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CCNP Enterprise Advanced Routing

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RAYMOND LACOSTE
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CCNP Enterprise Advanced Routing ENARSI 300-410 Official Cert Guide

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Example 7-29 *Routing Table After OSPF Inter-area Route Summarization*

```
R3# show ip route ospf | begin Gateway
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
O IA    10.12.1.0/24 [110/2] via 10.23.1.2, 00:02:04, GigabitEthernet0/1
O IA  172.16.0.0/16 [110/46] via 10.23.1.2, 00:00:22, GigabitEthernet0/1
```

Key Topic

The ABR performing inter-area summarization installs discard routes, which are routes to the Null0 interface that match the summarized network. Discard routes prevent routing loops where portions of the summarized network range do not have a more specific route in the RIB. The administrative distance (AD) for the OSPF summary discard route for internal networks is 110, and it is 254 for external networks. Example 7-30 shows the discard route to Null0 on R2.

Example 7-30 *Discard Route for Loop Prevention*

```
R2# show ip route ospf | begin Gateway
Gateway of last resort is not set

      172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
O        172.16.0.0/16 is a summary, 00:03:11, Null
O        172.16.1.0/24 [110/2] via 10.12.1.1, 00:01:26, GigabitEthernet0/0
O        172.16.2.0/24 [110/2] via 10.12.1.1, 00:01:26, GigabitEthernet0/0
O        172.16.3.0/24 [110/2] via 10.12.1.1, 00:01:26, GigabitEthernet0/0
```

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External Summarization

Key Topic

During OSPF redistribution, external routes are redistributed into the OSPF domain as Type 5 or Type 7 LSAs (NSSA). External summarization reduces the number of external LSAs in an OSPF domain. An external summarization route is configured on the ASBR router, and a smaller component route that matches the network range does not generate a Type 5/Type 7 LSA for the specific prefix. Instead, a Type 5/Type 7 LSA with the external summary route is created, and the smaller component routes in the summary route are suppressed.

Figure 7-27 demonstrates the concept with the external network summarization range 172.16.0.0/20 configured on the ASBR (R6). The ASBR creates only one Type 5/Type 7 LSA in Area 56 when EIGRP redistributes routes into OSPF.

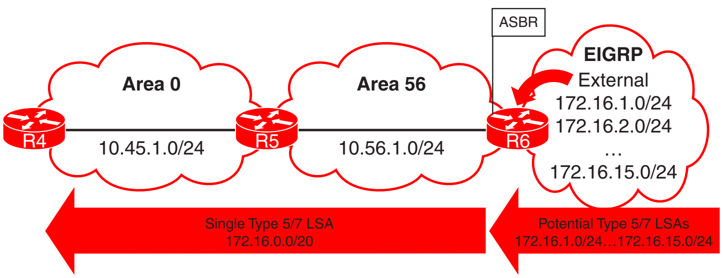

Figure 7-27 *External Summarization Concept*

Example 7-31 provides the routing table on R5 before external route summarization.

Example 7-31 *Routing Table Before External Summarization*

```
R5# show ip route ospf | begin Gateway
! Output omitted for brevity
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 7 subnets, 3 masks
O IA     10.3.3.0/24 [110/67] via 10.45.1.4, 00:01:58, GigabitEthernet0/0
O IA     10.24.1.0/29 [110/65] via 10.45.1.4, 00:01:58, GigabitEthernet0/0
O IA     10.123.1.0/24 [110/66] via 10.45.1.4, 00:01:58, GigabitEthernet0/0
      172.16.0.0/24 is subnetted, 15 subnets
O E2     172.16.1.0 [110/20] via 10.56.1.6, 00:01:00, GigabitEthernet0/1
O E2     172.16.2.0 [110/20] via 10.56.1.6, 00:00:43, GigabitEthernet0/1
..
O E2     172.16.14.0 [110/20] via 10.56.1.6, 00:00:19, GigabitEthernet0/1
O E2     172.16.15.0 [110/20] via 10.56.1.6, 00:00:15, GigabitEthernet0/1
```

To configure external summarization, you use the command **summary-address** *network subnet-mask* under the OSPF process. Example 7-32 demonstrates the configuration for external route summarization on R6 (the ASBR).

Example 7-32 *OSPF External Summarization Configuration*

```
R6
router ospf 1
 router-id 192.168.6.6
 summary-address 172.16.0.0 255.255.240.0
 redistribute eigrp 1 subnets
 network 10.56.1.0 0.0.0.255 area 56
```

Example 7-33 shows R5's routing table, which verifies that the component routes were summarized into the 172.16.0.0/20 summary network.

Example 7-33 *Routing Table After External Summarization*

```
R5# show ip route ospf | begin Gateway
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 7 subnets, 3 masks
O IA     10.3.3.0/24 [110/67] via 10.45.1.4, 00:04:55, GigabitEthernet0/0
O IA     10.24.1.0/29 [110/65] via 10.45.1.4, 00:04:55, GigabitEthernet0/0
O IA     10.123.1.0/24 [110/66] via 10.45.1.4, 00:04:55, GigabitEthernet0/0
      172.16.0.0/20 is subnetted, 1 subnets
```

```
O E2     172.16.0.0 [110/20] via 10.56.1.6, 00:00:02, GigabitEthernet0/1
```

```
R5# show ip route 172.16.0.0 255.255.240.0
Routing entry for 172.16.0.0/20
  Known via "ospf 1", distance 110, metric 20, type extern 2, forward metric 1
  Last update from 10.56.1.6 on GigabitEthernet0/1, 00:02:14 ago
  Routing Descriptor Blocks:
  * 10.56.1.6, from 192.168.6.6, 00:02:14 ago, via GigabitEthernet0/1
      Route metric is 20, traffic share count is 1
```

The summarizing ASBR installs a discard route to Null0 that matches the summary route as part of a loop-prevention mechanism. Example 7-34 shows the routing table of R6 with the external summary discard route.

Example 7-34 *R6 Discard Route Verification*

```
R6# show ip route ospf | begin Gateway
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 6 subnets, 3 masks
O IA     10.3.3.0/24 [110/68] via 10.56.1.5, 00:08:36, GigabitEthernet0/1
O IA     10.24.1.0/29 [110/66] via 10.56.1.5, 00:08:36, GigabitEthernet0/1
O IA     10.45.1.0/24 [110/2] via 10.56.1.5, 00:08:36, GigabitEthernet0/1
O IA     10.123.1.0/24 [110/67] via 10.56.1.5, 00:08:36, GigabitEthernet0/1
      172.16.0.0/16 is variably subnetted, 15 subnets, 3 masks
O        172.16.0.0/20 is a summary, 00:03:52, Null0
```

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NOTE ABRs for NSSAs act as ASBRs when a Type 7 LSA is converted to a Type 5 LSA. External summarization can be performed on ABRs only when they match this scenario.

Discontiguous Network

A network engineer who does not fully understand OSPF design might create a topology such as one illustrated in Figure 7-28. While R2 and R4 have OSPF interfaces in Area 0, traffic from Area 12 must cross Area 234 to reach Area 45. An OSPF network with this design is a *discontiguous network* because inter-area traffic is trying to cross a nonbackbone area.

Upon first glance at the routing tables on R2 and R4 in Figure 7-29, it seems as though routes are being advertised across Area 234; however, this is not the case. The 10.45.1.0/24 network is received by R4, injected into R4's Area 0, and then re-advertised to Area 234, where R2 installs the route.

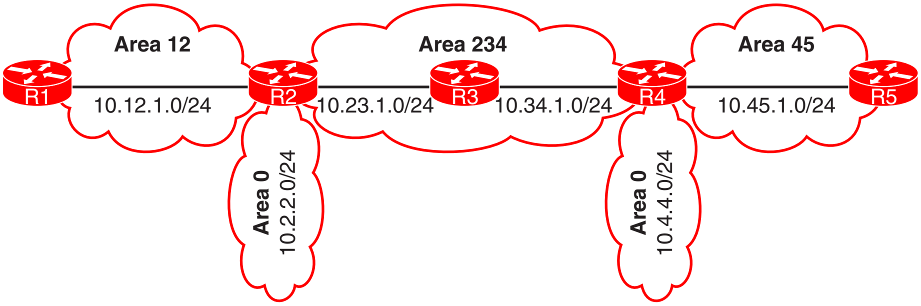

Figure 7-28 *Discontiguous Network*

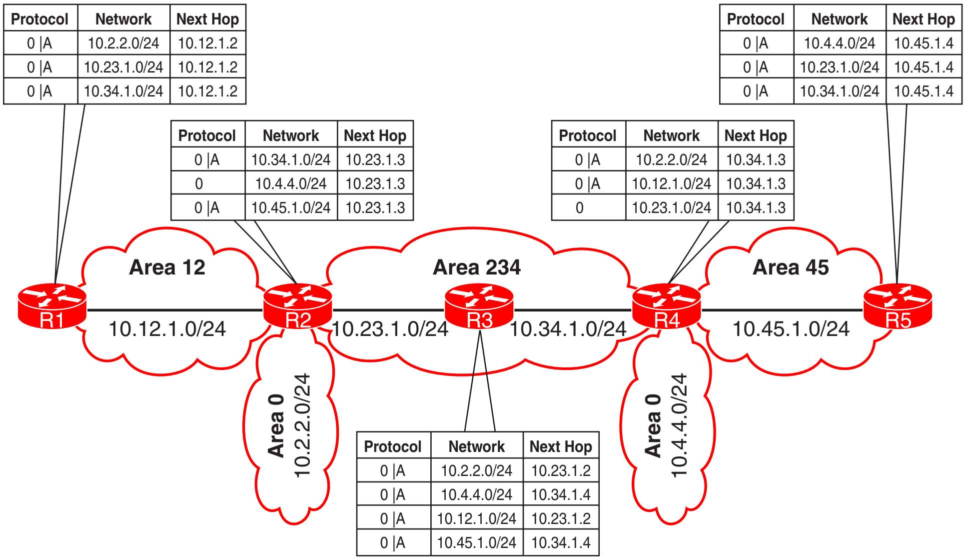

Figure 7-29 *OSPF Routes for a Discontiguous Network*

Key Topic

Most people would assume that R1 would learn about the route learned by Area 45 because R4 is an ABR. However, they would be wrong. ABRs follow three fundamental rules for creating Type 3 LSAs:

- Type 1 LSAs received from an area create Type 3 LSAs into backbone area and nonbackbone areas.
- Type 3 LSAs received from Area 0 are created for the nonbackbone area.
- Type 3 LSAs received from a nonbackbone area are only inserted into the LSDB for the source area. An ABR does not create a Type 3 LSA for the other areas (including a segmented Area 0).

The simplest fix for a discontiguous network is to ensure that Area 0 is contiguous and convert the interfaces on R2, R3, and R4 for the 10.23.1.0/24 and 10.34.1.0/24 networks to be members of Area 0. Another option is to use a virtual link, as discussed in the following section.

Virtual Links

Key Topic

OSPF *virtual links* provide a method to overcome discontiguous networks. Using a virtual link is similar to running a virtual tunnel within OSPF between an ABR and another multi-area OSPF router. The tunnel belongs to the backbone (Area 0), and therefore the router terminating the virtual link becomes an ABR if it does not have an interface already associated with Area 0.

Figure 7-30 revisits the discontiguous topology from the previous section and shows a contiguous backbone between R2 and R4, with a virtual link across Area 234. With the virtual link established, the routes from Area 12 are advertised into Area 45 and vice versa.

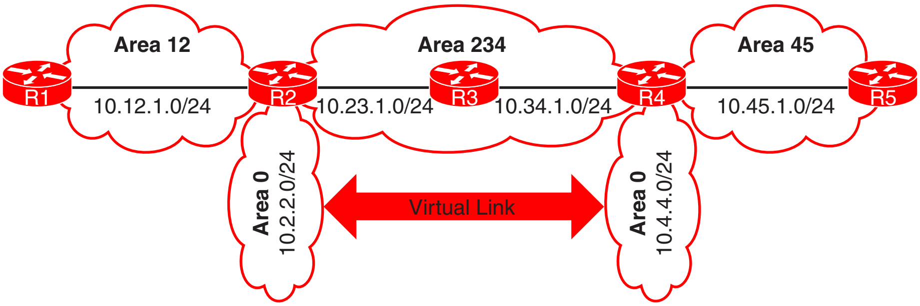

Figure 7-30 *Repair of Discontiguous Network with Virtual Links*

Key Topic

Virtual links are built between routers in the same area. The area in which the virtual link endpoints are established is known as the *transit area*. Each router identifies the remote router by its RID. The virtual link can be one hop away or multiple hops away from the remote device. The virtual link is built using Type 1 LSAs, where the neighbor state is Type 4, as identified earlier in the chapter, in Table 7-3.

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You configure the virtual link by using the command **area** *area-id* **virtual-link** *endpoint-RID*. The configuration is performed on both endpoints of the virtual link. At least one endpoint virtual link router has to be a member of Area 0, and virtual links cannot be formed on any OSPF stubby areas. In Figure 7-30, Area 234 cannot be an OSPF stub area.

Example 7-35 demonstrates the virtual link configuration between R2 and R4. Notice that the RID is specified as the remote tunnel endpoint, even though it is not advertised into OSPF.

Example 7-35 *OSPF Virtual Link Configuration*

```
R2
router ospf 1
 router-id 192.168.2.2
 area 234 virtual-link 192.168.4.4
 network 10.2.2.2 0.0.0.0 area 0
 network 10.12.1.2 0.0.0.0 area 12
```

```
 network 10.23.1.2 0.0.0.0 area 234
```

```
R4
router ospf 1
 router-id 192.168.4.4
area 234 virtual-link 192.168.2.2
 network 10.4.4.4 0.0.0.0 area 0
 network 10.34.1.4 0.0.0.0 area 234
 network 10.45.1.4 0.0.0.0 area 45
```

To verify the virtual link status, you use the command **show ip ospf virtual-links**. Example 7-36 shows the output. Notice that the output includes the virtual link status, the outbound interface to the endpoints, and the interface cost.

Interface cost for a virtual link cannot be set or dynamically generated as the metric for the intra-area distance between the two virtual link endpoints.

Example 7-36 *OSPF Virtual Link Verification*

```
R2# show ip ospf virtual-links
Virtual Link OSPF_VL0 to router 192.168.4.4 is up
  Run as demand circuit
  DoNotAge LSA allowed.
  Transit area 234, via interface GigabitEthernet0/1
Topology-MTID    Cost    Disabled     Shutdown      Topology Name
        0           2         no             no            Base
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
    Adjacency State FULL (Hello suppressed)
    Index 1/1/3, retransmission queue length 0, number of retransmission 0
    First 0x0(0)/0x0(0)/0x0(0) Next 0x0(0)/0x0(0)/0x0(0)
    Last retransmission scan length is 0, maximum is 0
    Last retransmission scan time is 0 msec, maximum is 0 msec
```

```
R4# show ip ospf virtual-links
! Output omitted for brevity
Virtual Link OSPF_VL0 to router 192.168.2.2 is up
  Run as demand circuit
  DoNotAge LSA allowed.
  Transit area 234, via interface GigabitEthernet0/0
Topology-MTID    Cost    Disabled     Shutdown      Topology Name
        0           2         no          no            Base
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
    Adjacency State FULL (Hello suppressed)
```