

Multi-Area OSPF

Fundamentals of Multi-area OSPF

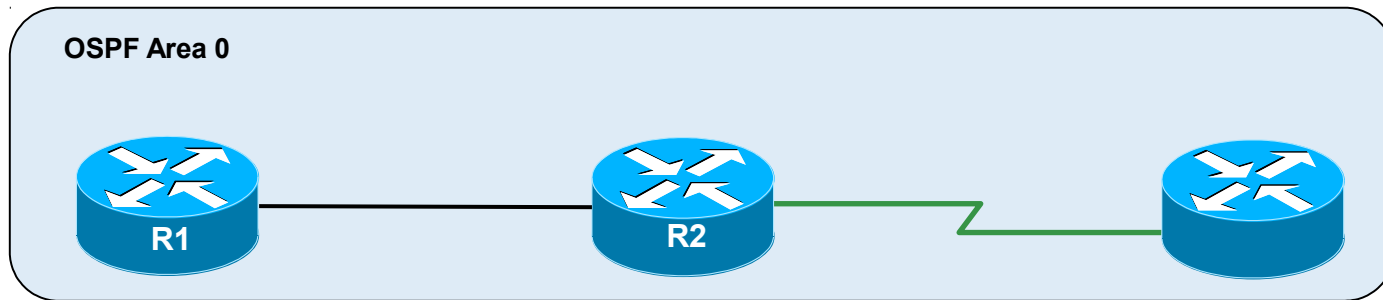
Adapted from a slide deck courtesy of Bob Vachon

OSPF is Hierarchical = Areas

- To make OSPF more efficient and scalable, OSPF supports hierarchical routing using **areas**.
- **OSPF area**: Group of routers that share the same link-state information in their LSDBs.
 - Reduces routing table entries.
 - Localizes impact of a topology change within an area.
 - Reduces traffic as detailed LSA flooding stops at the area boundary.
 - Requires a hierarchical network design.
- OSPF supports:
 - **Single-area OSPF**
 - **Multiarea OSPF**

Single-Area OSPF

- In single-area OSPF, all routers are in area 0.
 - Area 0 is also called the *backbone* area.
- Single-area OSPF is useful in smaller networks with few routers.
 - However, too many routers in one area would make the LSDBs very large and increase the load on the CPU.



Multi-Area OSPF

NOTE: Cisco recommends

- An area should have no more than 50 routers.
- A router should not be in more than 3 areas.

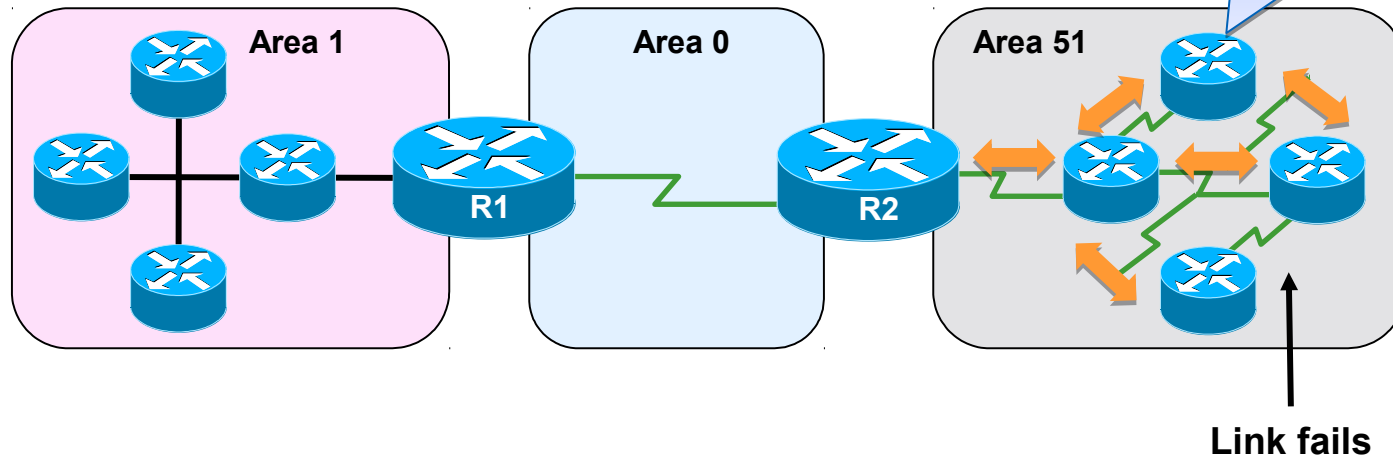
- Multiarea OSPF uses a two-layer area hierarchy.
 - Useful in larger network deployments to reduce processing and memory overhead.
 - All areas must connect via the backbone area (area 0).
 - Interconnecting routers are called *Area Border Routers (ABR)*.

Areas reduce the size of routing tables.

- Fewer routing table entries because network addresses can be summarized between areas.

Reduces the frequency of SPF calculations.

- Localizes the impact of a topology change within an area.
- For instance, it minimizes routing update impact because LSA flooding stops at the area boundary.

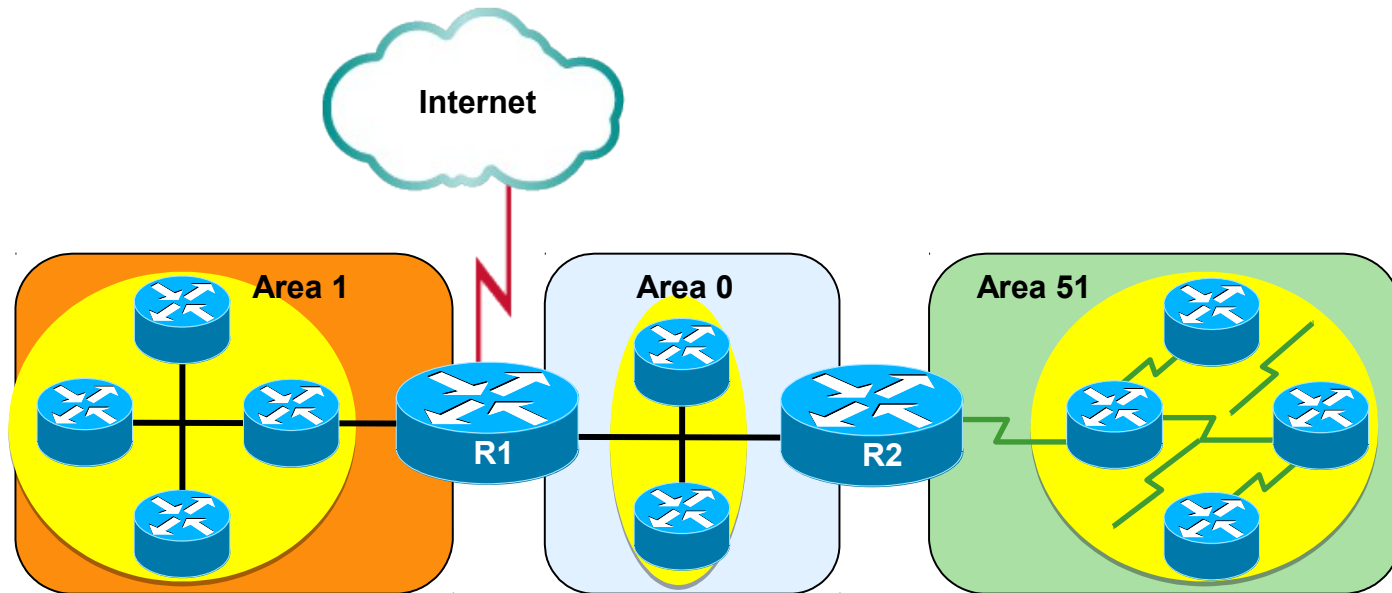


OSPF Router Types

Type of OSPF Router	Description
Internal router	<ul style="list-style-type: none">• Internal routers that have all their interfaces within the same area.• Internal routers in the same area have identical LSDBs.
Backbone router	<ul style="list-style-type: none">• All areas must be connected to Area 0 (or Area 0.0.0.0).• Area 0 is the backbone area.
Area Border Router (ABR)	<ul style="list-style-type: none">• ABR routers have interfaces attached to multiple areas and are responsible for:• Joining areas together.• Maintaining separate link-state databases for each area.• Routing traffic destined to/arriving from other areas.• Summarizing the area networks and flooding the information to Area 0.• An area can have one or more ABR.
Autonomous System Boundary Router (ASBR)	<ul style="list-style-type: none">• ASBRs have an interface connected to a non-OSPF (i.e., RIP or EIGRP) network.• Non-OSPF network information can be redistributed into the OSPF network.• Should reside in the backbone area.

Internal Routers

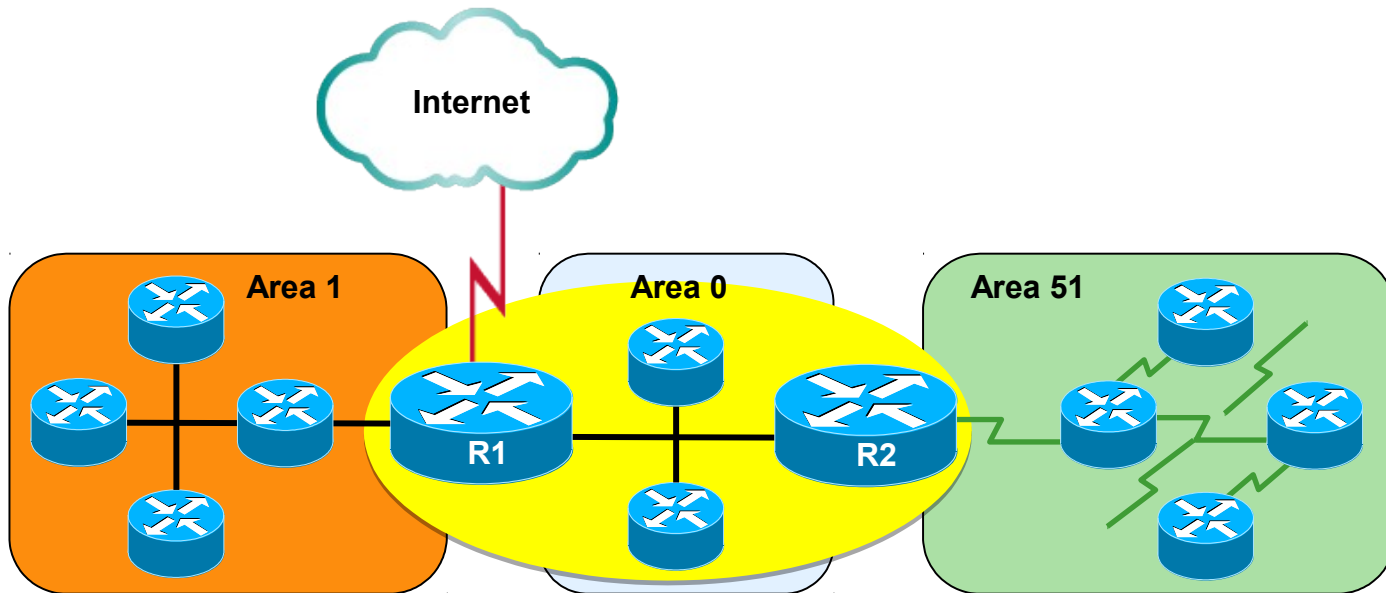
- These are routers with all of their interfaces in the same area.



- Internal routers in an area all have identical LSDBs.

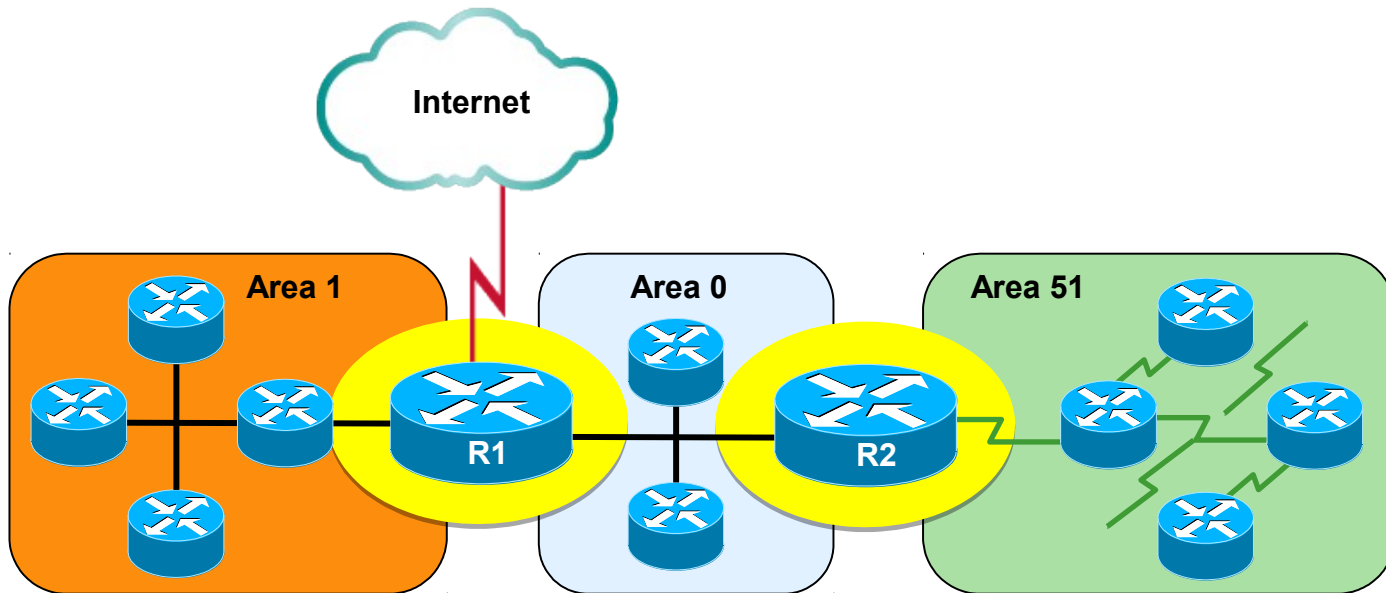
Backbone Routers

- These are routers with an interface(s) in the backbone area.



Area Border Router (ABR)

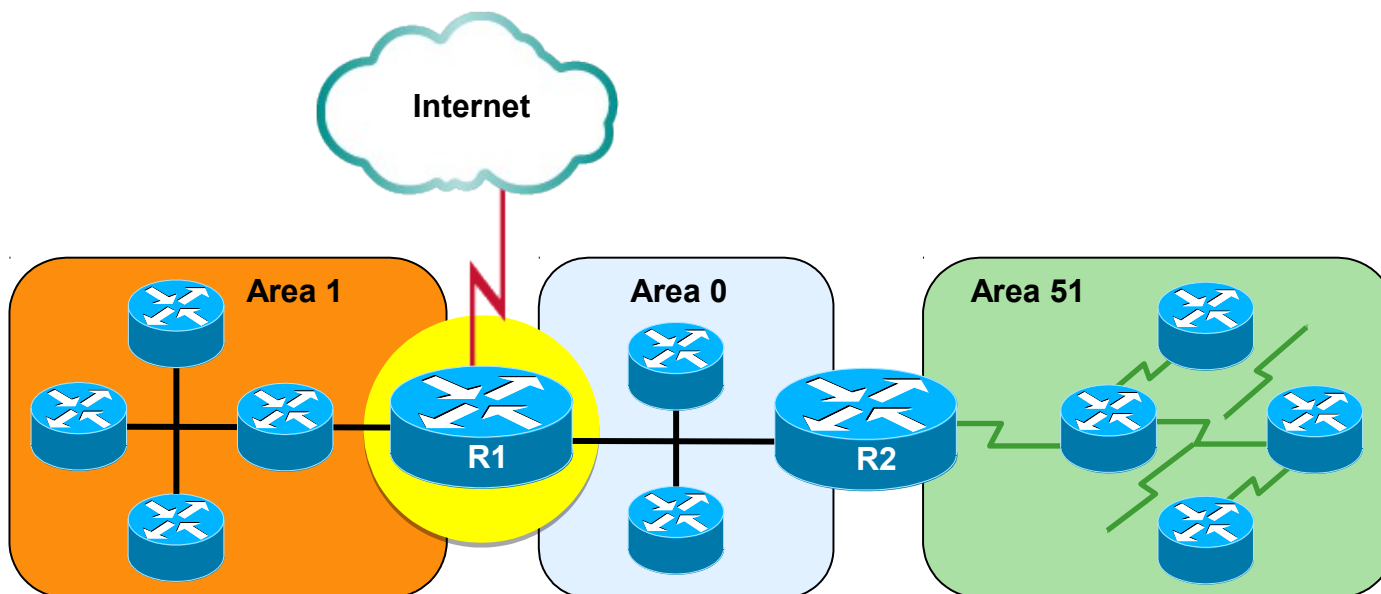
- A router has interfaces attached to multiple areas.



- ABRs:
 - Maintain separate LSDBs for each area it is connected to.
 - Are exit points for the area.
 - Distribute the routing information into the backbone and the backbone routers then forward the information to the other ABRs.

Autonomous System Boundary Router (ASBR)

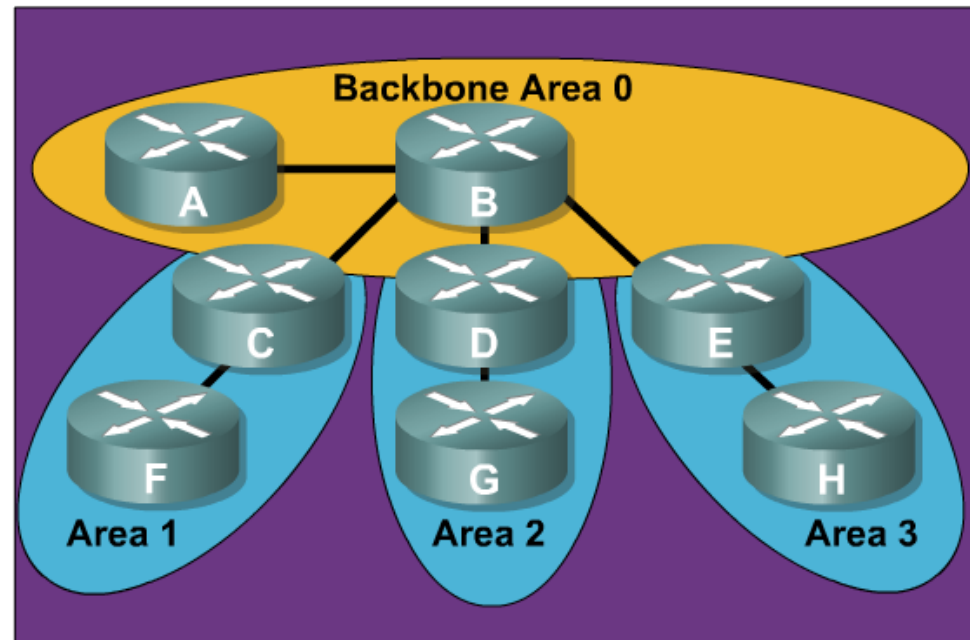
- This is a router that has at least one interface attached to an external non-OSPF network.



- An ASBR can redistribute non-OSPF network information into and out of the OSPF network.

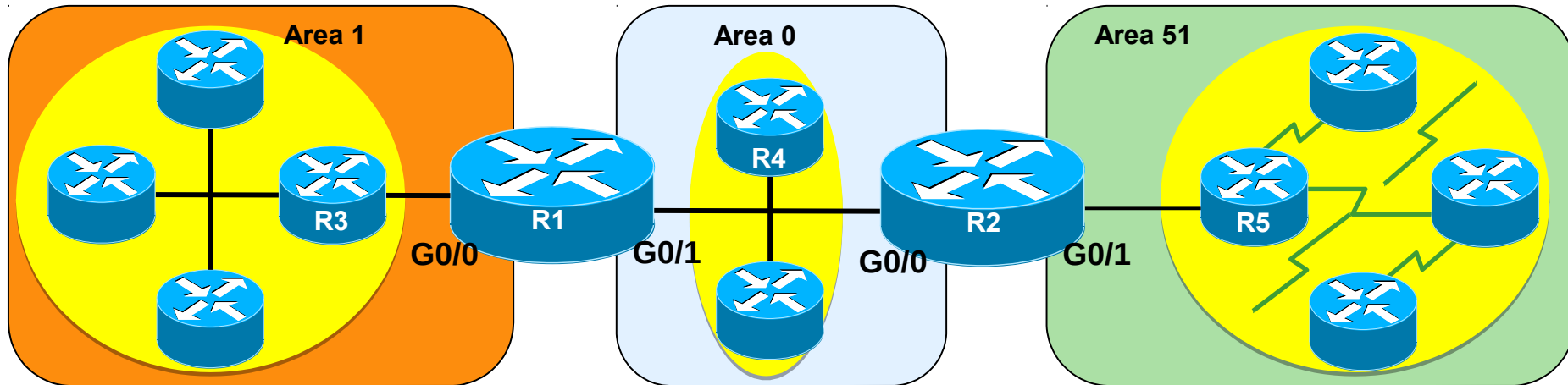
Name that OSPF Router!

- Routers **A, B, C, D** and **E** are:
 - *Backbone routers* and make up Area 0.
- Routers **C, D** and **E** are:
 - *Area border routers (ABRs)* because they attach other areas to Area 0.
- Routers **A, B, F, G**, and **H** are:
 - *Internal routers* because they are completely within an area and do not interconnect to any other area or autonomous system (AS).



Basics of Configuring Multi-Area OSPF

- Simply use different area numbers when activating/including an interface in OSPF



R1

```
router ospf 10
  exit
interface G0/0
  ip ospf 10 area 1
  exit
interface G0/1
  ip ospf 10 area 0
  exit
```

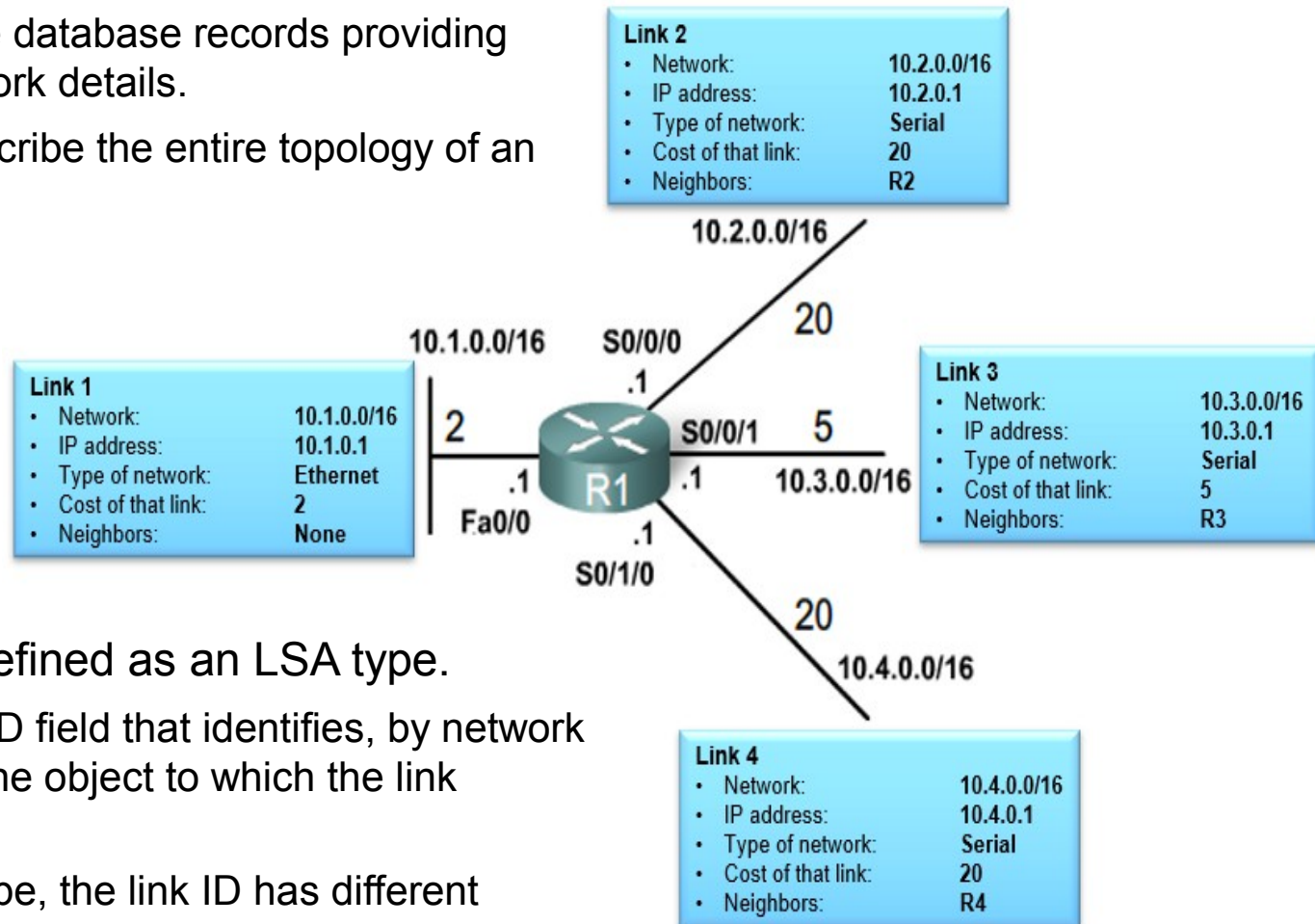
R2

```
router ospf 10
  exit
interface G0/0
  ip ospf 10 area 0
  exit
interface G0/1
  ip ospf 10 area 51
  exit
```

- What would the config look like for R3, R4, R5?
- The line between areas cuts through which network element?

Link-State Advertisements (LSAs)

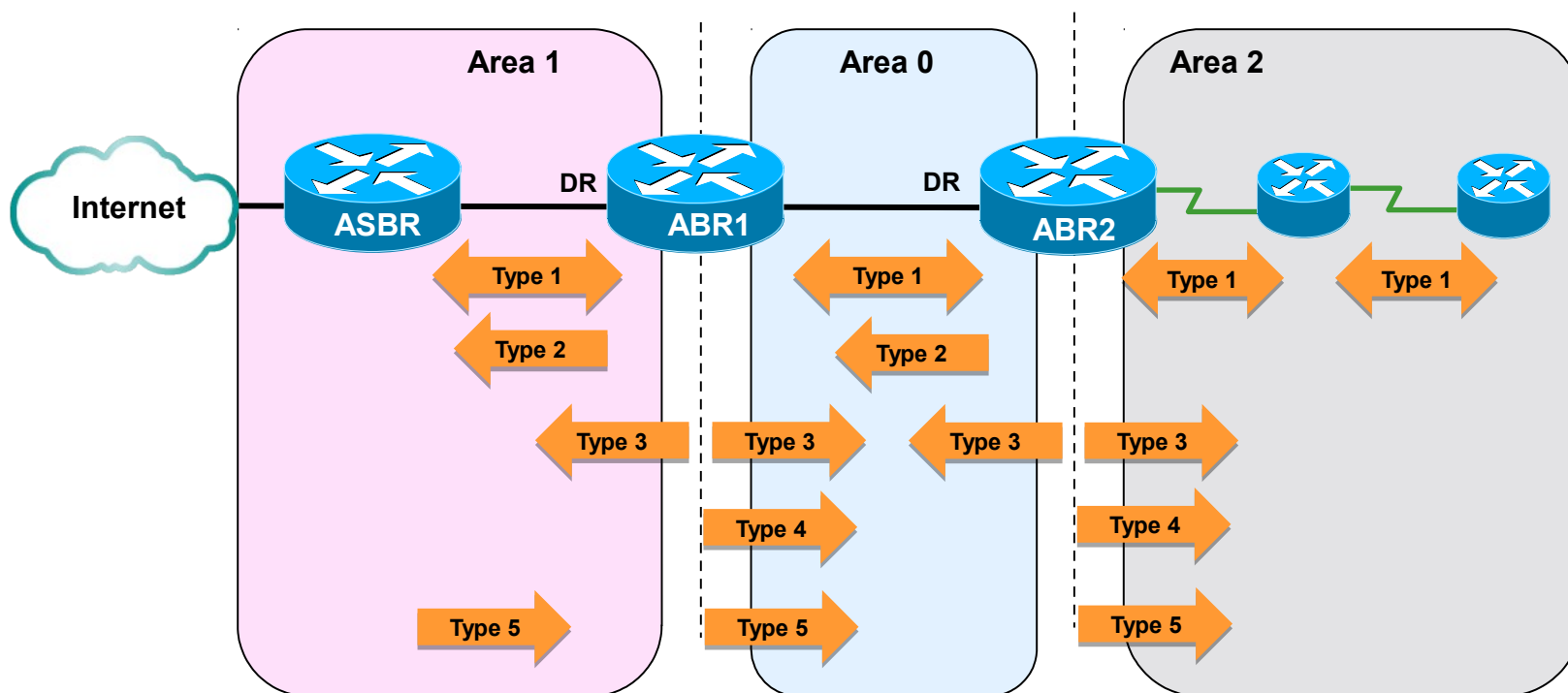
- LSAs are the building blocks of the OSPF LSDB.
 - Individually, they are database records providing specific OSPF network details.
 - Combined, they describe the entire topology of an OSPF area.



- Each router link is defined as an LSA type.
 - LSAs include a link ID field that identifies, by network number and mask, the object to which the link connects.
 - Depending on the type, the link ID has different meanings.

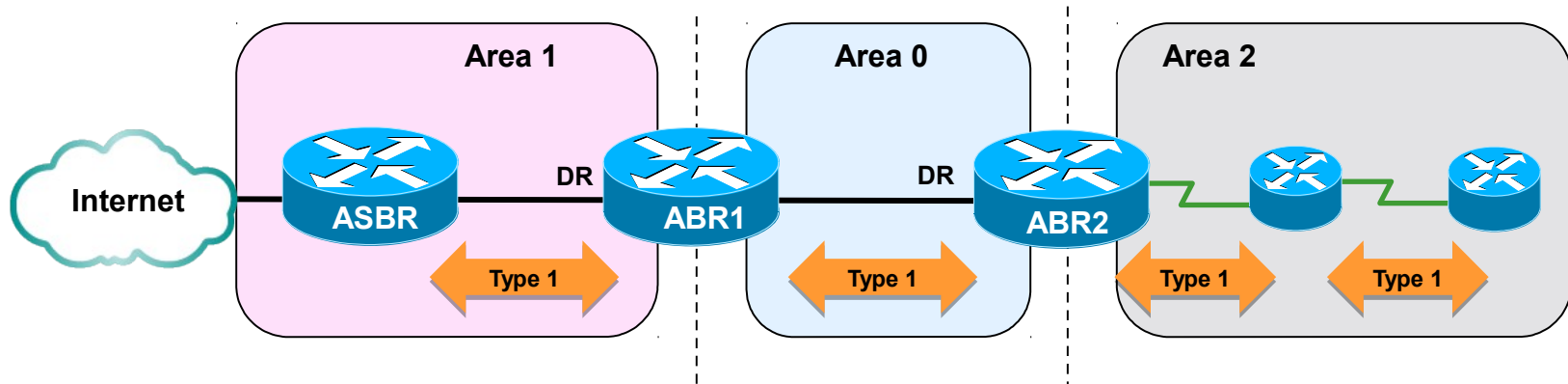
LSA Type Propagation

- LSAs differ on how they are generated and propagated within the routing domain.



Type 1 LSA Message Propagation

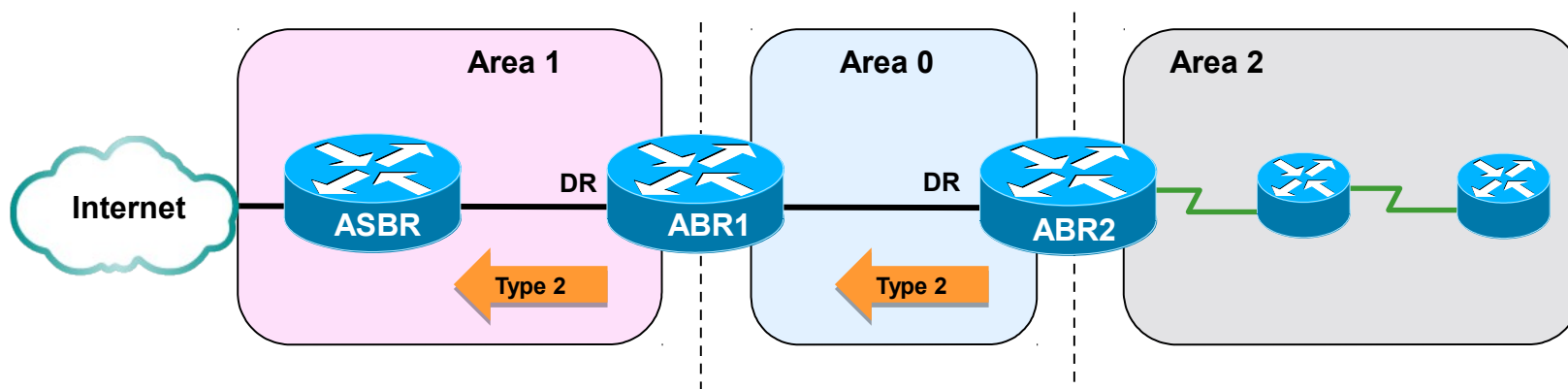
- All routers generate type 1 LSAs.
 - LSAs are flooded within the area and do not propagate beyond an ABR.



- Type 1 LSAs include a list of directly attached network prefixes (links) and link type.
- Routing Table Entry = **O**
- LSA link-state ID: the router ID of the originating router (RID).

Type 2 LSA Message Propagation

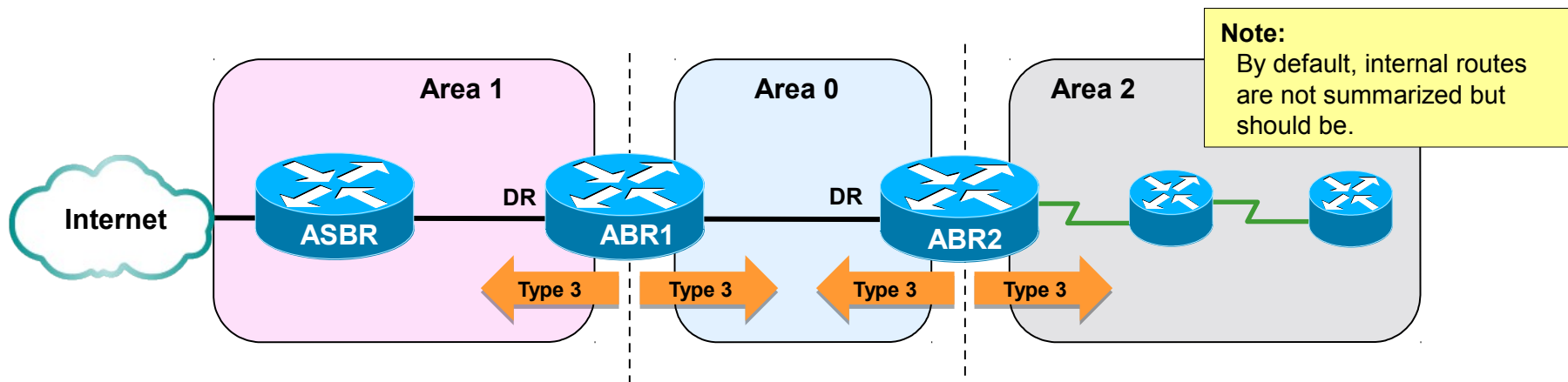
- Only a DR generates a type 2 LSA.
 - LSA is flooded within the multiaccess network and does not go beyond an ABR.



- LSA identifies the routers and the network address of the multiaccess link.
- Routing Table Entry = **O**
- LSA link-state ID: DR router ID.

Type 3 LSA Message Propagation

- ABRs flood type 3 LSAs to other areas and are regenerated by other ABRs to flood throughout the AS.



- LSA describes a network address learned by type 1 LSAs.
 - An LSA is required for every subnet.

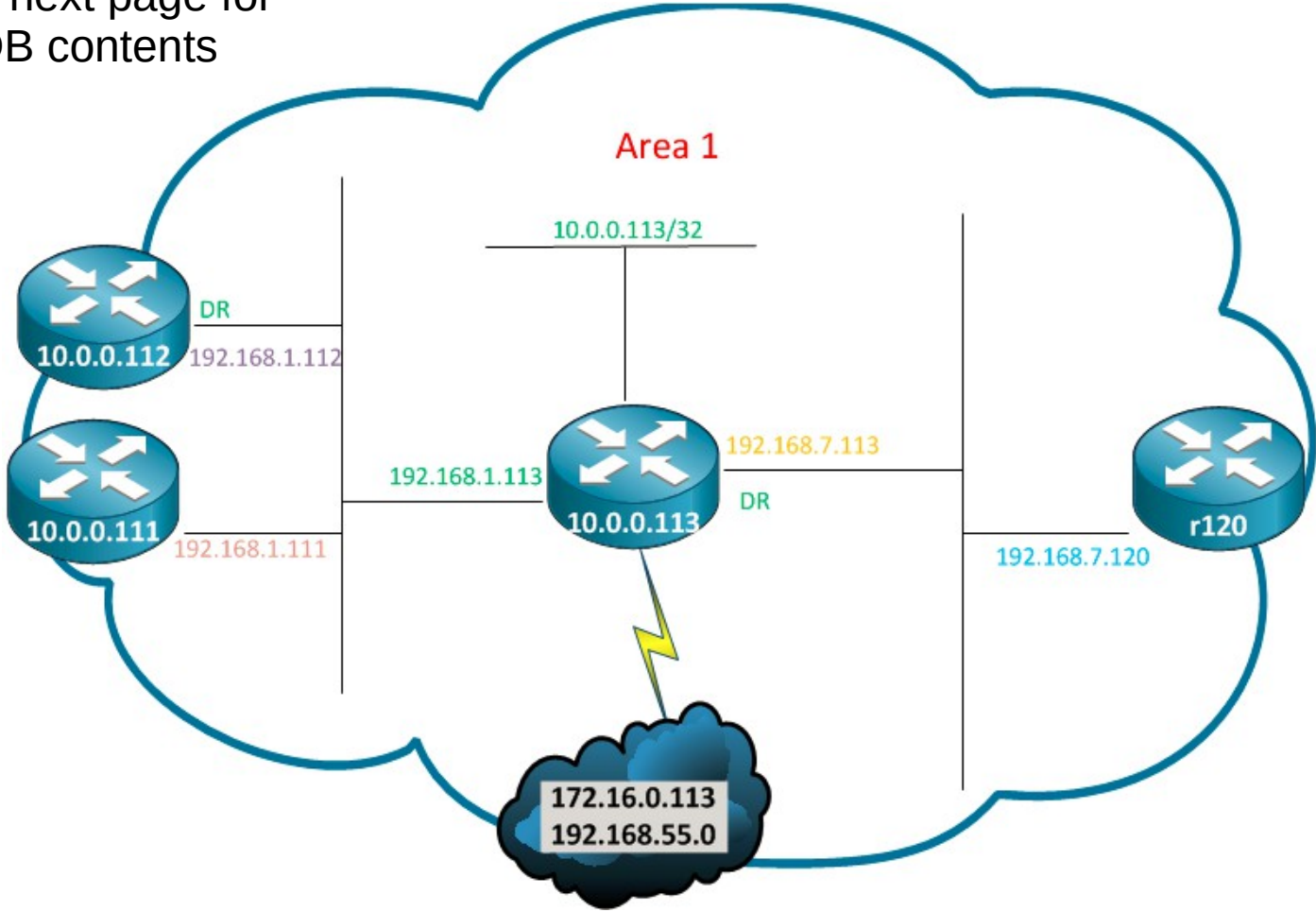
- Routing Table Entry = **O IA**

If the Routing Table contains routes marked "O IA" it's proof that OSPF is configured as multi-area

- Link-state ID: **Network address or subnet advertised in the summary LSA**

Full Topology Diagram for LSDB

See next page for LSDB contents



from: <https://community.cisco.com/t5/networking-knowledge-base/reading-and-understanding-the-ospf-database/ta-p/3145995>

How LSA Types Appear in the LSDB

R120#show ip ospf database

OSPF Router with ID (10.0.0.120) (Process ID 1)

Type 1=Routers

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
10.0.0.111	10.0.0.111	600	0x8000023A	0x0092B3	1
10.0.0.112	10.0.0.112	1246	0x80000234	0x009CAC	1
10.0.0.113	10.0.0.113	148	0x8000022C	0x004399	3
10.0.0.120	10.0.0.120	152	0x80000240	0x0046CB	1

Type 2=Bcast links

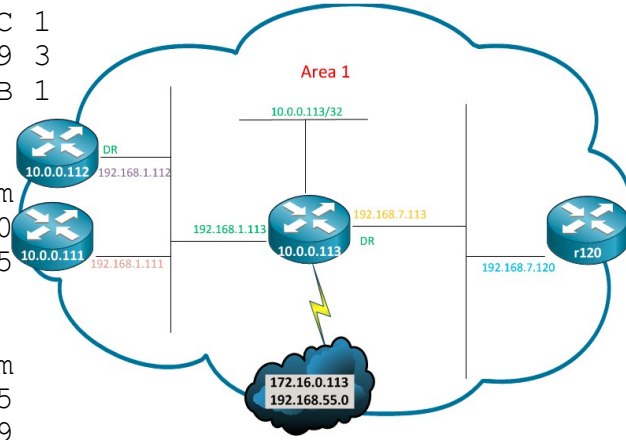
Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.112	10.0.0.112	1862	0x80000237	0x00D860
192.168.7.113	10.0.0.113	12	0x80000001	0x00E8F5

Type 3=Inter-area

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
10.0.0.119	10.0.0.111	1215	0x8000022A	0x00A845
10.0.0.119	10.0.0.112	1862	0x80000229	0x00A449
192.168.0.0	10.0.0.111	1215	0x80000234	0x00D842
192.168.0.0	10.0.0.112	1862	0x80000233	0x00D446
192.168.2.0	10.0.0.111	1215	0x80000234	0x0027E7
192.168.2.0	10.0.0.112	1862	0x80000233	0x0023EB
192.168.3.0	10.0.0.111	1215	0x80000232	0x008481
192.168.3.0	10.0.0.112	1862	0x80000232	0x007E86
192.168.4.0	10.0.0.111	1215	0x80000232	0x00798B
192.168.4.0	10.0.0.112	1862	0x80000232	0x007390
192.168.5.0	10.0.0.111	1215	0x80000232	0x006E95
192.168.5.0	10.0.0.112	1862	0x80000232	0x00689A
192.168.6.0	10.0.0.111	1215	0x80000231	0x00C930
192.168.6.0	10.0.0.112	1862	0x80000231	0x00C335



If the LSDB contains "Summary Net Link States" it's proof that OSPF is configured as multi-area

Route Designator in Routing Table

```
R1# show ip route
<output omitted>
Gateway of last resort is not set
172.31.0.0/24 is subnetted, 2 subnets
O IA 172.31.2.0 [110/1563] via 10.1.1.1, 00:12:35, FastEthernet0/0
O IA 172.31.1.0 [110/782] via 10.1.1.1, 00:12:35, FastEthernet0/0
10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C 10.200.200.13/32 is directly connected, Loopback0
C 10.1.3.0/24 is directly connected, Serial0/0/0
O 10.1.2.0/24 [110/782] via 10.1.3.4, 00:12:35, Serial0/0/0
C 10.1.1.0/24 is directly connected, FastEthernet0/0
O 10.1.0.0/24 [110/782] via 10.1.1.1, 00:12:37, FastEthernet0/0
```

Route Designator	Description	
O	OSPF intra-area (router LSA) and network LSA	<ul style="list-style-type: none">• Networks from within the router's area.• Advertised by way of router LSAs and network LSAs.
O IA	OSPF inter-area (summary LSA)	<ul style="list-style-type: none">• Networks from outside the router's area but within the OSPF AS.• Advertised by way of summary LSAs.

Reminder: "O IA" entries in the routing table prove OSPF is running across multiple areas.

OSPF Two-Layer Hierarchy - Review

- **Backbone Area**
 - Referred to as Area 0
 - Also known as the Transit Area.
- **Regular (Standard) Areas**
 - Also known as a nonbackbone areas.
 - All regular areas must connect to the backbone area.

