



Multiarea OSPF



Scaling Networks

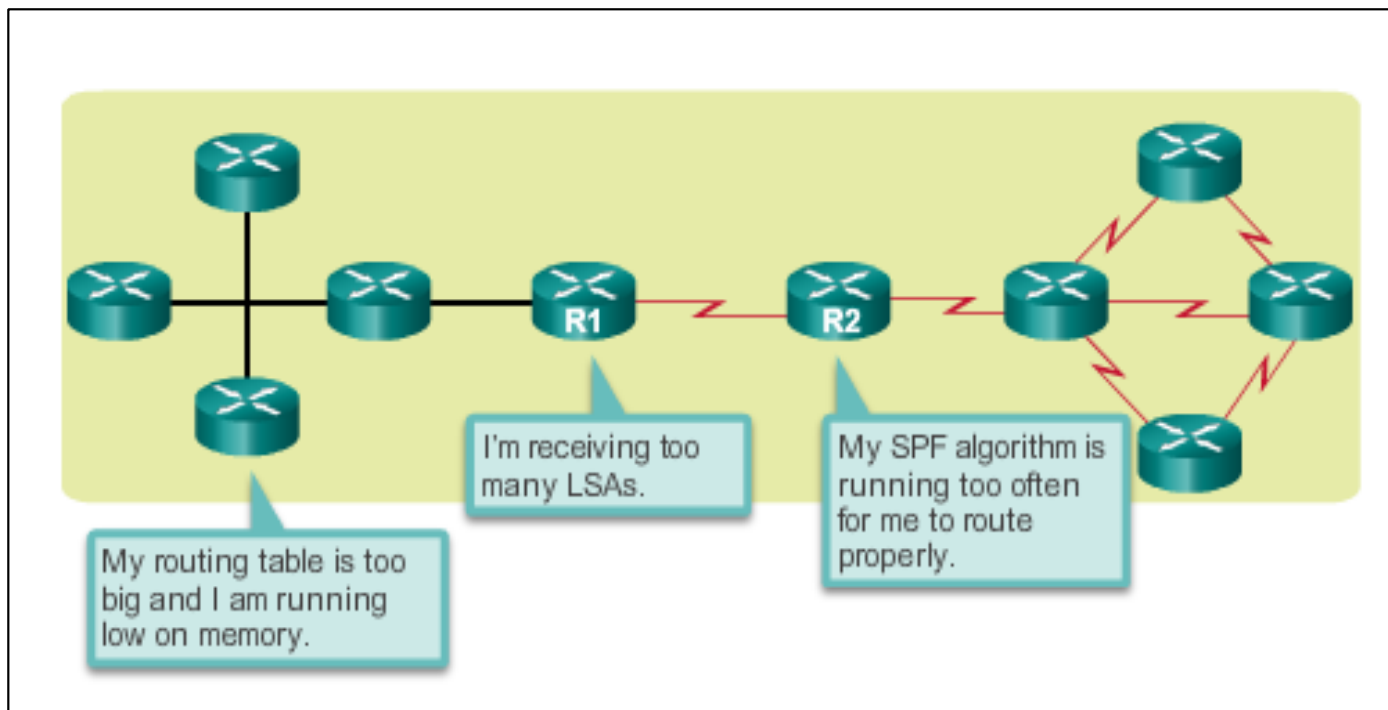
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Why Multiarea OSPF?

Single-Area OSPF

Single-area OSPF is useful in smaller networks. If an area becomes too big, the following issues must be addressed:

- Large routing table (no summarization by default)
- Large link-state database (LSDB)
- Frequent SPF algorithm calculations

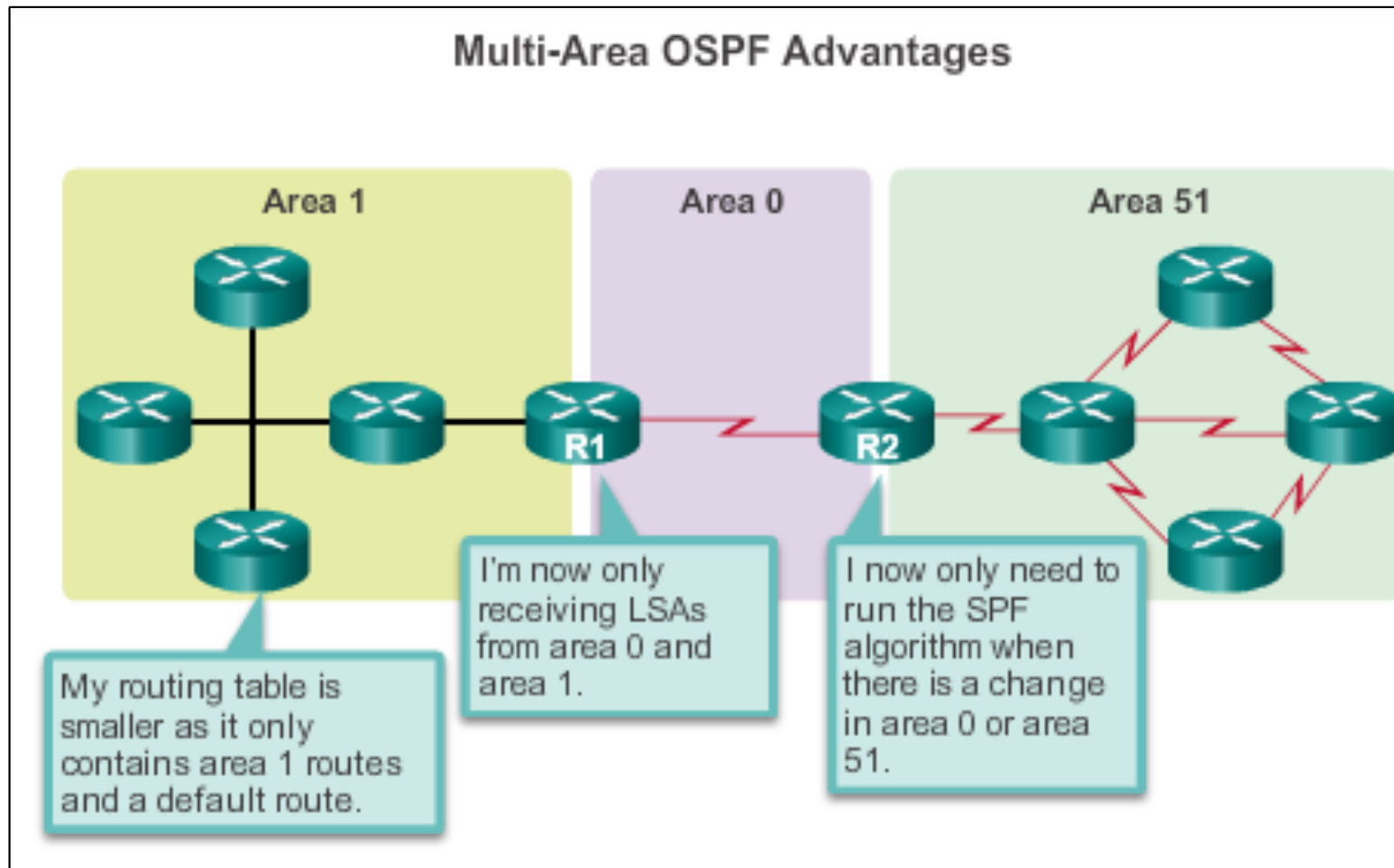




Why Multiarea OSPF?

Multiarea OSPF

Multiarea OSPF requires a hierarchical network design and the main area is called the backbone area, or area 0, and all other areas must connect to the backbone area.





Why Multiarea OSPF?

OSPF Two-Layer Area Hierarchy

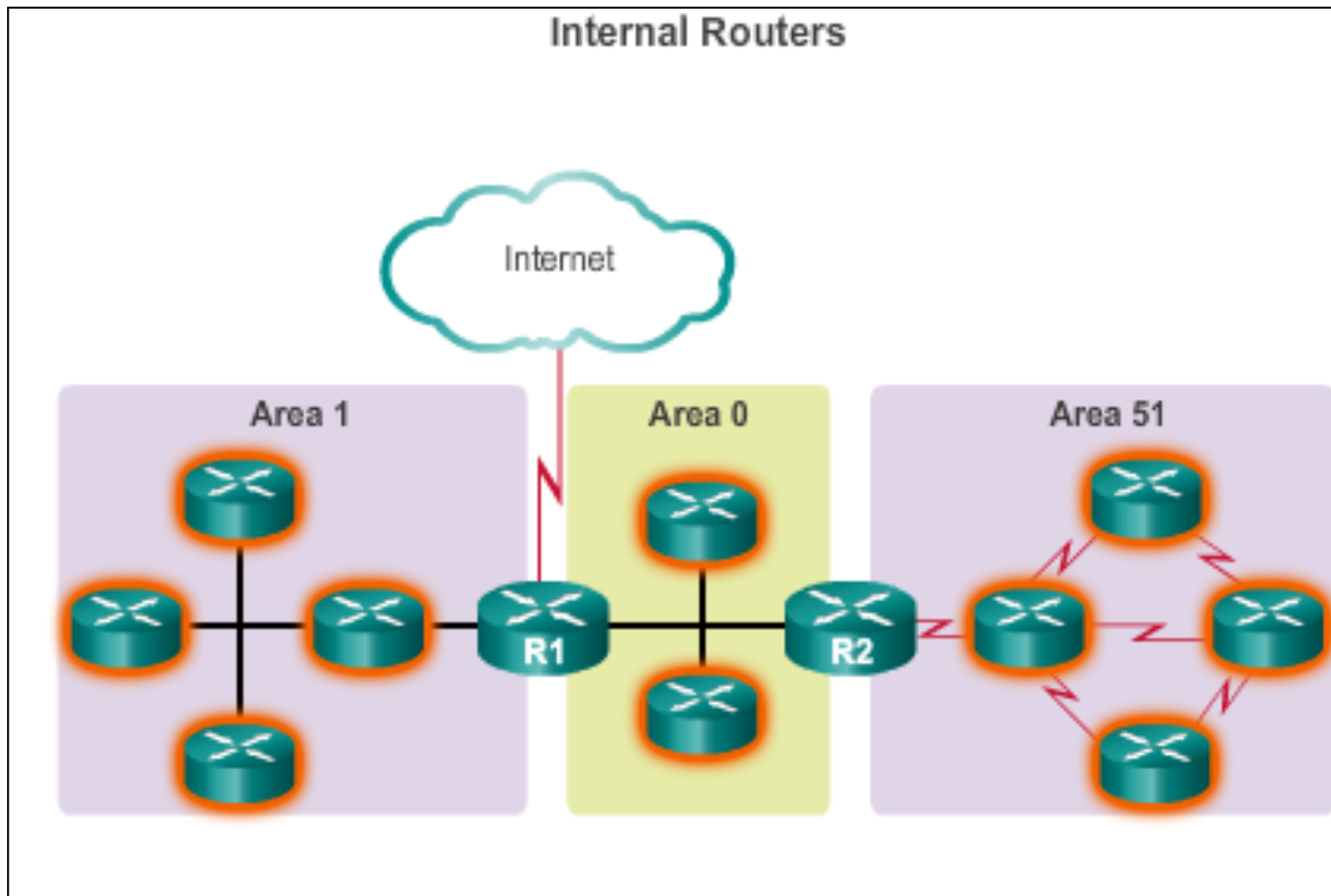
Multiarea OSPF is implemented in a two-layer area hierarchy:

- **Backbone (transit) area**
 - Area whose primary function is the fast and efficient movement of IP packets.
 - Interconnects with other OSPF area types.
 - Called OSPF area 0, to which all other areas directly connect.
- **Regular (nonbackbone) area**
 - Connects users and resources.
 - A regular area does not allow traffic from another area to use its links to reach other areas.



Why Multiarea OSPF?

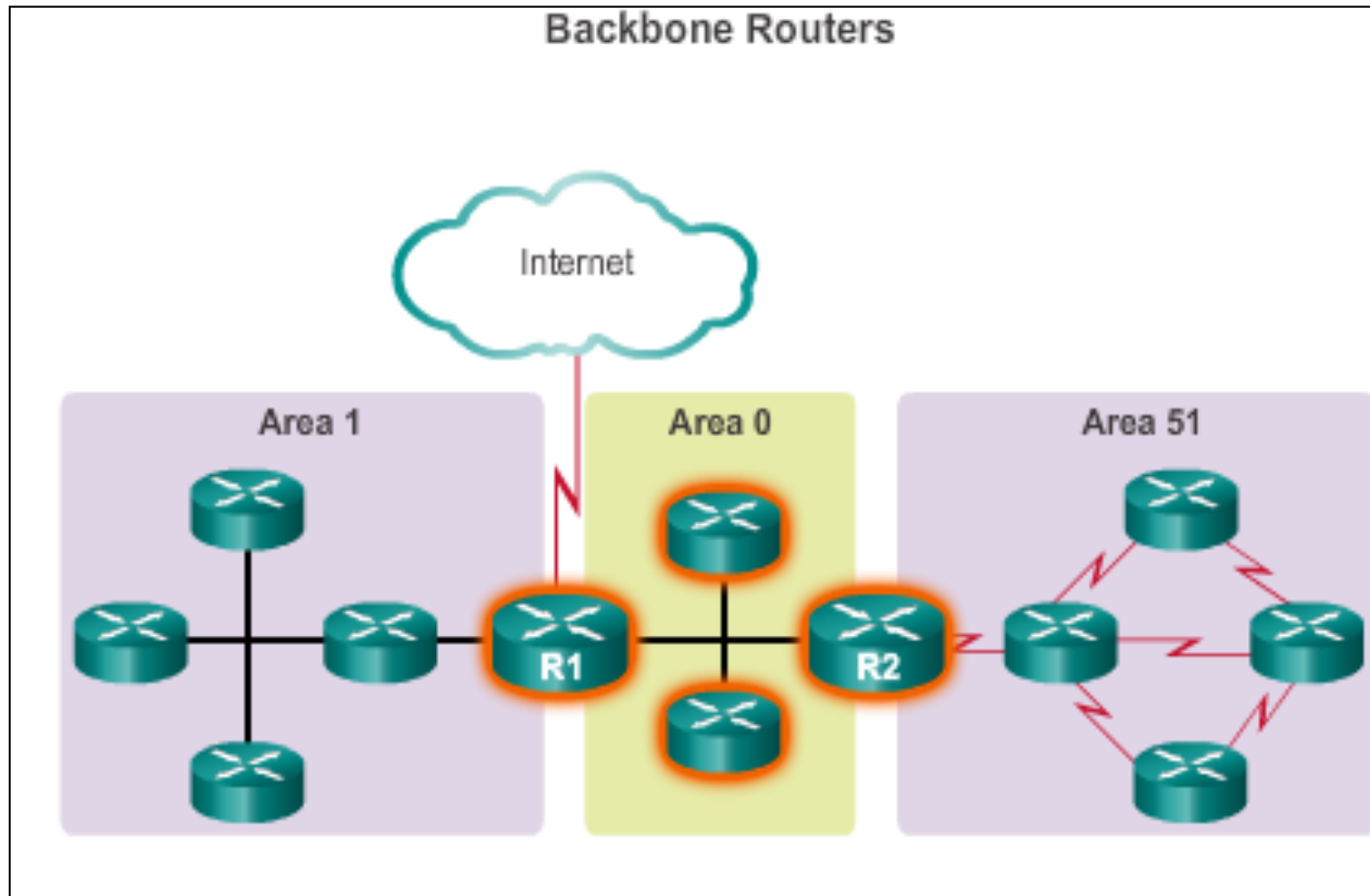
Types of OSPF Routers





Why Multiarea OSPF?

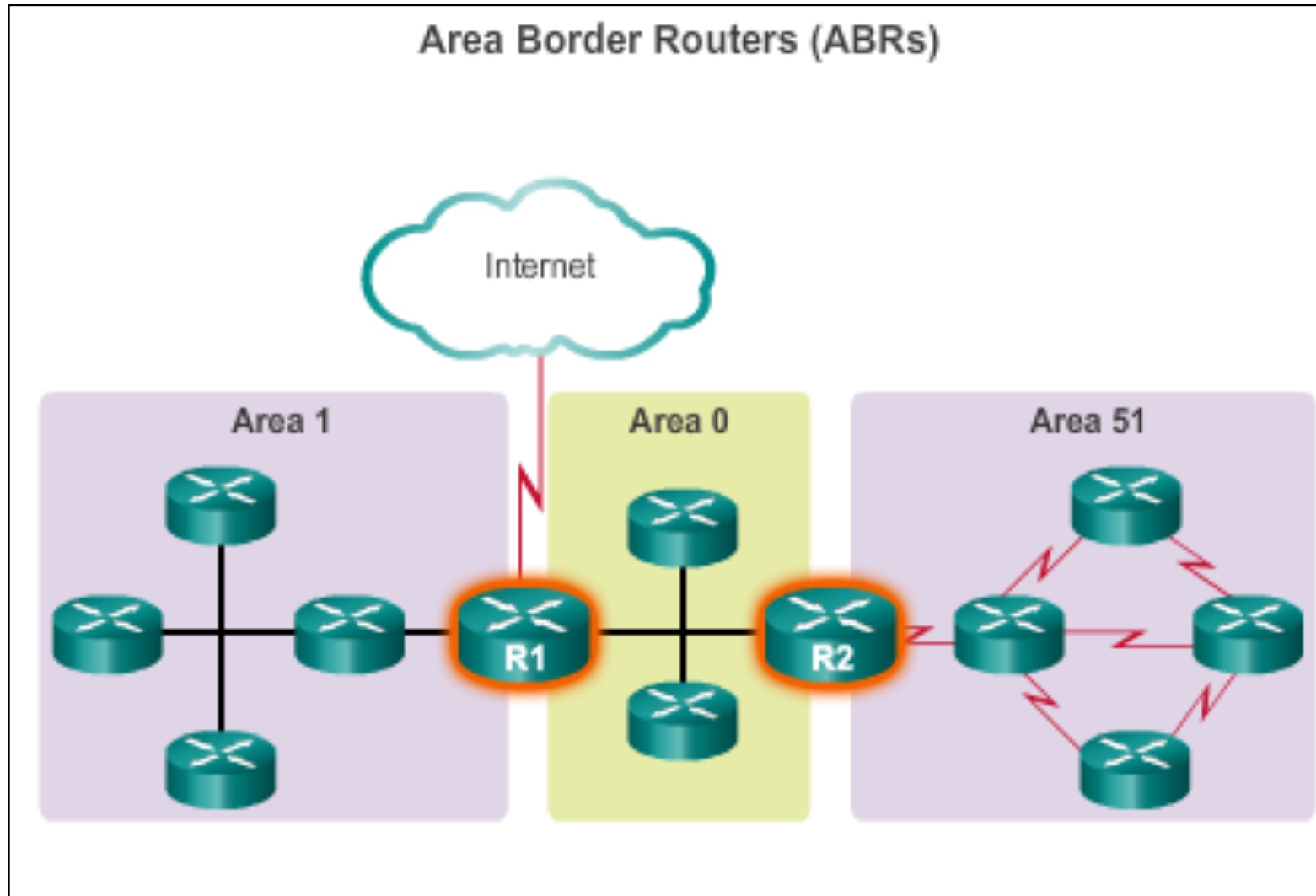
Types of OSPF Routers (cont.)





Why Multiarea OSPF?

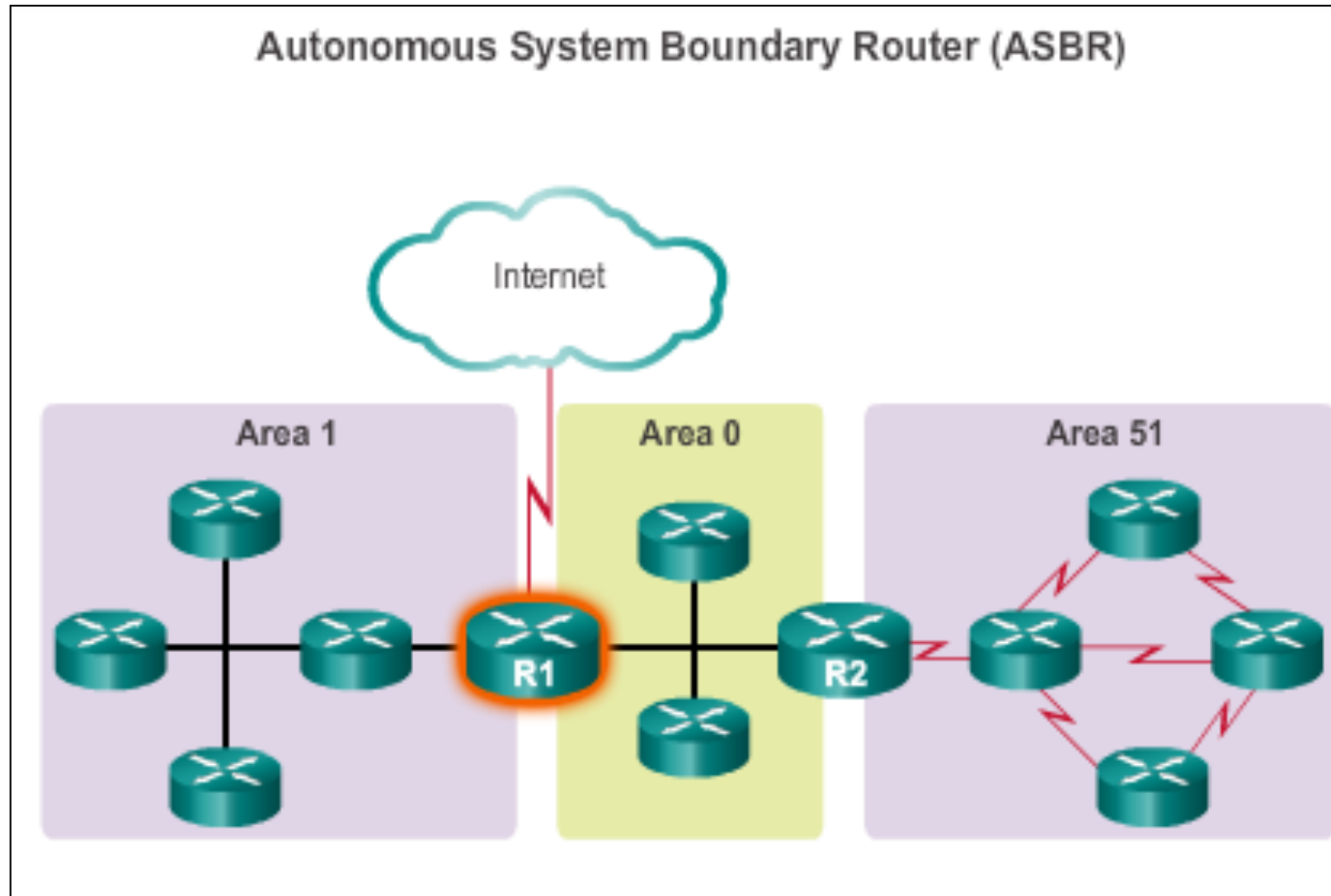
Types of OSPF Routers (cont.)





Why Multiarea OSPF?

Types of OSPF Routers (cont.)





Multiarea OSPF LSA Operation

OSPF LSA Types

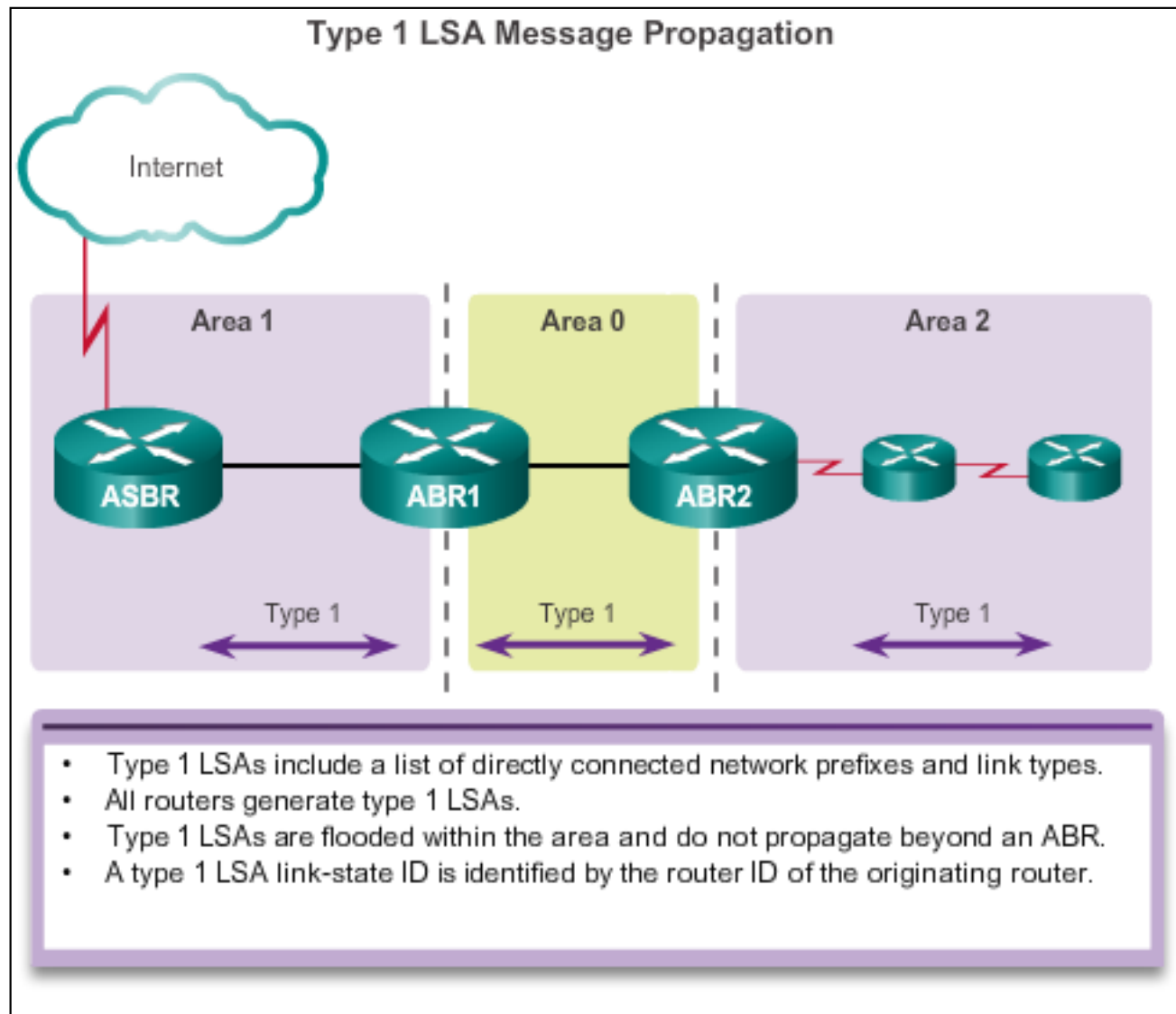
LSA Type	Description
1	Router LSA
2	Network LSA
3 and 4	Summary LSAs
5	AS External LSA
6	Multicast OSPF LSA
7	Defined for NSSAs
8	External Attributes LSA for Border Gateway Protocol (BGP)
9, 10, or 11	Opaque LSAs

Most common and covered in this course – 1 thru 5



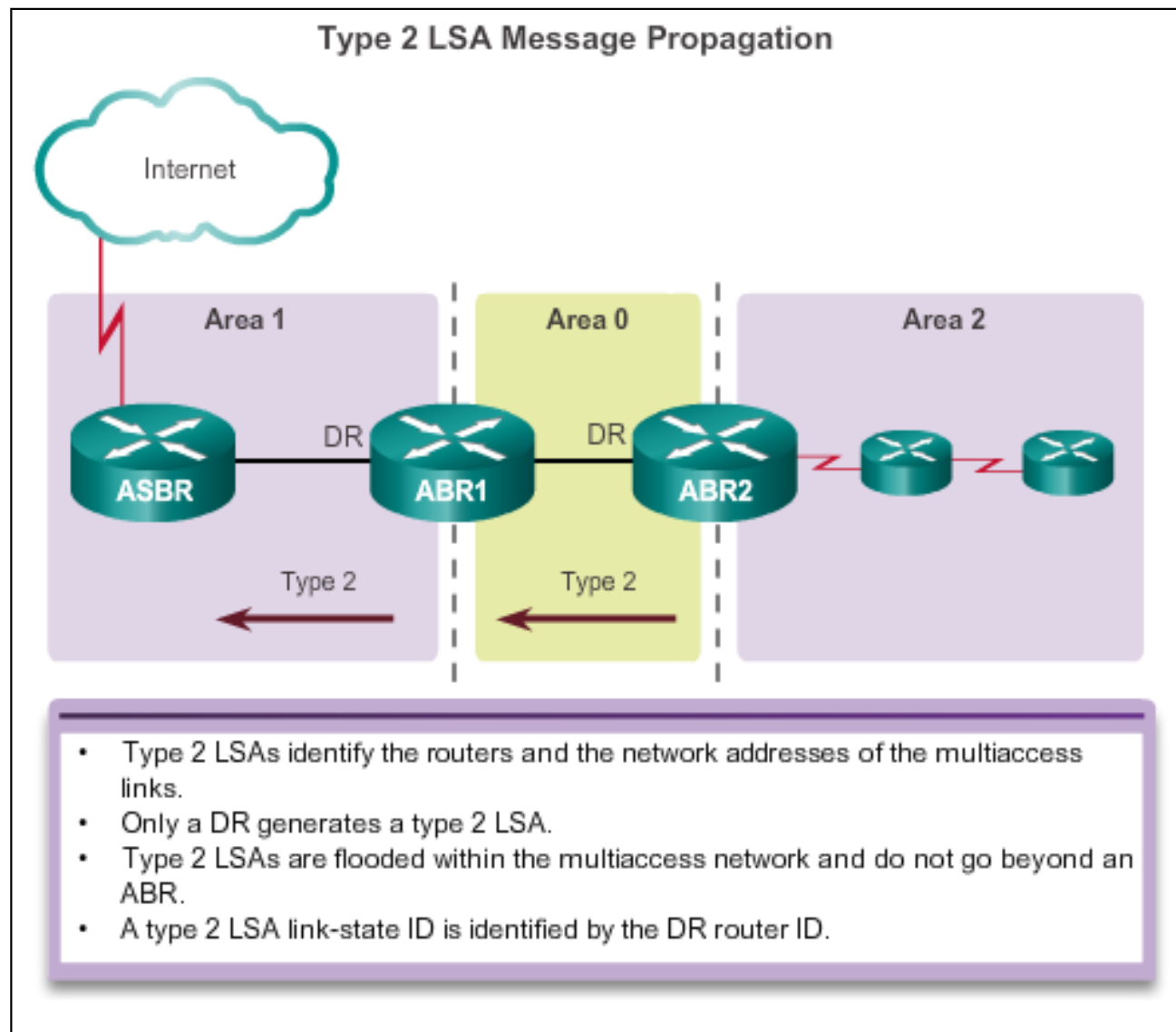
Multiarea OSPF LSA Operation

OSPF LSA Type 1 Router LSA



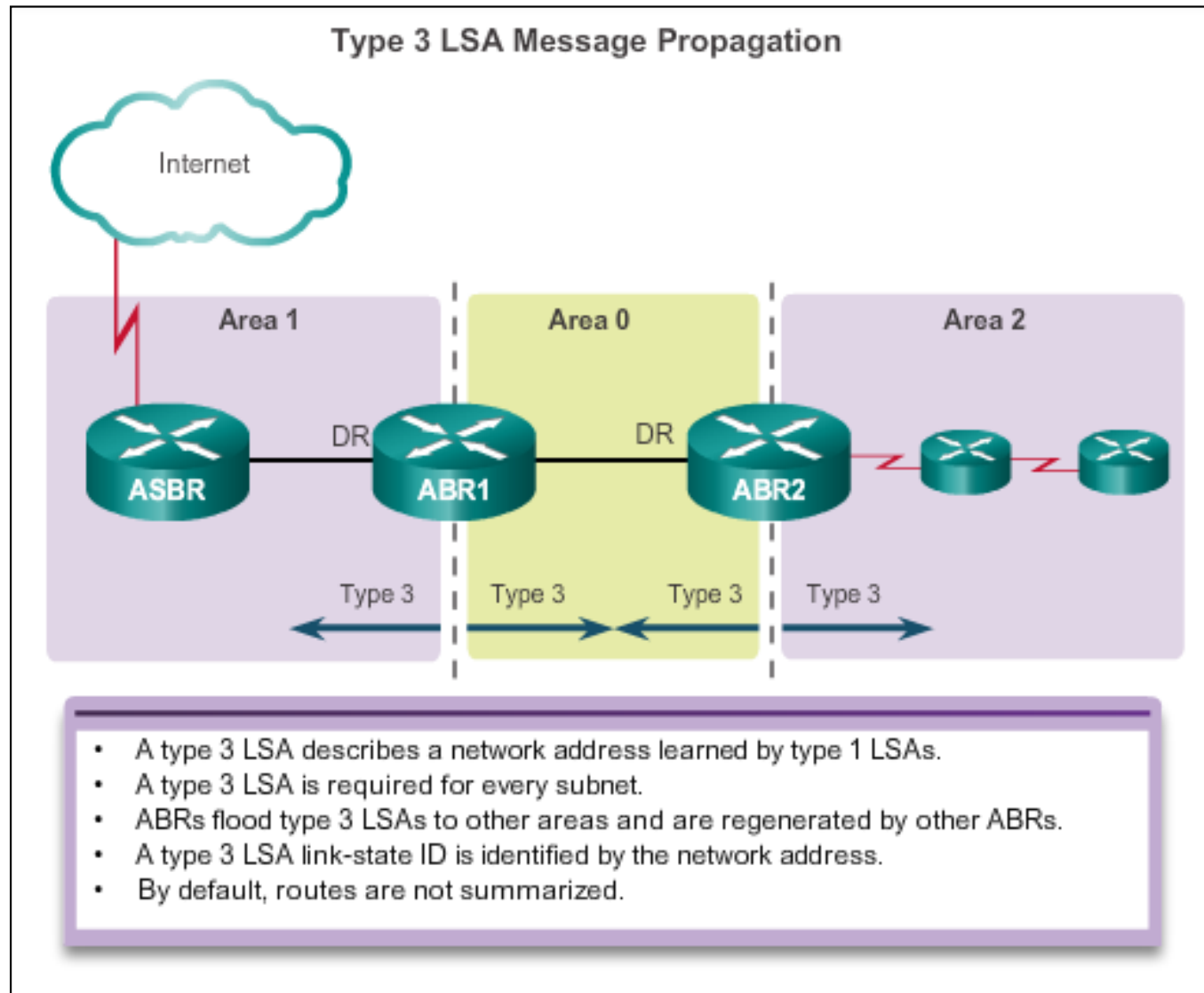
Multiarea OSPF LSA Operation

OSPF LSA Type 2 Network LSA



Multiarea OSPF LSA Operation

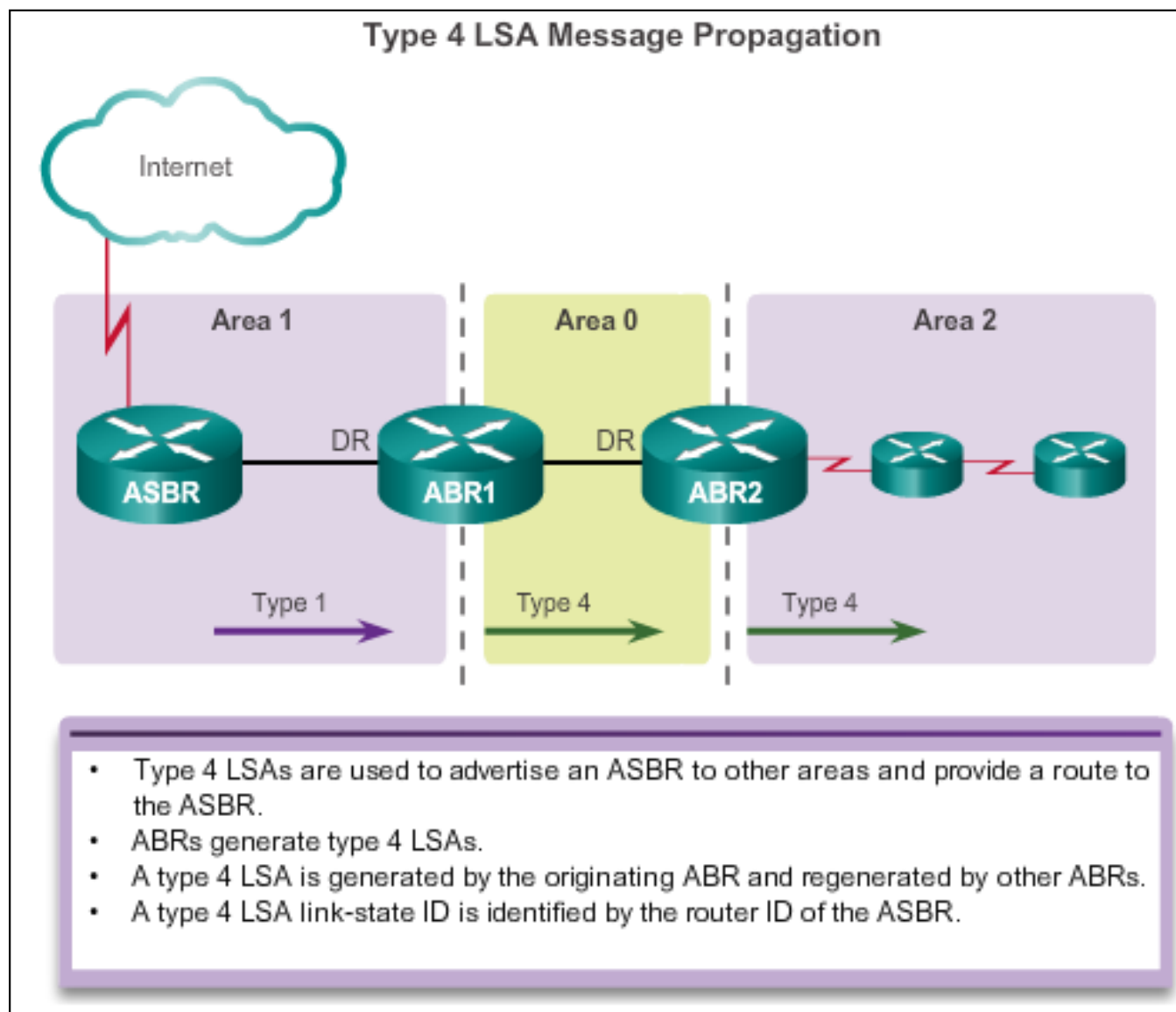
OSPF LSA Type 3 Summary LSA





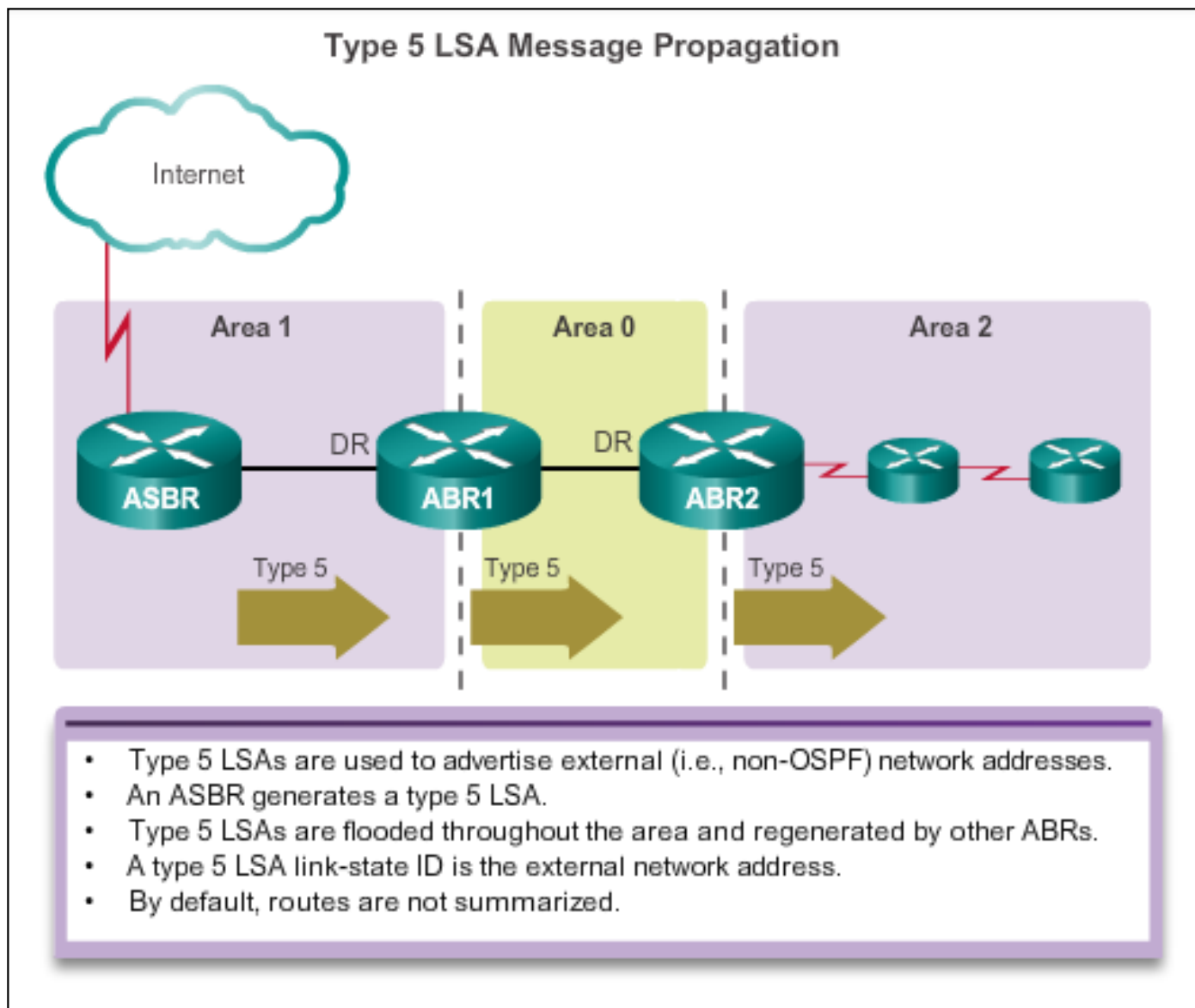
Multiarea OSPF LSA Operation

OSPF LSA Type 4 Summary LSA



Multiarea OSPF LSA Operation

OSPF LSA Type 5 AS External LSA





OSPF Routing Tables and Route Types

OSPF Routing Table Entries

- **O** – Router (type 1) and network (type 2) LSAs describe the details within an area (the route is intra-area).
- **O IA** – Summary LSAs appear in the routing table as IA (interarea routes)
- **O E1** or **OE 2** – External LSAs external type 1 (E1) or external type 2 (E2) routes

Router and Network 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 Routing Tables and Route Types

OSPF Route Calculation

1. All routers calculate the best paths to destinations within their area (intra-area) and add these entries to the routing table.
2. All routers calculate the best paths to the other areas within the internetwork (interarea) or type 3 and type 4 LSAs.
3. All routers calculate the best paths to the external autonomous system (type 5) destinations. These are noted with either an O E1 or an O E2 route designator.

Steps to OSPF Convergence

3

1

2

1

```
R1# show ip route | begin Gateway
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#
```

- Calculate intra-area OSPF routes.
- Calculate best path to interarea OSPF routes.
- Calculate best path route to external non-OSPF networks.



Configuring Multiarea OSPF



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Configuring Multiarea OSPF

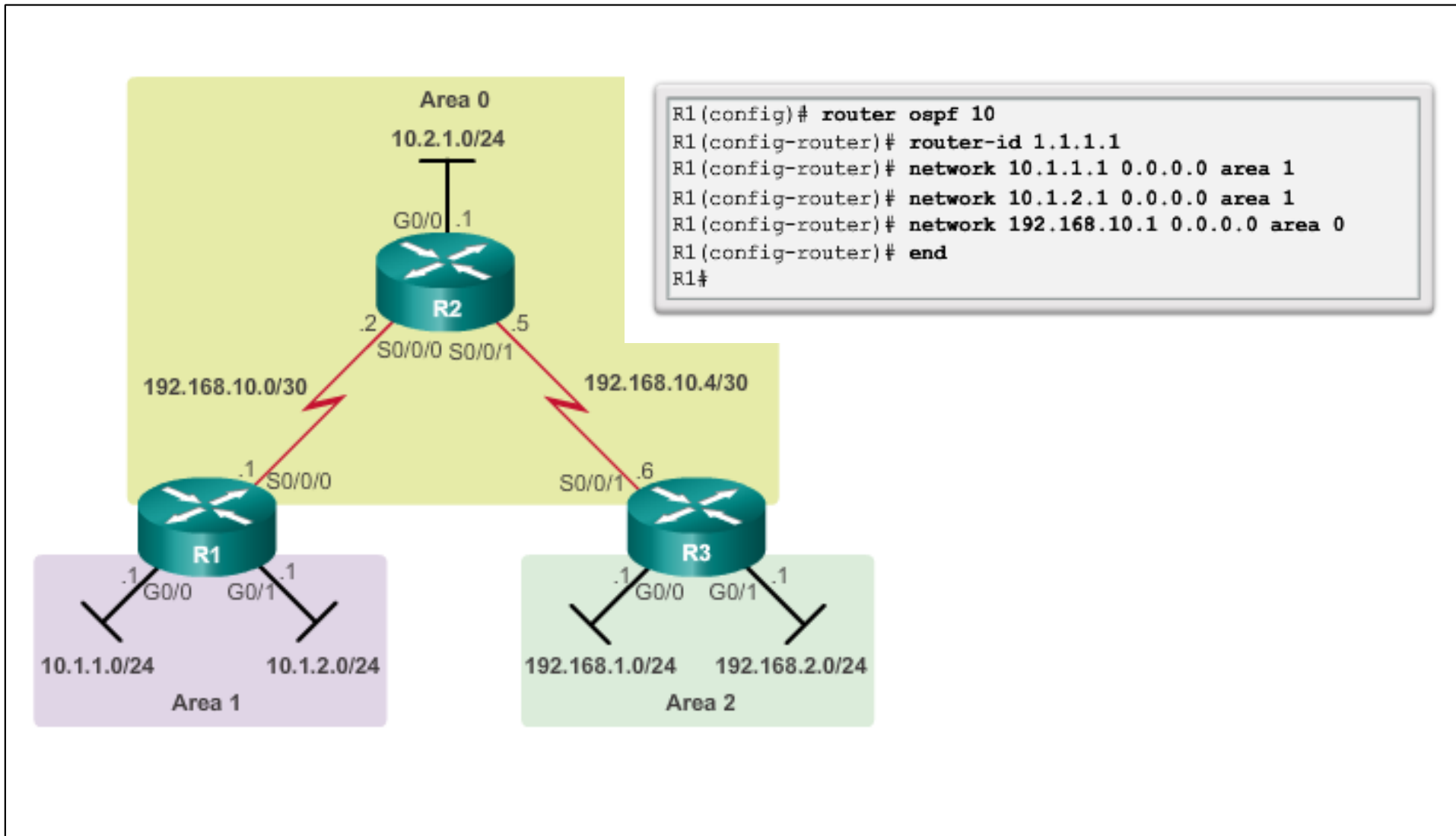
Implementing Multiarea OSPF

Implementation Plan Steps

1. Gather the network requirements and parameters.
2. Define the OSPF parameters.
3. Configure OSPF.
4. Verify OSPF.



Configuring Multiarea OSPF

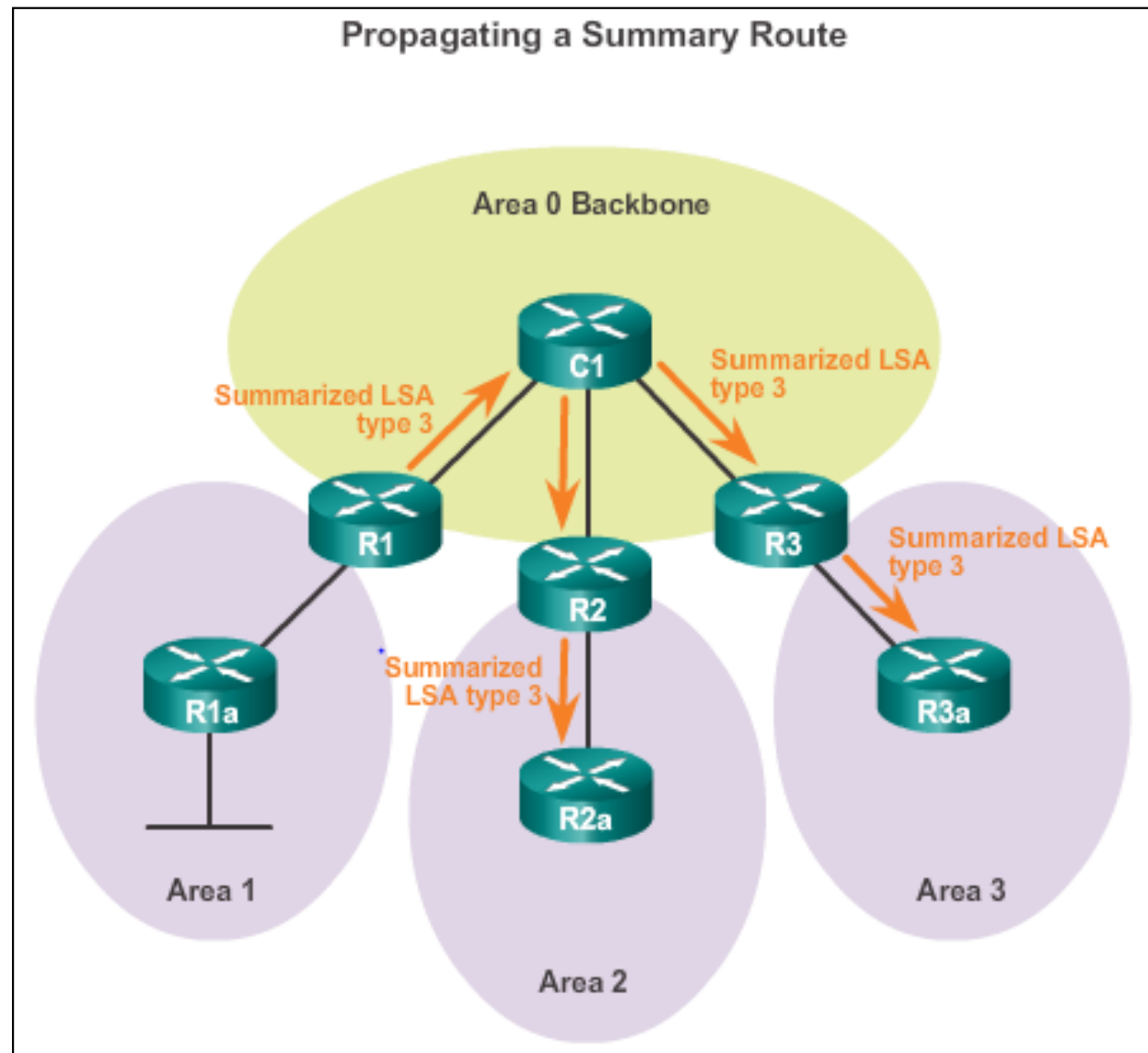




OSPF Route Summarization

OSPF Route Summarization

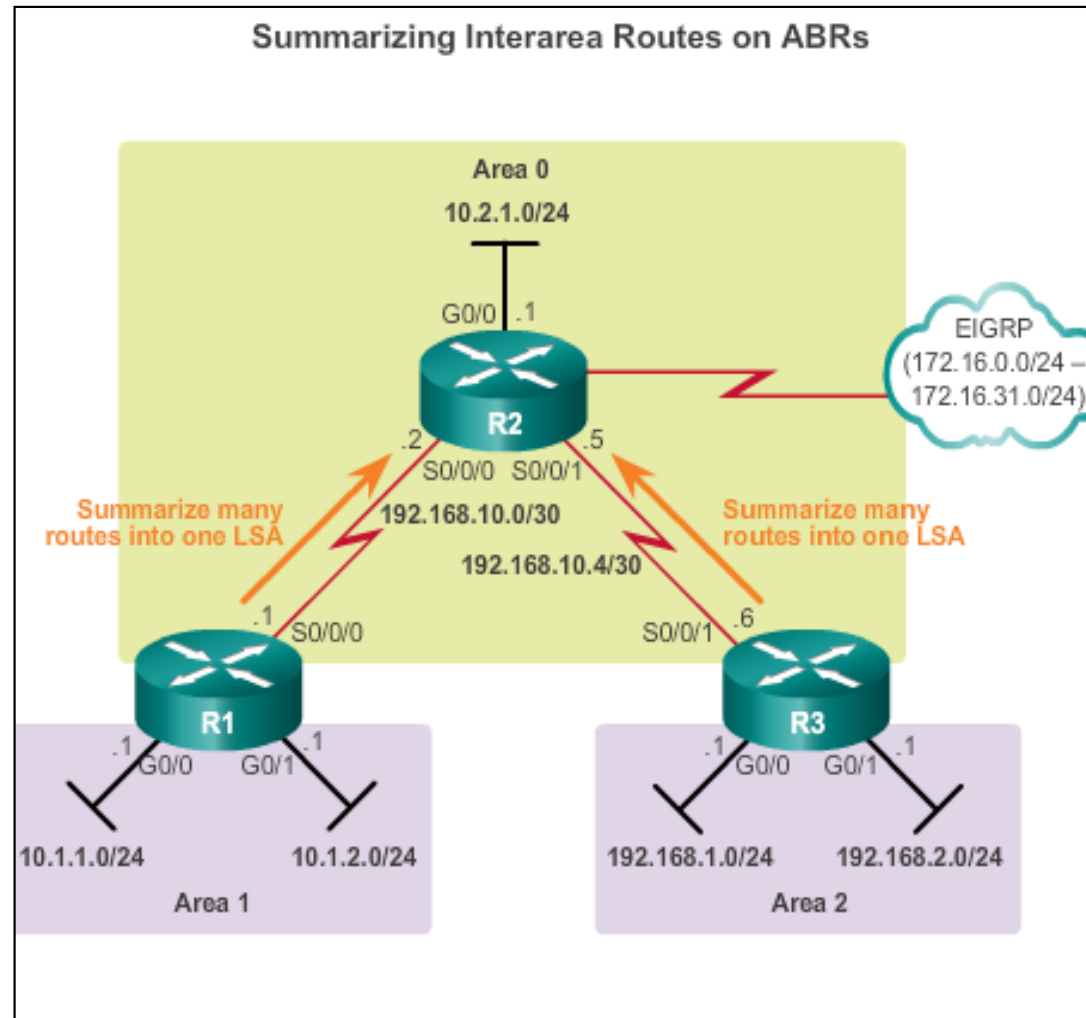
- R1 forwards a summary LSA to the core router C1.
- C1, in turn, forwards the summary LSA to R2 and R3.
- R2 and R3 then forward it to their respective internal routers.



OSPF Route Summarization

Interarea and External Route Summarization

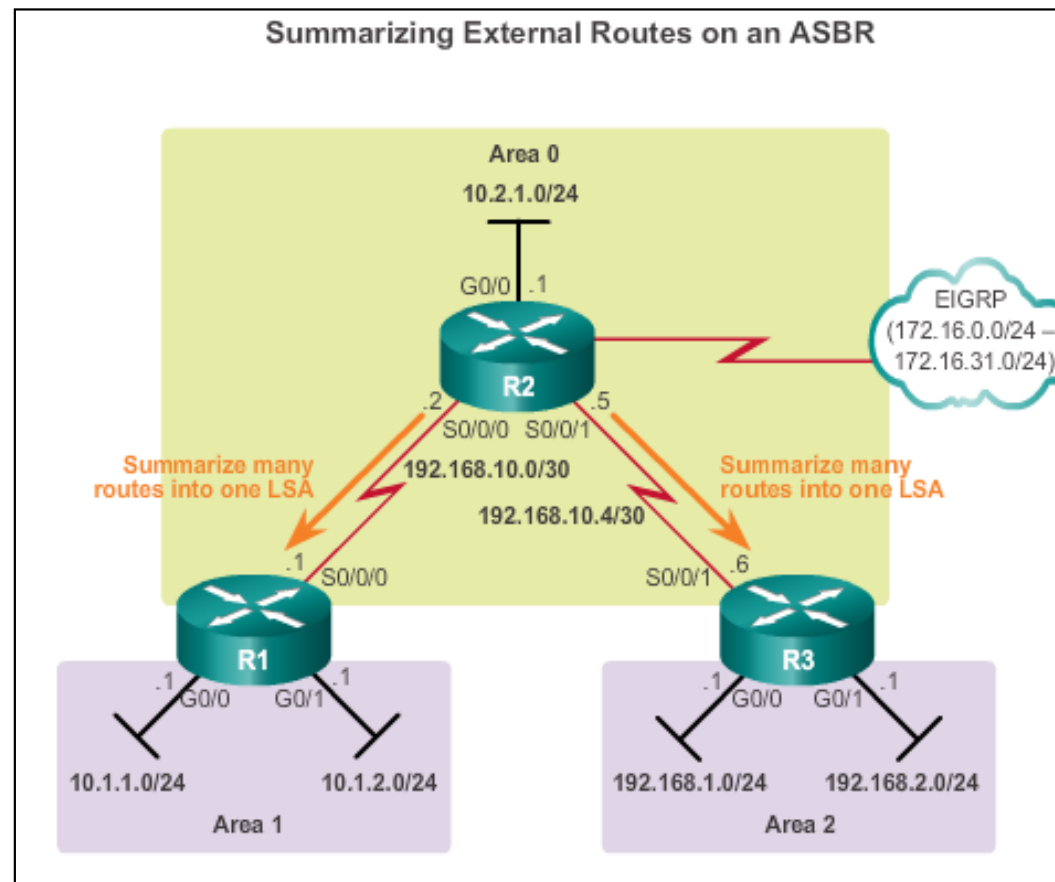
Occurs on ABRs and applies to routes from within each area



OSPF Route Summarization

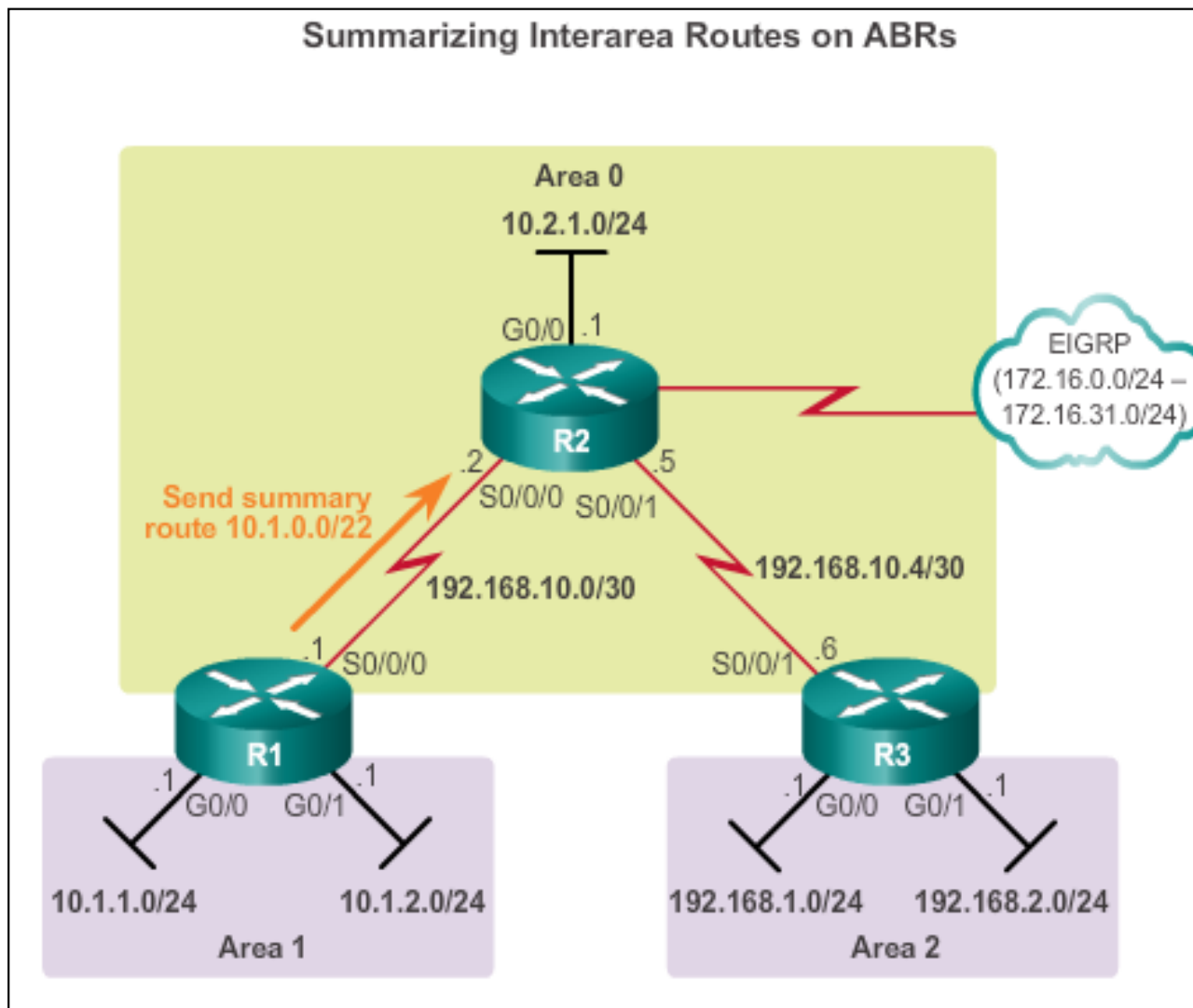
Interarea and External Route Summarization (cont.)

Specific to external routes that are injected into OSPF via route redistribution; ASBRs summarize external routes



OSPF Route Summarization

Interarea Route Summarization





OSPF Route Summarization

Interarea Route Summarization (cont.)

Verify the R1 Routing Table Before Summarization

```
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, 00:00:49,
        Serial0/0/0
O IA    192.168.1.0/24 [110/1295] via 192.168.10.2, 00:00:49,
        Serial0/0/0
O IA    192.168.2.0/24 [110/1295] via 192.168.10.2, 00:00:49,
        Serial0/0/0
        192.168.10.0/24 is variably subnetted, 3
        masks
O       192.168.10.4/30 [110/1294] via 192.168.10.5, 00:00:49, Serial0/0/0
R1#
```

Verify the R3 Routing Table Before Summarization

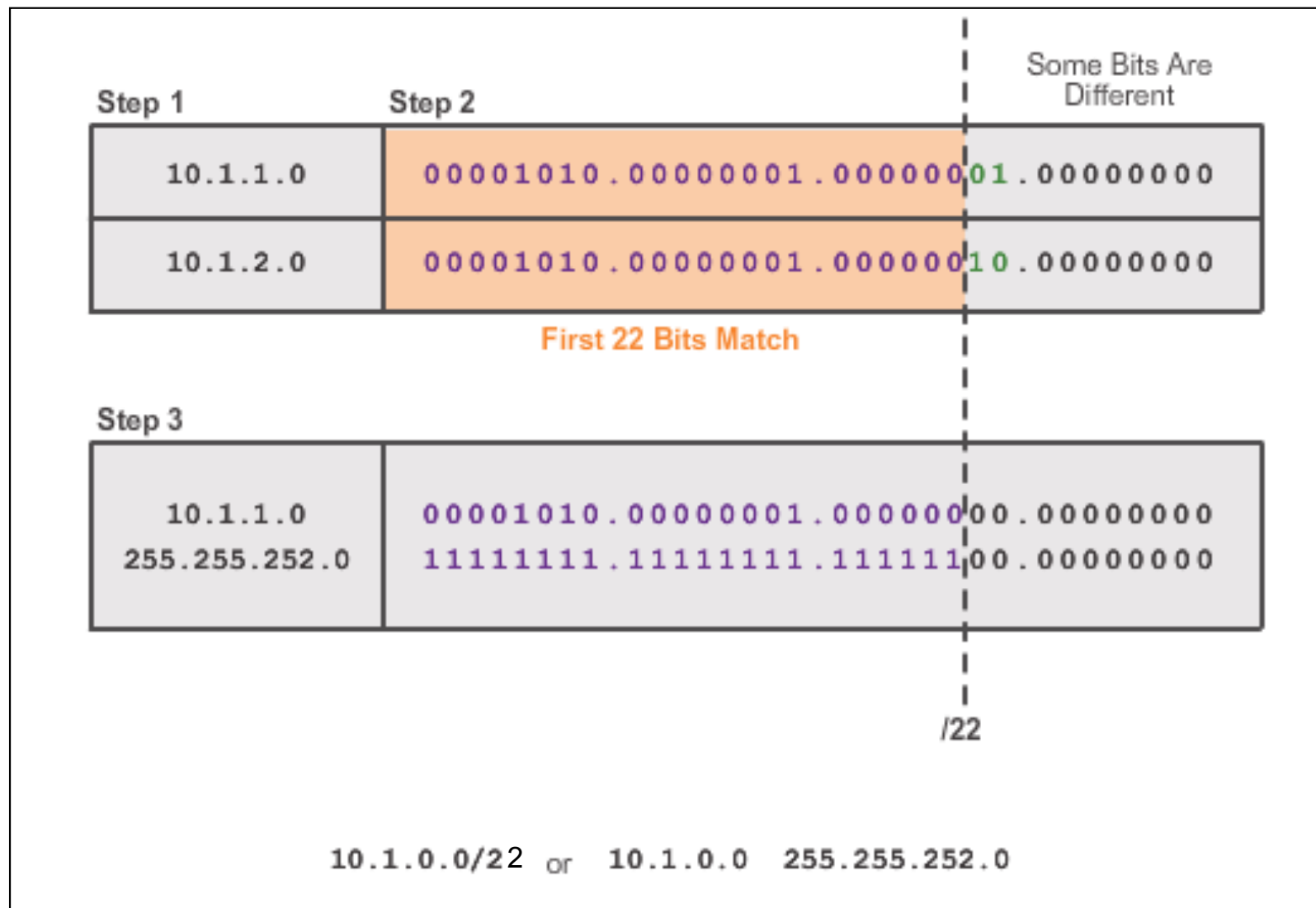
```
R3# show ip route ospf | begin Gateway
Gateway of last resort is not set

    10.0.0.0/24 is subnetted, 3 subnets
O IA    10.1.1.0 [110/1295] via 192.168.10.5, 00:27:14, Serial0/0/1
O IA    10.1.2.0 [110/1295] via 192.168.10.5, 00:27:14, Serial0/0/1
O       10.2.1.0 [110/648] via 192.168.10.5, 00:27:57, Serial0/0/1
        192.168.10.0/24 is variably subnetted, 3 subnets, 2 masks
O       192.168.10.0/30 [110/1294] via 192.168.10.5, 00:27:57,
        Serial0/0/1
R3#
```




OSPF Route Summarization

Calculating the Summary Route





OSPF Route Summarization

Configuring Interarea Route Summarization

R1

```
R1(config)# router ospf 10
R1(config-router)# area 1 range 10.1.0.0 255.255.252.0
R1(config-router)#
```

```
R1# 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 10.1.0.0/22 is a summary, 00:00:09, Null0
O 10.2.1.0/24 [110/648] via 192.168.10.2, 00:00:09,
Serial0/0/0
O IA 192.168.1.0/24 [110/1295] via 192.168.10.2, 00:00:09,
Serial0/0/0
O IA 192.168.2.0/24 [110/1295] via 192.168.10.2, 00:00:09,
Serial0/0/0
192.168.10.0/24 is variably subnetted, 3 subnets
masks
O 192.168.10.4/30 [110/1294] via 192.168.10.2,
00:00:09, Serial0/0/0
R1#
```

R3

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

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
O IA 10.1.0.0/22 [110/1295] via 192.168.10.5, 00:00:06,
Serial0/0/1
O 10.2.1.0/24 [110/648] via 192.168.10.5, 00:29:23,
Serial0/0/1
192.168.10.0/24 is variably subnetted, 3 subnets, 2
masks
O 192.168.10.0/30 [110/1294] via 192.168.10.5,
00:29:23, Serial0/0/1
R3#
```



Verifying Multiarea OSPF

Verifying Multiarea OSPF

The same verification commands are used to verify single-area OSPF and can be used to verify multiarea OSPF:

- `show ip ospf neighbor`
- `show ip ospf`
- `show ip ospf interface`

Commands specific to multiarea information include:

- `show ip protocols`
- `show ip ospf interface brief`
- `show ip route ospf`
- `show ip ospf database`

Note: For OSPFv3, substitute `ip` with `ipv6`.



Verifying Multiarea OSPF

Verifying General Multiarea OSPF Settings

```
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#
```

Beror på version (brief)

```
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#
```



Verifying Multiarea OSPF

Verify the OSPF 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#
```



Verifying Multiarea OSPF

Verifying the Multiarea OSPF LSDB

Verifying the OSPF LSDB on R1

```
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#
```



Multiarea OSPF Summary

- Better choice for larger networks than single-area.
- Solves the issues of large routing table, large LSDB, and frequent SPF algorithm calculations.
- Main area is called the backbone area, or area 0.
- Recalculating the database is kept within an area.
- Four different types of OSPF routers:
 - Internal router
 - Backbone router
 - ABR
 - ASBR
- A router simply becomes an ABR when it has two network statements in different areas.



Multiarea OSPF Summary (cont.)

- Link-state advertisements (LSAs) are the building blocks of OSPF.
 - Type 1 LSAs are referred to as the router link entries.
 - Type 2 LSAs are referred to as the network link entries and are flooded by a DR.
 - Type 3 LSAs are referred to as the summary link entries and are created and propagated by ABRs.
 - A type 4 summary LSA is generated by an ABR only when an ASBR exists within an area.
 - Type 5 external LSAs describe routes to networks outside the OSPF autonomous system, originated by the ASBR and are flooded to the entire autonomous system.
- SPF tree is used to determine the best paths.
- OSPF routes in an IPv4 routing table are identified using the following descriptors: O, O IA, O E1, or O E2.



Multiarea OSPF Summary (cont.)

- The following example displays a multiarea OSPF configuration:

```
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
```

- Does not perform autosummarization, but can be manually configured using the **summary-address** *address mask* router configuration mode command



Multiarea OSPF Summary (cont.)

- The following commands are used to verify OSPF configurations:
 - `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`

