 192.168.1.1 FastEthernet0/0
10 80000014
01:49:13: OSPF: delete lsa id 13.0.0.0, type 5, adv rtr 192.168.1.1 from delete
list
01:49:13: OSPF: delete lsa id 12.0.0.0, type 5, adv rtr 192.168.1.1 from delete
list
01:49:13: OSPF: delete lsa id 11.0.0.0, type 5, adv rtr 192.168.1.1 from delete
list
01:49:13: OSPF: Started Building Type 7 External Routes
01:49:13: OSPF: ex_delete_old_routes
01:49:13: OSPF: Started Building Type 7 External Routes
01:49:13: OSPF: ex_delete_old_routes
ABR-1#un all
All possible debugging has been turned off
ABR-1#
```

### ABR-1#show ip ospf

```
Routing Process "ospf 1" with ID 192.168.2.1
Supports only single TOS(TOS0) routes
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 3. Checksum Sum 0x8BE9
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) (Inactive)
    Number of interfaces in this area is 1
    Area has no authentication
    SPF algorithm executed 48 times
    Area ranges are
    Number of LSA 11. Checksum Sum 0x66DFD
    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 21 times
    Area ranges are
    Number of LSA 1. Checksum Sum 0xFC5D
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
```

ABR-1#



## ABR-1: OSPF SPF Calculation

ABR-1#**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

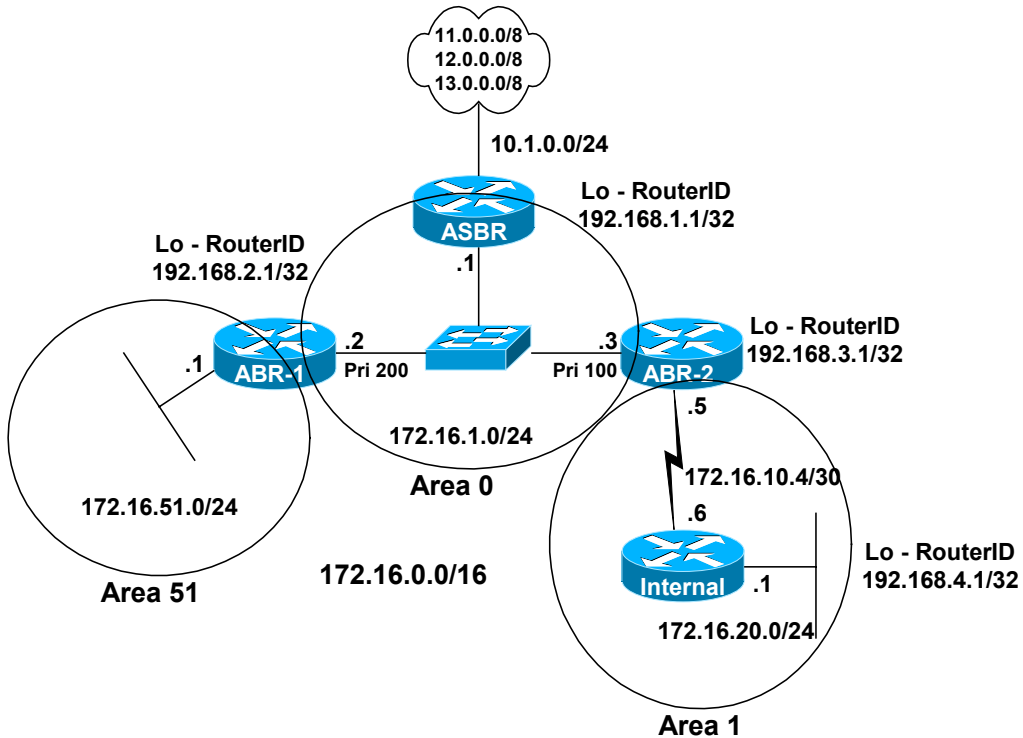
Gateway of last resort is not set

```
    172.16.0.0/24 is subnetted, 1 subnets
C       172.16.51.0 is directly connected, Loopback1
    192.168.2.0/32 is subnetted, 1 subnets
C       192.168.2.1 is directly connected, Loopback0
ABR-1#
```

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

## Lab 5: OSPF Default Route

- All areas normal areas
- Adding a default route on the ASBR
- Adding the `default-information originate` command on the ASBR



### Changes in configs

#### ASBR (add this command)

```
ip route 0.0.0.0 0.0.0.0 Null0
```

## Adding a Default Route

ASBR#**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 0.0.0.0 to network 0.0.0.0

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/2] via 172.16.1.2, 00:05:36, FastEthernet0/0
O IA 172.16.20.0/24 [110/783] via 172.16.1.3, 00:05:36, FastEthernet0/0
O IA 172.16.10.4/30 [110/782] via 172.16.1.3, 00:05:36, FastEthernet0/0
C 172.16.1.0/24 is directly connected, FastEthernet0/0
10.0.0.0/24 is subnetted, 1 subnets
C 10.1.0.0 is directly connected, FastEthernet0/1
S 11.0.0.0/8 is directly connected, Null0
S 12.0.0.0/8 is directly connected, Null0
192.168.1.0/32 is subnetted, 1 subnets
C 192.168.1.1 is directly connected, Loopback0
S 13.0.0.0/8 is directly connected, Null0
S* 0.0.0.0/0 is directly connected, Null0
```

ASBR#

ABR-1#**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

```
172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C 172.16.51.0/24 is directly connected, Loopback1
O IA 172.16.20.0/24 [110/783] via 172.16.1.3, 00:06:05, FastEthernet0/0
O IA 172.16.10.4/30 [110/782] via 172.16.1.3, 00:06:05, FastEthernet0/0
C 172.16.1.0/24 is directly connected, FastEthernet0/0
O E2 11.0.0.0/8 [110/20] via 172.16.1.1, 00:06:05, FastEthernet0/0
O E2 12.0.0.0/8 [110/20] via 172.16.1.1, 00:06:05, FastEthernet0/0
O E2 13.0.0.0/8 [110/20] via 172.16.1.1, 00:06:05, FastEthernet0/0
192.168.2.0/32 is subnetted, 1 subnets
C 192.168.2.1 is directly connected, Loopback0
```

ABR-1#

- Notice that there is the default route was **not** propagated by the ASBR to this or any of the other routers.
- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

## Adding a Default Route

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

- This command is required to propagate the default route to other routers in the OSPF routing domain.
- This is **not** the same default route that is injected into stub and totally stubby areas by the ABR.

```
ASBR#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 0.0.0.0 to network 0.0.0.0
```

```
       172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA   172.16.51.1/32 [110/2] via 172.16.1.2, 00:06:42, FastEthernet0/0
O IA   172.16.20.0/24 [110/783] via 172.16.1.3, 00:06:42, FastEthernet0/0
O IA   172.16.10.4/30 [110/782] via 172.16.1.3, 00:06:42, FastEthernet0/0
C      172.16.1.0/24 is directly connected, FastEthernet0/0
       10.0.0.0/24 is subnetted, 1 subnets
C      10.1.0.0 is directly connected, FastEthernet0/1
S      11.0.0.0/8 is directly connected, Null0
S      12.0.0.0/8 is directly connected, Null0
       192.168.1.0/32 is subnetted, 1 subnets
C      192.168.1.1 is directly connected, Loopback0
S      13.0.0.0/8 is directly connected, Null0
S* 0.0.0.0/0 is directly connected, Null0
ASBR#
```

```
ABR-1#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 172.16.1.1 to network 0.0.0.0
```

```
       172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C      172.16.51.0/24 is directly connected, Loopback1
O IA   172.16.20.0/24 [110/783] via 172.16.1.3, 00:07:02, FastEthernet0/0
O IA   172.16.10.4/30 [110/782] via 172.16.1.3, 00:07:02, FastEthernet0/0
C      172.16.1.0/24 is directly connected, FastEthernet0/0
O E2  11.0.0.0/8 [110/20] via 172.16.1.1, 00:07:02, FastEthernet0/0
O E2  12.0.0.0/8 [110/20] via 172.16.1.1, 00:07:02, FastEthernet0/0
O E2  13.0.0.0/8 [110/20] via 172.16.1.1, 00:07:02, FastEthernet0/0
       192.168.2.0/32 is subnetted, 1 subnets
C      192.168.2.1 is directly connected, Loopback0
O*E2 0.0.0.0/0 [110/1] via 172.16.1.1, 00:00:27, FastEthernet0/0
ABR-1#
```

- The ABR now has a default route of its own, via the ASBR!

## Adding a Default Route

Internal#**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 172.16.10.5 to network 0.0.0.0

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA 172.16.51.1/32 [110/783] via 172.16.10.5, 00:07:06, Serial0
C    172.16.20.0/24 is directly connected, FastEthernet0
C    172.16.10.4/30 is directly connected, Serial0
O IA 172.16.1.0/24 [110/782] via 172.16.10.5, 00:12:10, Serial0
    192.168.4.0/32 is subnetted, 1 subnets
C    192.168.4.1 is directly connected, Loopback0
O E2 11.0.0.0/8 [110/20] via 172.16.10.5, 00:16:11, Serial0
O E2 12.0.0.0/8 [110/20] via 172.16.10.5, 00:16:12, Serial0
O E2 13.0.0.0/8 [110/20] via 172.16.10.5, 00:16:12, Serial0
O*E2 0.0.0.0/0 [110/1] via 172.16.10.5, 00:00:41, Serial0
```

Internal#

- LSA 1 and LSA 2: Denoted by "O" or "C"
- LSA 3: Denoted by "IA"
- LSA 5: Denoted by "E1" or "E2" (default)

**Notice there does not look like a difference between this default route and the one injected by the ABR when configured as a stub.**