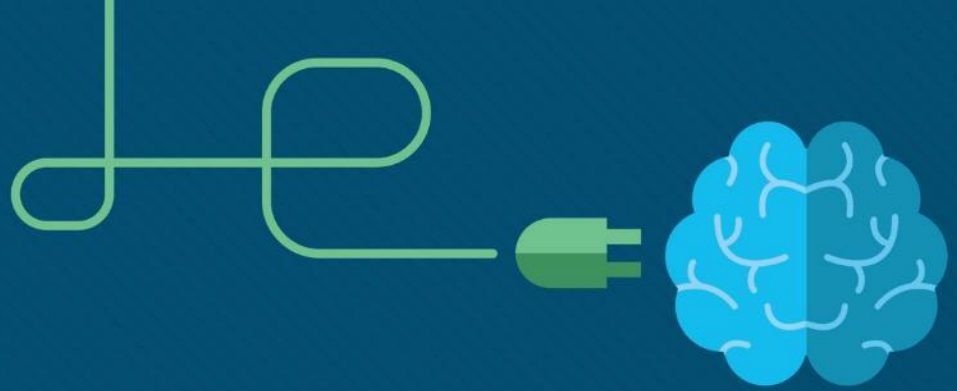


Chapter 9: Multiarea OSPF

CCNA Routing and Switching

Scaling Networks v6.0

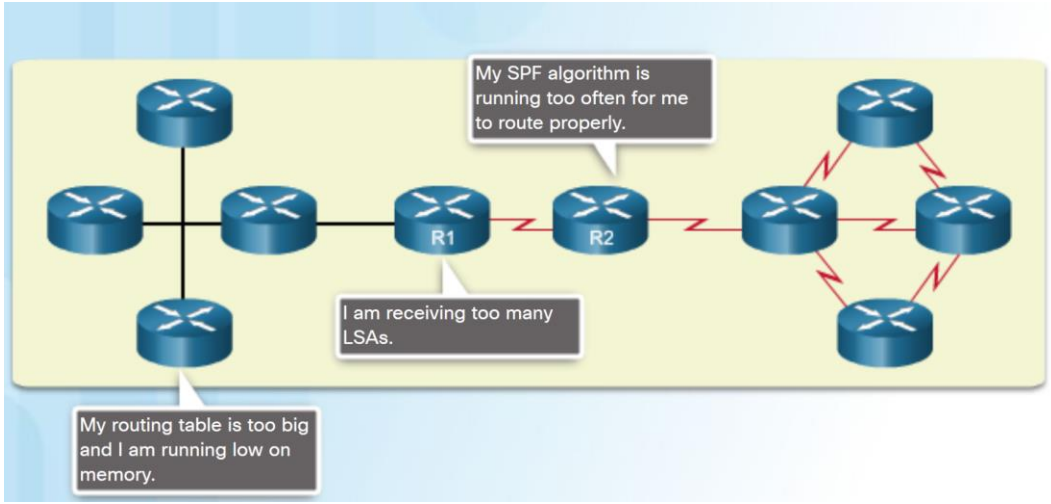
Chapter 9 - Sections & Objectives

- 9.1 Multiarea OSPF Operation
  - Explain how multiarea OSPF operates in a small to medium-sized business network.
    - Explain why multiarea OSPF is used.
    - Explain how multiarea OSPFv2 uses link-state advertisements.
    - Explain how multiarea OSPF establishes neighbor adjacencies.
- 9.2 Implement Multiarea OSPF
  - Implement multiarea OSPFv2 and OSPFv3.
    - Configure multiarea OSPFv2 and OSPFv3 in a routed network.
    - Verify multiarea OSPFv2 and OSPFv3 operation.

9.1 Multiarea OSPF Operation

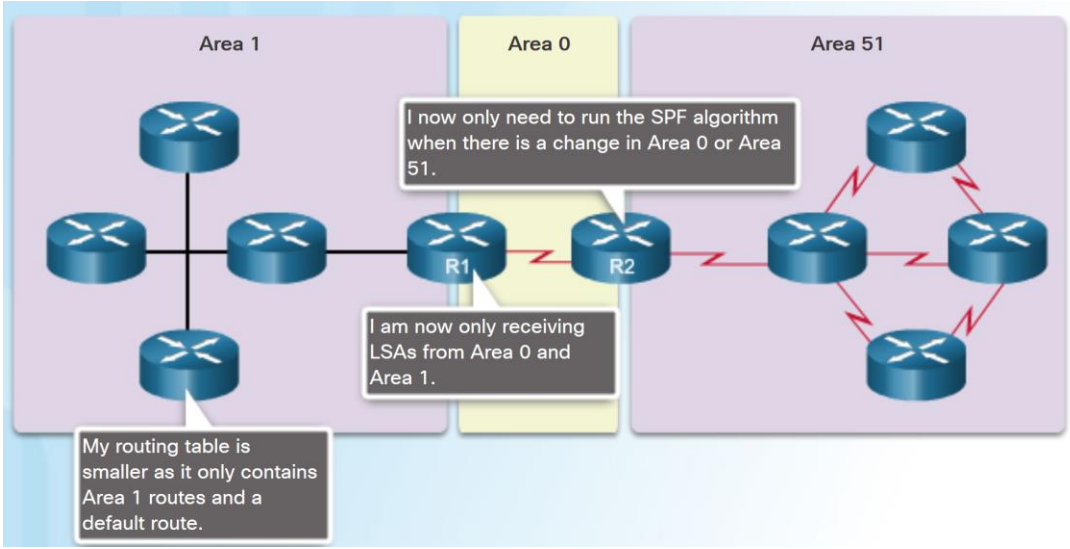
Single-Area OSPF

- Issues in a large single area OSPF:
  - Large routing table
  - Large link-state database (LSDB)
  - Frequent SPF algorithm calculations
- To make OSPF more efficient and scalable, OSPF supports hierarchical routing using areas.

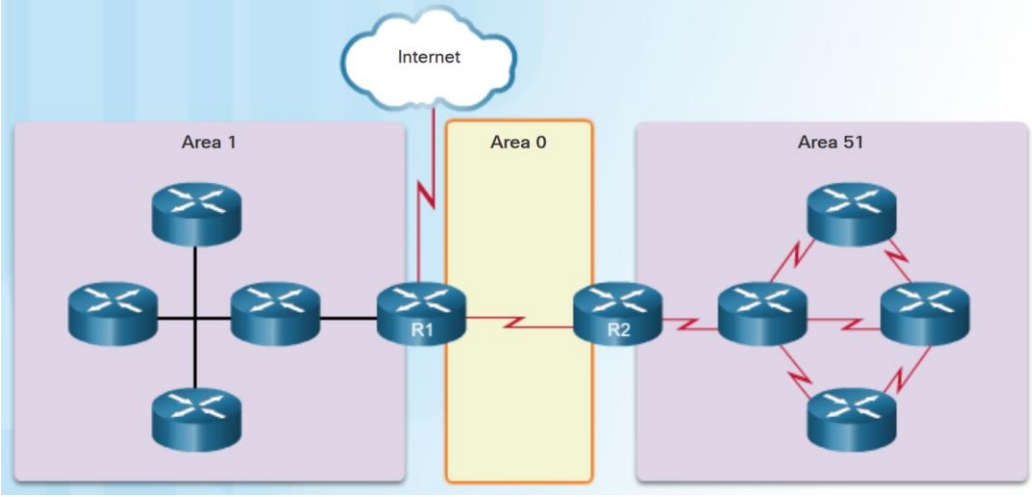


Multiarea OSPF

- Multiarea OSPF:
  - Large OSPF area is divided into smaller areas.
  - Reduces processing and memory overhead.
  - Requires a hierarchical network design.
  - The main area is the backbone area (area 0) and all other areas connect to it.
- Advantages of Multiarea OSPF:
  - Smaller routing tables - Fewer routing table entries as network addresses can be summarized between areas.
  - Reduced link-state update overhead.
  - Reduced frequency of SPF calculations.

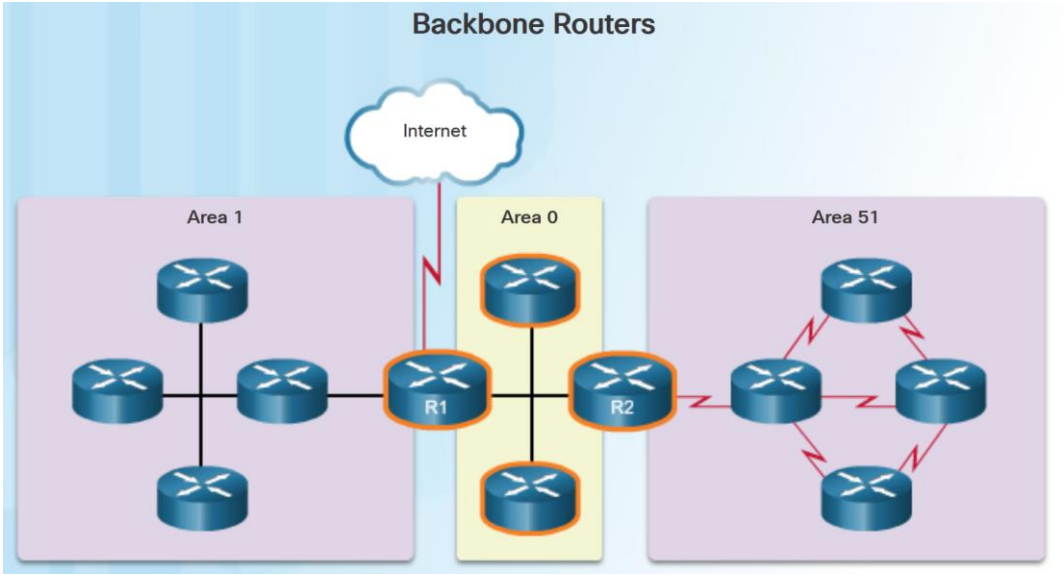


OSPF Two-Layer Area Hierarchy



- Multiarea OSPF is implemented in a two-layer area hierarchy.
- Backbone (Transit) area - An OSPF area whose primary function is the fast and efficient movement of IP packets:
  - Interconnects with other OSPF area types.
  - Also called OSPF area 0.
- Regular (nonbackbone) area - Connects users and resources:
  - Usually set up along functional or geographical groupings
  - All traffic from other areas must cross a transit area.

Types of OSPF Routers



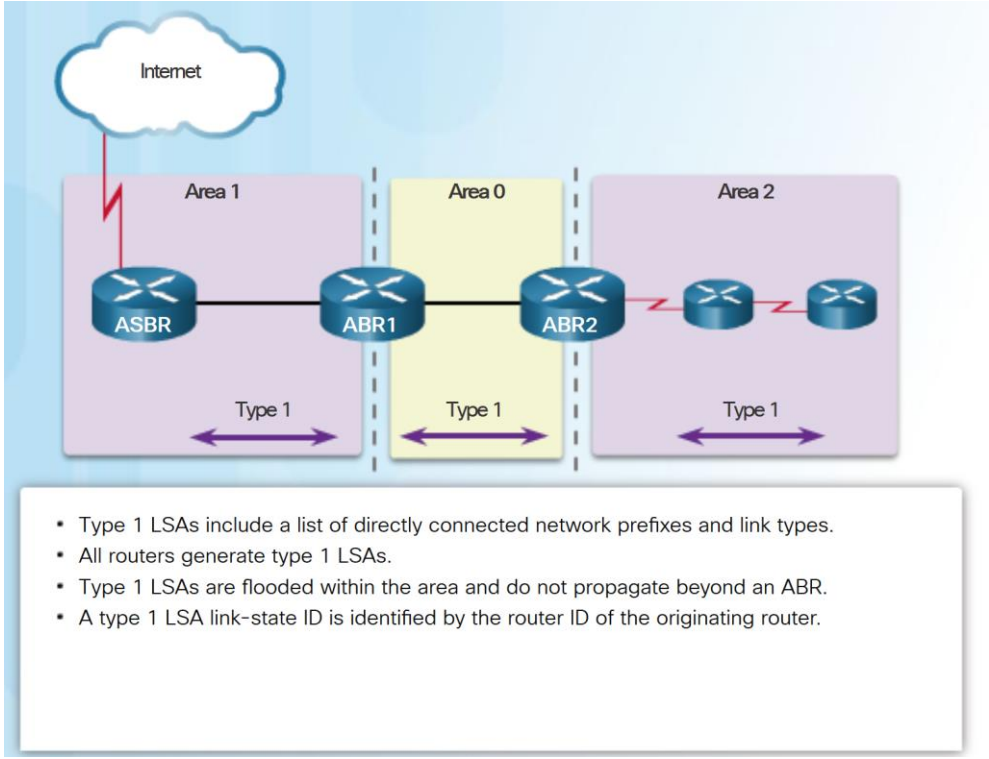
- There are four different types of OSPF routers:
  - Internal router –A router that has all of its interfaces in the same area.
  - Backbone router - A router in the backbone area. The backbone area is set to area 0
  - Area Border Router (ABR) – A router that has interfaces attached to multiple areas.
  - Autonomous System Boundary Router (ASBR) – A router that has at least one interface attached to an external internetwork.
- A router can be classified as more than one router type.

OSPF LSA Types

LSA Type	Description
1	Router LSA
2	Network LSA
3 and 4	Summary LSAs
5	AS External LSA
6	Multicast OSPF LSA
7	Defined for NSSAs
8	External Attributes LSA for Border Gateway Protocol (BGP)
9, 10, or 11	Opaque LSAs

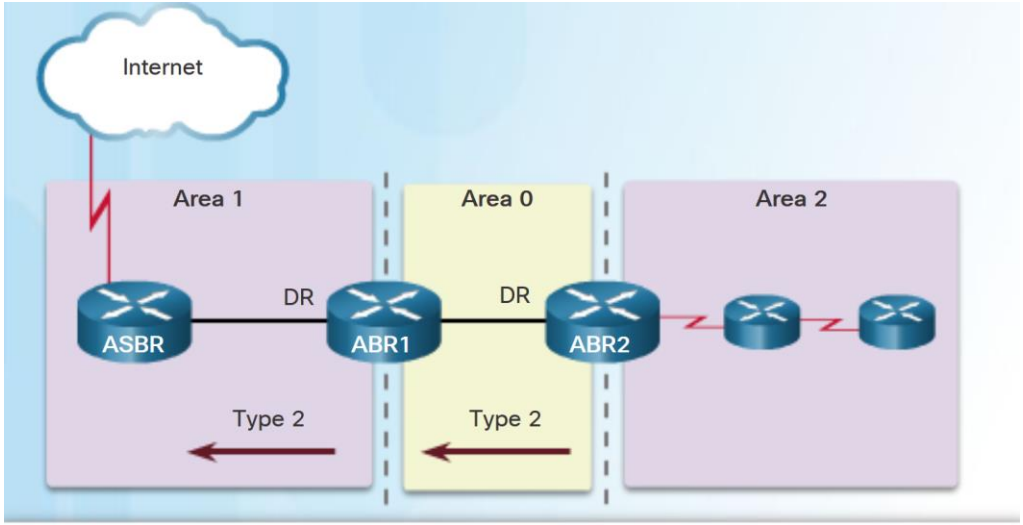
- LSAs individually act as database records and provide specific OSPF network details.
- LSAs in combination describe the entire topology of an OSPF network or area.
- Any implementation of multiarea OSPF must support the first five LSAs

OSPF LSA Type 1



- Routers advertise their directly connected OSPF-enabled links in a type 1 LSA .
- Type 1 LSAs are also referred to as router link entries.
- Type 1 LSAs are flooded only within the area in which they originated.
- ABRs advertise the networks learned from the type 1 LSAs to other areas as type 3 LSAs.
- The type 1 LSA link ID is identified by the router ID of the originating router.

OSPF LSA Type 2

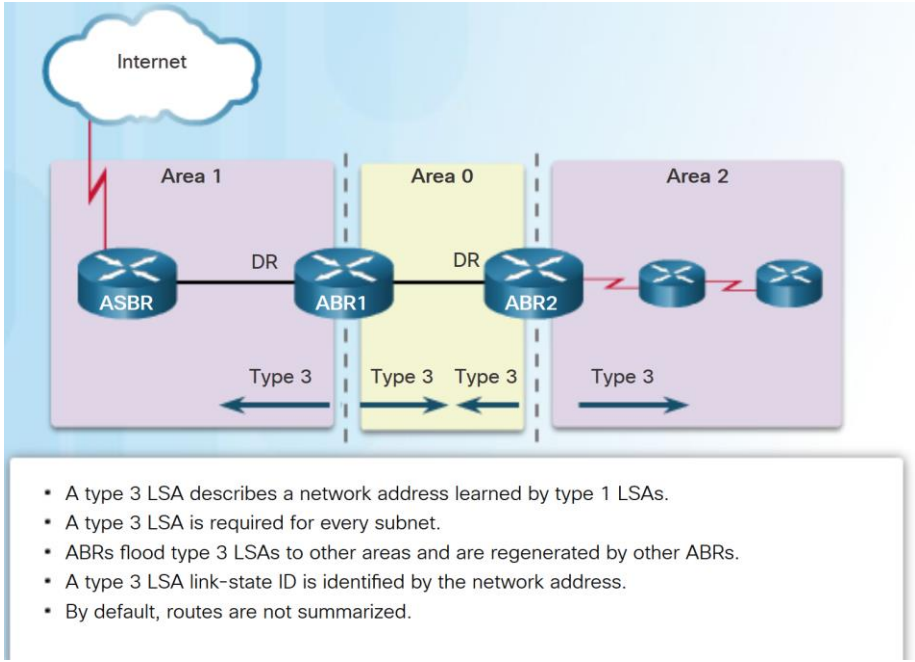


- Type 2 LSAs identify the routers and the network addresses of the multiaccess links.
- Only a DR generates a type 2 LSA.
- Type 2 LSAs are flooded within the multiaccess network and do not go beyond an ABR.
- A type 2 LSA link-state ID is identified by the DR router ID.

- Type 2 LSAs have the following characteristics:
  - Only found on multiaccess and nonbroadcast multiaccess (NBMA) networks
  - Contain the router ID and IP address of the DR, along with the router ID of all other routers on the multiaccess segment
  - Give other routers information about multiaccess networks within the same area
  - Not forwarded outside of an area
  - Also referred to as network link entries
  - Link-state ID is DR router ID

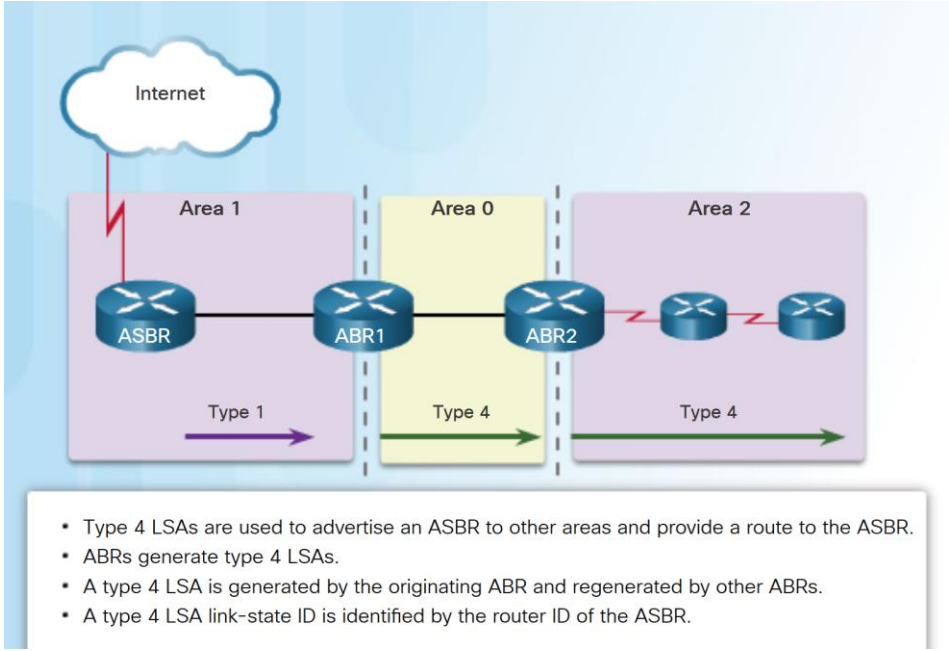
OSPF LSA Type 3

- Type 3 LSAs have the following characteristics:
  - They are used by ABRs to advertise networks from other areas.
  - The ABR creates a type 3 LSA for each of its learned OSPF networks.
  - ABRs flood type 3 LSAs from one area to other areas.
  - To reduce impact of flooding in a large OSPF deployment, configuration of manual route summarization on the ABR is recommended.
  - The link-state ID is set to the network address.

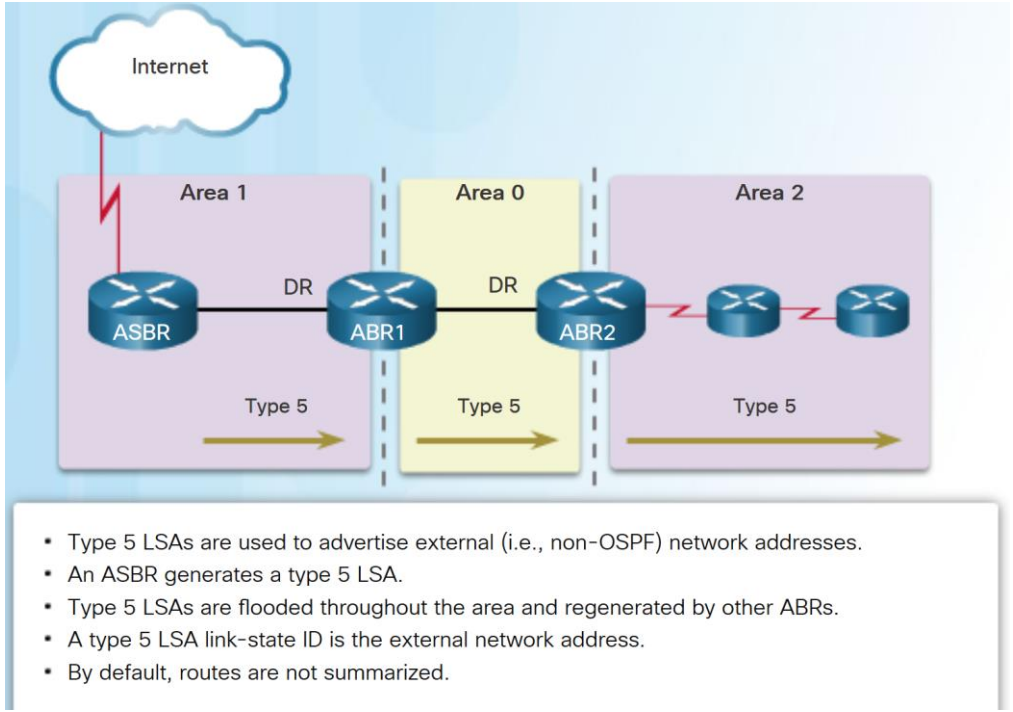


OSPF LSA Type 4

- Type 4 LSAs have the following characteristics:
  - They identify an ASBR and provide a route to it.
  - They are generated by an ABR only when an ASBR exists within an area.
  - They are flooded to other areas by ABRs.
  - The link-state ID is set to the ASBR router ID.



OSPF LSA Type 5



- Type 5 LSAs have the following characteristics:
  - They advertise external routes, also referred to as external LSA entries.
  - They are originated by the ASBR and flooded to the entire routing domain.
  - The link-state ID is the external network number.

OSPF Routing Table Entries

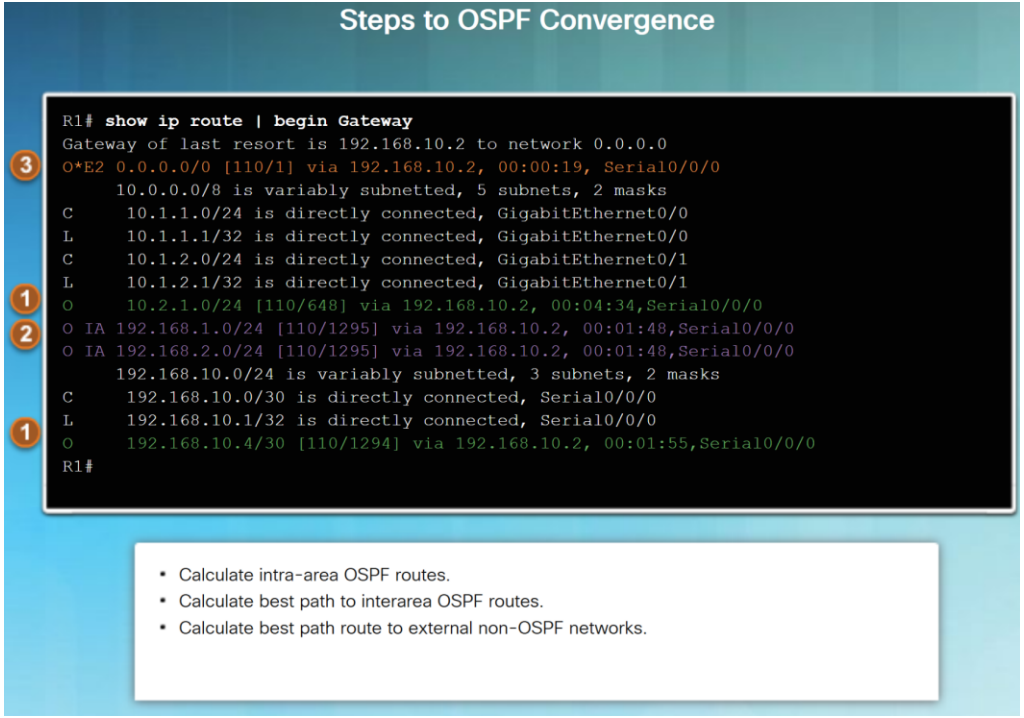
```
R1# show ip route
Codes:L - local, C-connected, S-static, R-RIP, M-mobile, B-BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su-IS-IS summary, L1-IS-IS level-1, L2-IS-IS level-2
      ia - IS-IS inter area,*-candidate default,U-per-user static route
      o - ODR, P-periodic downloaded static route, H-NHRP, l-LISP
      + - replicated route, % - next hop override

Gateway of last resort is 192.168.10.2 to network 0.0.0.0

O*E2 0.0.0.0/0 [110/1] via 192.168.10.2, 00:00:19, Serial0/0/0
     10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
C       10.1.1.0/24 is directly connected, GigabitEthernet0/0
L       10.1.1.1/32 is directly connected, GigabitEthernet0/0
C       10.1.2.0/24 is directly connected, GigabitEthernet0/1
L       10.1.2.1/32 is directly connected, GigabitEthernet0/1
O       10.2.1.0/24 [110/648] via 192.168.10.2, 00:04:34, Serial0/0/0
O IA 192.168.1.0/24 [110/1295] via 192.168.10.2, 00:01:48,Serial0/0/0
O IA 192.168.2.0/24 [110/1295] via 192.168.10.2, 00:01:48,Serial0/0/0
     192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.10.0/30 is directly connected, Serial0/0/0
L       192.168.10.1/32 is directly connected, Serial0/0/0
O       192.168.10.4/30 [110/1294] via 192.168.10.2, 00:01:55,Serial0/0/0
R1#
```

- OSPF routes in an IPv4 routing table are identified using the following descriptors:
  - O - The routing table reflects the link-state information with a designation of O, meaning that the route is intra-area
  - O IA - Summary LSAs appear in the routing table as IA (interarea routes).
  - O E1 or O E2 - External LSAs appear in the routing table marked as external type 1 (E1) or external type 2 (E2) routes.

OSPF Route Calculation



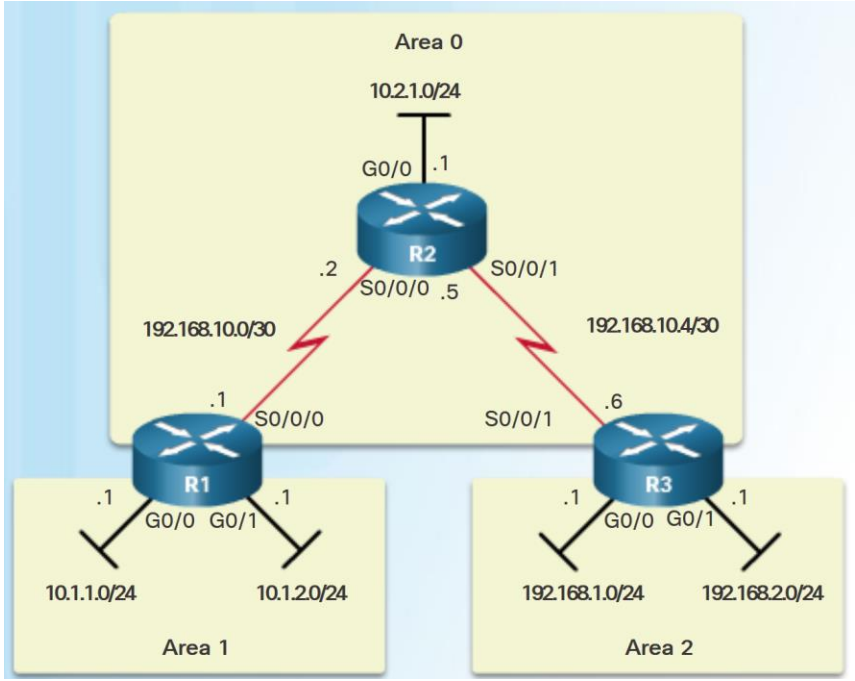
- The order in which the best paths are calculated is as follows:
  - All routers calculate the best path or paths to destinations within their area (intra-area). These are the type 1 and type 2 LSAs – O.
  - All routers calculate the best path or paths to the other areas within the internetwork. Type 3 LSAs - O IA.
  - All routers calculate the best path or paths to the external autonomous system (type 5) destinations - O E1 or an O E2 .

9.2 Configuring Multiarea OSPF

Implementing Multiarea OSPF

- There are 4 steps to implementing multiarea OSPF:
  - Step 1. Gather the network requirements and parameters
  - Step 2. Define the OSPF parameters
    - Single area or multiarea OSPF?
    - IP addressing plan
    - OSPF areas
    - Network topology
  - Step 3. Configure the multiarea OSPF implementation based on the parameters.
  - Step 4. Verify the multiarea OSPF implementation

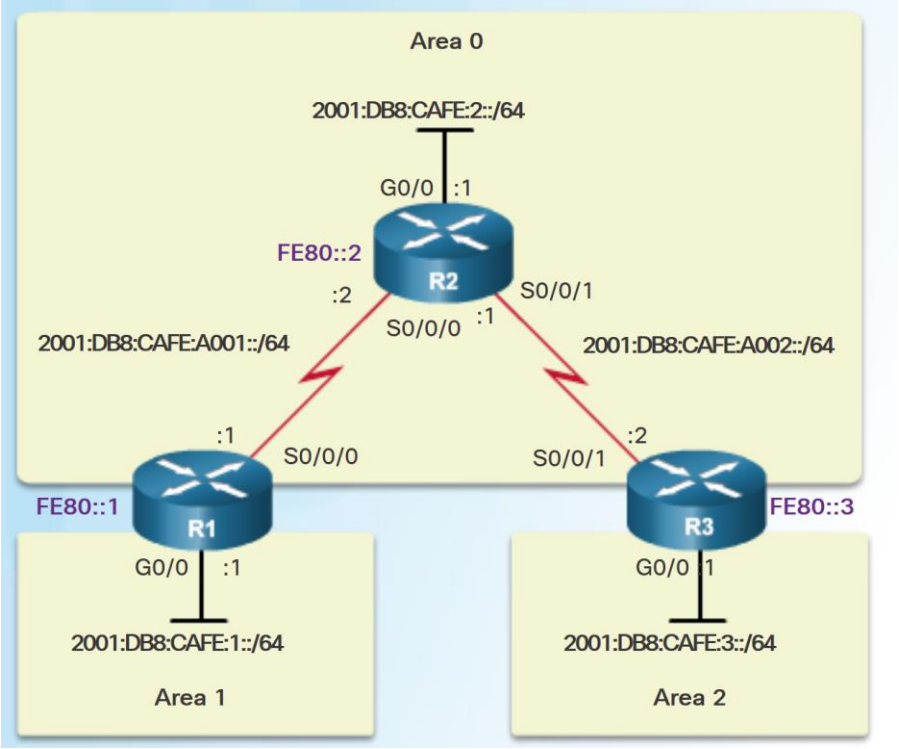
Configuring Multiarea OSPFv2




```
R1(config)# router ospf 10
R1(config-router)# router-id 1.1.1.1
R1(config-router)# network 10.1.1.1 0.0.0.0 area 1
R1(config-router)# network 10.1.2.1 0.0.0.0 area 1
R1(config-router)# network 192.168.10.1 0.0.0.0 area 0
R1(config-router)# end
R1#
```

- There are no special commands to implement multiarea OSPFv2.
- A router becomes an ABR when it has two network statements in different areas.
- R1 is an ABR because it has interfaces in area 1 and an interface in area 0.

Configuring Multiarea OSPFv3



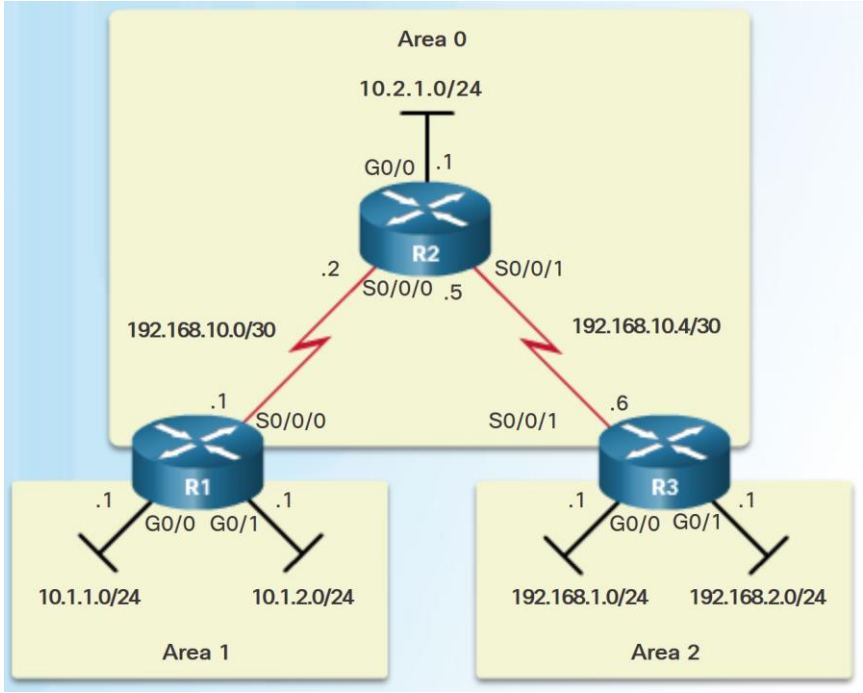

```
R1(config)# ipv6 router ospf 10
R1(config-rtr)# router-id 1.1.1.1
R1(config-rtr)# exit
R1(config)#
R1(config)# interface GigabitEthernet 0/0
R1(config-if)# ipv6 ospf 10 area 1
R1(config-if)#
R1(config-if)# interface Serial0/0/0
R1(config-if)# ipv6 ospf 10 area 0
R1(config-if)# end
R1#
```

- There are no special commands required to implement multiarea OSPFv3.
- A router becomes an ABR when it has two interfaces in different areas.

Verifying Multiarea OSPFv2

- Commands to verify multiarea OSPFv2
  - **show ip ospf neighbor**
  - **show ip ospf**
  - **show ip ospf interface**
  - **Show ip protocols**
  - **show ip ospf interface brief**
  - **show ip route ospf**
  - **show ip ospf database**

Note: For the equivalent OSPFv3 command, simply substitute ipv6 for ip.



Verify General Multiarea OSPFv2 Settings

- Use the **show ip protocols** command to verify the OSPFv2 status.
  - Lists routing protocols configured on router, number of areas, router ID and networks included in routing protocol.
- Use the **show ip ospf interface brief** command to display OSPFv2-related information for OSPFv2-enabled interfaces.
  - Lists the OSPFv2 process ID, area that the interfaces are in, and interface cost.

```
R1# show ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 10"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 1.1.1.1
  It is an area border router
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    10.1.1.1 0.0.0.0 area 1
    10.1.2.1 0.0.0.0 area 1
    192.168.10.1 0.0.0.0 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    3.3.3.3              110      02:20:36
    2.2.2.2              110      02:20:39
  Distance: (default is 110)
```

```
R1# show ip ospf interface brief
Interface  PID   Area  IP Address/Mask  Cost  State  Nbrs F/C
Se0/0/0    10    0     192.168.10.1/30  64    P2P    1/1
Gi0/1      10    1     10.1.2.1/24      1     DR     0/0
Gi0/0      10    1     10.1.1.1/24      1     DR     0/0
R1#
```

Verify the OSPFv2 Routes

```
R1# show ip route ospf | begin Gateway
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
O     10.2.1.0/24 [110/648] via 192.168.10.2, 00:26:03, Serial0/0/0
O IA  192.168.1.0/24 [110/1295] via 192.168.10.2, 00:26:03, Serial0/0/0
O IA  192.168.2.0/24 [110/1295] via 192.168.10.2, 00:26:03, Serial0/0/0
      192.168.10.0/24 is variably subnetted,3 subnets,2 masks
O     192.168.10.4/30 [110/1294] via 192.168.10.2, 00:26:03, Serial0/0/0
R1#
```

- Use the **show ip route ospf** command to verify the muliarea OSPFv2 configuration..
  - O represents OSPFv2 routes and IA represents interarea, which means that the route originated from another area.

Verify the Multiarea OSPFv2 LSDB

```
R1# show ip ospf database
            OSPF Router with ID (1.1.1.1) (Process ID 10)

                Router Link States (Area 0)
Link ID         ADV Router      Age  Seq#       Checksum  Link count
1.1.1.1         1.1.1.1         725  0x80000005 0x00F9B0  2
2.2.2.2         2.2.2.2         695  0x80000007 0x003DB1  5
3.3.3.3         3.3.3.3         681  0x80000005 0x00FF91  2
                Summary Net Link States (Area 0)
Link ID         ADV Router      Age  Seq#       Checksum
10.1.1.0        1.1.1.1         725  0x80000006 0x00D155
10.1.2.0        1.1.1.1         725  0x80000005 0x00C85E
192.168.1.0     3.3.3.3         681  0x80000006 0x00724E
192.168.2.0     3.3.3.3         681  0x80000005 0x006957

                Router Link States (Area 1)
Link ID         ADV Router      Age  Seq#       Checksum  Link count
1.1.1.1         1.1.1.1         725  0x80000006 0x007D7C  2
                Summary Net Link States (Area 1)
Link ID         ADV Router      Age  Seq#       Checksum
10.2.1.0        1.1.1.1         725  0x80000005 0x004A9C
192.168.1.0     1.1.1.1         725  0x80000005 0x00B593
192.168.2.0     1.1.1.1         725  0x80000005 0x00AA9D
192.168.10.0    1.1.1.1         725  0x80000005 0x00B3D0
192.168.10.4    1.1.1.1         725  0x80000005 0x000E32
R1#
```

- Use the **show ip ospf database** command to verify the contents of the OSPFv2 LSDB.

Verify Multiarea OSPFv3

```
R1# show ipv6 protocols
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "ND"
IPv6 Routing Protocol is "ospf 10"
  Router ID 1.1.1.1
  Area border router
  Number of areas: 2 normal, 0 stub, 0 nssa
  Interfaces (Area 0):
    Serial0/0/0
  Interfaces (Area 1):
    GigabitEthernet0/0
  Redistribution:
    None
R1#
```

```
R1# show ipv6 ospf interface brief
Interface    PID   Area        Intf ID    Cost  State Nbrs F/C
Se0/0/0      10    0           6          647   P2P   1/1
Gi0/0        10    1           3          1     DR    0/0
R1#
```

- Use the **show ipv6 protocols** command to verifyOSPFv3.
- Use the **show ipv6 interface brief** to verify the OSPFv3-enabled interfaces and the area to which they belong.
- Use **show ipv6 route ospf** to display the routing table.
- Use **show ipv6 ospf database** to display the contents of the LSDB.

```
R1# show ipv6 route ospf
IPv6 Routing Table - default - 8 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route,B - BGP,
       R - RIP, H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea,
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, ND - ND Default,
       NDp - ND Prefix, DCE - Destination, NDr - Redirect, O - OSPF Intra,
       OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2, ON1 - OSPF NSSA ext 1,
       ON2 - OSPF NSSA ext 2
O   2001:DB8:CAFE:2::/64 [110/648]
     via FE80::2, Serial0/0/0
OI  2001:DB8:CAFE:3::/64 [110/1295]
     via FE80::2, Serial0/0/0
O   2001:DB8:CAFE:A002::/64 [110/1294]
     via FE80::2, Serial0/0/0
R1#
```

9.3 Chapter Summary

Chapter 9: Multiarea OSPF

- Explain how multiarea OSPF operates in a small to medium-sized business network.
- Implement multiarea OSPFv2 and OSPFv3.


CISCO