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
Why Multiarea OSPF?

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:

- 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.
Why Multiarea OSPF?

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.
Why Multiarea OSPF?

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.
Multiarea OSPF LSA Operation

OSPF LSA Types

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

- 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
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.

- Type 1 LSAs include a list of directly connected network prefixes and link types.
- All routers generate type 1 LSAs.
- Type 1 LSAs are flooded within the area and do not propagate beyond an ABR.
- A type 1 LSA link-state ID is identified by the router ID of the originating router.
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

- 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 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.
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.
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.

- Type 5 LSAs are used to advertise external (i.e., non-OSPF) network addresses.
- An ASBR generates a type 5 LSA.
- Type 5 LSAs are flooded throughout the area and regenerated by other ABRs.
- A type 5 LSA link-state ID is the external network address.
- By default, routes are not summarized.
**OSPF Routing Table and Types of Routes**

### OSPF Routing Table Entries

<table>
<thead>
<tr>
<th>RIP</th>
<th>show ip route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codes:</td>
<td>L - local, C-connected, S-static, R-RIP, M-mobile, B-BGP</td>
</tr>
<tr>
<td>D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area</td>
<td></td>
</tr>
<tr>
<td>N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2</td>
<td></td>
</tr>
<tr>
<td>E1 - OSPF external type 1, E2 - OSPF external type 2</td>
<td></td>
</tr>
<tr>
<td>Ia - IS-IS inter area, *-candidate default, D-per-user static route</td>
<td></td>
</tr>
<tr>
<td>o - ODR, P-periodic downloaded static route, H-NHBP, L-LISP</td>
<td></td>
</tr>
<tr>
<td>+ - replicated route, % - next hop override</td>
<td></td>
</tr>
</tbody>
</table>

Gateway of last resort is 192.168.10.2 to network 0.0.0.0

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Mask</th>
<th>Gateway</th>
<th>Distance</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0.0.0/0</td>
<td>0</td>
<td>192.168.10.2</td>
<td>0</td>
<td>Serial0/0/0</td>
</tr>
<tr>
<td>10.0.0.0/8</td>
<td>0</td>
<td>192.168.10.2</td>
<td>0</td>
<td>Serial0/0/0</td>
</tr>
<tr>
<td>C 10.1.1.0/24</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
</tr>
<tr>
<td>L 10.1.1.0/24</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
</tr>
<tr>
<td>C 10.1.2.0/24</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
</tr>
<tr>
<td>L 10.2.1.0/24</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
<td>0</td>
<td>GigabitEthernet0/0/0</td>
</tr>
<tr>
<td>O 192.168.10.0/24</td>
<td>0</td>
<td>192.168.10.2</td>
<td>0</td>
<td>Serial0/0/0</td>
</tr>
</tbody>
</table>

- **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.
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
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
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.
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 OSPF

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`. 
Verifying Multiarea OSPF

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.
Use the **show ip route ospf** command to verify the multiarea OSPFv2 configuration.

- **O** represents OSPFv2 routes and **IA** represents interarea, which means that the route originated from another area.
### Verifying Multiarea OSPF

#### Verify the Multiarea OSPFv2 LSDB

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

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
<th>Link count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1.1</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000005</td>
<td>0x00F9B0</td>
<td>2</td>
</tr>
<tr>
<td>2.2.2.2</td>
<td>2.2.2.2</td>
<td>695</td>
<td>0x800000007</td>
<td>0x0030B1</td>
<td>5</td>
</tr>
<tr>
<td>3.3.3.3</td>
<td>3.3.3.3</td>
<td>681</td>
<td>0x800000005</td>
<td>0x00F9B1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Summary Net Link States (Area 0)**

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.1.0</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000006</td>
<td>0x00D155</td>
</tr>
<tr>
<td>10.1.2.0</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000005</td>
<td>0x00C85E</td>
</tr>
<tr>
<td>192.168.1.0</td>
<td>3.3.3.3</td>
<td>681</td>
<td>0x800000006</td>
<td>0x00724E</td>
</tr>
<tr>
<td>192.168.2.0</td>
<td>3.3.3.3</td>
<td>681</td>
<td>0x800000005</td>
<td>0x006957</td>
</tr>
</tbody>
</table>

**Router Link States (Area 1)**

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1.1</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000006</td>
<td>0x00D7D7</td>
</tr>
</tbody>
</table>

**Summary Net Link States (Area 1)**

<table>
<thead>
<tr>
<th>Link ID</th>
<th>ADV Router</th>
<th>Age</th>
<th>Seq#</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2.1.0</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000005</td>
<td>0x004A9C</td>
</tr>
<tr>
<td>192.168.1.0</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000005</td>
<td>0x00B593</td>
</tr>
<tr>
<td>192.168.2.0</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000005</td>
<td>0x00AA9D</td>
</tr>
<tr>
<td>192.168.10.0</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000005</td>
<td>0x00B3D0</td>
</tr>
<tr>
<td>192.168.10.4</td>
<td>1.1.1.1</td>
<td>725</td>
<td>0x800000005</td>
<td>0x00GE32</td>
</tr>
</tbody>
</table>
Verifying Multiarea OSPF

Verify Multiarea OSPFv3

- Use the `show ipv6 protocols` command to verify OSPFv3.
- 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.
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.