SWINBURNE

CENTRE FOR ADVANCED INTERNET ARCHITECTURES

TNE20002/TNE70003

Topic 10 Multi-Area OSPF V1.1

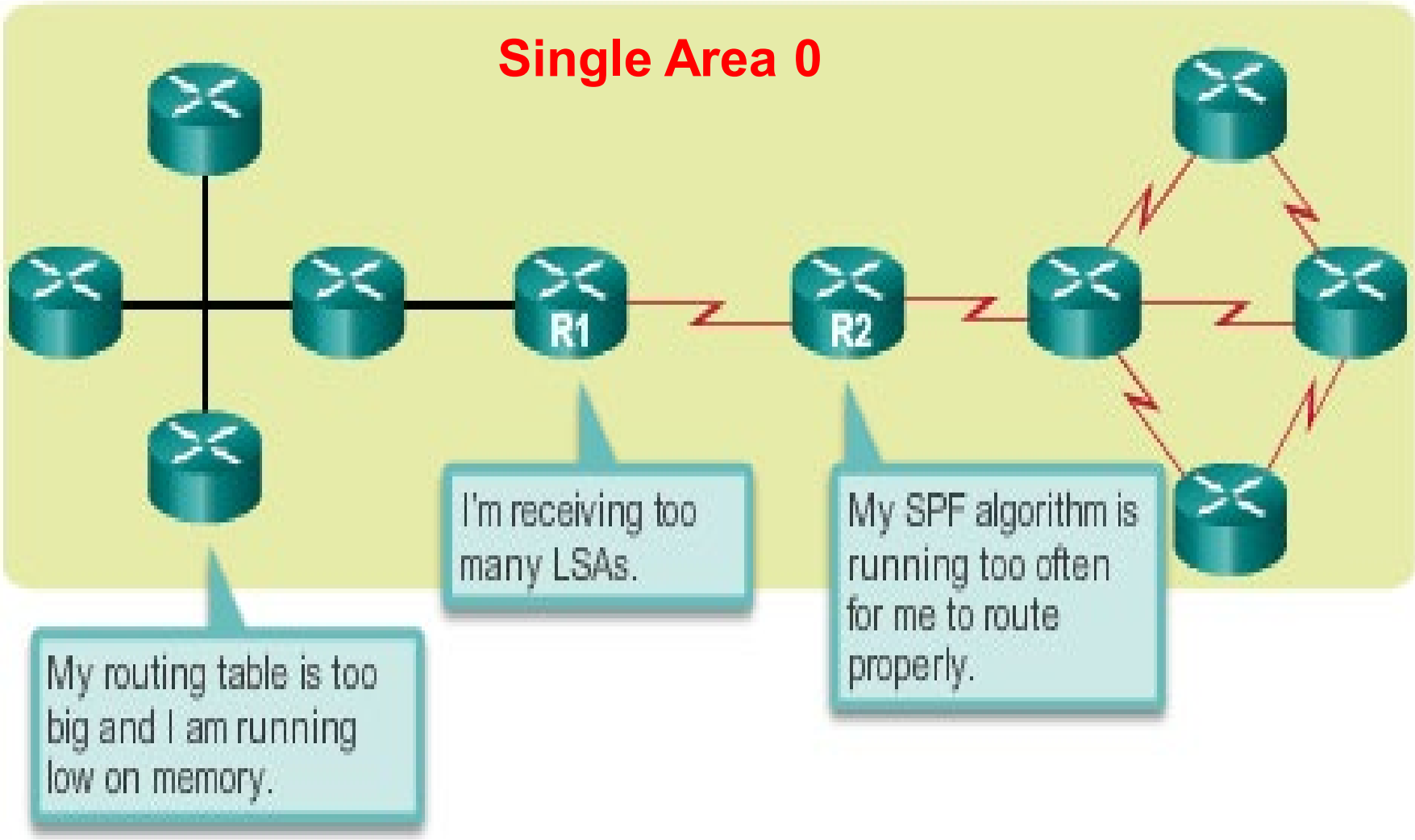
Why Multi-Area OSPF?

- Single-area OSPF is useful for smaller networks.

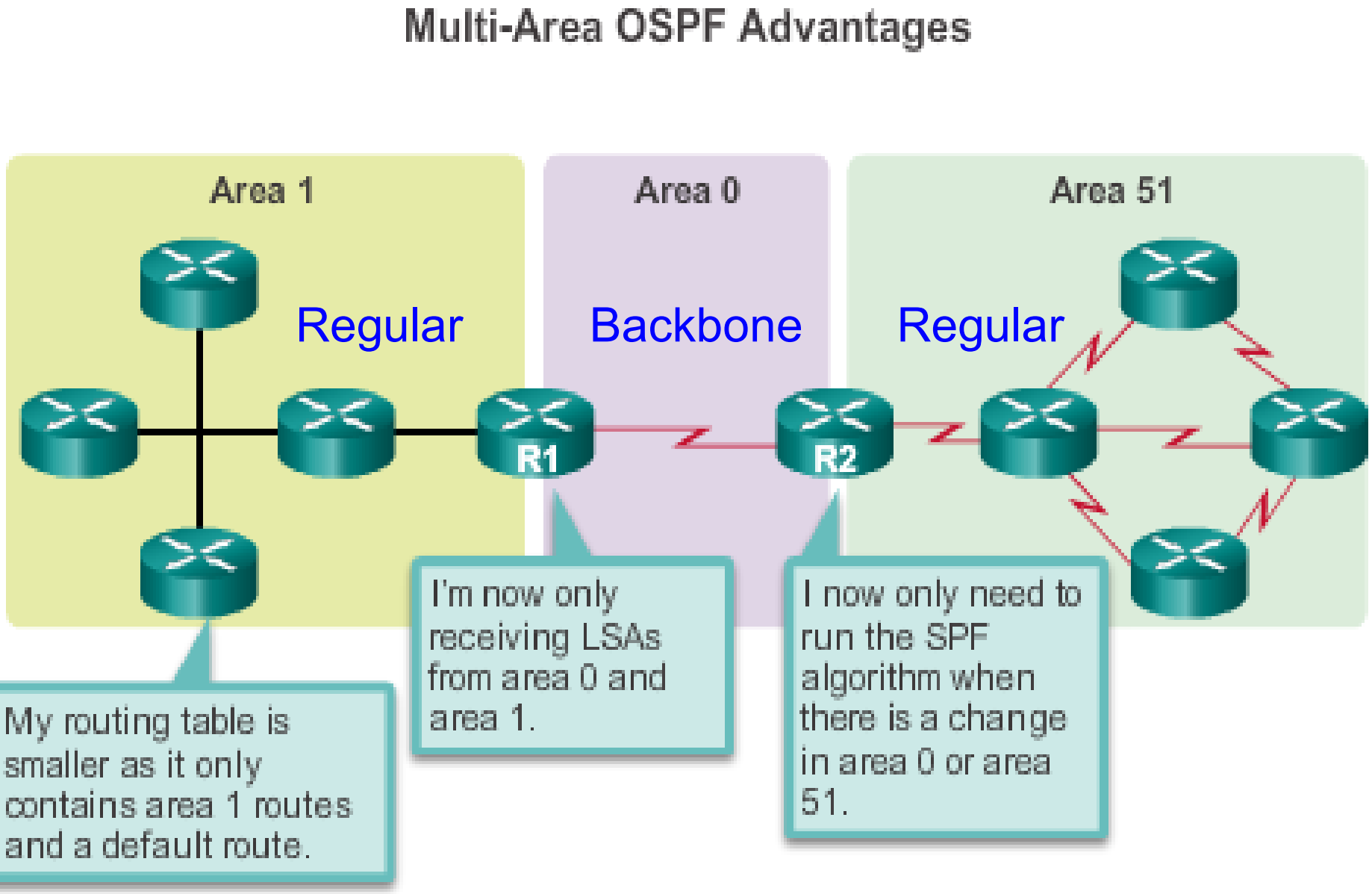
- If an area becomes too large (Cisco state an area should have no more than 50 routers), the following issues must be addressed:

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

Why Multi-Area OSPF?



Multi-Area OSPF

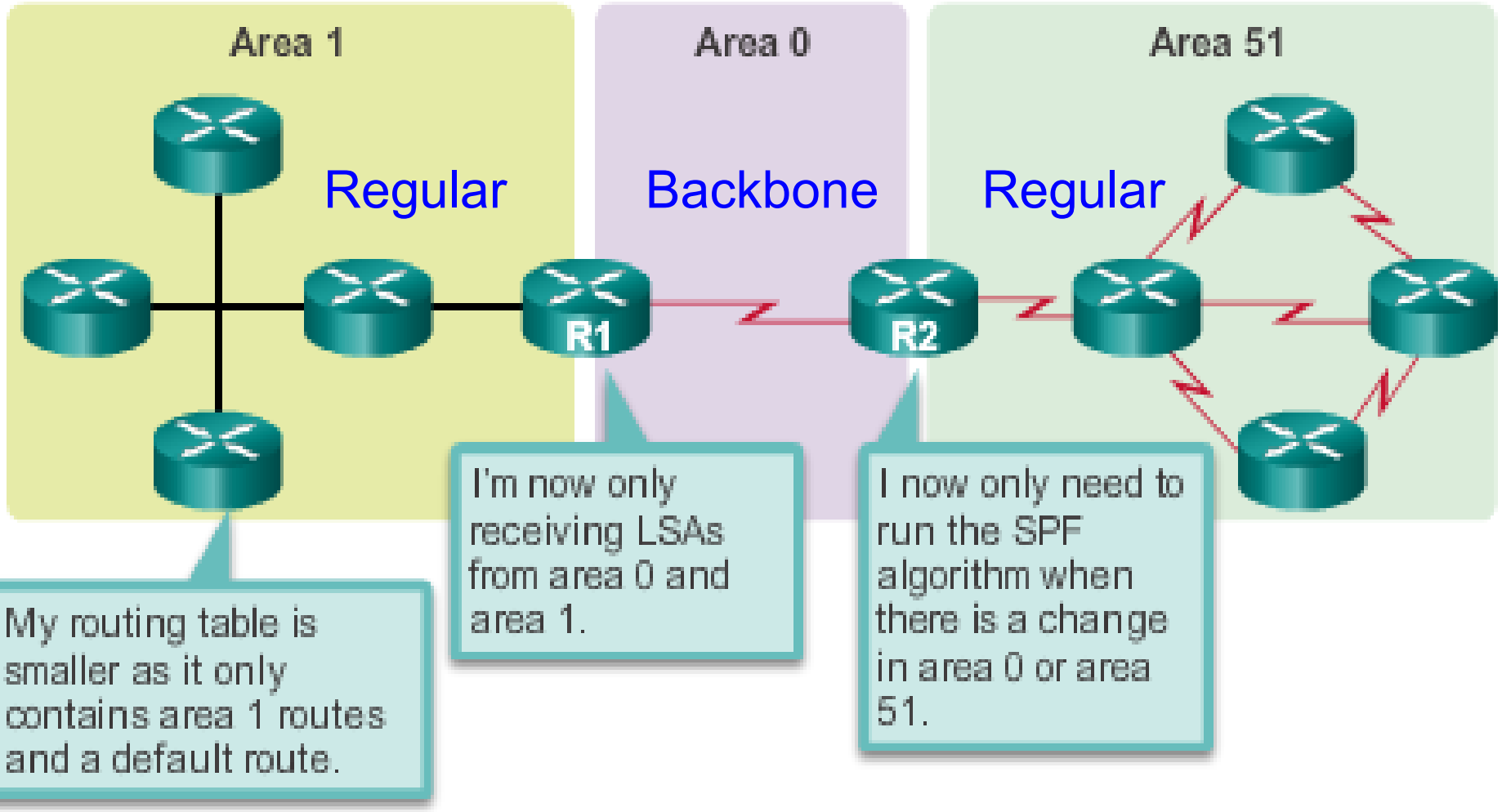


OSPF Two-Layer Area Hierarchy

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

- **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, eg Area 1 to Area 51

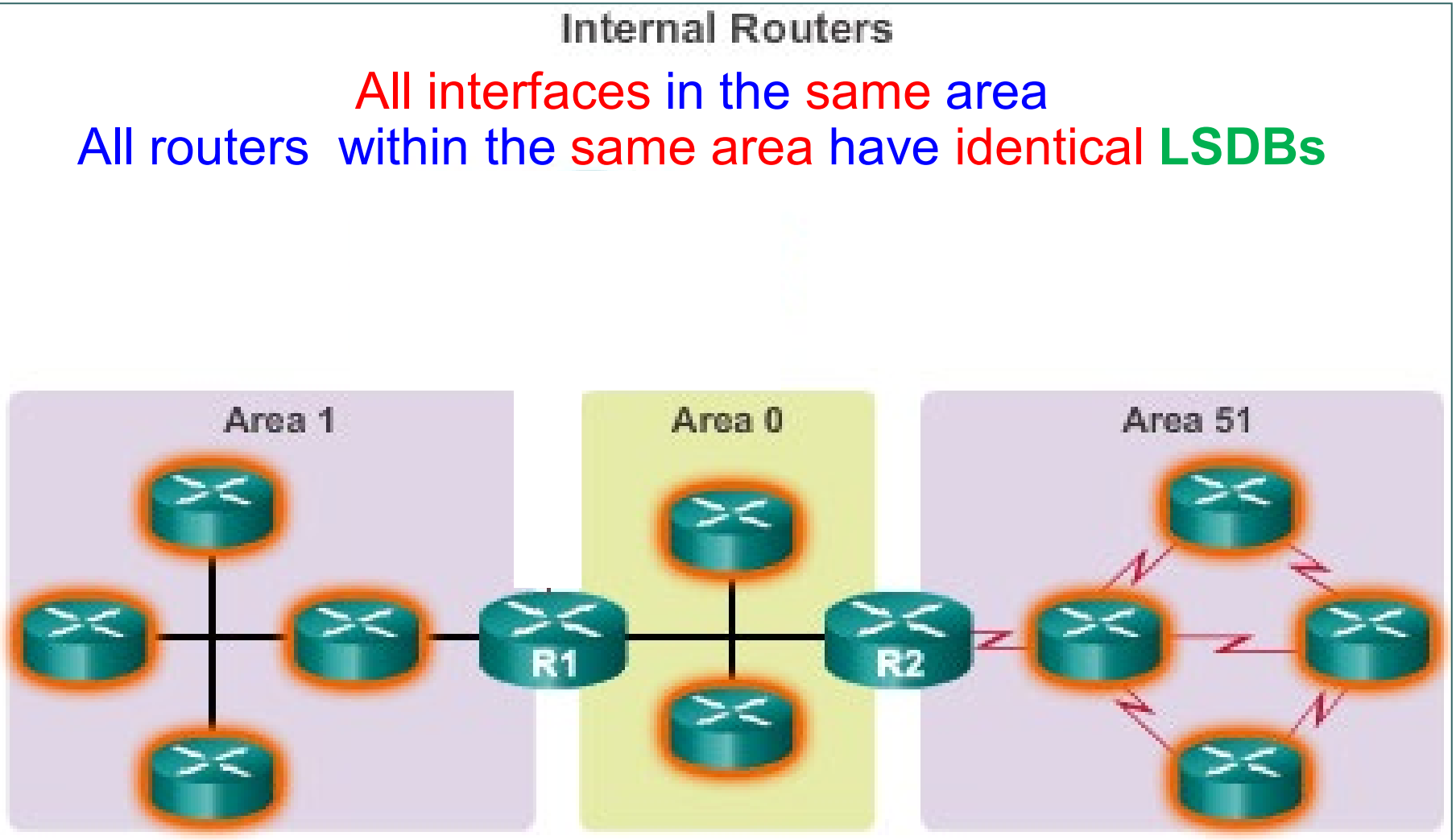
Multi-Area OSPF



Types of OSPF Routers

- Internal Router
- Backbone Router
- Area Border Router (ABR)
- Autonomous System Boundary Router (ASBR)
- A router may have more than one role

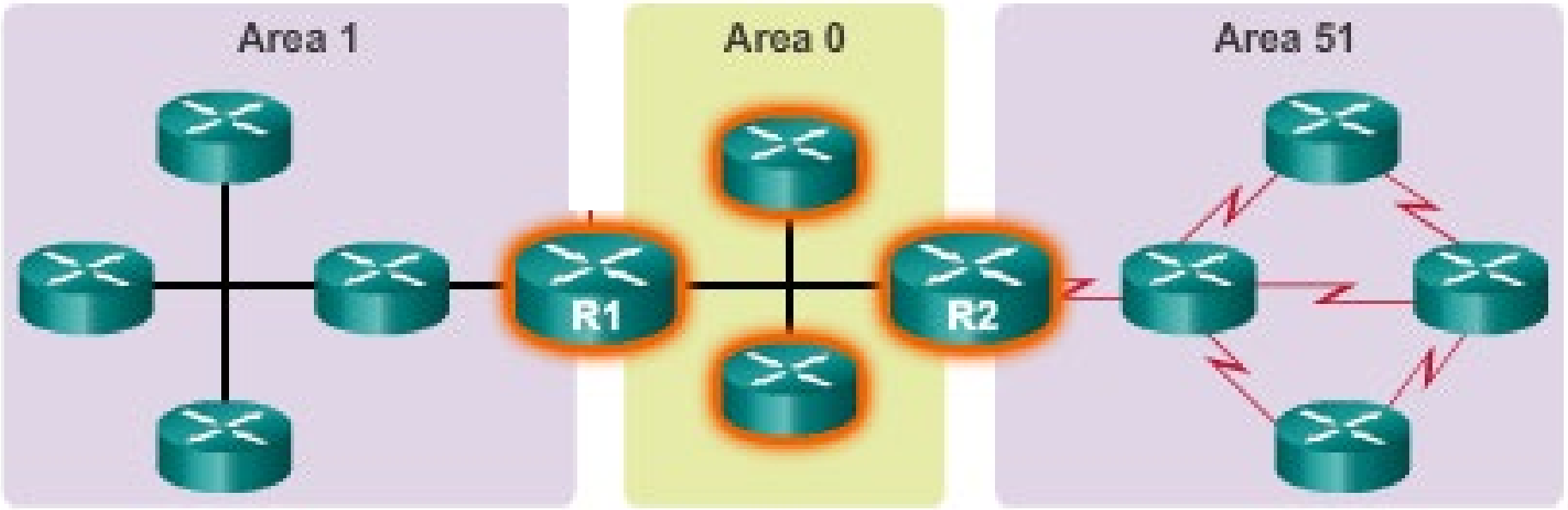
Types of OSPF Routers - Internal



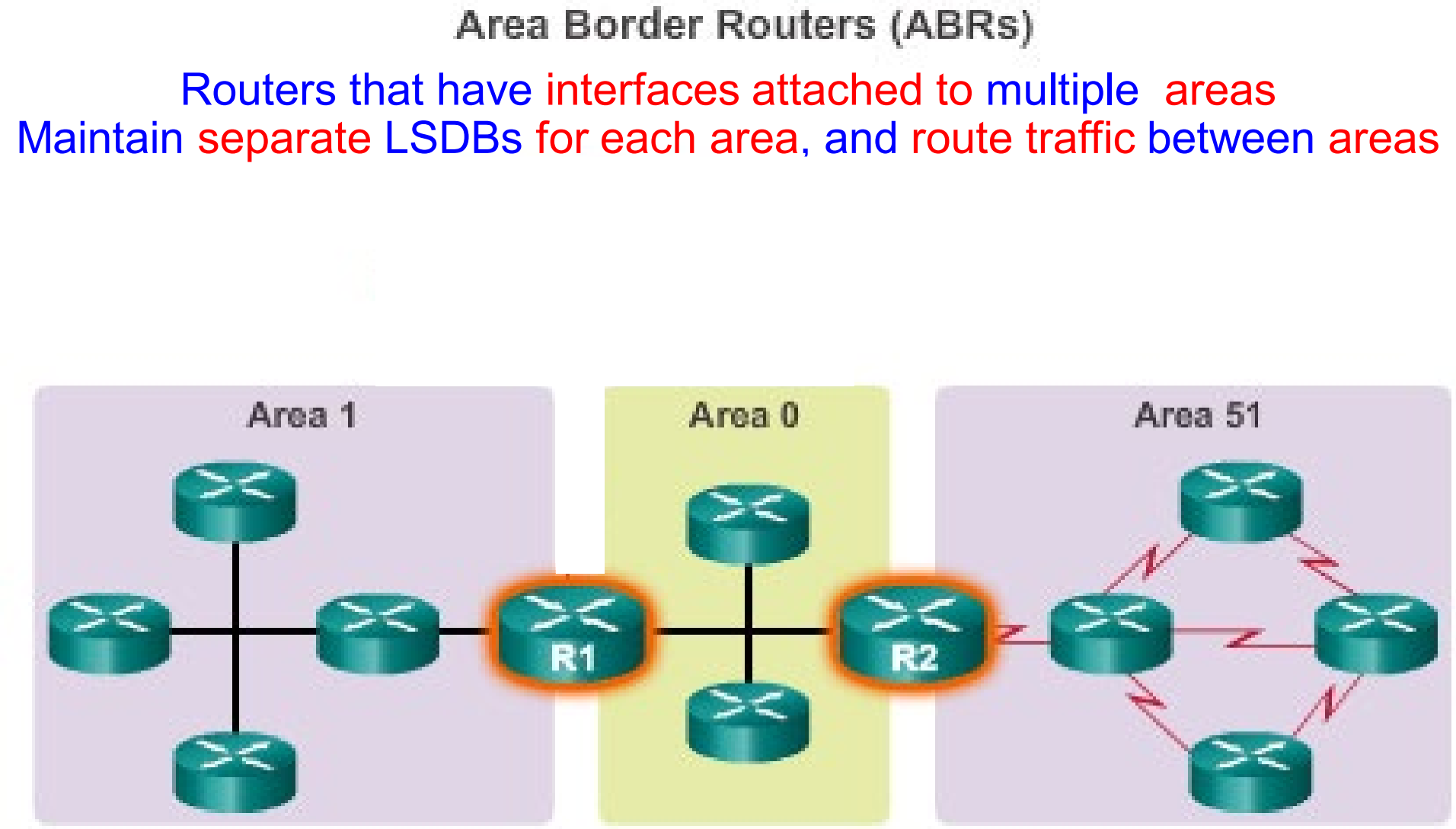
Types of OSPF Routers - Backbone

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



Types of OSPF Routers – Area Border

- 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 ABR of the local area

- ABRs distribute routing information into backbone

- Backbone routers forward routing information to other ABRs

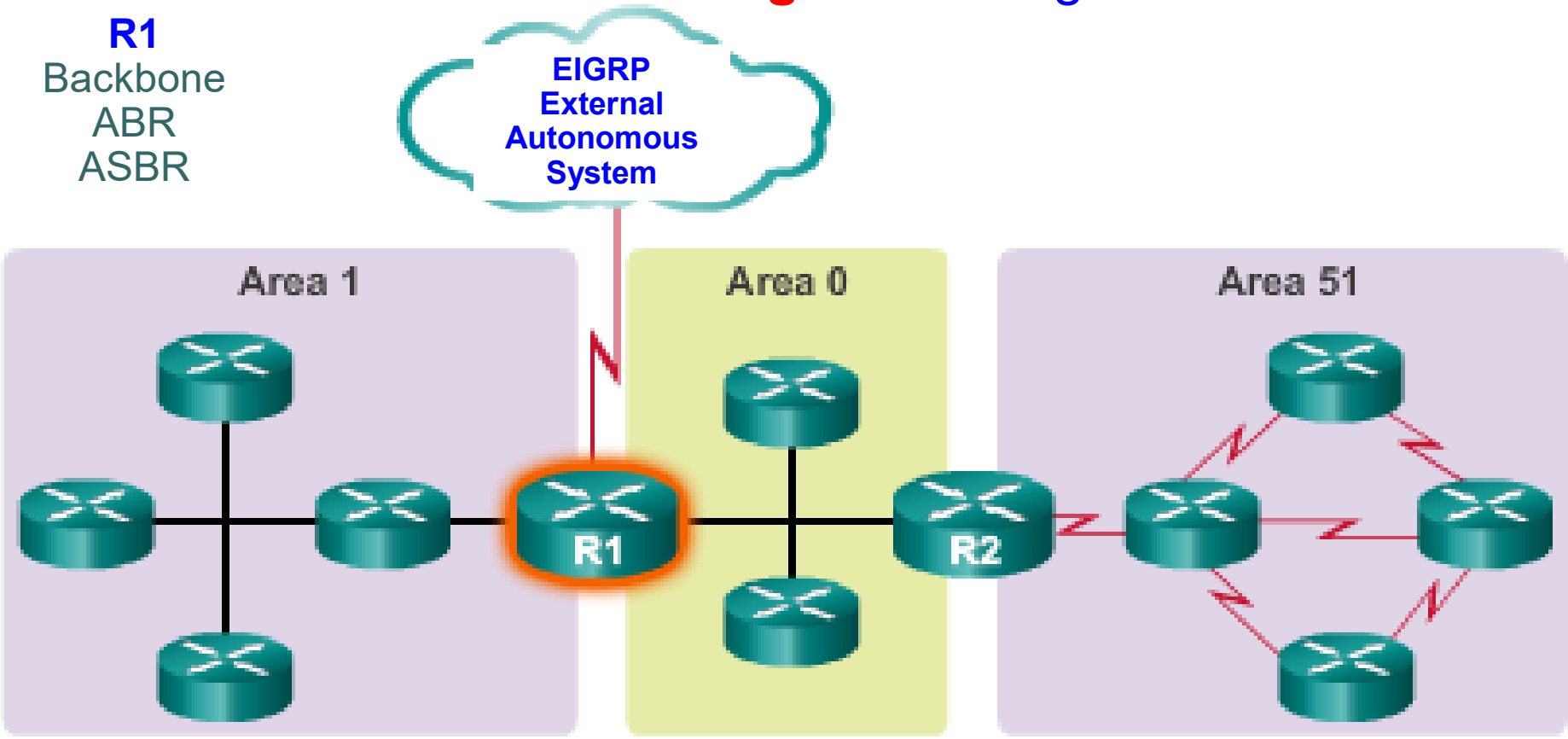
- ABRs are the only point where address summarization can be configured, to summarize the routing information from the LSDBs of their attached areas

Types of OSPF Routers – Autonomous System Boundary

Autonomous System Boundary Router (ASBR)

Routers that have at least one interface attached to a **different routing domain** eg EIGRP

R1
Backbone
ABR
ASBR



Types of OSPF Routers – Autonomous System Boundary

- Different Routing Domains
  - A domain using EIGRP

- ASBRs can redistribute external EIGRP routes into the OSPF domain

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 eg EIGRP

OSPF LSA (Link State Advertisement) 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

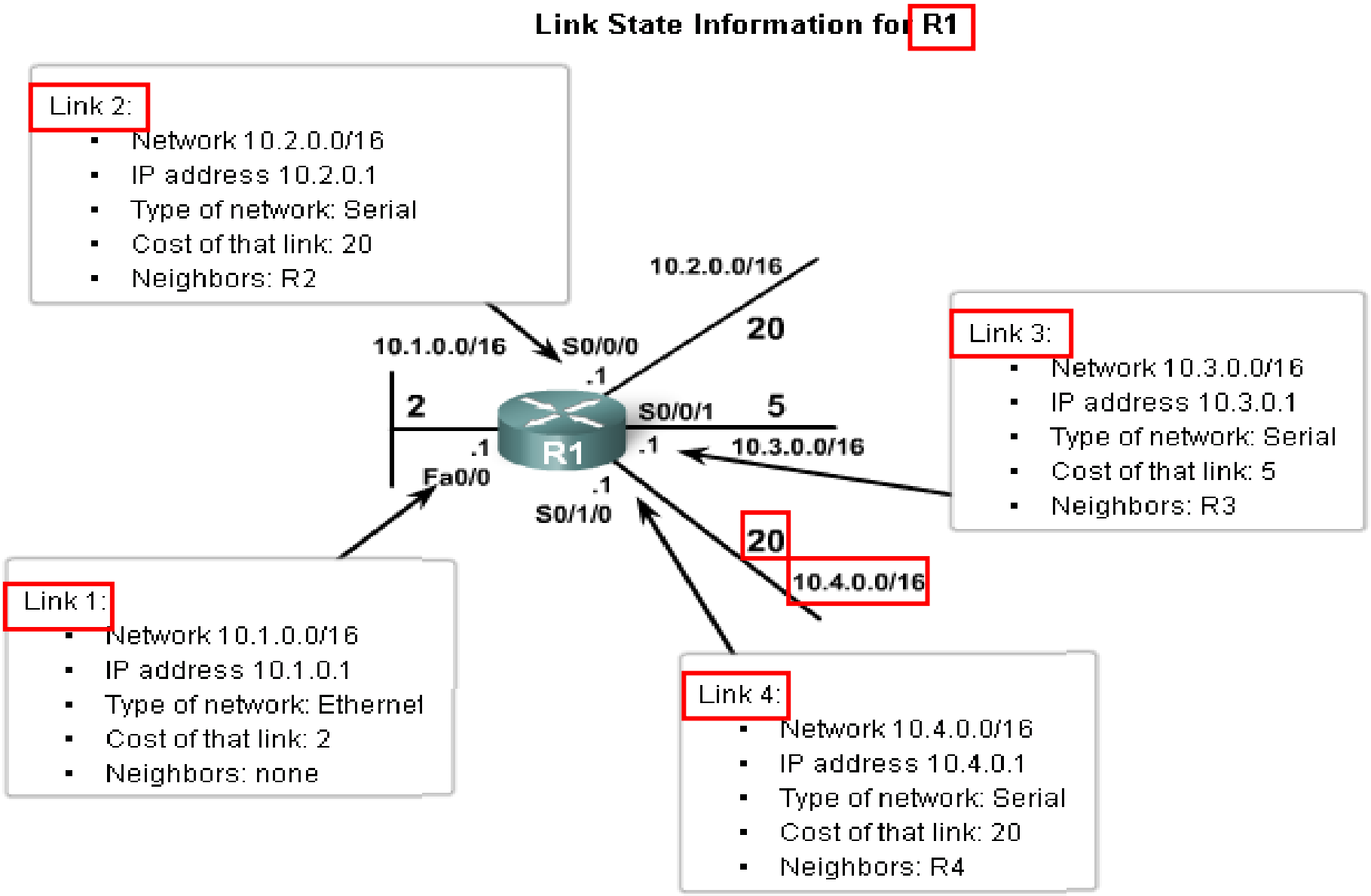
The building blocks of OSPF, **Only 1 to 5**,
will be covered

Type 1 - Router LSA

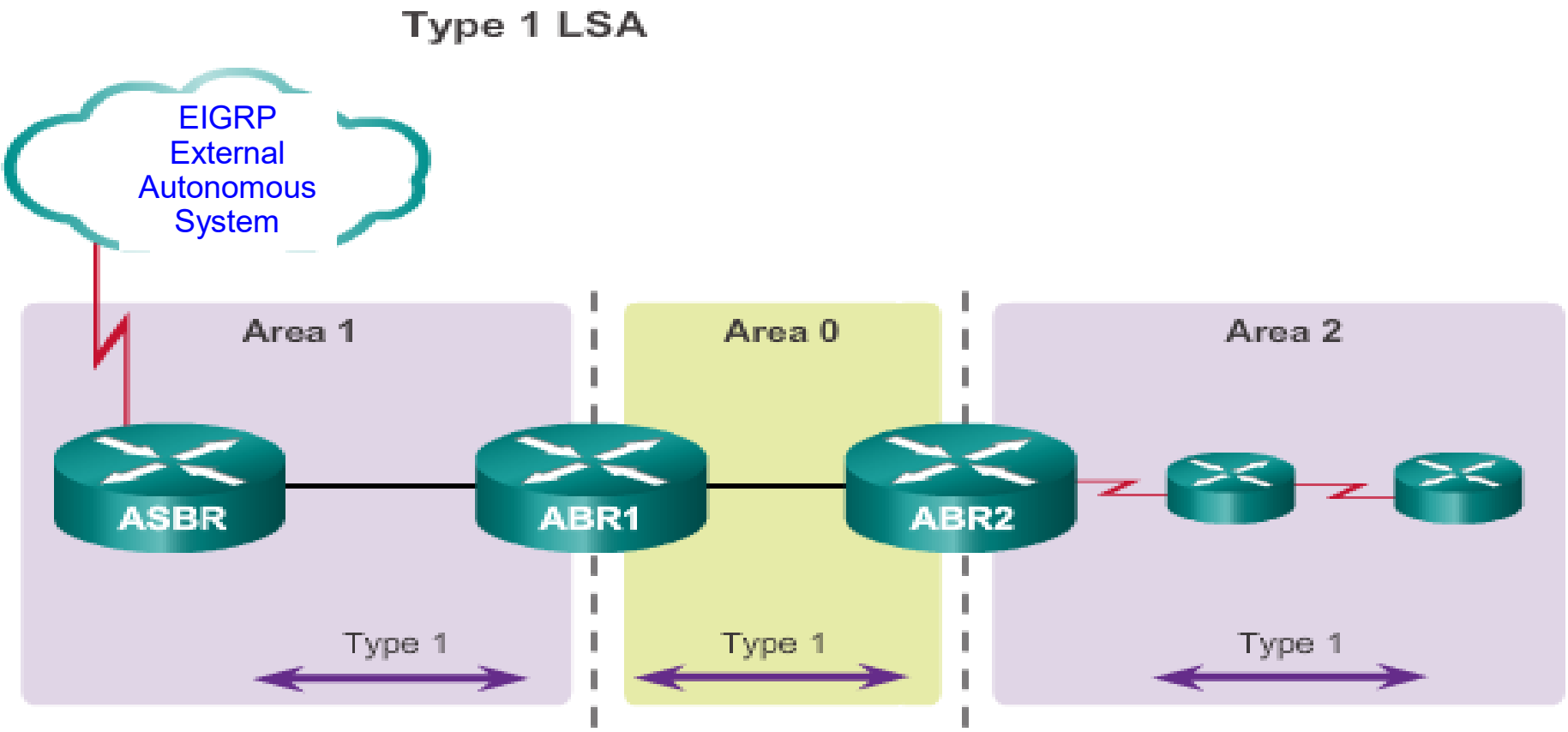
- Every router generates Type 1 LSAs for each area to which it belongs

- Describes the states of the router's links to the other routers in the area and are flooded only **within** a particular area

Type 1 - Router LSA



Type 1 - Router LSA



- 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.

OSPF – Router ID

- To use OSPF a Router must have a Router ID to identify the router within the OSPF network;
  it uses an IP address as its ID
- Routers have multiple IP addresses, which one should be used?
- **Router ID** is derived based on **3 criteria** in order of precedence:
  1. Configured using OSPF ***router-id*** command
  2. If router-id command not used, router chooses **highest** IP address of any **loopback** interfaces.
  3. If no loopback interfaces are configured, the **highest** IP address on any **active** interface is used

Type 2 - Network LSA – Multi Access Networks

- DRs (Designated routers) generate Type 2 network LSAs for multi-access networks
- Describe the set of routers attached to a particular multi-access network
- Are not forwarded outside of an area

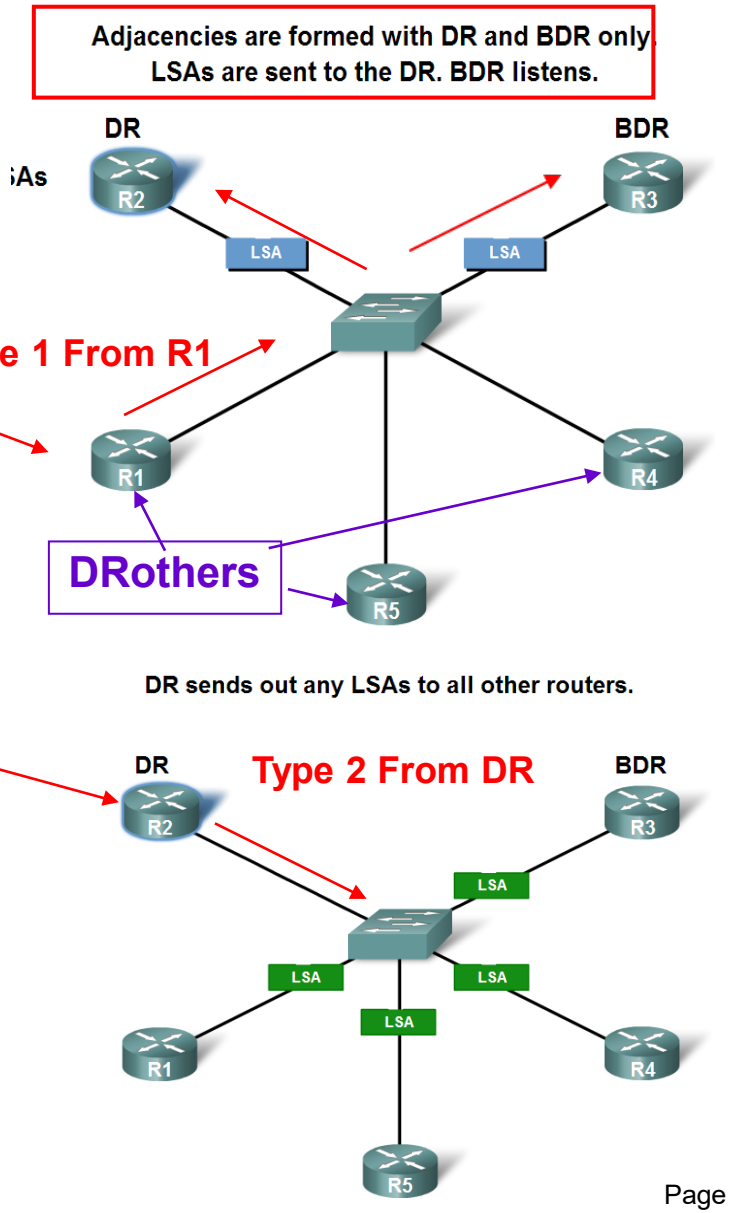
Type 2 - Network LSA – Multi Access Networks

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

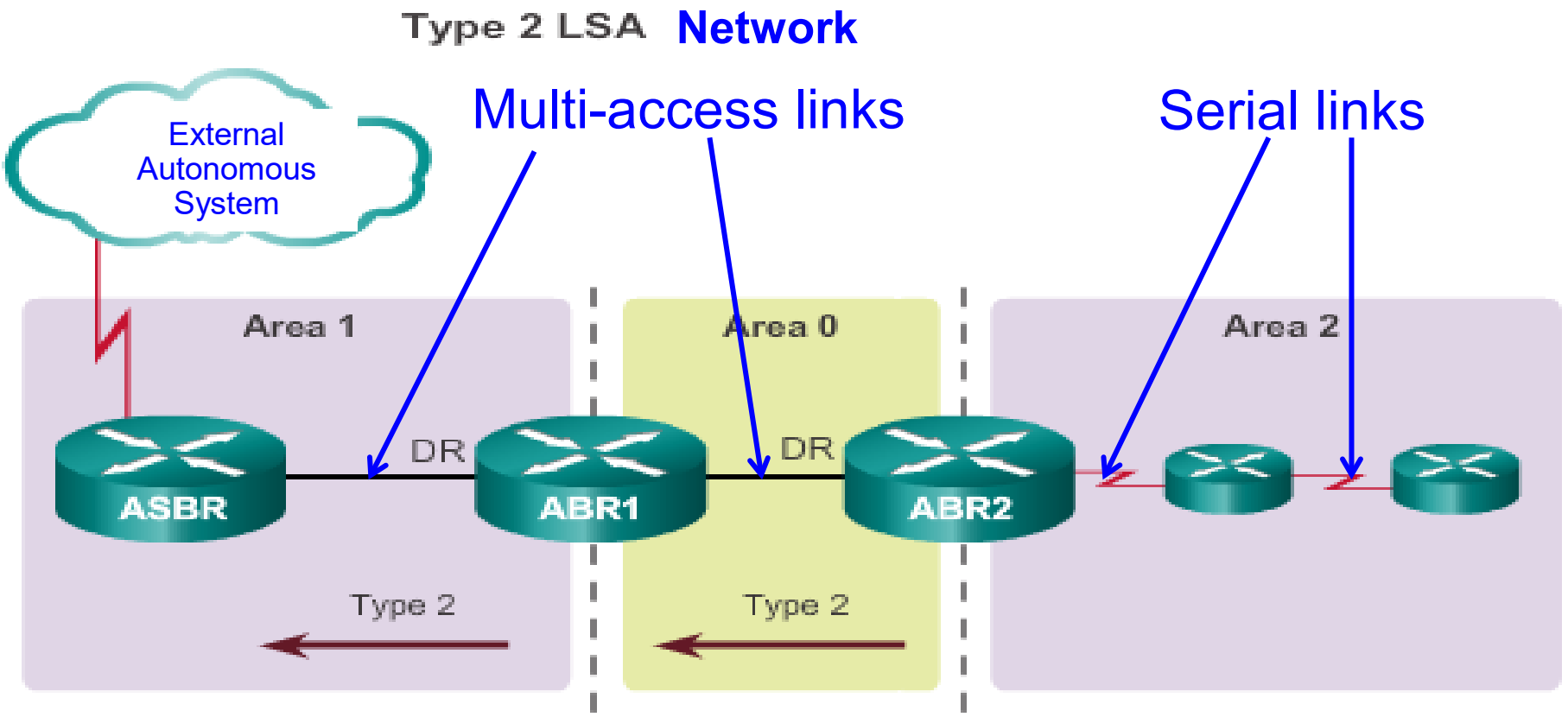
Sending and Receiving LSAs

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

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



Operation 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.

How do we Learn about networks in other Areas?

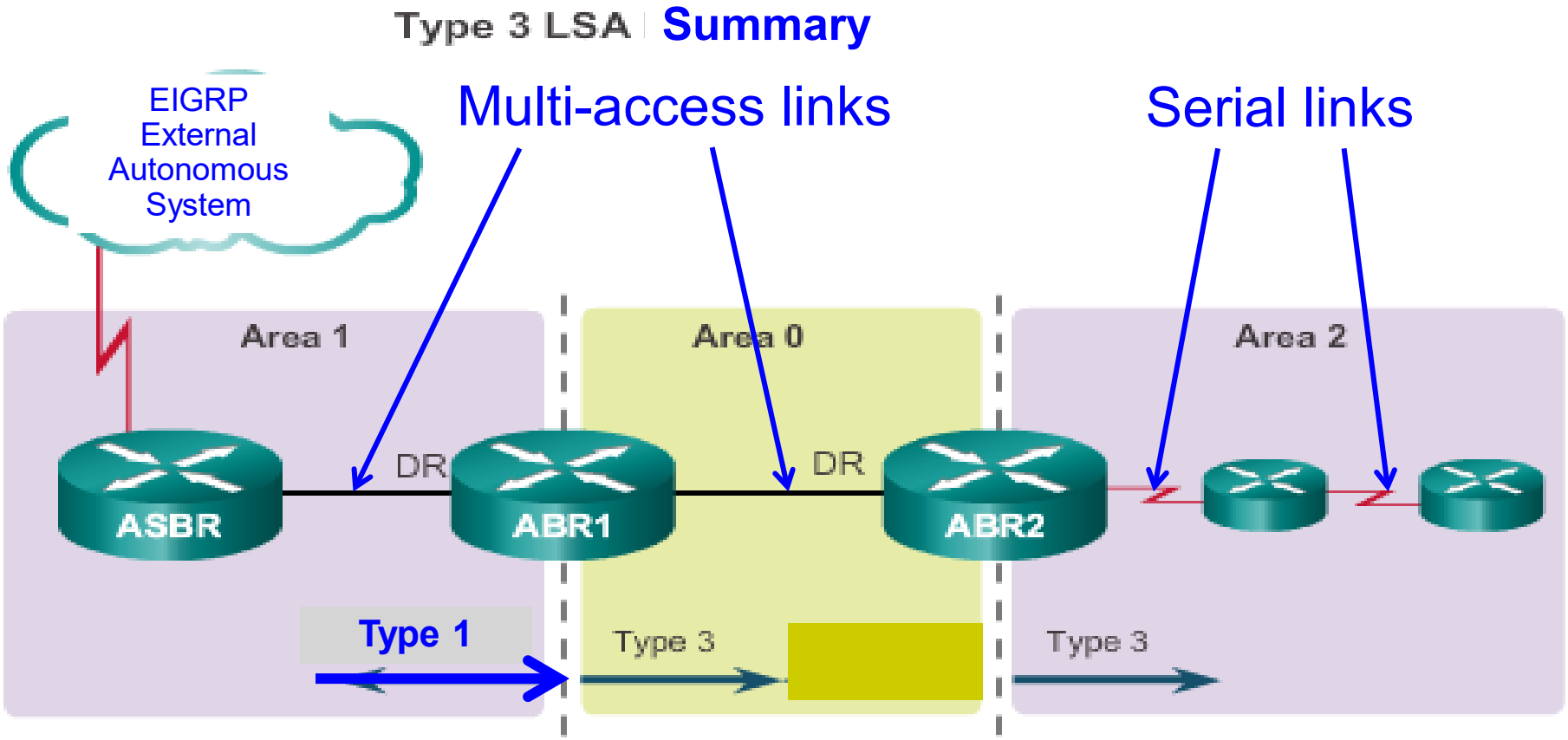
- Type 3 Summary LSA
- Type 4 Summary LSA
- ABRs are the only point where address summarization can be configured, to summarize the routing information from the LSDBs of there attached areas
- Do not cause a router to run SPF algorithm

Type 3 - Summary LSA

- Describe interarea routes

- Describe routes to an area's networks, may include summary routes, are created and generated by ABR.

OSPF LSA Type 3



- A type 3 LSA describes a network address learned by type 1 LSAs.
- A type 3 LSA is required for every subnet.
- ABRs flood type 3 LSAs to other areas and are regenerated by other ABRs.
- A type 3 LSA link-state ID is identified by the network address.

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

- 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

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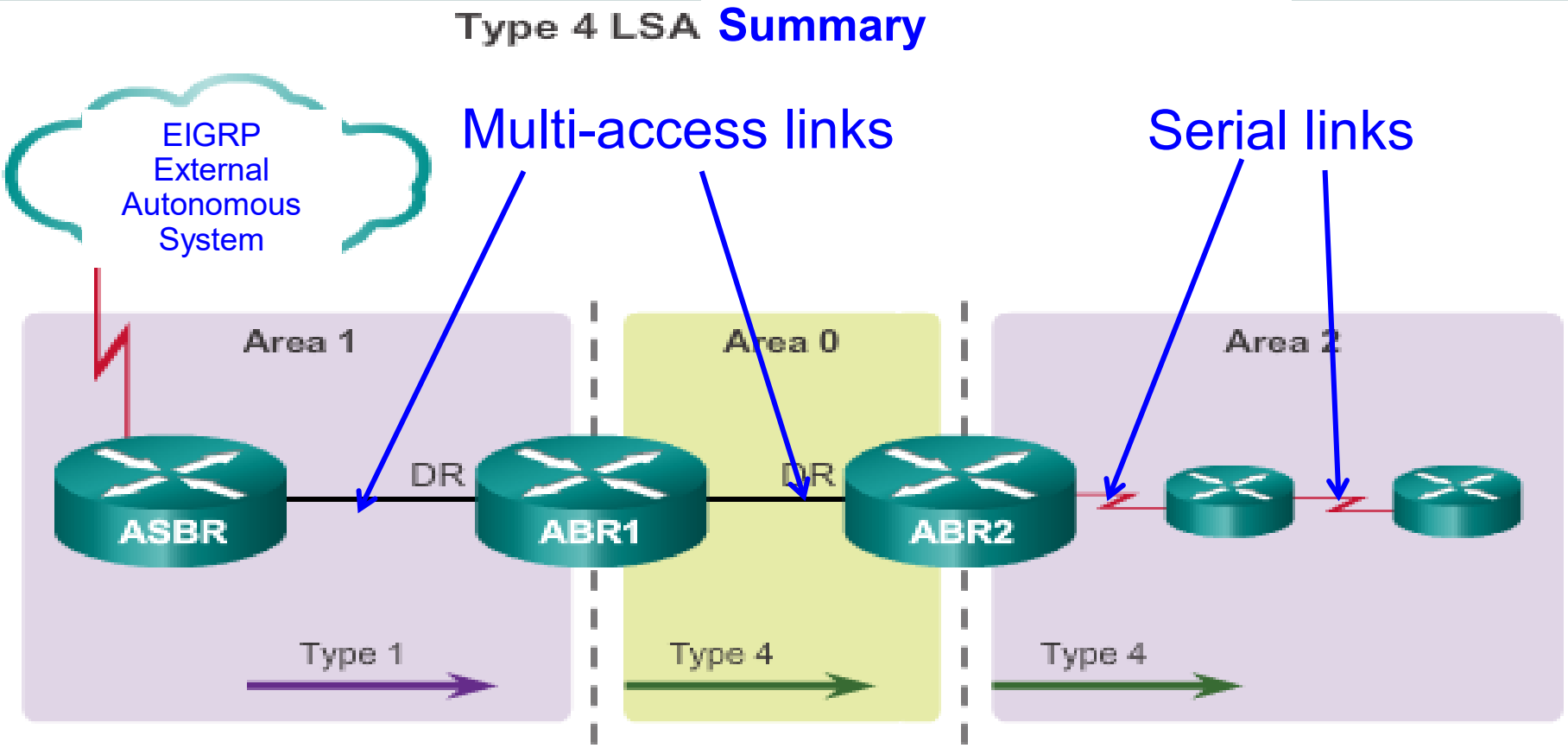
Multiarea OSPF LSA Operation OSPF LSA Type 4



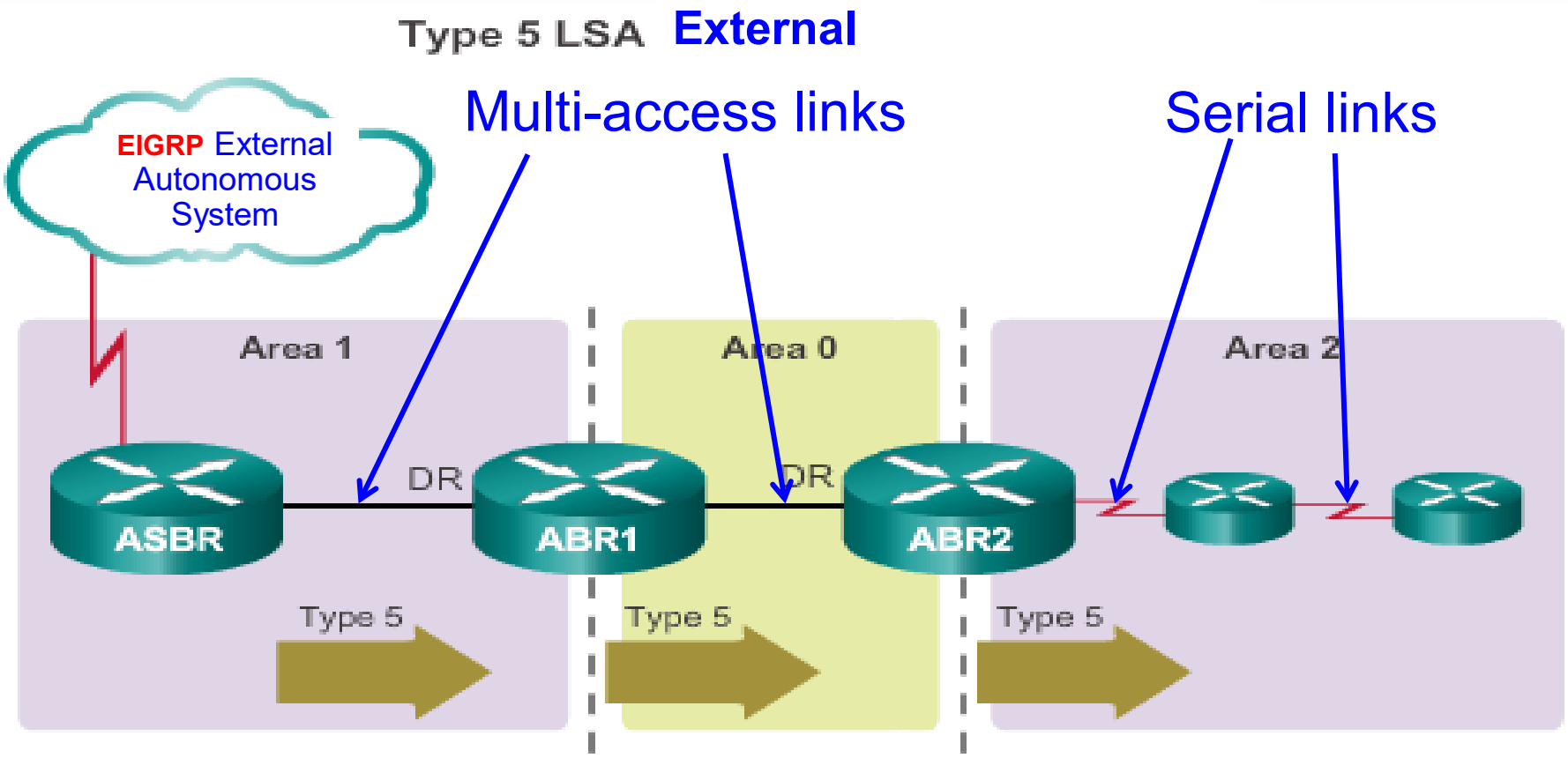
- Type 4 LSAs are used to advertise an ASBR to other areas and provide a route to the ASBR. Learned from Type 1
- ABRs generate type 4 LSAs.
- A type 4 LSA is generated by the originating ABR and regenerated by other ABRs.
- A type 4 LSA link-state ID is identified by the router ID of the ASBR.

Type 5 - Autonomous System External LSA

- 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



- 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 – Steps to Convergence

1. 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

2. 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

3. 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

OSPF – 3 Steps to Convergence – Routing Table

Steps to OSPF Convergence

```
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#
```

3

1

2

1

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

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#
```

[OSPF Multi Area Explained - YouTube]

The END