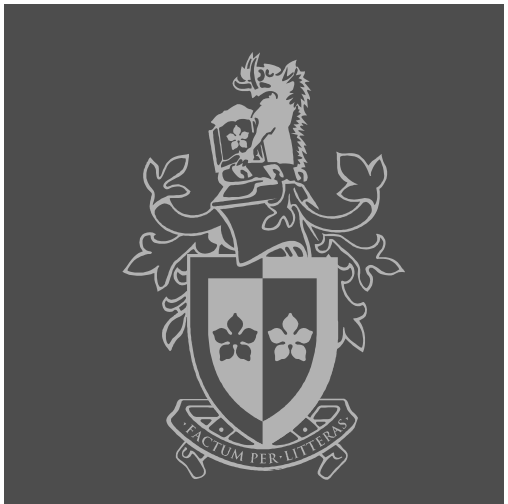
SWINBURNE

CENTRE FOR ADVANCED INTERNET ARCHITECTURES

TNE20002/TNE70003

Topic 6 Multi-Area OSPF



Rev 1.3

Outline

6.1 Multiarea OSPF Overview

- Large Single Area OSPF
- Advantages of Multiarea OSPF

6.2 Types of OSPF Routers

- Internal Router & Backbone Router
- Area Border Router (ABR)
- Autonomous System Boundary Router (ASBR)
- Designated Router (DR) & Backup designated Router(BDR)

6.3 Multiarea OSPF LSA Message Types

- OSPF LSA Message Types 1 - 5

6.4 Implementing Multiarea OSPF

- Multiarea OSPF Populate Routing table
- Verifying Multiarea OSPF

Why Multi-Area OSPF?

Single-area OSPF is useful for smaller networks. eg. < 30 routers

Data Structures

- Neighbor Tables
- Topology Table
- Routing Table

Large Single Area OSPF

If an area becomes too large

(Cisco state an area should have no more than 50 routers),

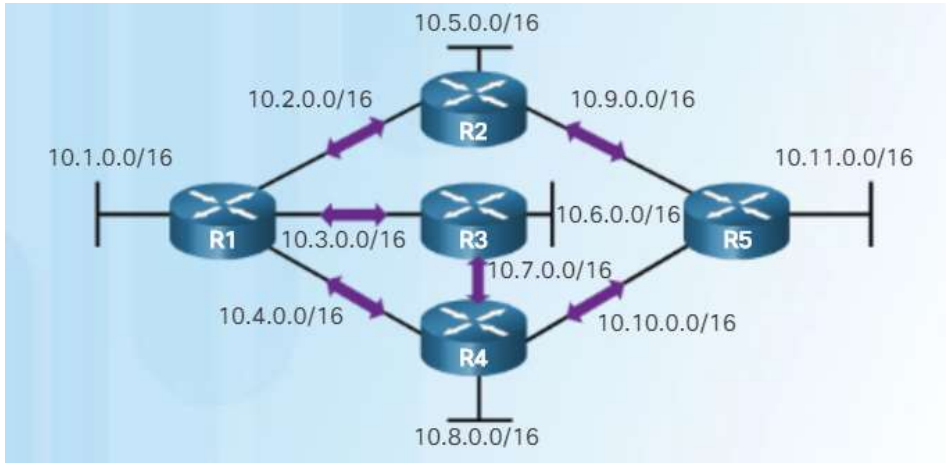
the following issues must be addressed:

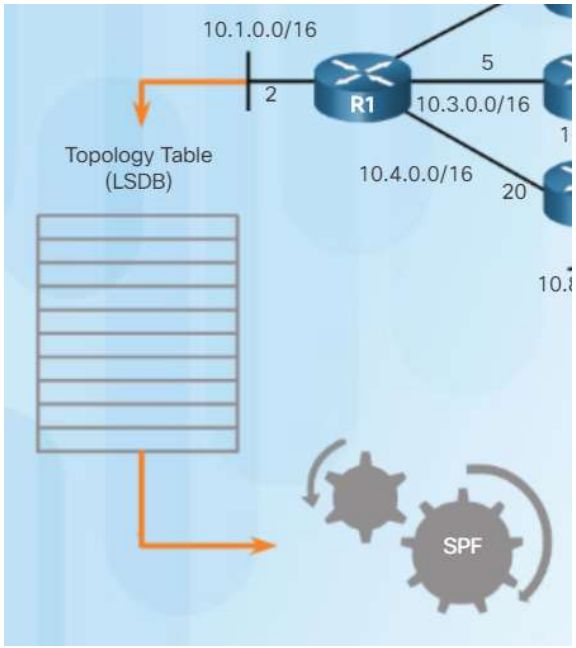
- Large routing table
- Large link-state database (LSDB)
- Frequent SPF algorithm calculations

Building LSDB

Link State Process to populate tables

1. Use hello packets to establish neighbor adjacencies
2. Use LSAs to flood the area with cost and state of links





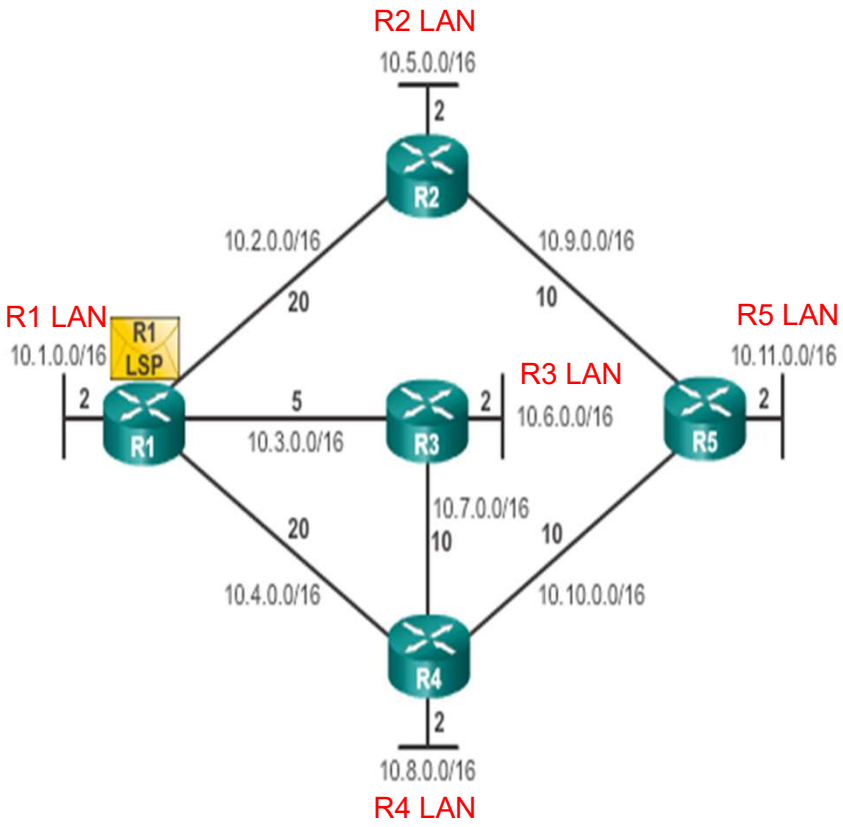
3. Each router builds a topology table or LSDB
4. Each router runs the SPF algorithm resulting in the SPF tree

5. Each router builds a routing table that includes the path to get to the distant network and the cost to get there.

Destination	Shortest Path	Cost
10.5.0.0/16	R1→R2	22
10.6.0.0/16	R1→R3	7
10.7.0.0/16	R1→R3	15
10.8.0.0/16	R1→R3→R4	17
10.9.0.0/16	R1→R2	30
10.10.0.0/16	R1→R3→R4	25
10.11.0.0/16	R1→R3→R4→R5	27
10.5.0.0/16	R1→R2	22

Link State Database: R1 to R2 LAN, R1 to R3 LAN ,etc

R1 Topology Table →



R1 Link-State Database

R1's Link-State Database:

LSPs from R2:

- Connected to neighbor R1 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R5 on network 10.9.0.0/16, cost of 10
- Has a network 10.5.0.0/16, cost of 2

LSPs from R3:

- Connected to neighbor R1 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.7.0.0/16, cost of 10
- Has a network 10.6.0.0/16, cost of 2

LSPs from R4:

- Connected to neighbor R1 on network 10.4.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.7.0.0/16, cost of 10
- Connected to neighbor R5 on network 10.10.0.0/16, cost of 10
- Has a network 10.8.0.0/16, cost of 2

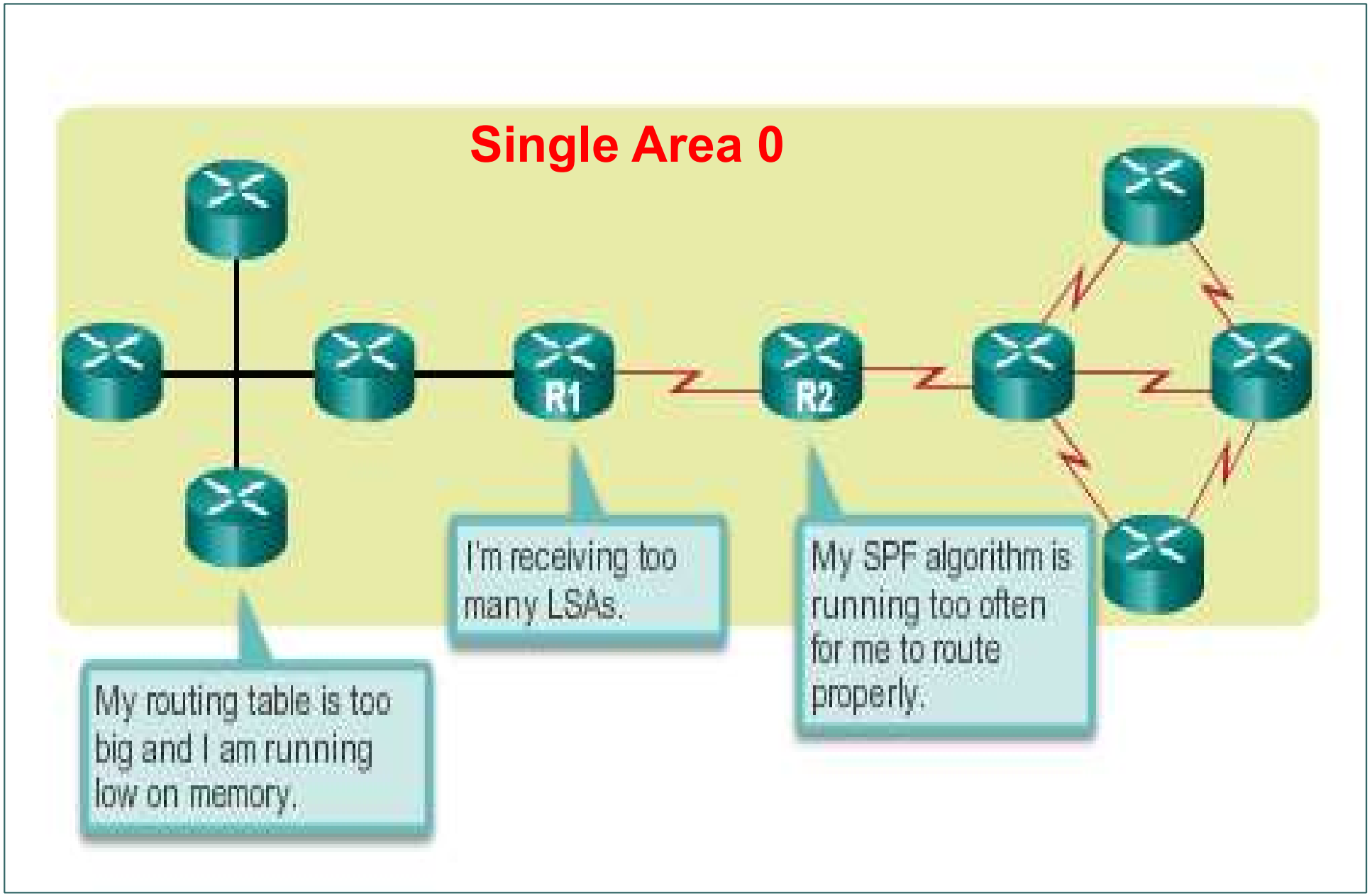
LSPs from R5:

- Connected to neighbor R2 on network 10.9.0.0/16, cost of 10
- Connected to neighbor R4 on network 10.10.0.0/16, cost of 10
- Has a network 10.11.0.0/16, cost of 2

R1 Link-states:

- Connected to neighbor R2 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.4.0.0/16, cost of 20

Why Multi-Area OSPF?



OSPF Two-Layer Area Hierarchy

Multiarea OSPF is implemented in a two-layer area hierarch.

Backbone (transit) area

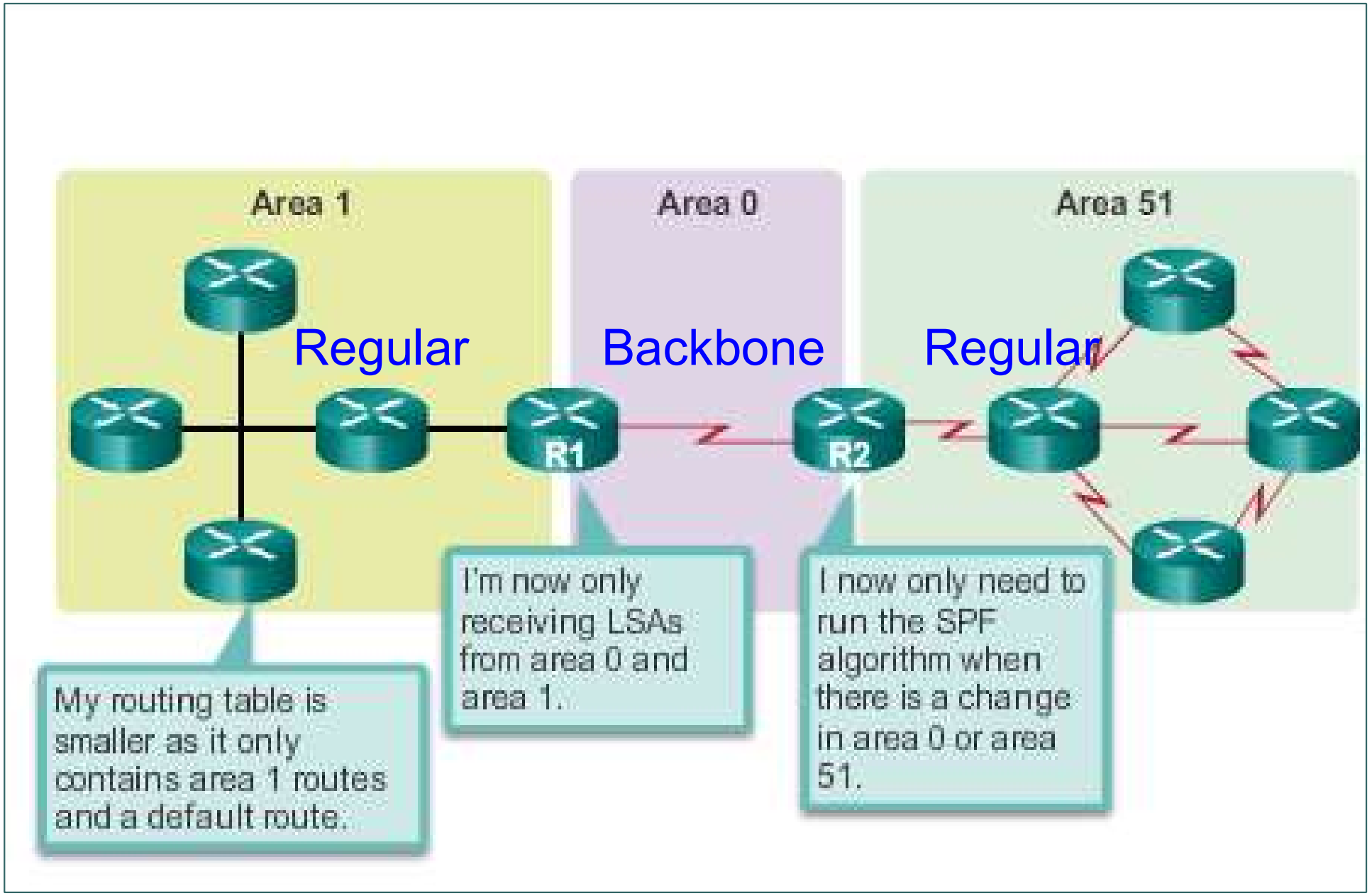
Called OSPF area 0, to which all other areas directly connect.

Regular (non backbone) area

Connects users and resources.

A regular area does not allow routing traffic from other regular areas, e.g. Area 1 to Area 51

Multi-Area OSPF



6.2 Types of OSPF Routers

- Internal Router & Backbone Router
- Area Border Router (ABR)
- Autonomous System Boundary Router (ASBR)
- Designated Router (DR) & Backup designated Router(BDR)

Types of OSPF Routers

Types of OSPF Routers

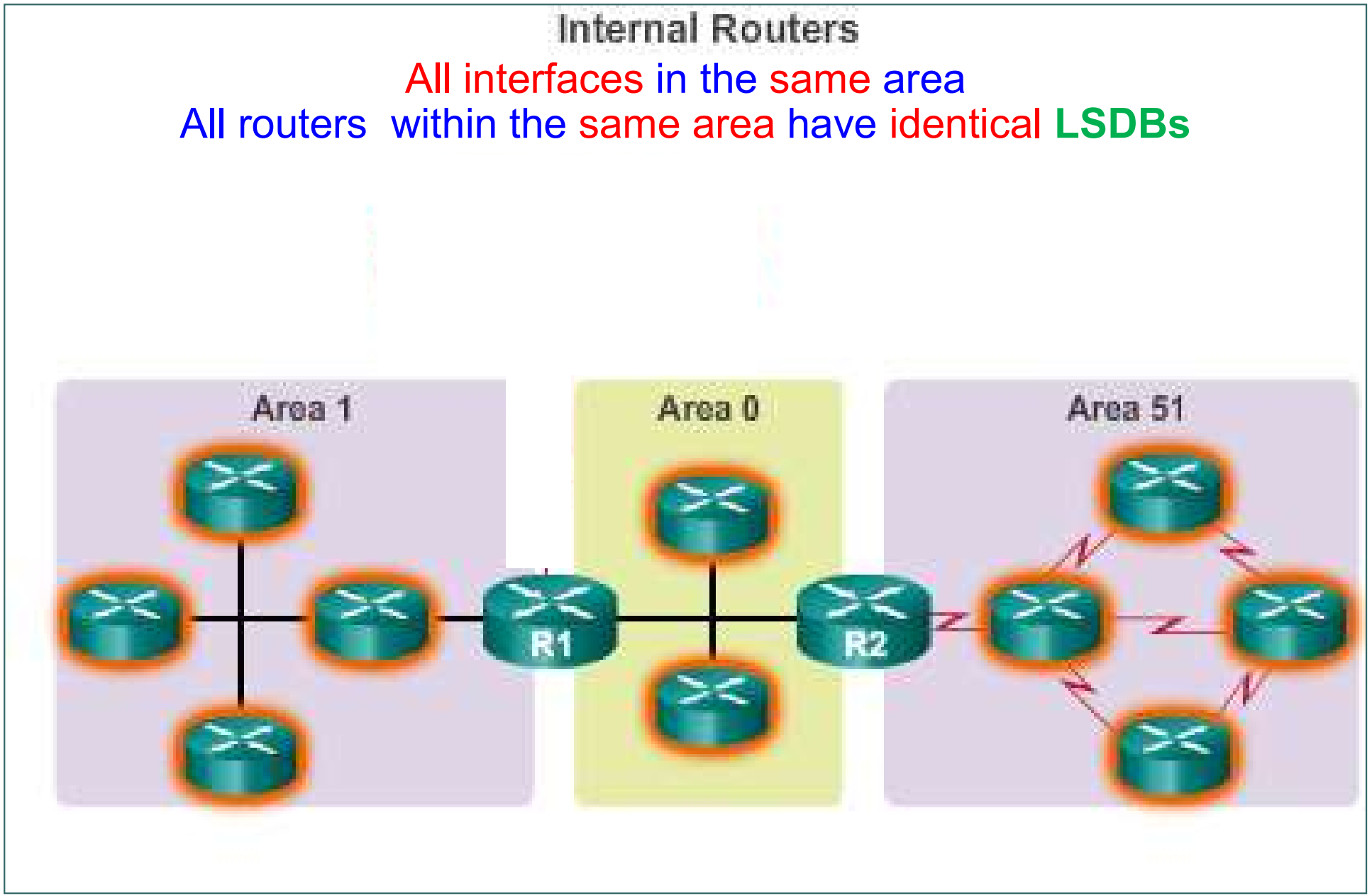
- Internal Router
- Backbone Router
- Area Border Router (ABR)
- Autonomous System Boundary Router (ASBR)

Multiaccess OSPF Networks

- Designated Router (DR)
- Backup designated Router (BDR)
- Other Router (OR)

Designated Router **(DR)** & Backup designated Router **(BDR)** in Multiaccess OSPF Networks

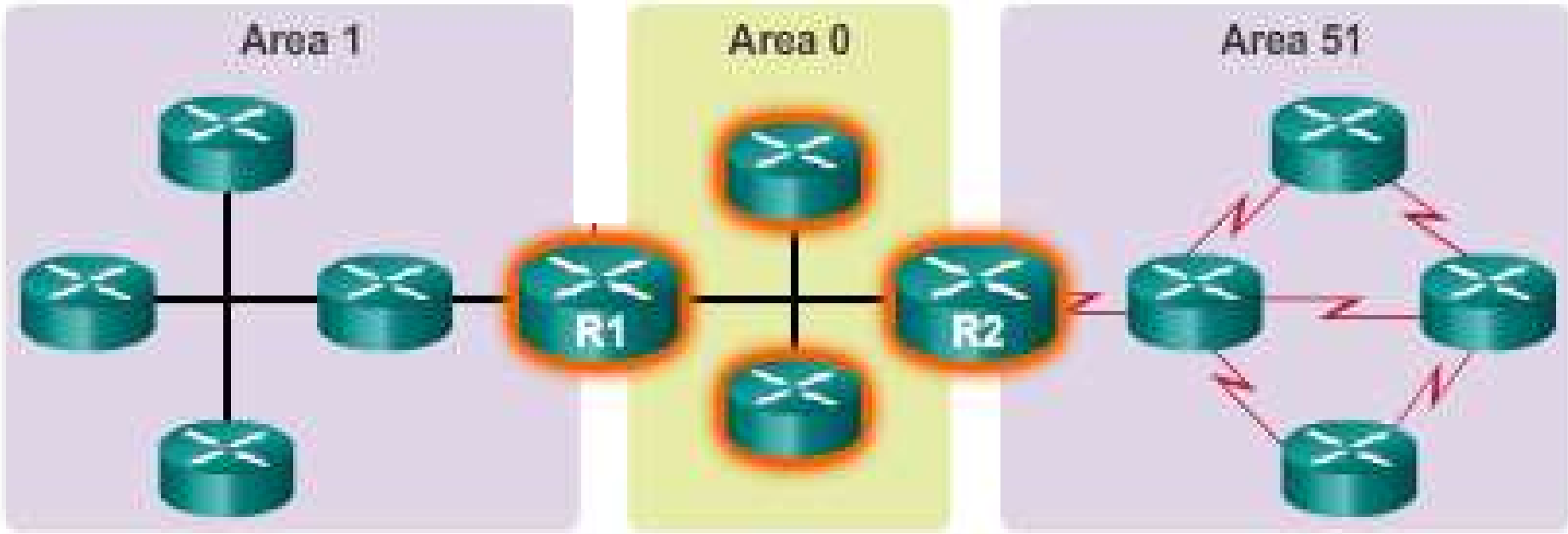
Types of OSPF Routers - Internal



Types of OSPF Routers - Backbone

Backbone Routers

Routers that sit within the perimeter of backbone area 0 and have at least one interface connected to area 0



Types of OSPF Routers – Area Border

Area Border Routers (ABRs)

ABRs connect area 0 to a (Regular) non backbone area

Are exit points for an area

Routing information destined for another area can get there only via the ABRs of the local area.

ABRs distribute routing information into backbone.

Backbone routers forward routing information to other ABRs

ABRs are the only point where address summarization can be configured,

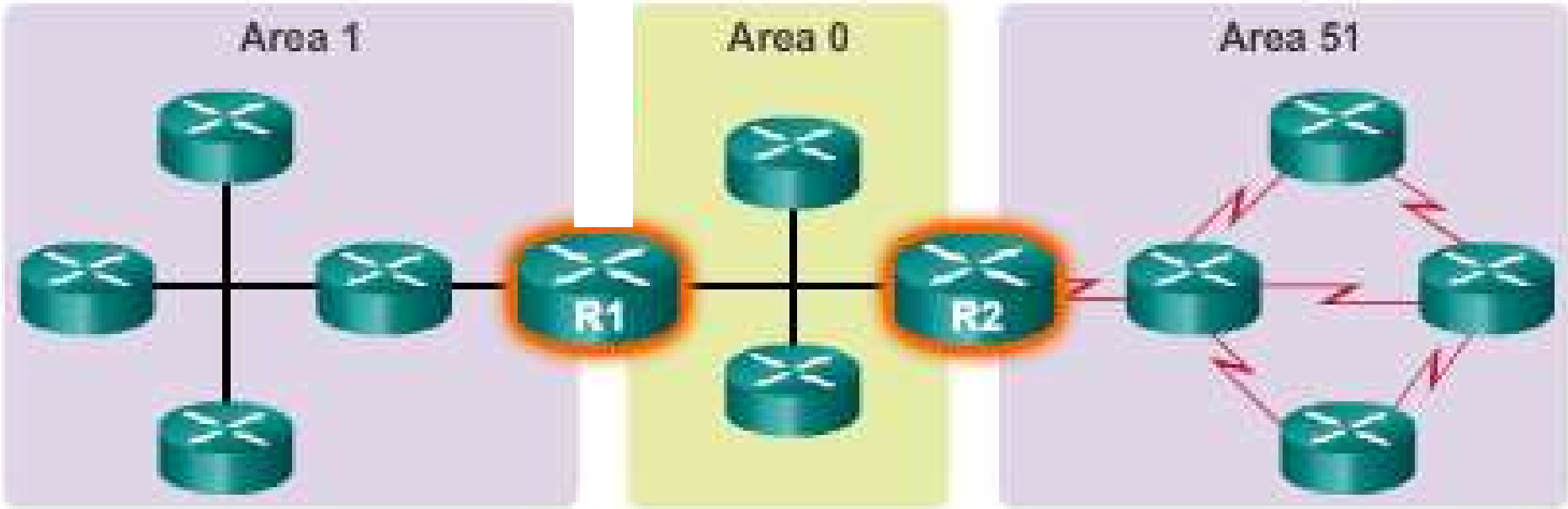
In order to summarize the routing information from the LSDBs of their attached areas.

Types of OSPF Routers – Area Border

Area Border Routers (ABRs)

Routers that have interfaces attached to multiple areas

Maintain separate LSDBs for each area, and route traffic between areas

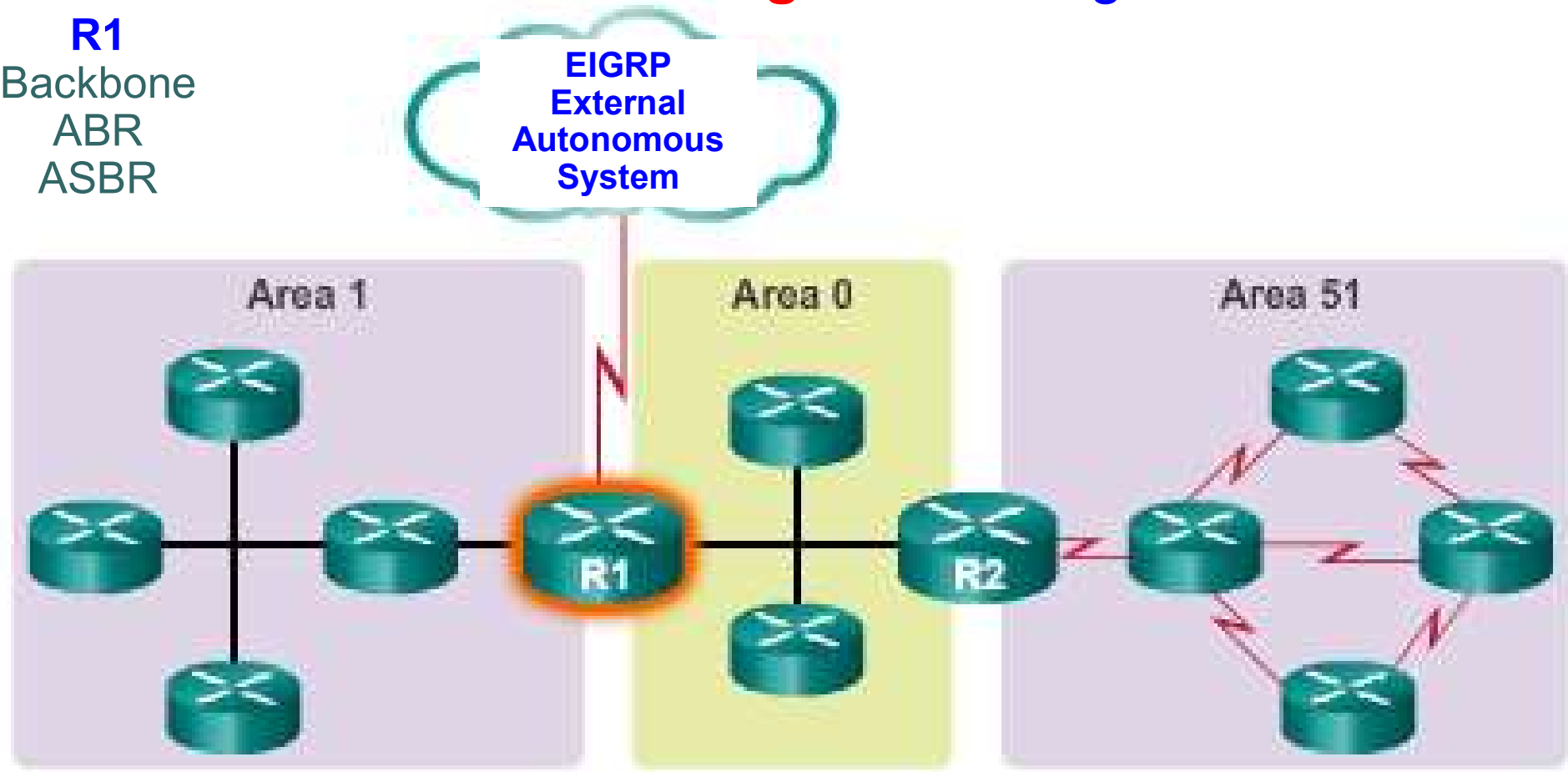


OSPF Routers – Autonomous System Boundary

Autonomous System Boundary Router (ASBR)

Routers that have at least one interface attached to a **different routing domain** e.g. EIGRP

R1
Backbone
ABR
ASBR



Types of OSPF Routers – Autonomous System Boundary

Autonomous System Boundary Routers (ASBRs)

ASBRs are required when there is

Different Routing Domains

To an external internetwork eg. EIGRP

ASBRs can redistribute external EIGRP routes into the OSPF domain

Types of OSPF Routers – (DR) and (BDR)

MultiAccess Networks

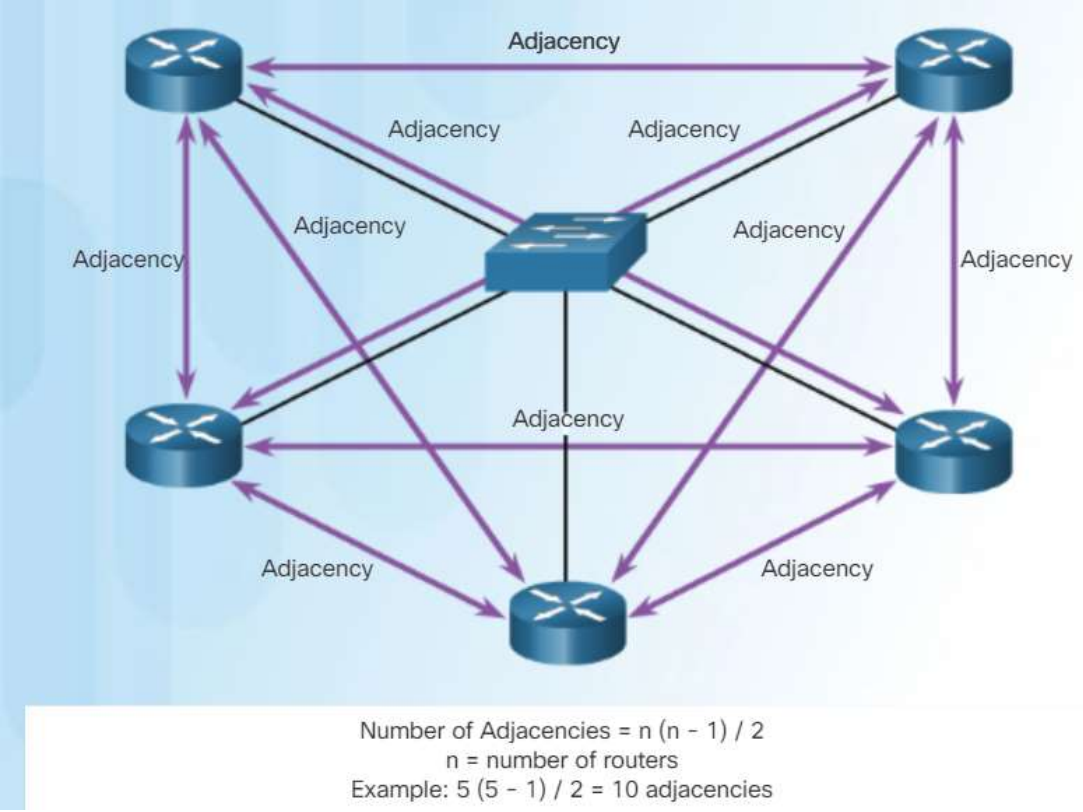
Designated Router (DR) & Backup Designated Router (BDR)

Role of (DR) and (BDR) s in MultiAccess Networks

Election to Select (DR) & (BDR)

DR is the only Router used to sent LSAs on MultiAccess Networks

Reduce the No. of LSAs sent on MultiAccess Networks



Reduce the No. of LSAs sent

Routers	Adjacencies
n	n (n - 1) / 2
5	10
10	45
20	190
100	4,950

Types of OSPF Routers

Internal Router

All interfaces in the same area

Backbone Router

Routers that sit within the perimeter of backbone area 0 and have at least one interface connected to area 0

Area Border Router (ABR)

Routers that have interfaces attached to multiple areas

Autonomous System Boundary Router (ASBR)

Routers that have at least one interface attached to a different routing domain e.g. EIGRP

Designated Router (DR) & Backup Designated Router (BDR)

Role of **(DR)** and (BDR) s in MultiAccess OSPF Networks

6.3 Multiarea OSPF LSA Message Types

- OSPF LSA Message Types 1-5

OSPF LSA (Link State Advertisement) Message 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

The building blocks of OSPF, **Only 1 to 5**,
will be covered

Type 1 - Router LSA

OSPF Type 1 LSAs

Every router generates Type 1 LSAs for area to which it belongs

LSA s act as database records providing specific OSPF network details.

Routers use Type 1 LSAs to advertise their directly connected OSPF enabled links

Type 1 LSAs describe the state of router's links to the other routers in the same area

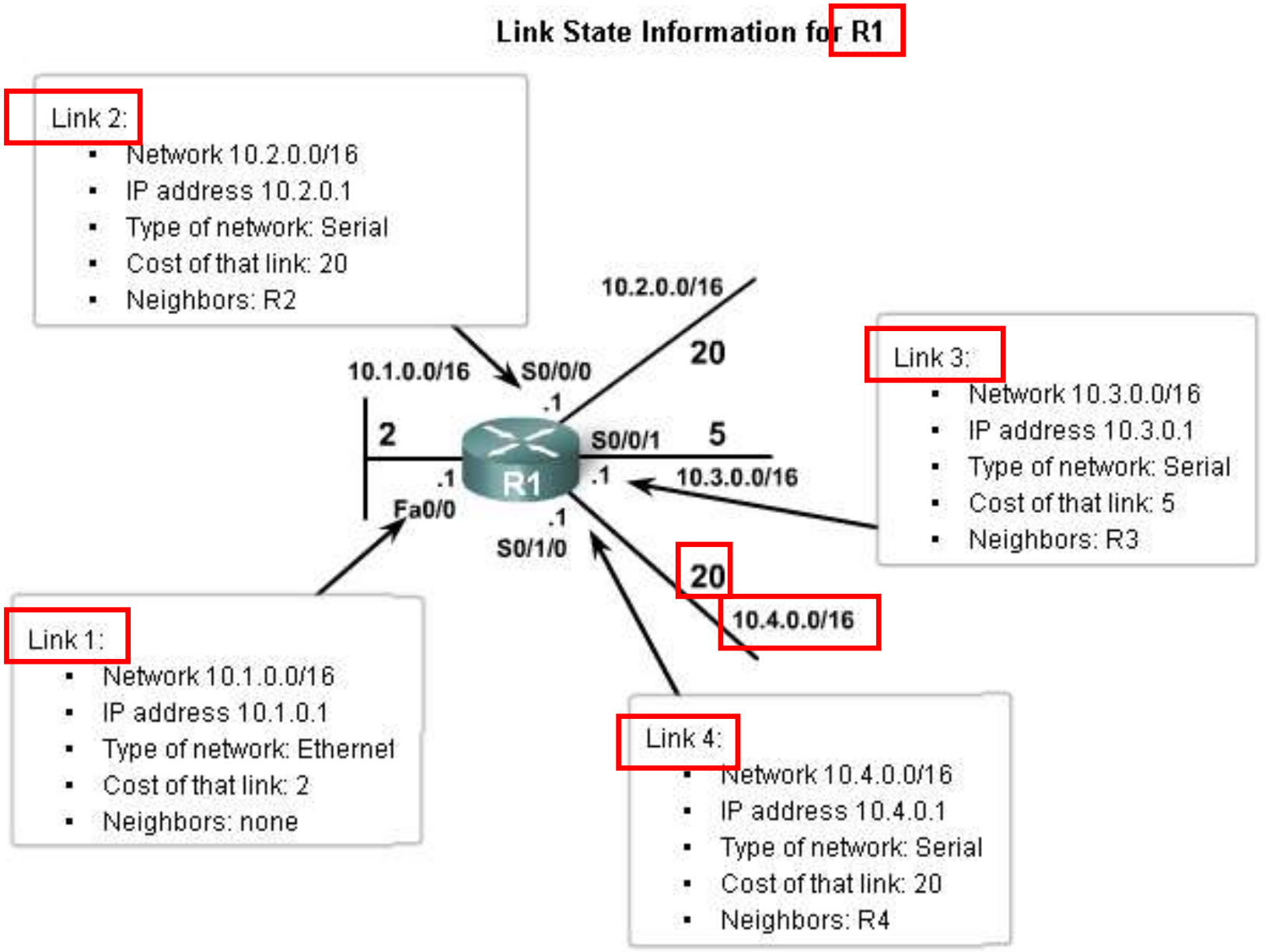
Type 1 LSAs are flooded only **within** the area from which they originated.

Note.

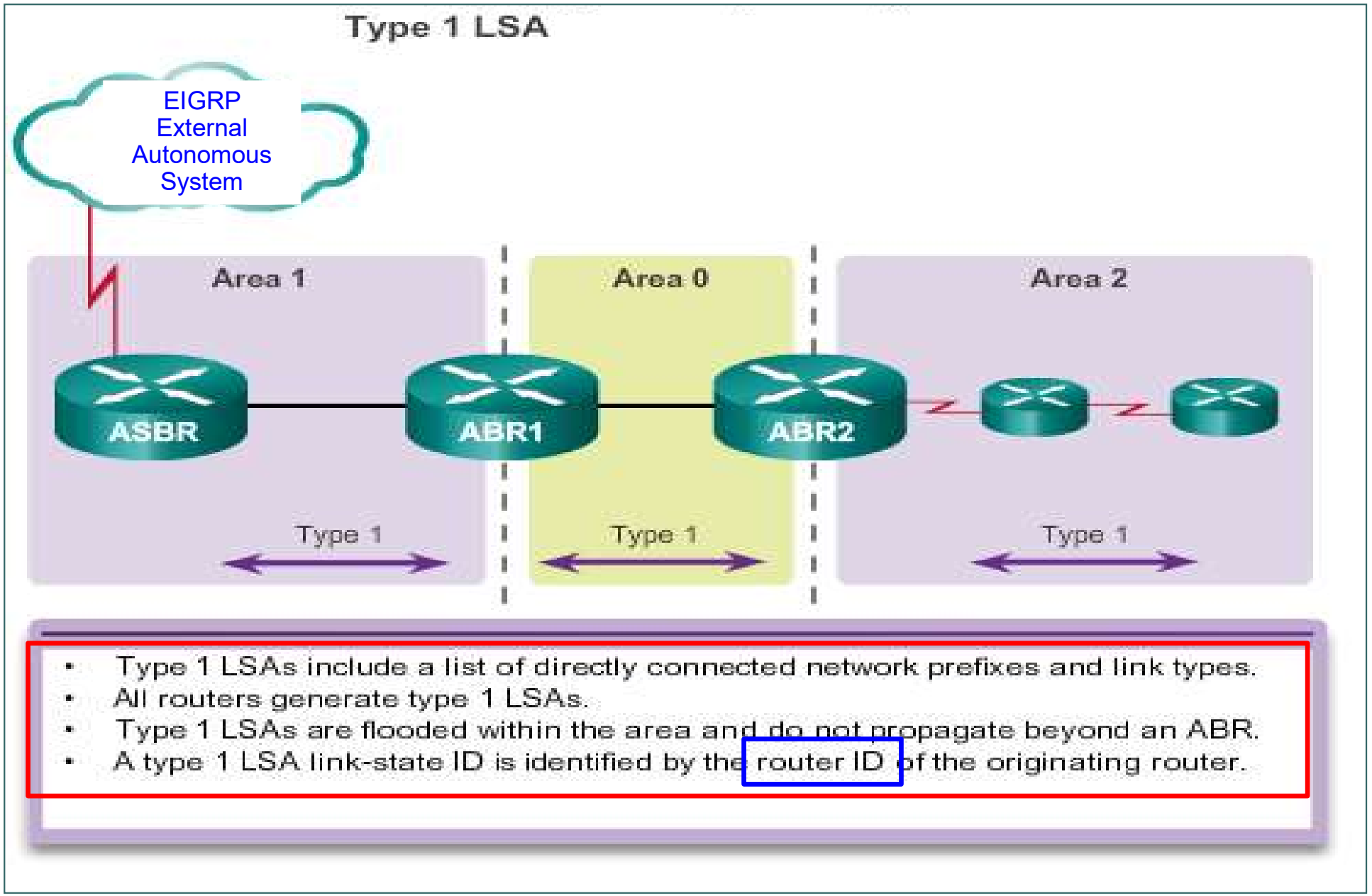
ABR Routers advertise networks learned via Type 1 LSAs

to other areas using Type 3 LSAs.

Type 1 - Router LSA



Type 1 - Router LSA



Type 2 - Network LSA – Multi Access Networks

OSPF Type 2 LSAs

Describe the set of routers attached to a particular multi-access network

DRs (Designated routers) generate Type 2 LSAs for multi-access networks

Type 2 LSAs are not forwarded outside of an area

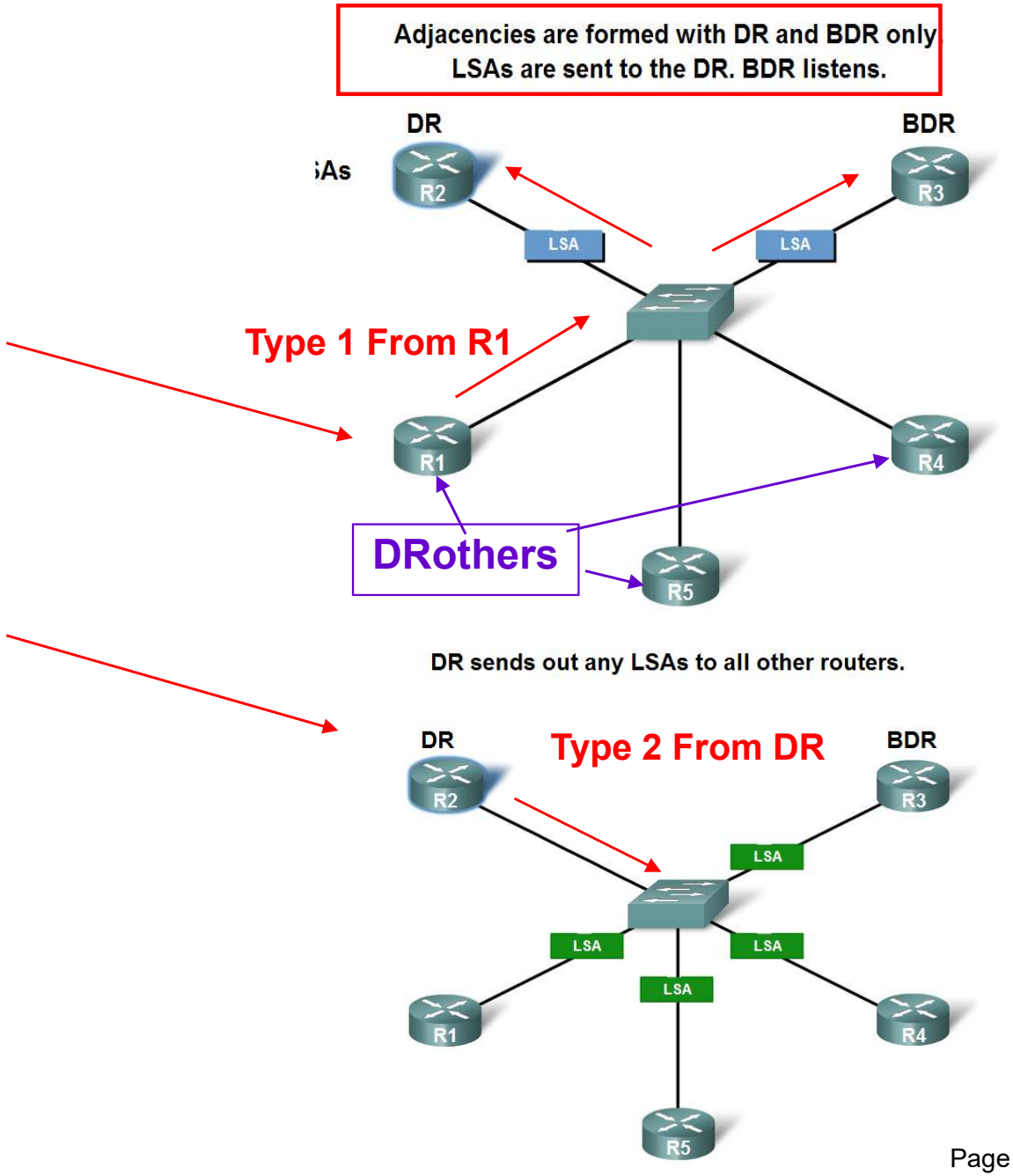
Type 2 - Network LSA – Multi Access Networks

Designated router (DR) and
Backup designated router (BDR)

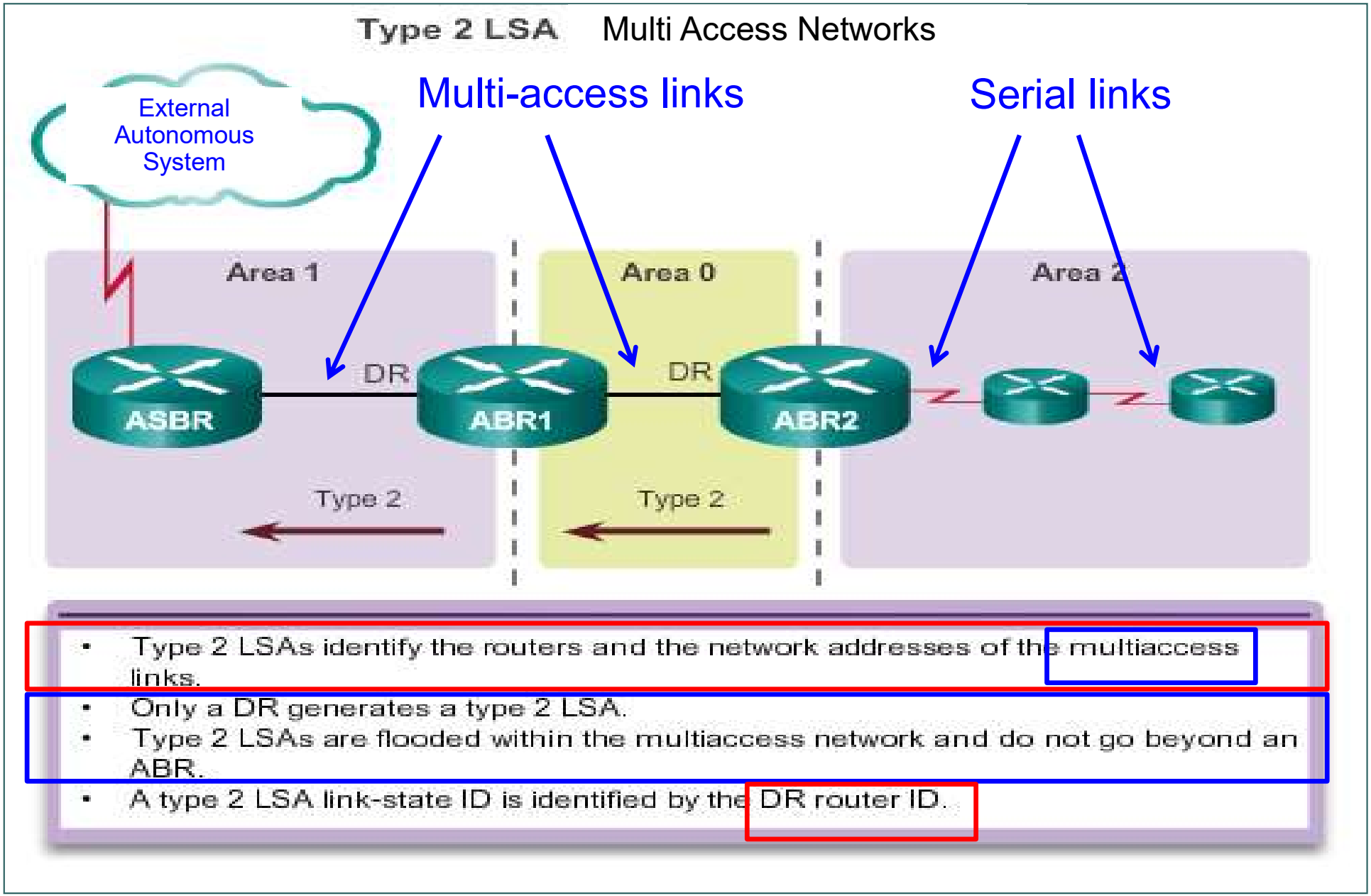
Sending and Receiving LSAs

Router R1 sends Type 1 LSAs via multicast address 224.0.0.6
to DR & BDR

DR sends Type 2 LSAs via multicast address 224.0.0.5
to DRothers (all other routers)



Operation OSPF LSA **Type 2**



How do we Learn about networks in other Areas?

Type 3 Summary LSA

* Describe interarea routes

* Describe routes to an area's networks, may include summary routes,
* Type 3 LSAs are created and generated by ABR.

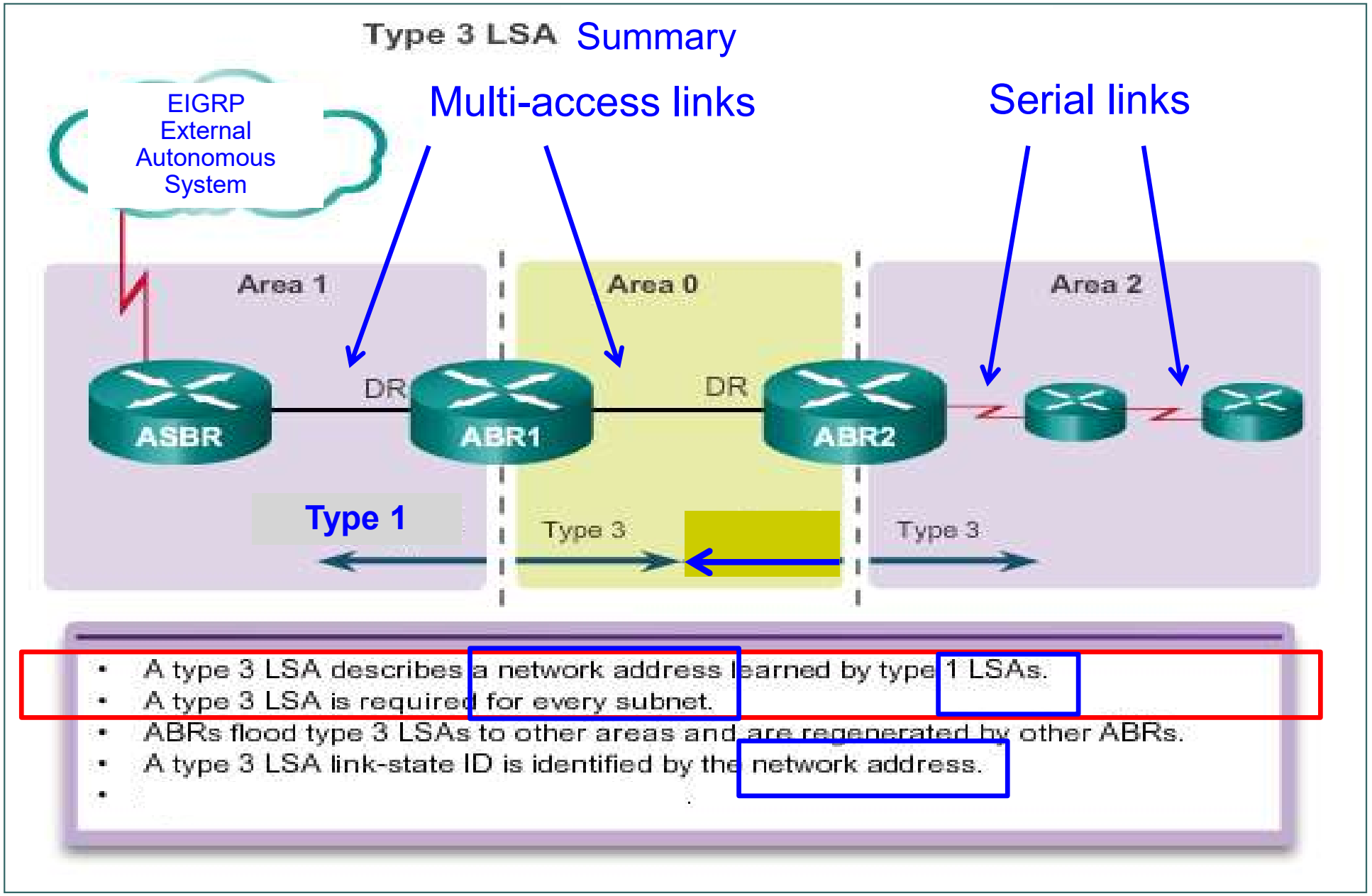
Type 4 Summary LSA

* generated by an ABR only when an
  Autonomous System Boundary Router exists within an area

ABRs are the only point where address summarization can be configured, to summarize the routing information from the LSDBs of there attached areas

Do not cause a router to run SPF algorithm

OSPF LSA Type 3



Type 3 - Summary LSA

An Area Border Router (ABR) takes information it has learned on one of its attached areas and summarizes it before sending it out to other areas it is connected to

This summarization provides scalability by removing detailed topology information for other areas, because their routing information is summarized into just an network address, prefix and cost.

Type 4 – ASBR Summary LSA

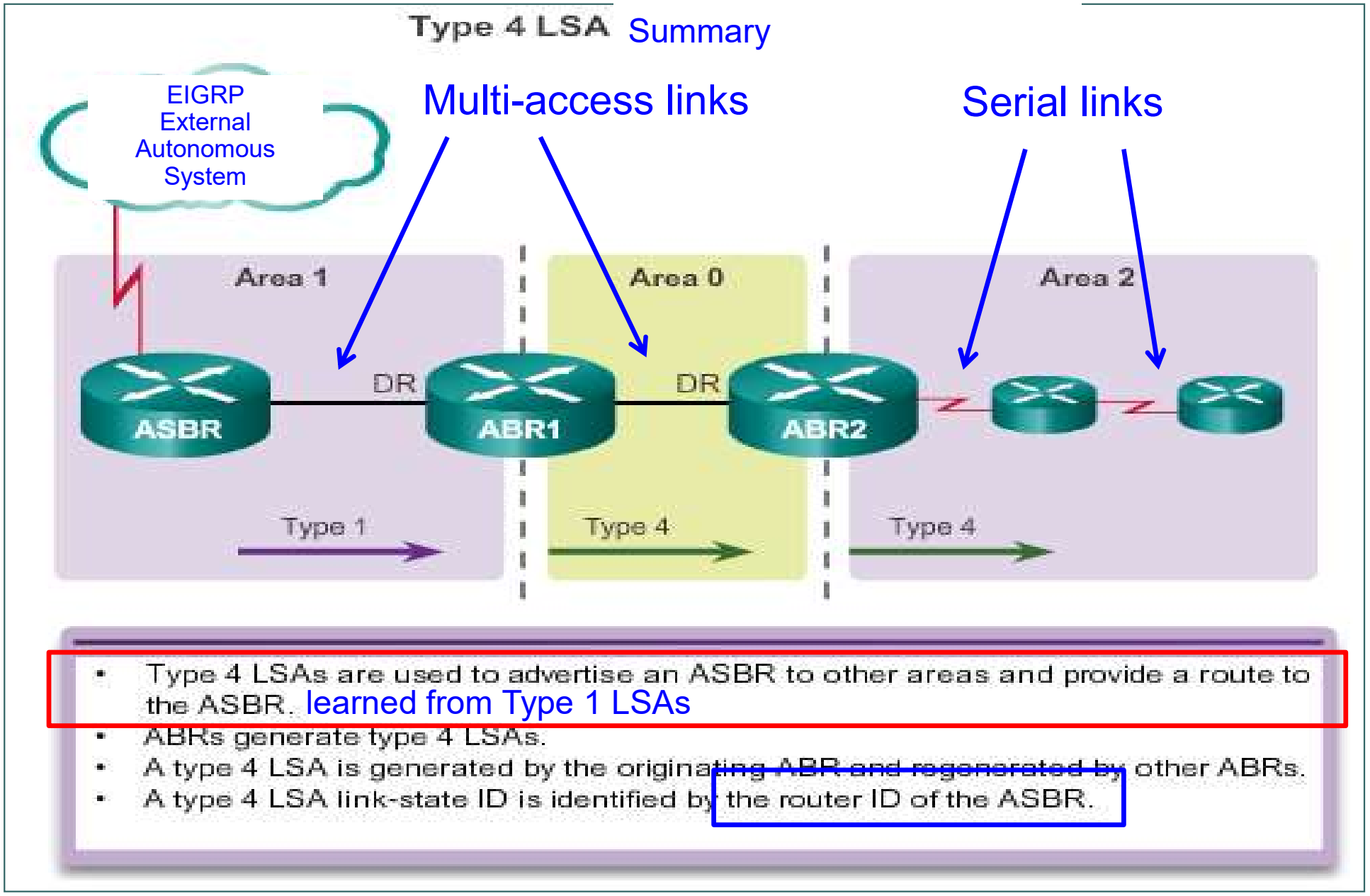
OSPF Type 4 ASBR Summary LSA

* Is generated by an ABR only when an Autonomous System Boundary Router exists within an area.

* Provides the route to the ASBR (Router), to routers in other areas

.

OSPF ASBR Summary Type 4 LSA



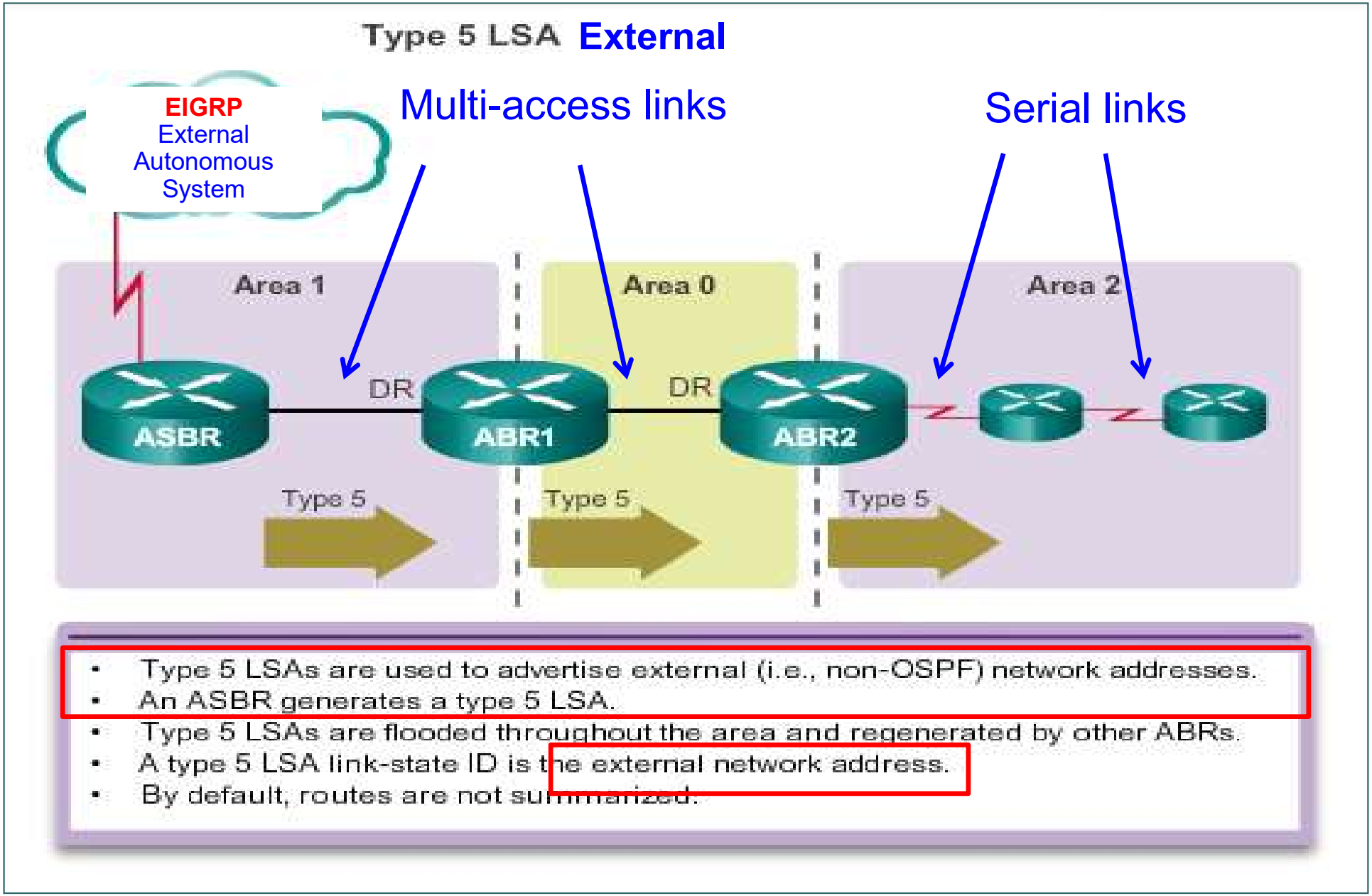
Type 5 - Autonomous System External LSA

OSPF Type 5 Autonomous System External LSA s

* Describe routes to networks outside the OSPF autonomous system.

* Generated by the ASBR and are flooded to the entire autonomous system.

OSPF LSA **Type 5**



6.4 Implementing Multiarea OSPF

- Multiarea OSPF Populate Routing table
- Verifying Multiarea OSPF

Multiarea OSPF – Populate Routing table

Multiarea OSPF Convergence Step1.

Calculate Intra Area OSPF Routes

All routers via **LSAs type 1 and 2**,

calculate via SPF algorithm

the **least cost paths** to destinations

within their area (**intra-area**)

and **add** these entries to the **routing** table.

Designator **O** in routing table

Multiarea OSPF – Populate Routing table

Multiarea OSPF Convergence Step2.

Inter Area OSPF Routes

All routers via **LSAs type 3 and 4**

receive the **least cost paths** to the

networks in **other areas**

within the internetwork (**inter-area**) .

Designator **O IA** in routing table

Multiarea OSPF – Populate Routing table

Multiarea OSPF Convergence Step3.

OSPF Routes to External Non OSPF Networks

All routers via **LSA type 5**,

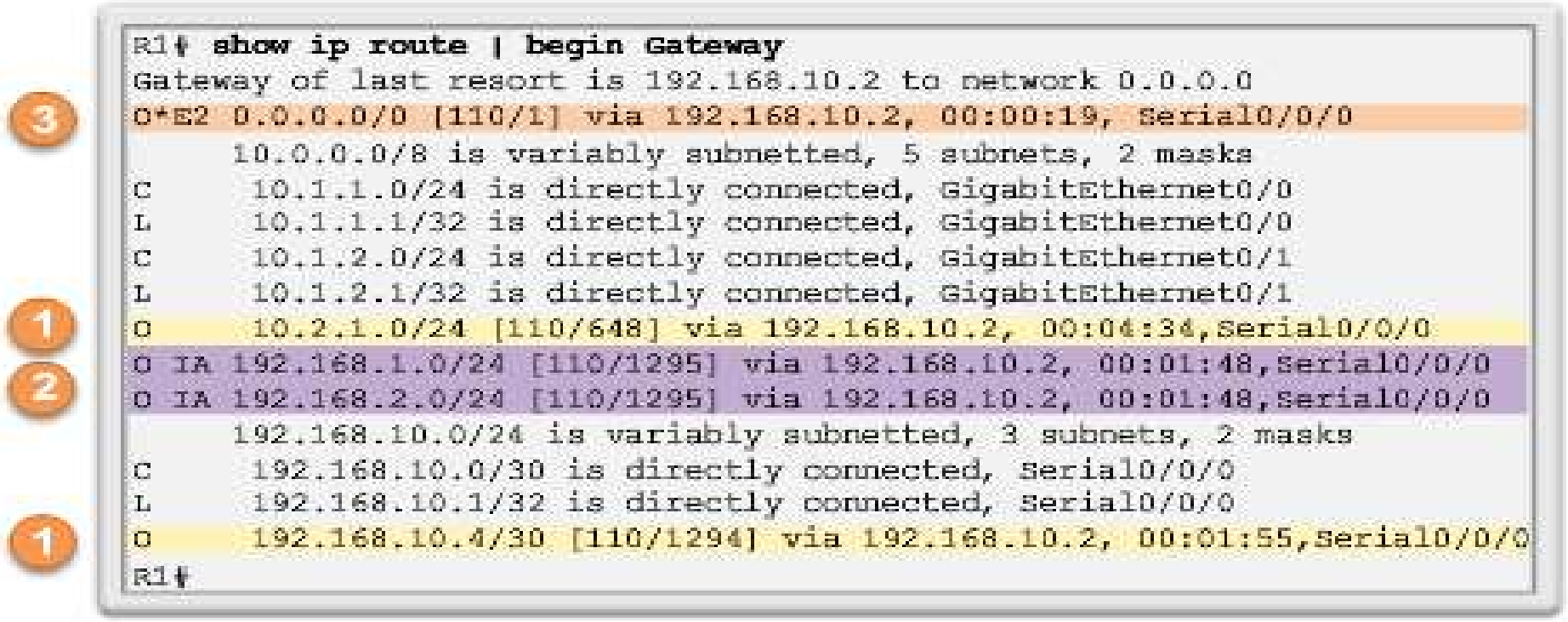
receive the **least cost paths** to the **external**

autonomous system destinations.

Designator **O E2** in routing table

Multiarea OSPF – Steps to Populate Routing Table

Steps to OSPF Convergence



1. Calculate via SPF least cost paths to intra-area routes
2. Insert least cost paths to inter-area networks
3. Insert least cost paths to external non-OSPF networks

..

Multiarea OSPF Routing Table Entries

- **O** – Router describe the details within an area (the route is intra-area).
- **O IA** – Summary inter-area routes
- **O E2** – External 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#
```

Configuring Multiarea OSPF

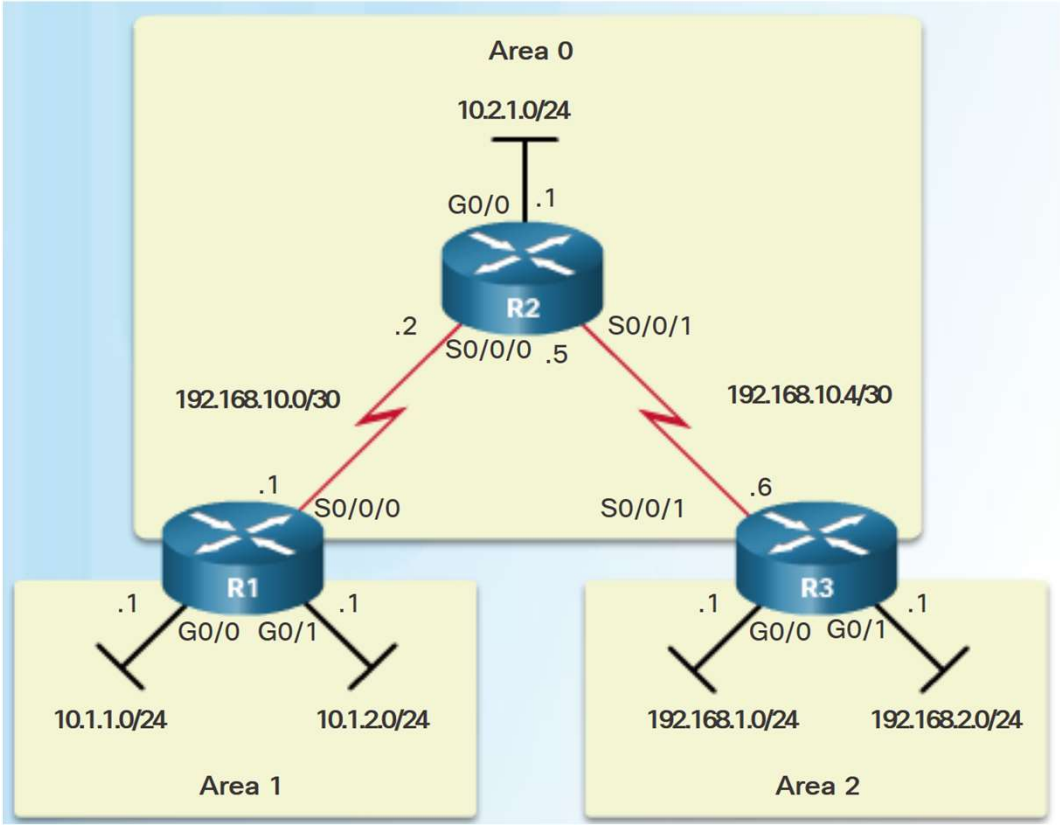
Configuring Multiarea OSPFv2 requires careful planning to gather network requirements
IP addressing plan
OSPF Areas
Network topology

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 interface in area 1 and an interface in area 0.

```
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#
```



Verifying Multiarea OSPF

Commands to verify multiarea OSPF

*show ip ospf neighbor
*show ip ospf interface
*Show ip protocols
*show ip ospf interface brief
*show ip route ospf
*show ip ospf database

Example.
* show ip protocols

to verify the OSPF status.
List routing protocols configured on router,
number of areas, router ID
and networks included in routing protocol.

```
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)
```

* show ip ospf interface brief

to display the OSPF process ID,
interfaces assigned to areas,
and interface cost.

```
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

Commands to verify multiarea OSPF

Verification Information	Show ip protocols	show ip ospf interface brief	show ip route ospf	show ip ospf database
Process ID	Y	Y		Y
State of OSPF Interface		Y		
Networks Configured	Y			
Interface Cost		Y		
Router ID	Y			Y
Administrative Distance	Y		Y	
Number of Areas	Y			
Networks from other Areas	Y		Y	
All Known Routes	Y		Y	
Total Cost of Route			Y	