

OSPF

Multi-Area OSPF



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Module 3

Topics

- Areas
- LSAs
- show ip ospf database (summary of link state database)
- show ip route
- Stub Areas
- Totally Stubby Areas
- E1 and E2 routes
- Default Routes
- Route Summarization
- NSSA (Not So Stubby Areas)

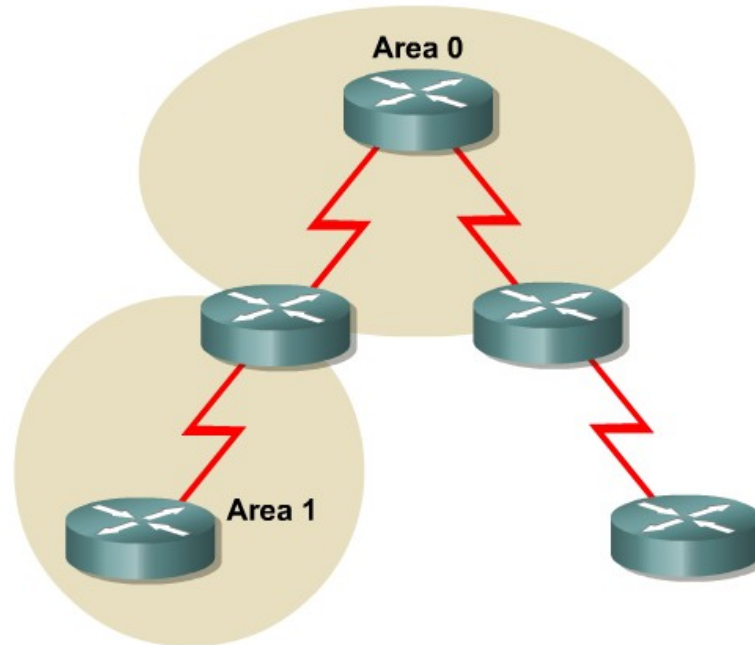
Issues with large OSPF nets

- **Large link-state table**
 - Each router maintains a LSDB for all links in the area
 - The LSDB requires the use of memory
- **Frequent SPF calculations**
 - A topology change in an area causes each router to re-run SPF to rebuild the SPF tree and the routing table.
 - A flapping link will affect an entire area.
 - SPF re-calculations are done only for changes within that area.
- **Large routing table**
 - Typically, the larger the area the larger the routing table.
 - A larger routing table requires more memory and takes more time to perform the route look-ups.

Solution: Divide the network into multiple areas

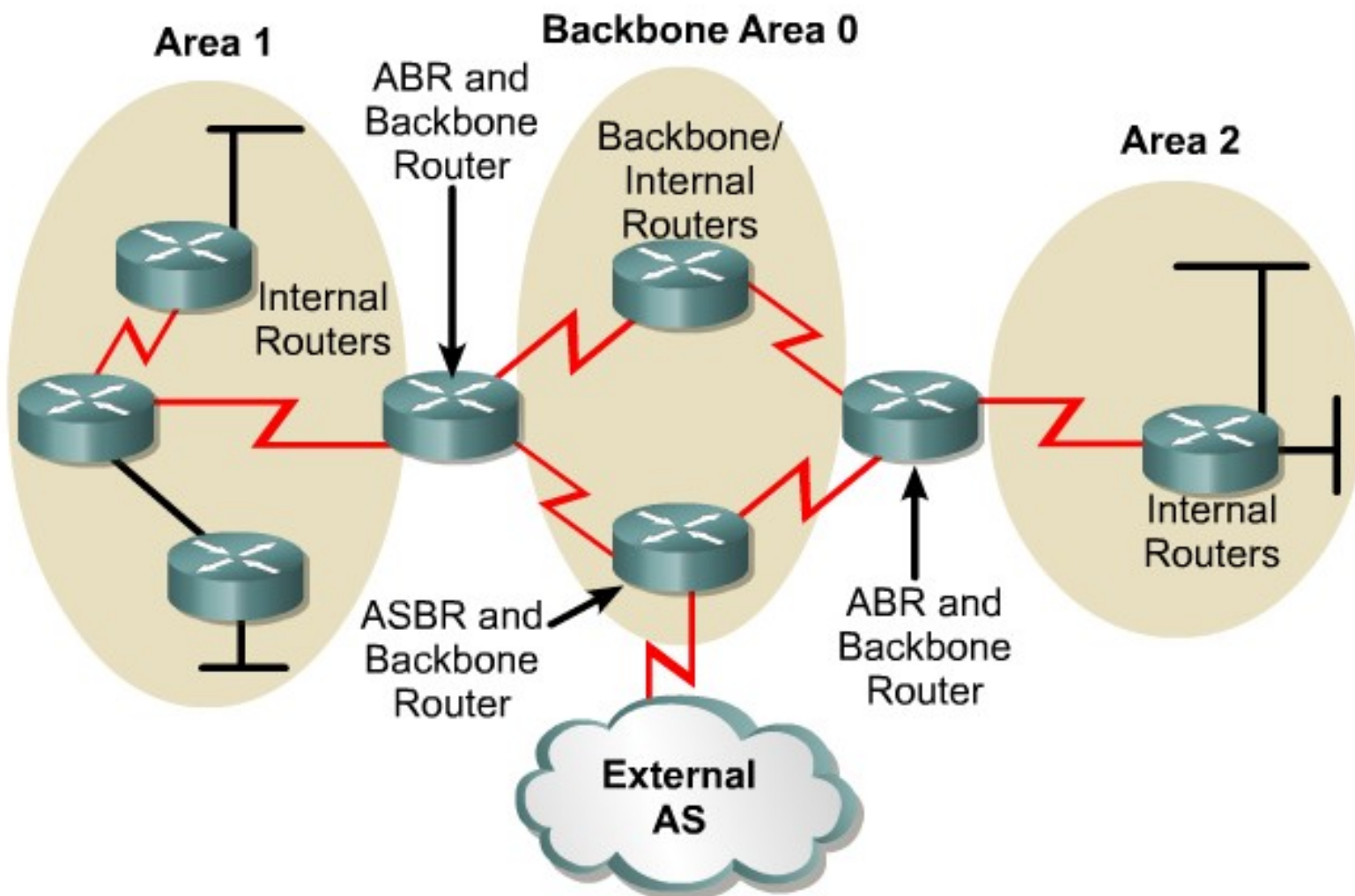
OSPF uses “Areas”

- Hierarchical routing enables you to separate large internetworks (autonomous systems) into smaller internetworks that are called **areas**.
- With this technique, routing still occurs between the areas (called **inter-area routing**), but many of the smaller internal routing operations, such as recalculating the database – re-running the SPF algorithm, are restricted within an area.



By dividing an OSPF domain into multiple areas, problems such as route flapping can be isolated.

OSPF Router Types



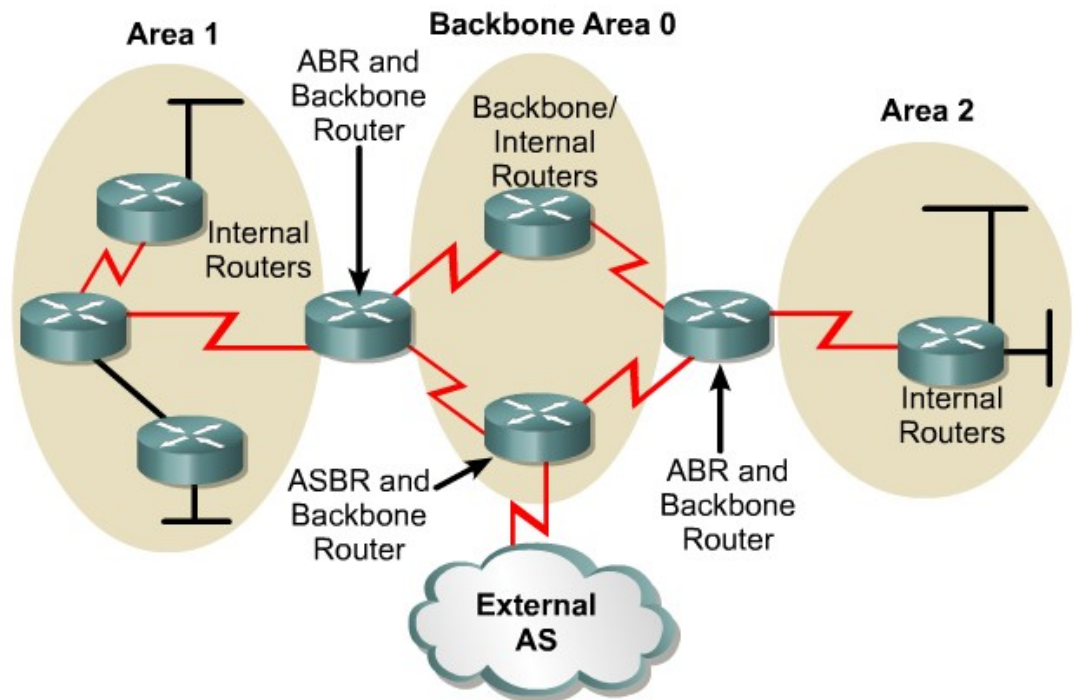
OSPF Router Types

Internal: Routers with all their interfaces within the same area

Backbone: Routers with at least one interface connected to area 0

ASBR: (Autonomous System Boundary Router): Routers that have at least one interface connected to an external internetwork (another autonomous system)

ABR: (Area Border Router): Routers with interfaces attached to multiple areas.



OSPF Type 4 - Link State Advertisements

- Now we will look at OSPF Type 4 packets more closely

OSPF packet types

Type	Description
1	Hello (establishes and maintains adjacency relationships with neighbors)
2	Database description packet (describes the contents of an OSPF router's link-state database)
3	Link-state request (requests specific pieces of a neighbor router's link-state database)
4	Link-state update (transports link-state advertisements (LSAs) to neighbor routers)
5	Link-state acknowledgement (Neighbor routers acknowledge receipt of the LSAs)

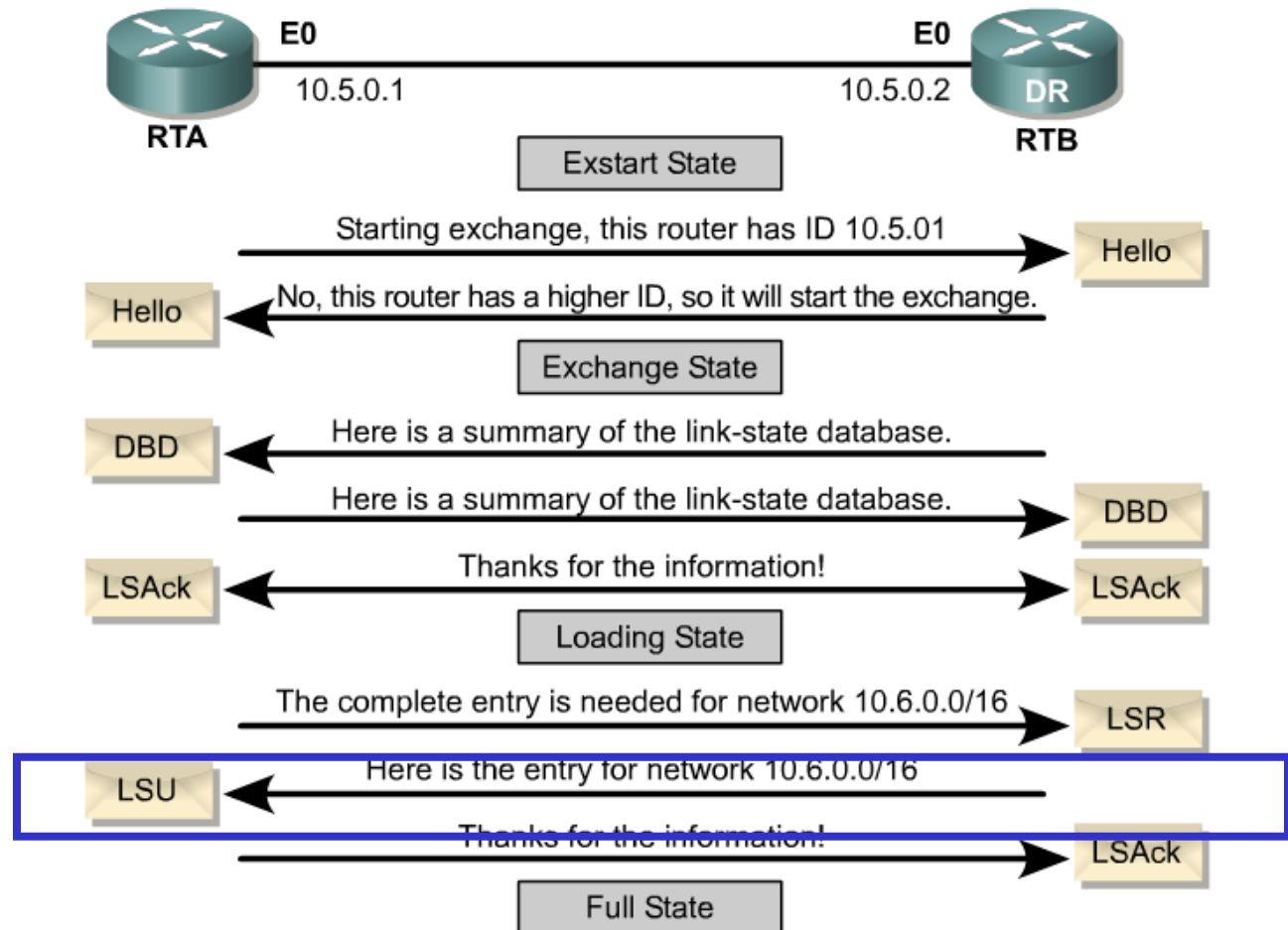
OSPF packet types

OSPF Type-4 packets have 7 LSA packets (later)

Type	Description	LSA Type	Name	Description
1	Hello (establishes and maintains adjacency relationships with neighbors)			
2	Database description packet (router's link-state database)			
3	Link-state request (requests link-state database)			
4	Link-state update (transport neighbor routers)	1	Router link entry (record) (O-OSPF)	Generated by each router for each area it belongs to. It describes the states of the router's link to the area. These are only flooded within a particular area. The link status and cost are two of the descriptors provided.
	Link-state acknowledgement receipt of the LSAs)	2	Network link entry (O-OSPF)	Generated by Designated Router in multiaccess networks. They describe the set of routers attached to a particular network. LSA Type 2 messages are flooded only within the area that contains the network.
		3 or 4	Summary link entry (IA-OSPF Inter area)	Originated by ABRs. They describes the links between the ABR and the internal routers of a local area. These entries are flooded throughout the backbone area to the other ABRs. Type-3 messages describe routes to networks within the local area and are sent to the backbone area. Type-4 messages describe reachability to ASBRs. These link entries are not flooded through totally stubby areas.
		5	Autonomous system external link entry (E1-OSPF external type-1)	Originated by the ASBR. Describes routes to destinations external to the autonomous system. Flooded throughout an OSPF autonomous system except for stub and totally stubby areas.

LSA Types

LSAs used for discovering routes and reaching Full State, along with Maintain Routes



LSA Types

LSA Types 1 through 5

- We will look at these in detail as we discuss areas in this module.

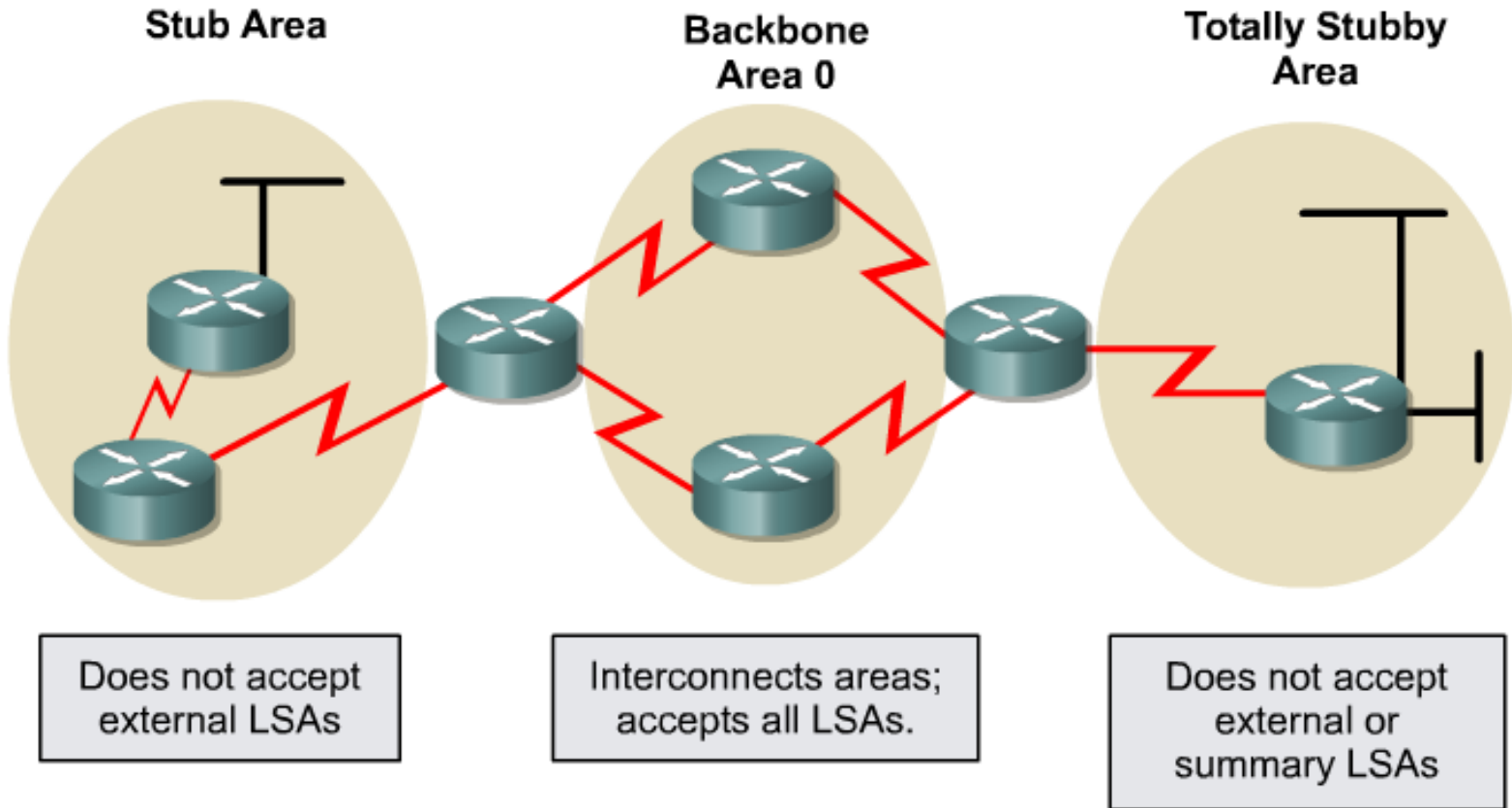
LSA Type 7 NSSA External Link Entry

- Originated by an ASBR connected to an NSSA.
- Type 7 messages can be flooded throughout NSSAs and translated into LSA Type 5 messages by ABRs.
- Routes learned via Type-7 LSAs are denoted by either a “N1” or and “N2” in the routing table. (Compare to E1 and E2).
- We will discuss this more later when we look at NSSA areas.

Area Types

- Standard or Normal Areas
 - Backbone
 - Non-Backbone
- Stub
 - Stub Area
 - Totally Stubby Area (TSA)
 - Not-so-stubby-area (NSSA)

Area Types

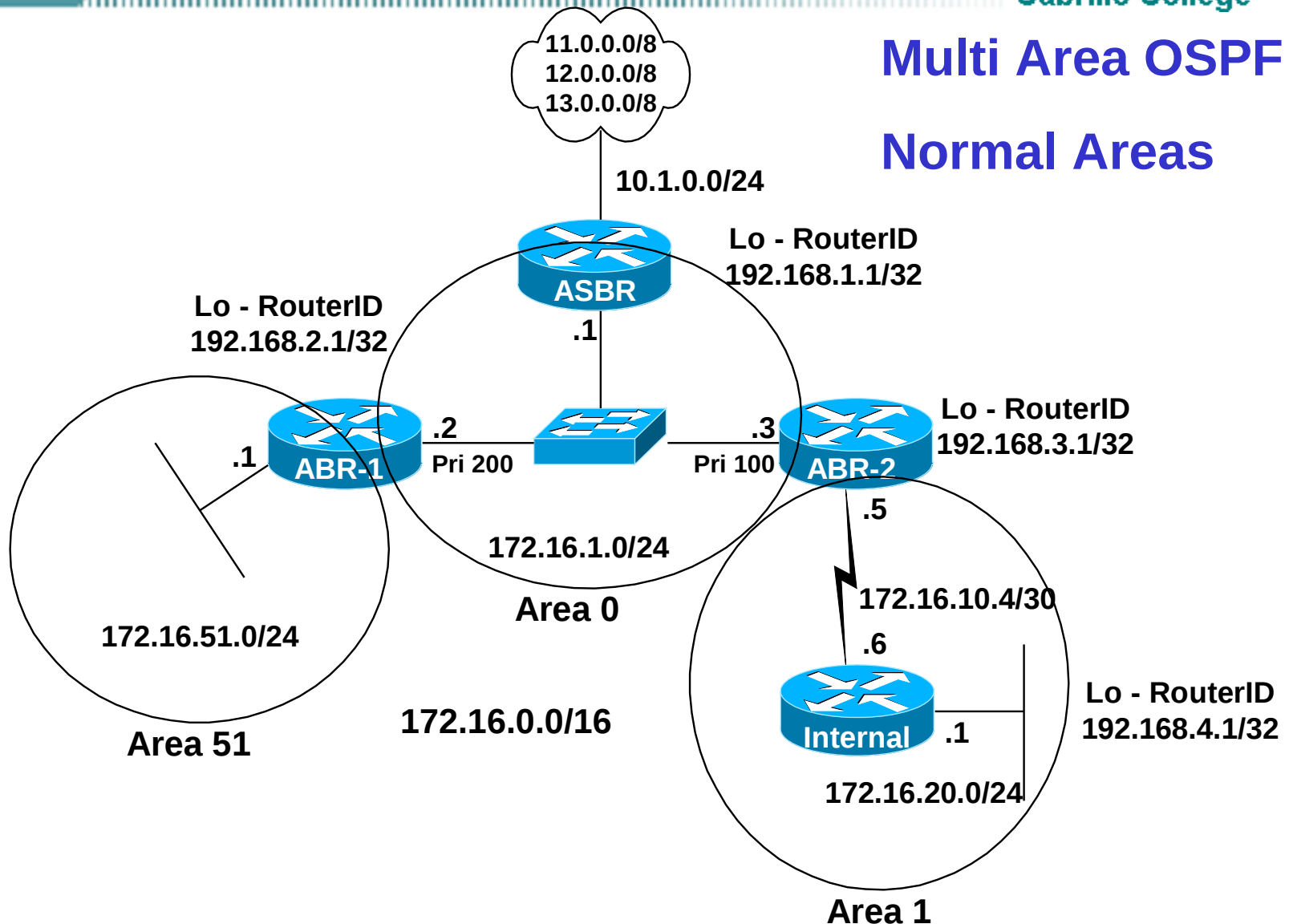


Part I - LSAs using all normal areas

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Multi Area OSPF

Normal Areas



1. OSPF Multi-Areas - All Normal Areas

ASBR

```
router ospf 1
 redistribute static
 network 172.16.1.0 0.0.0.255 area 0
!
ip classless
ip route 11.0.0.0 255.0.0.0 Null0
ip route 12.0.0.0 255.0.0.0 Null0
ip route 13.0.0.0 255.0.0.0 Null0
```

ABR-1

```
interface FastEthernet0/0
 ip address 172.16.1.2 255.255.255.0
 ip ospf priority 200

router ospf 1
 network 172.16.1.0 0.0.0.255 area 0
 network 172.16.51.0 0.0.0.255 area 51
```

ABR-2

```
interface FastEthernet0
 ip address 172.16.1.3 255.255.255.0
 ip ospf priority 100
!
router ospf 1
 network 172.16.1.0 0.0.0.255 area 0
 network 172.16.10.4 0.0.0.3 area 1
```

Internal

```
router ospf 1
 network 172.16.0.0 0.0.255.255 area 1
```

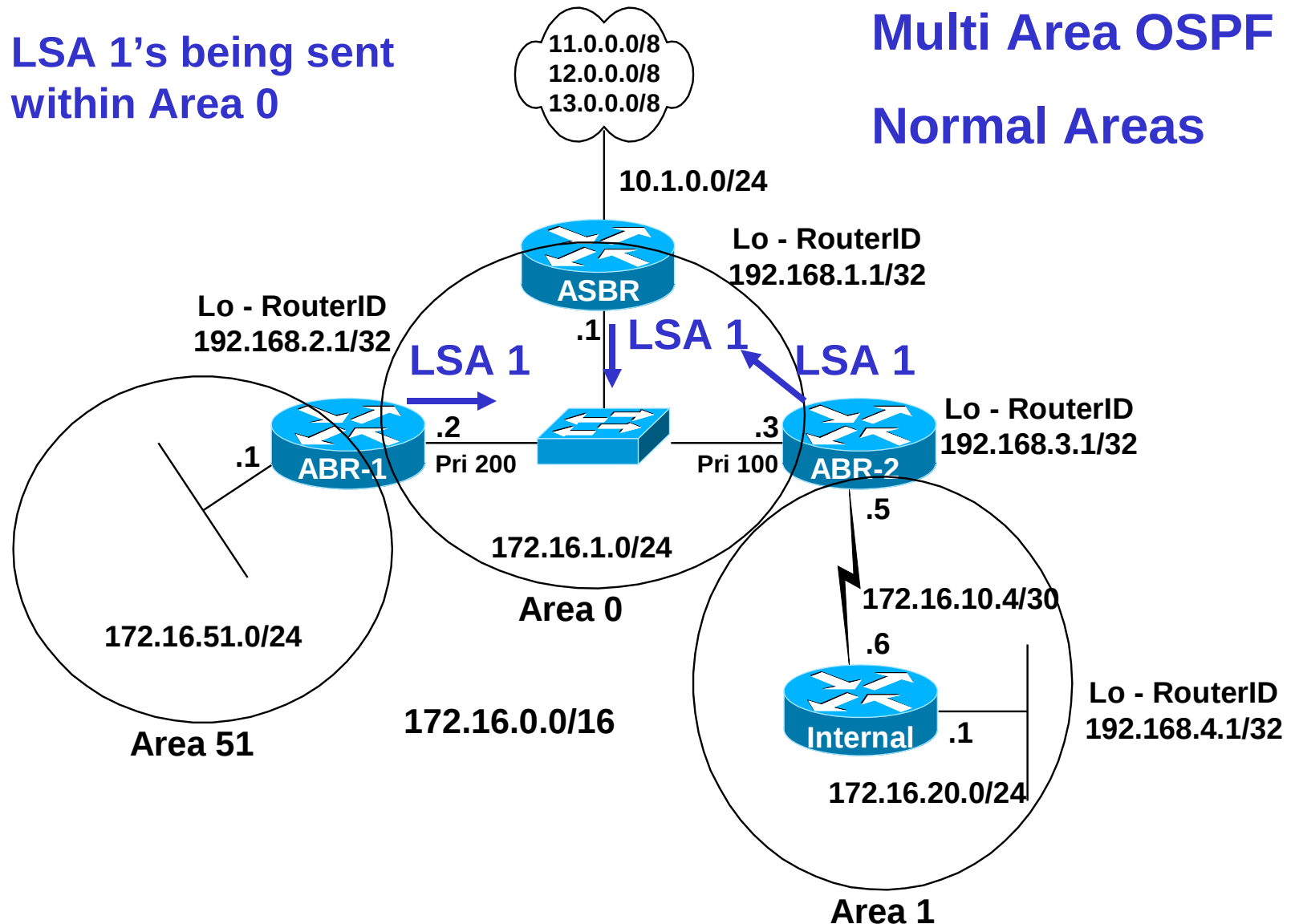
ABR contains network statements for each area it belongs to, using the proper area value.

LSA 1 - Router Link States

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Multi Area OSPF Normal Areas

LSA 1's being sent
within Area 0

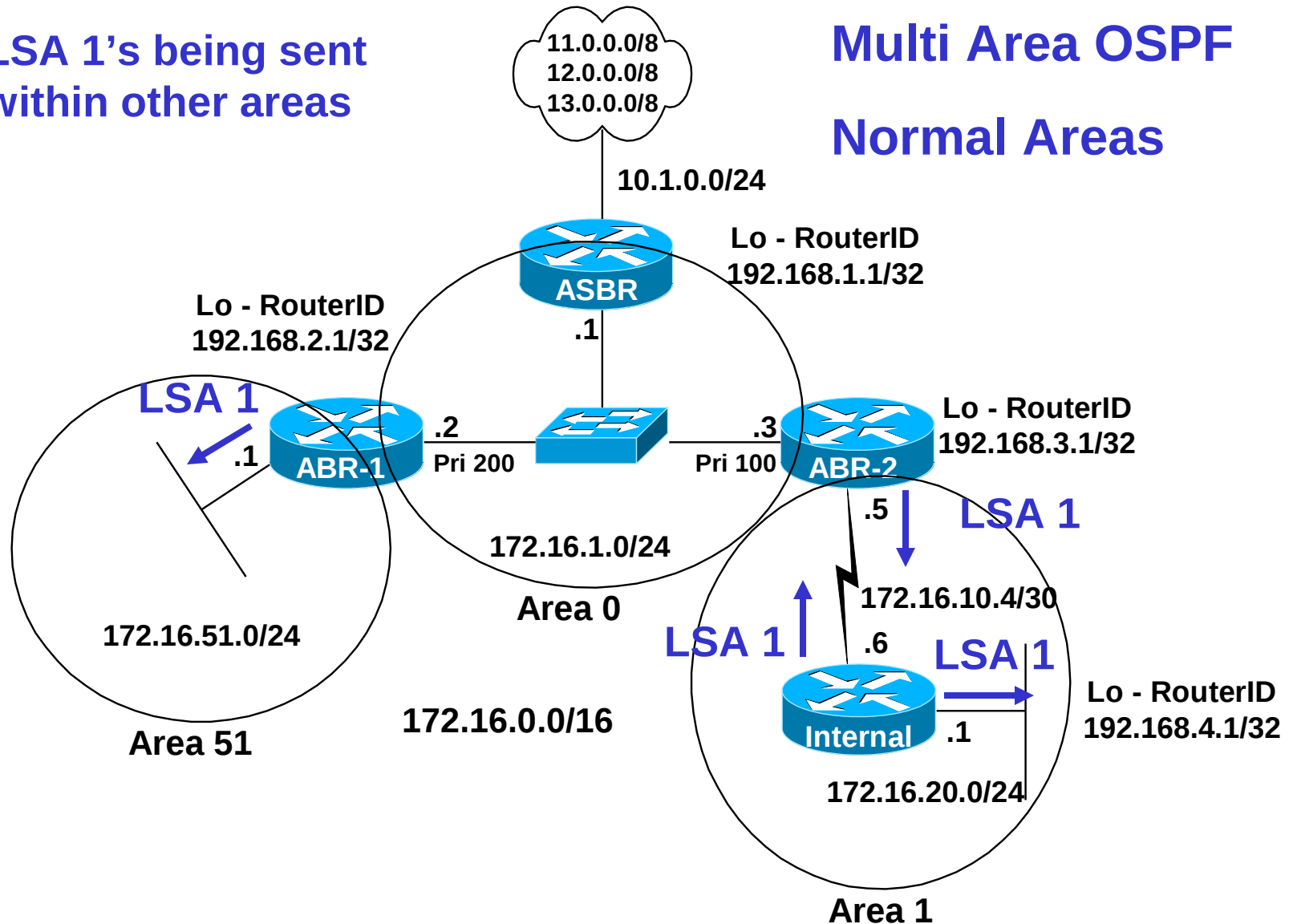


LSA 1 - Router Link States

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LSA 1's being sent
within other areas

Multi Area OSPF
Normal Areas



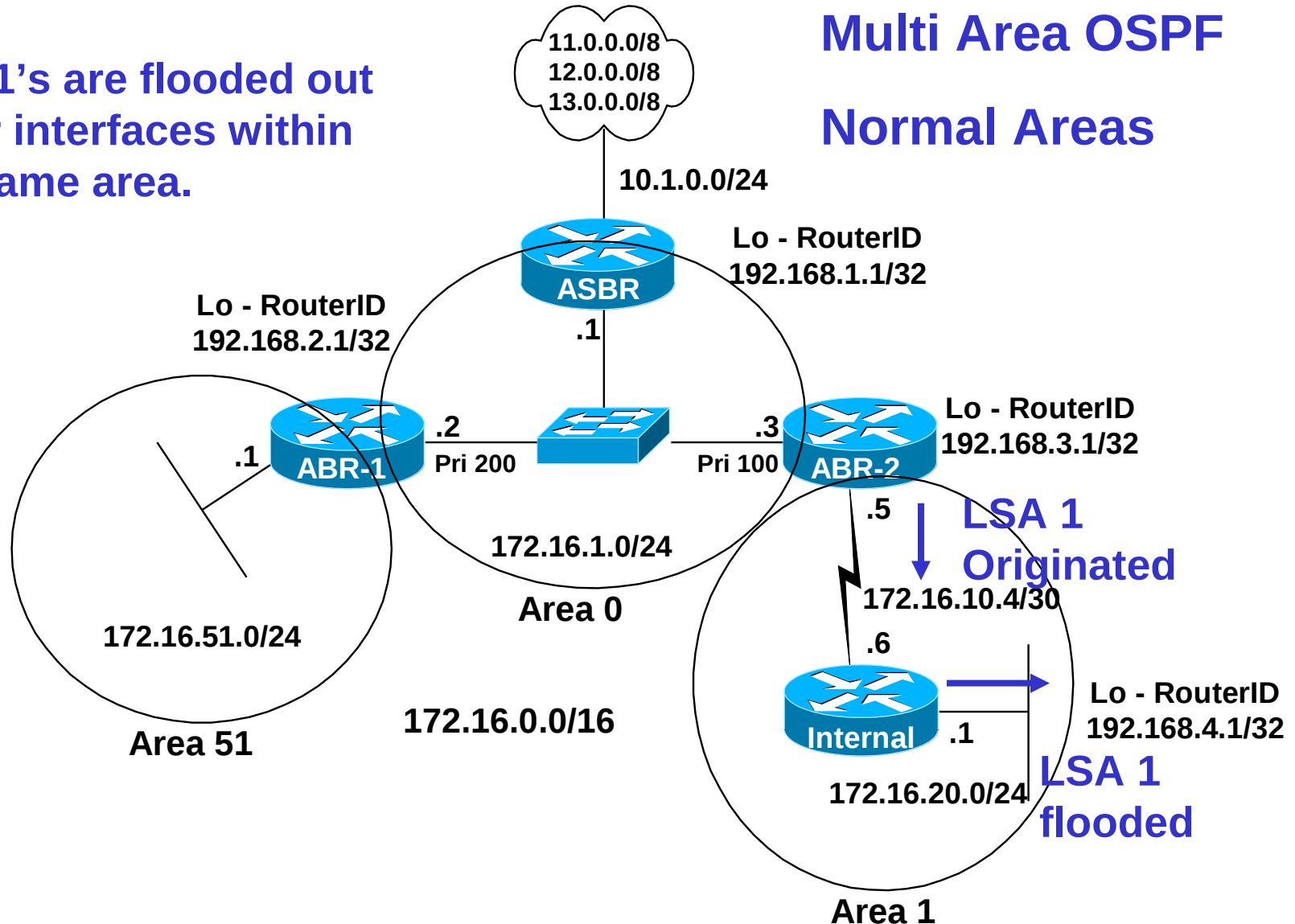
LSA 1 - Router Link States

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Multi Area OSPF

Normal Areas

LSA 1's are flooded out other interfaces within the same area.



LSA 1 - Router Link States

For Router Links:

- The **Link State ID** is always the same as the **Advertising Router**
 - **Advertising Router** is the Router ID of the router that created this LSA 1
-

Internal#**show ip ospf data**

OSPF Router with ID (192.168.4.1) (Process ID 1)

Router Link States (Area 1) <- Note the Area!

(LSA 1 - Links in the area to which this router belongs.)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	898	0x80000003	0xCE56	2
192.168.4.1	192.168.4.1	937	0x80000003	0xFD44	3

- **Bottom line:** Router Link States (LSA1's) should display all the RouterIDs of routers in that area, including its own.
- **Rick's reminder: LSA 1 -> "my one area"**

LSA 1 - Router Link States

```
ABR-2#show ip ospf data
```

```
OSPF Router with ID (192.168.3.1) (Process ID 1)
```

```
Router Link States (Area 1) <- Note the Area!
```

(LSA 1 - Links in the area to which this router belongs.)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	786	0x80000003	0xCE56	2
192.168.4.1	192.168.4.1	828	0x80000003	0xFD44	3

- **Bottom line:** Router Link States (LSA1's) should display all the RouterIDs of routers in that area, including its own.
- **Rick's reminder: LSA 1 -> "my one area"**

LSA 1 - Router Link States

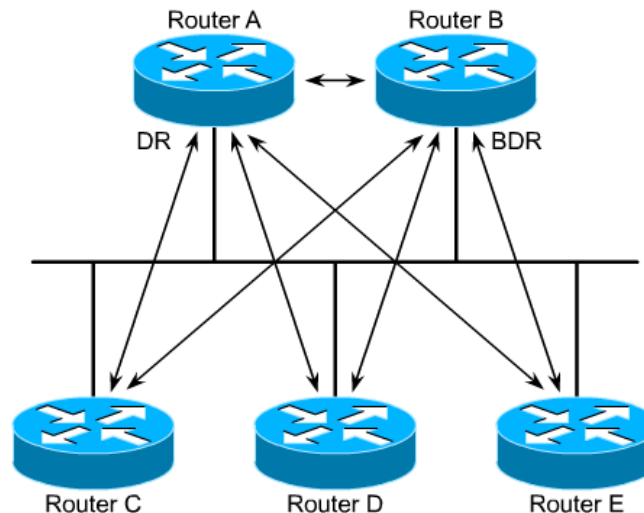
ABR-2 - show ip route

```
    172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA    172.16.51.1/32 [110/2] via 172.16.1.2, 00:11:44, FastEthernet0
O      172.16.20.0/24 [110/782] via 172.16.10.6, 00:12:29, Serial0
C      172.16.10.4/30 is directly connected, Serial0
C      172.16.1.0/24 is directly connected, FastEthernet0
O E2 11.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
O E2 12.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
O E2 13.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
    192.168.3.0/32 is subnetted, 1 subnets
C      192.168.3.1 is directly connected, Loopback1
```

- Denoted by just an “O” in the routing table, or a “C”
- Why is there only just an “O” for this network and not the other networks?
 - Directly connected or via another area.

LSA 2 - Network Link States

- **LSA 2 – Network LSA**
- **Generated by the DR** on every multi-access network
- Denoted by just an “O” in the routing table or “C” if the network is directly connected.
- **Flooded only within the originating area.**
- LSA 2’s are in link state database for **all** routers within area, even those routers on not on multi-access networks or DRs on other multi-access networks in the same area.
- ABR may include a set of LSA 2s for each area it belongs to.



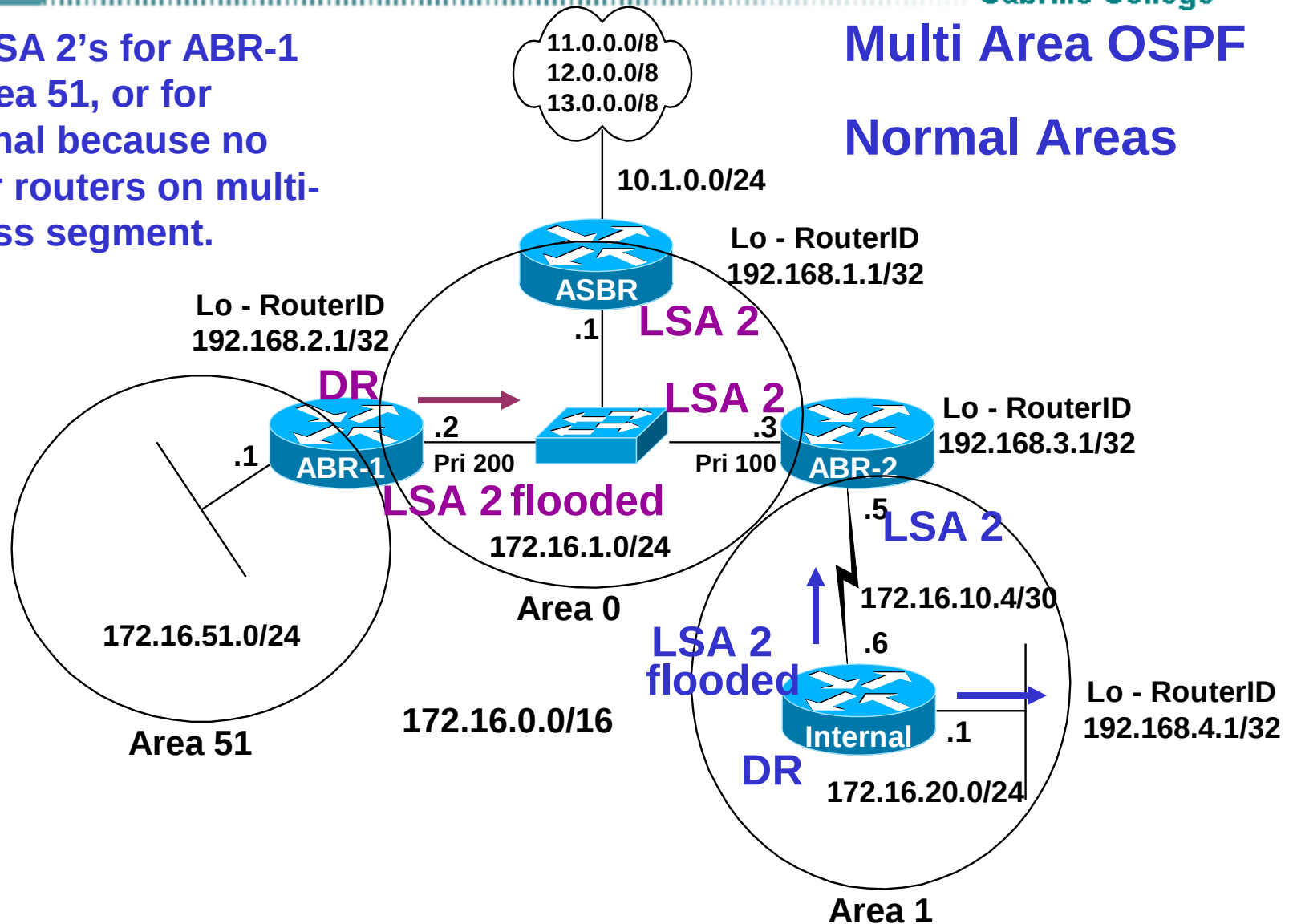
LSA 2 - Network Link States

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Multi Area OSPF

Normal Areas

No LSA 2's for ABR-1
in Area 51, or for
Internal because no
other routers on multi-
access segment.



LSA 2 - Network Link States

```
ASBR#show ip ospf data
```

```
    OSPF Router with ID (192.168.1.1) (Process ID 1)
```

```
        Net Link States (Area 0)
        (LSA 2 - Generated by the DR)
```

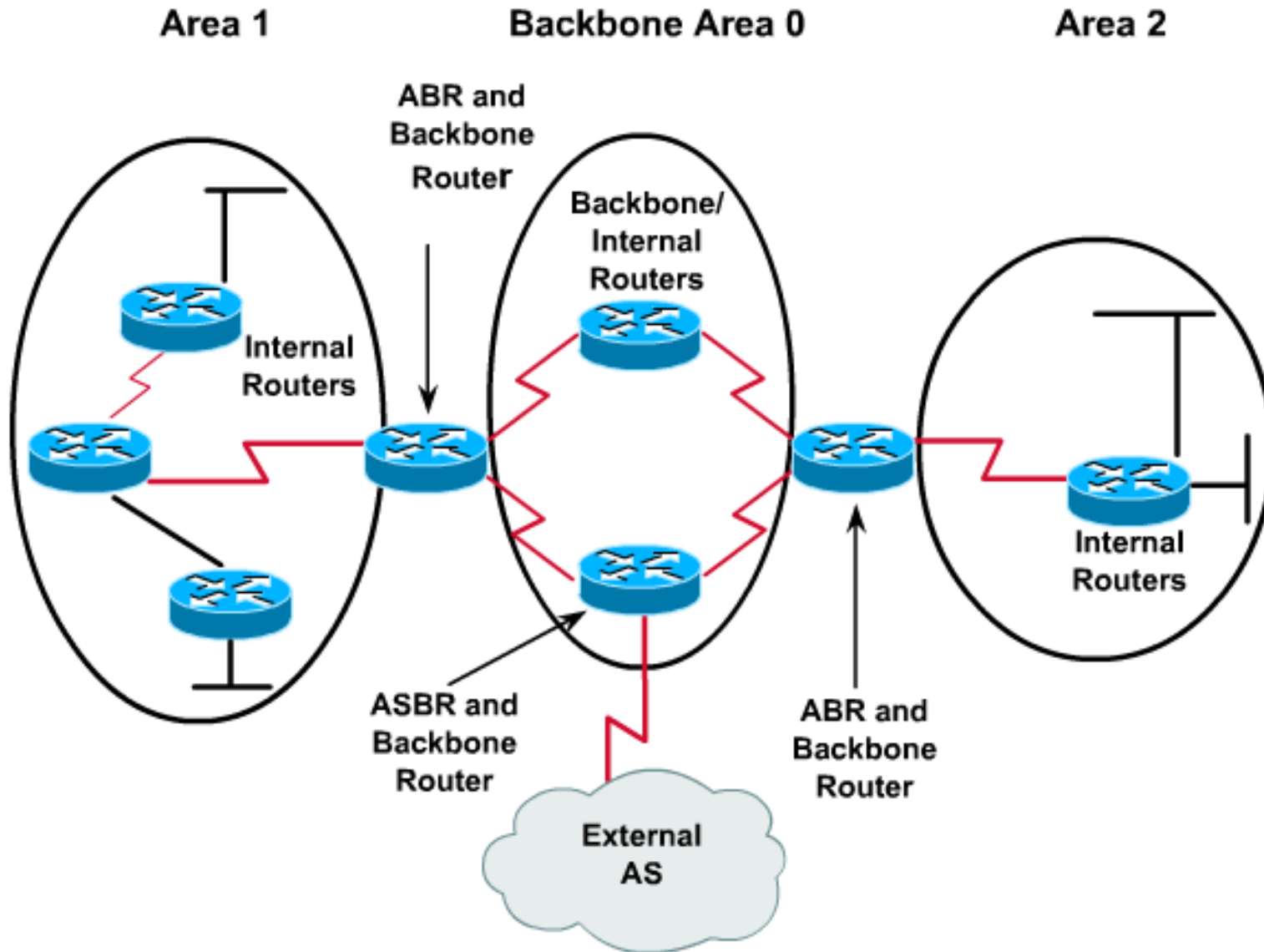
Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.2	192.168.2.1	201	0x8000000D	0xCFE8

- **Link ID** 172.16.1.2 = IP address of DR on MultiAccess Network
- **ADV Router** 192.168.2.1 = Router ID of DR
- **Bottom line:** Net Link States (LSA2's) should display the RouterIDs of the DRs on all multi-access networks in the area and their IP addresses.
- **Rick's reminder: LSA 2 -> "Ethernet = Layer 2 or D R"**
1 2

LSA 3 – Summary Net Link States

- **LSA 3 – Summary LSA**
- Originated by the **ABR**.
- Describes links between **ABR** and **Internal Routers** of the Local Area
- ABR will include a set of LSA 3's for each area it belongs to.
- LSA 3s are flooded throughout the backbone (Area 0) and to other ABRs.
- Routes learned via LSA type 3s are denoted by an "IA" (Inter-area) in the routing table.

LSA 3 – Summary Net Link States

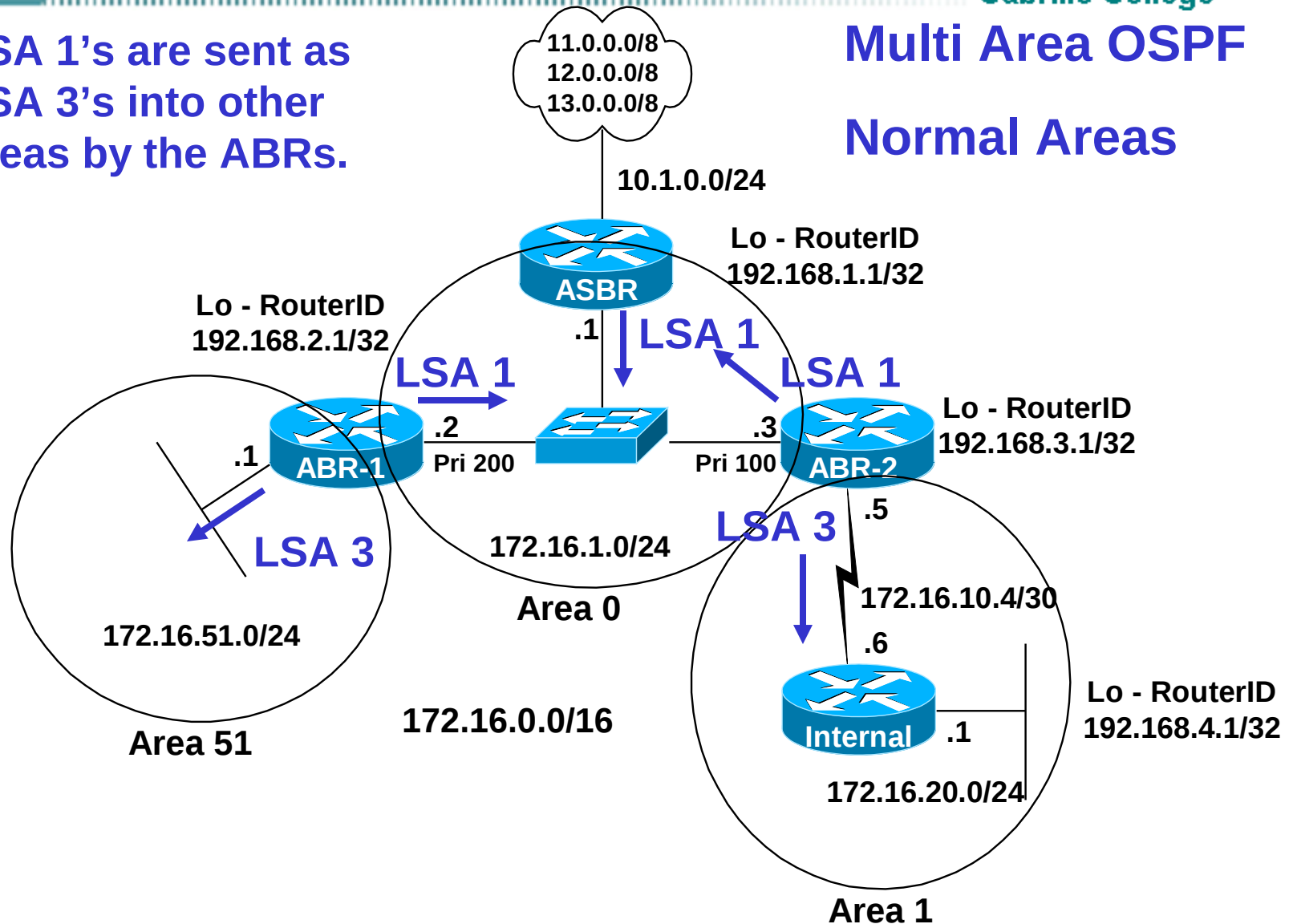


LSA 3 – Summary Net Link States

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Multi Area OSPF Normal Areas

LSA 1's are sent as
LSA 3's into other
areas by the ABRs.



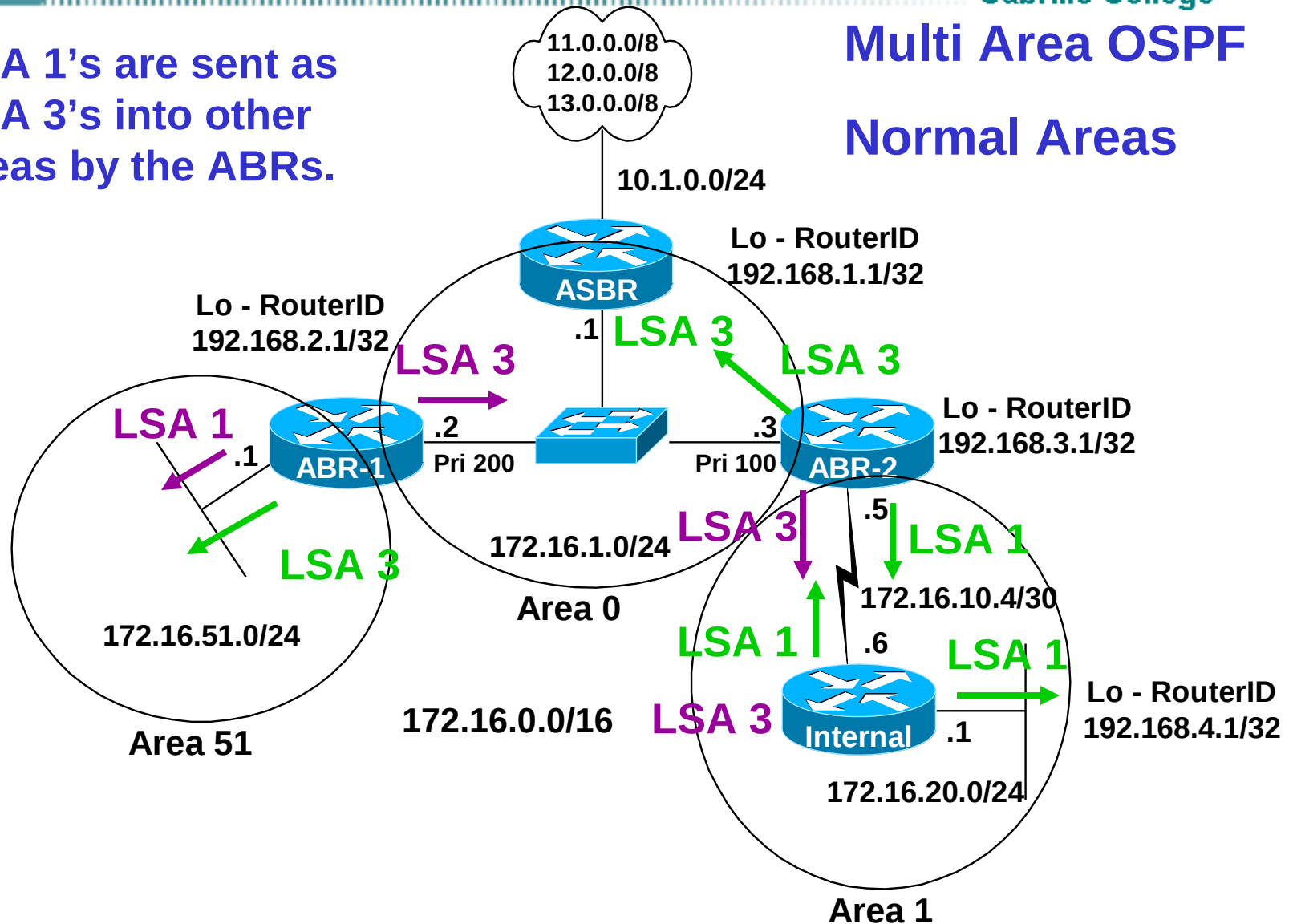
LSA 3 – Summary Net Link States

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Multi Area OSPF

Normal Areas

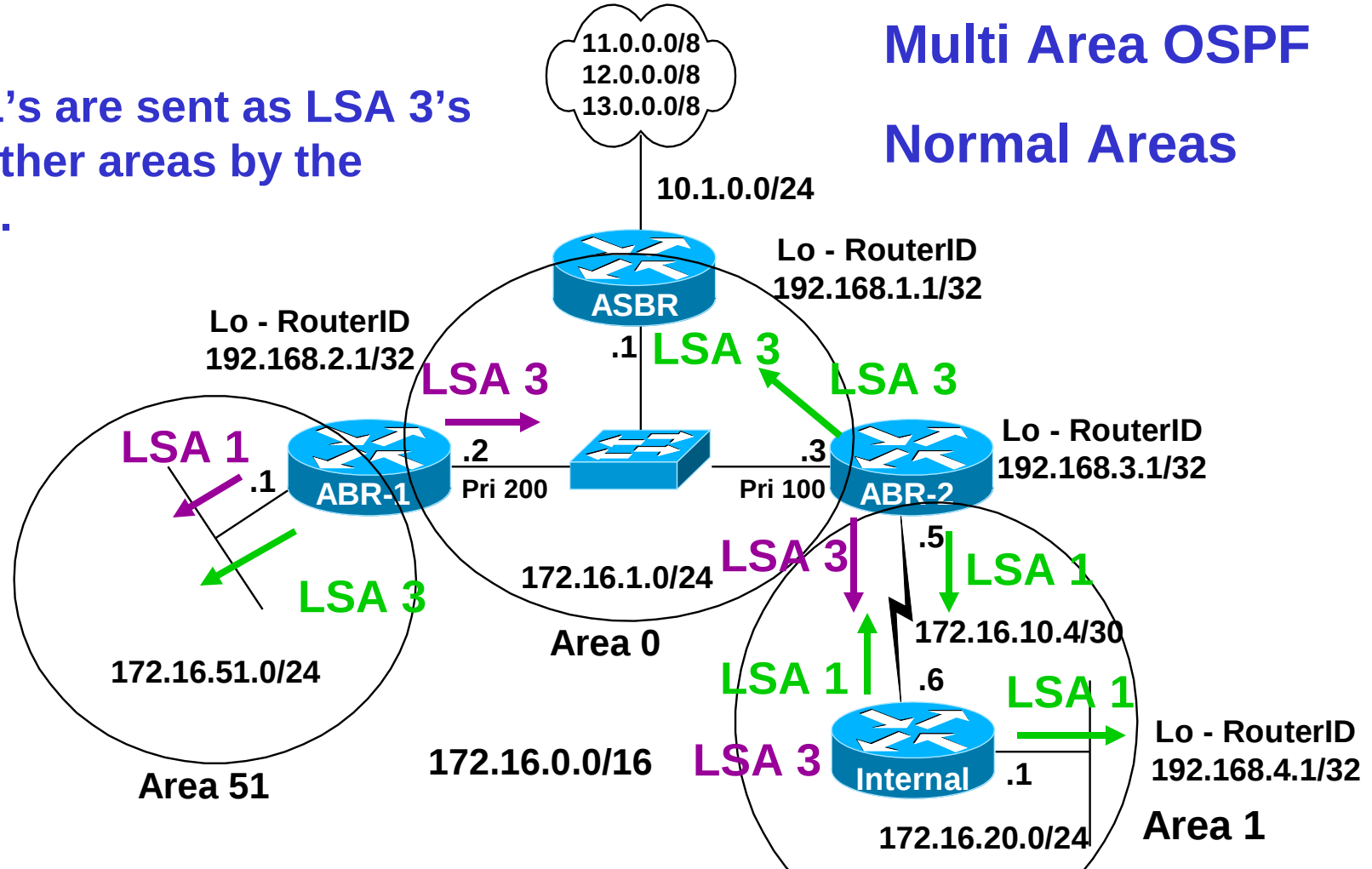
LSA 1's are sent as
LSA 3's into other
areas by the ABRs.



LSA 1's are sent as LSA 3's into other areas by the ABRs.

Multi Area OSPF

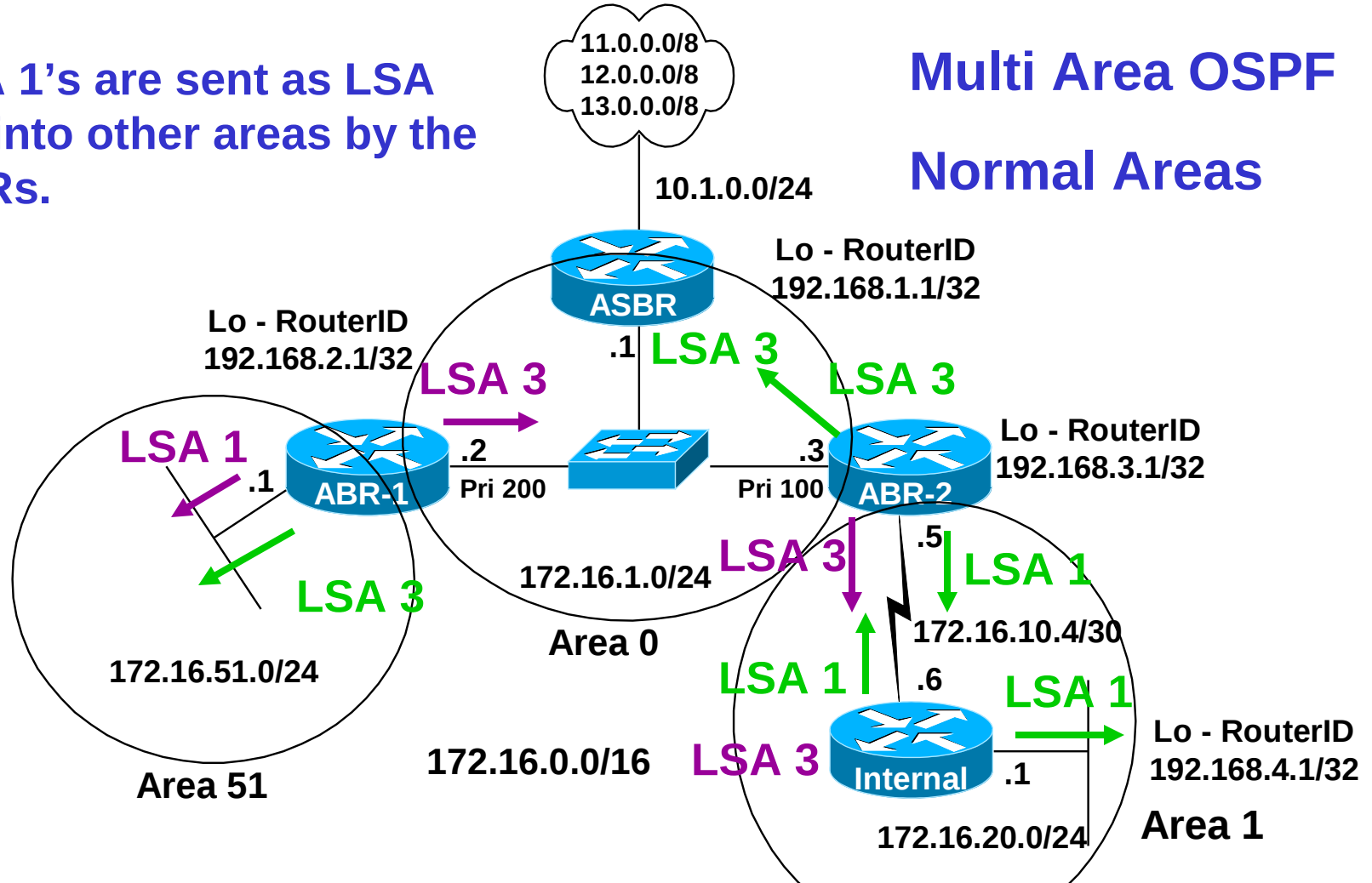
Normal Areas



- Routers only see the topology of the area they belong to.
- When a link in one area changes, the adjacent routers originate in LSA 1's and flood them within the area, causing intra-area (internal) routers to re-run the SPF and recalculating the routing table.
- ABRs do not announce topological information between areas.
- ABRs only inject routing information into other areas, which is basically a distance-vector technique.

LSA 1's are sent as LSA 3's into other areas by the ABRs.

Multi Area OSPF Normal Areas



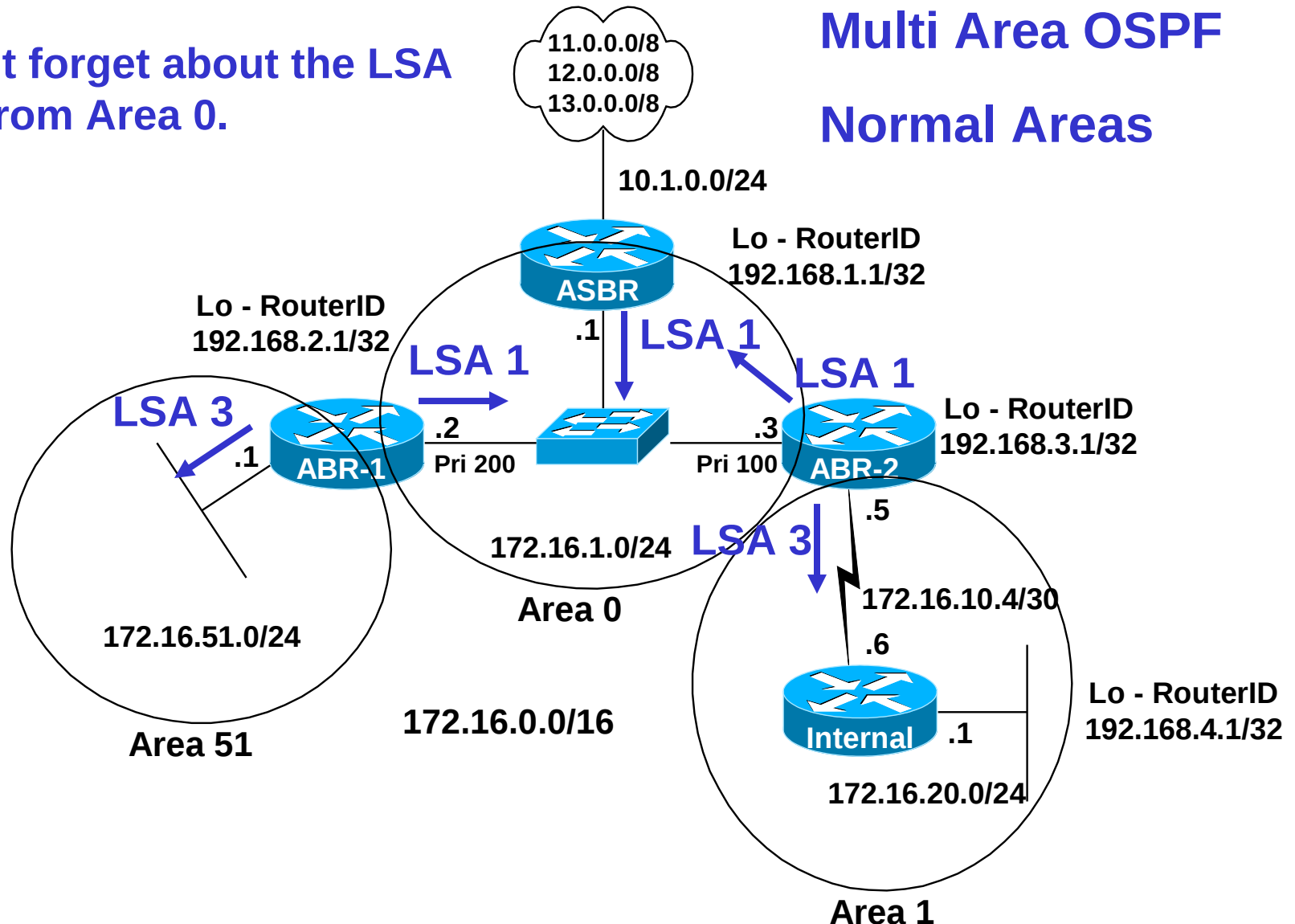
- ABRs calculate intra-area routes for directly attached areas and announce them to all other areas as inter-area routes, using LSA 3's.
- OSPF ABRs will only announce inter-area routes that were learned from the backbone area, area 0.
- The backbone area serves as a repository for inter-area routes.
- This keeps OSPF safe from routing loops.

LSA 3 – Summary Net Link States

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Don't forget about the LSA 1's from Area 0.

Multi Area OSPF Normal Areas



LSA 3 – Summary Net Link States

ASBR

ASBR# show ip route

```
    172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA   172.16.51.1/32 [110/2] via 172.16.1.2, 00:02:54, FastEthernet0/0
O IA   172.16.20.0/24 [110/783] via 172.16.1.3, 00:02:54, FastEthernet0/0
O IA   172.16.10.4/30 [110/782] via 172.16.1.3, 00:02:54, FastEthernet0/0
C      172.16.1.0/24 is directly connected, FastEthernet0/0
    10.0.0.0/24 is subnetted, 1 subnets
C      10.1.0.0 is directly connected, FastEthernet0/1
S      11.0.0.0/8 is directly connected, Null0
S      12.0.0.0/8 is directly connected, Null0
    192.168.1.0/32 is subnetted, 1 subnets
C      192.168.1.1 is directly connected, Loopback0
S      13.0.0.0/8 is directly connected, Null0
```

- Routes learned via LSA type 3s are denoted by an “**IA**” (Inter-Area Routes) in the routing table.

Another example: non-area 0 router, Internal

Internal# show ip ospf database

**LSA 3 - Generated by the ABR. Describes links between ABR and
Internal Routers of the Local Area**

(Area 51 networks - Advertising Router ABR-2)

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.0	192.168.3.1	848	0x80000005	0xD339
172.16.51.1	192.168.3.1	843	0x80000001	0xB329

Internal# show ip route

172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks

O IA 172.16.51.1/32 [110/783] via 172.16.10.5, 00:13:48, Serial0

C 172.16.20.0/24 is directly connected, FastEthernet0

C 172.16.10.4/30 is directly connected, Serial0

O IA 172.16.1.0/24 [110/782] via 172.16.10.5, 00:13:53, Serial0

192.168.4.0/32 is subnetted, 1 subnets

C 192.168.4.1 is directly connected, Loopback0

O E2 11.0.0.0/8 [110/20] via 172.16.10.5, 00:14:41, Serial0

O E2 12.0.0.0/8 [110/20] via 172.16.10.5, 00:14:41, Serial0

O E2 13.0.0.0/8 [110/20] via 172.16.10.5, 00:14:42, Serial0

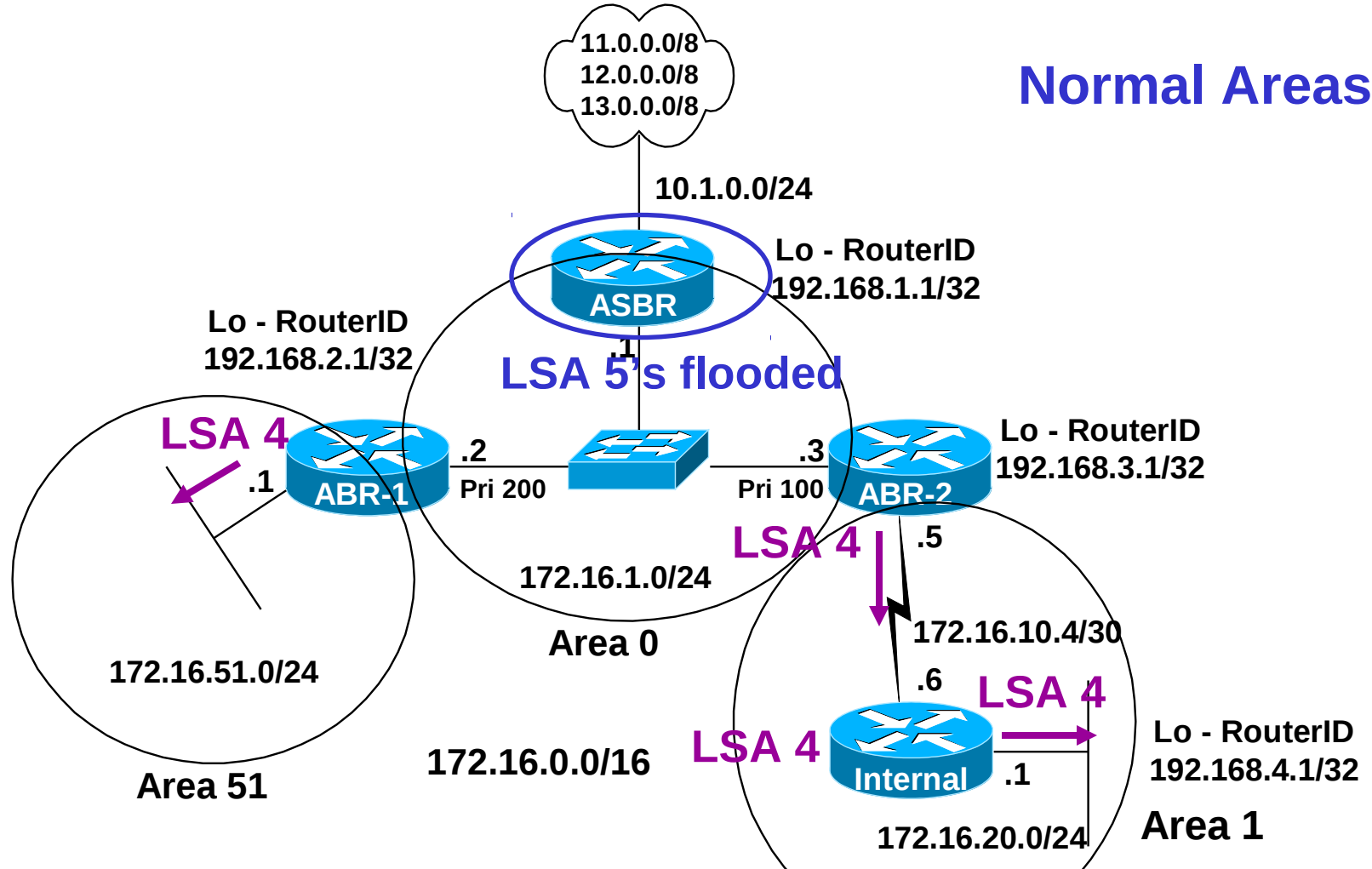
LSA 4 – ASBR Summary Link States

- **LSA 4 – ASBR Summary LSA**
- **Originated by the ABR.**
- Flooded throughout the backbone area to the other ABRs.
- Describes the **reachability to the ASBRs**
- Advertises an ASBR (Router ID) not a network
- Included in routing table as an “IA” route.
- Same format as a LSA 3 - Summary LSA, except LSA 4 ASBR Summary LSA the Network Mask field is always 0

Exceptions

- **Not** flooded to Stub and Totally Stubby networks.
- More on this later

Normal Areas



- Flooded throughout the backbone area to the other ABRs.
- Describes the **reachability to the ASBRs**
- How do the ABRs know about the ASBR?
- When routers receive an LSA 5 (AS External LSA) with external route information, the routers denote the Router ID being the ASBR.

LSA 4 – ASBR Summary Link States

ABR-2

ABR-2# show ip ospf database

Summary ASB Link States (Area 1)

LSA 4 - Reachability to ASBR.

Not flooded to Stub and Totally Stubby networks.

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.1	192.168.3.1	801	0x80000003	0x93CC

- **Link ID** 192.168.1.1 = Router ID of ASBR
- **ADV Router** 192.168.3.1 = Router ID ABR advertising route
- **Bottom line:** Routers in non-area 0, should see Router ID of ASBR and its ABR to get there .
- **Rick's reminder: LSA 4 -> "Reachability to the A S B R"**
1 2 3 4

LSA 4 – ASBR Summary Link States

Internal

```
Internal# show ip ospf database
```

```
Summary ASB Link States (Area 1)
```

```
LSA 4 - Reachability to ASBR.
```

```
Not flooded to Stub and Totally Stubby networks.
```

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.1	192.168.3.1	912	0x80000003	0x93CC

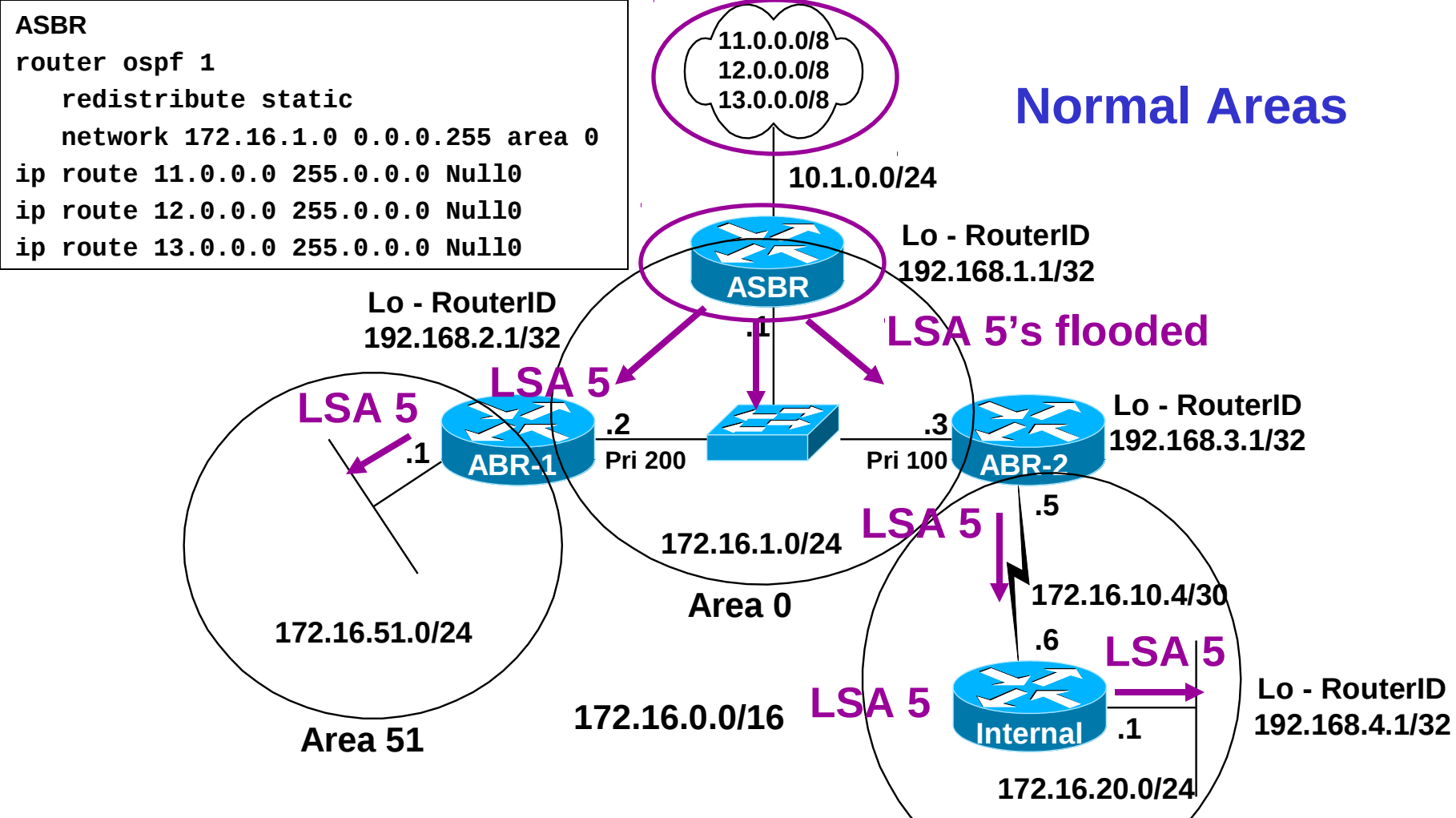
- **Link ID** 192.168.1.1 = Router ID of ASBR
- **ADV Router** 192.168.3.1 = Router ID ABR advertising route
- **Note:** No LSA 4s for Area 0 on Router B

LSA 5 - AS External Link States

- **LSA 5 – AS External LSA**
- **Originated by the ASBR.**
- Describes destination **networks external to the Autonomous System (This OSPF Routing Domain)**
- Flooded throughout the OSPF AS except to stub and totally stubby areas
- Denoted in routing table as E1 or E2 (default) route (soon)
- We will discuss default routes later.
- **ASBR** – Router which “redistributes” routes into the OSPF domain.

Exceptions

- **Not flooded to Stub and Totally Stubby networks.**
- **More on this later**



- “Redistribute” command creates an ASBR router.
- Originated by the ASBR.
- Describes destination networks external to the OSPF Routing Domain
- Flooded throughout the OSPF AS except to stub and totally stubby areas

LSA 5 - AS External Link States

ABR-2

ABR-2# show ip ospf database

AS External Link States <- Note, NO Area!

*LSA 5 - External Networks originated by the ASBR,
Flooded throughout A.S. except to Stub and Totally Stubby*

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	1191	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	1191	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	1191	0x80000001	0x2503	0

- **Link ID** = External Networks
- **ADV Router** = Router ID of ASBR
- **Note:** For ABRs: There is only one set of “AS External Link States” in database summary. In other words, an ABR router will only show one set of “AS External Link States,” not one per area.
- **Bottom line:** All Routers should see External networks and the Router ID of ASBR to get there .
- **Rick’s reminder: LSA 5 -> O T H E R networks**
1 2 3 4 5

LSA 5 - AS External Link States

ABR-2

ABR-2# show ip route

```
172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks
O IA    172.16.51.1/32 [110/2] via 172.16.1.2, 00:11:44, FastEthernet0
O       172.16.20.0/24 [110/782] via 172.16.10.6, 00:12:29, Serial0
C       172.16.10.4/30 is directly connected, Serial0
C       172.16.1.0/24 is directly connected, FastEthernet0
O E2 11.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
O E2 12.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
O E2 13.0.0.0/8 [110/20] via 172.16.1.1, 00:11:44, FastEthernet0
      192.168.3.0/32 is subnetted, 1 subnets
C      192.168.3.1 is directly connected, Loopback1
```

- Designated by “E2”
- Notice that the cost is 20 for all three routes, we will see why later.
- It has to do with E2 routes and **where the default cost is 20**.
 - Redistribute command (Route Optimization chapter): If a value is not specified for the **metric** option, and no value is specified using the **default-metric** command, the **default metric value is 0, except for OSPF where the default cost is 20**.

LSA 5 - AS External Link States

```
Internal# show ip ospf database
```

Type-5 AS External Link States

LSA 5 - External Networks originated by the ASBR,
Flooded throughout A.S. except to Stub and Totally Stubby

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	1191	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	1191	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	1191	0x80000001	0x2503	0

```
Internal# show ip route
```

172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks

O IA 172.16.51.1/32 [110/783] via 172.16.10.5, 00:13:48, Serial0

C 172.16.20.0/24 is directly connected, FastEthernet0

C 172.16.10.4/30 is directly connected, Serial0

O IA 172.16.1.0/24 [110/782] via 172.16.10.5, 00:13:53, Serial0

192.168.4.0/32 is subnetted, 1 subnets

C 192.168.4.1 is directly connected, Loopback0

O E2 11.0.0.0/8 [110/20] via 172.16.10.5, 00:14:41, Serial0

O E2 12.0.0.0/8 [110/20] via 172.16.10.5, 00:14:41, Serial0

O E2 13.0.0.0/8 [110/20] via 172.16.10.5, 00:14:42, Serial0

LSA 5 - AS External Link States

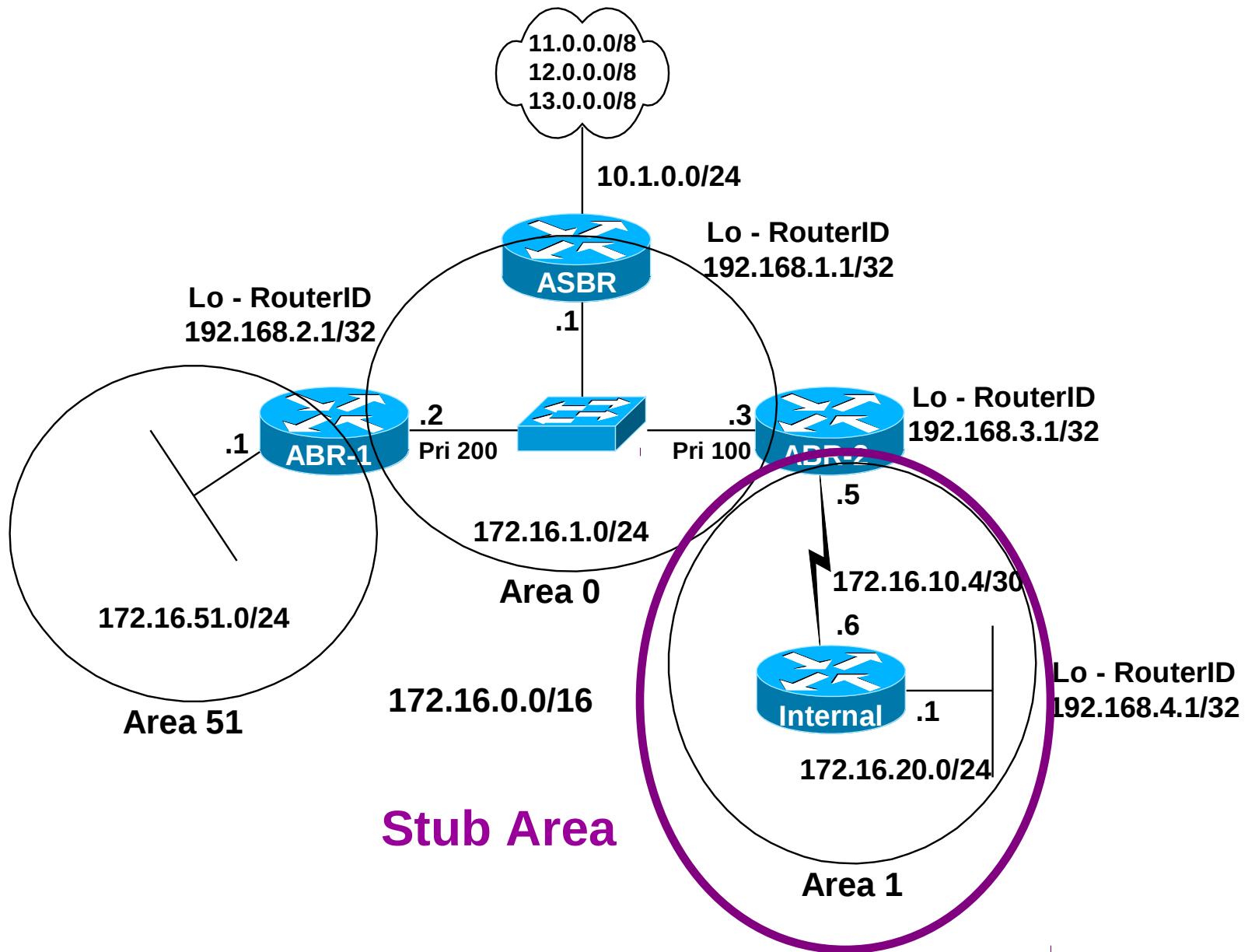
E1 vs. E2 External Routes

- External routes fall under two categories:
 - external type 1
 - external type 2 (**default**)
- The difference between the two is in the way the cost (metric) of the route is being calculated.
- The cost of a **type 2** route is always the external cost, irrespective of the interior cost to reach that route.
- A **type 1** cost is the addition of the external cost and the internal cost used to reach that route.
- A type 1 route is always preferred over a type 2 route for the same destination.
- More later...

Stub Areas

Considerations for both Stub and Totally Stubby Areas

- An area could be qualified a stub when:
 - There is a single exit point (a single ABR) from that area. More than one ABR can be used, but be ready to “accept non-optimal routing paths.”
 - If routing to outside of the area does not have to take an optimal path.
- The area is not needed as a transit area for virtual links (later).
- The ASBR is not within the stub area
- The area is not the backbone area (area 0)
- Stub areas will result in memory and processing savings depending upon the size of the network.



Stub Areas

Receives all routes from within A.S.:

- Within the local area - LSA 1s and LSA 2s (if appropriate)
- From other areas (Inter-Area) - LSA 3s

Does **not** receive routes from External A.S. (External Routes).

ABR:

- ABR blocks all LSA 4s and LSA 5s.
- 'If LSA 5s are not known inside an area, LSA 4s are not necessary.'
- LSA 3s are propagated by the ABR.

Note: Default route is automatically injected into stub area by **ABR**

- External Routes: Once the ABR gets a packet headed to a default route, it must have a default route, either static or propagated by the ASBR via default information originate (coming!)

Configuration:

- All routers in the area must be configured as “stub”

Stub Areas

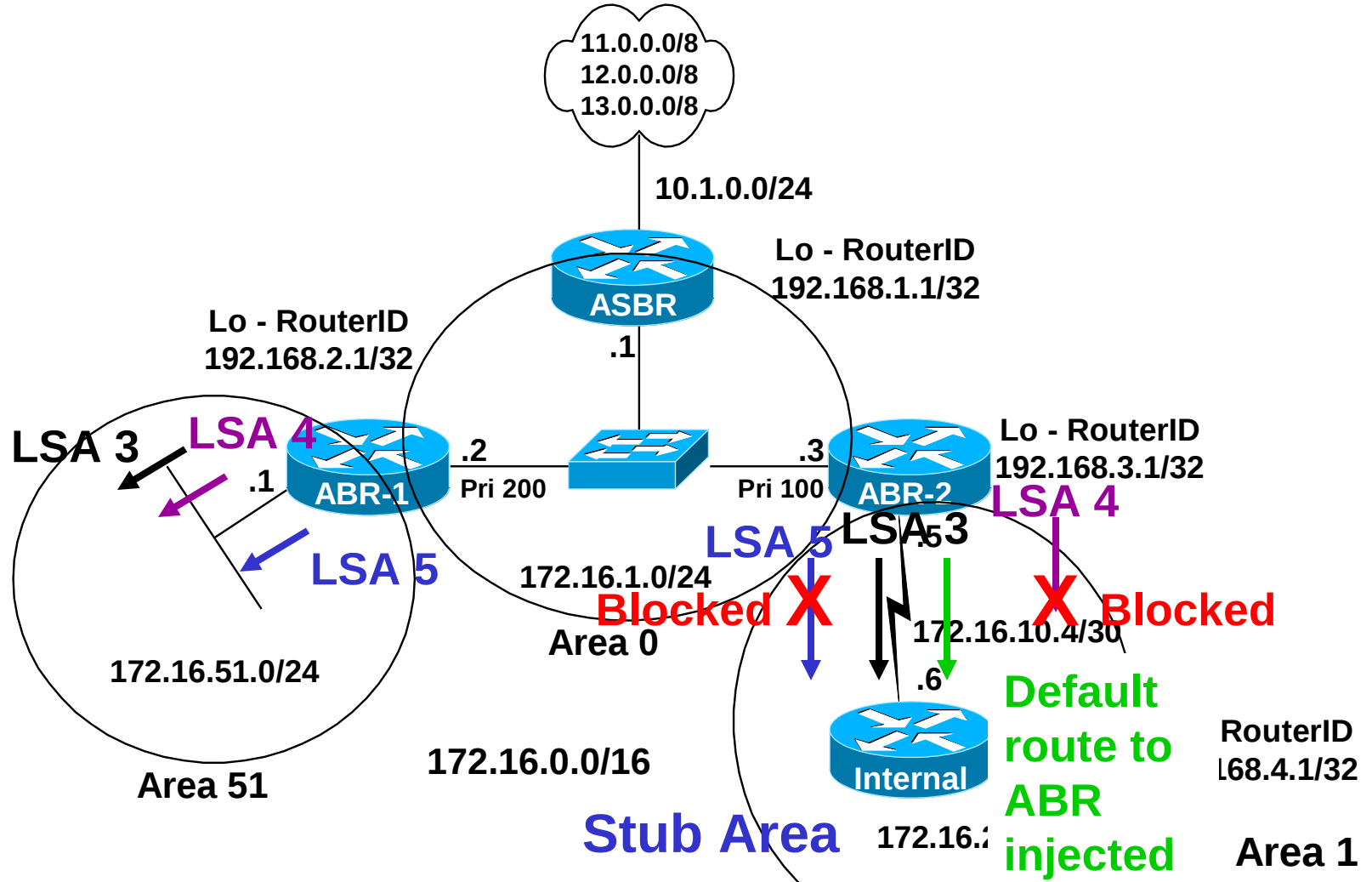
ABR-2

```
router ospf 1
 network 172.16.1.0 0.0.0.255 area 0
 network 172.16.10.4 0.0.0.3 area 1
 area 1 stub << Command: area area stub
```

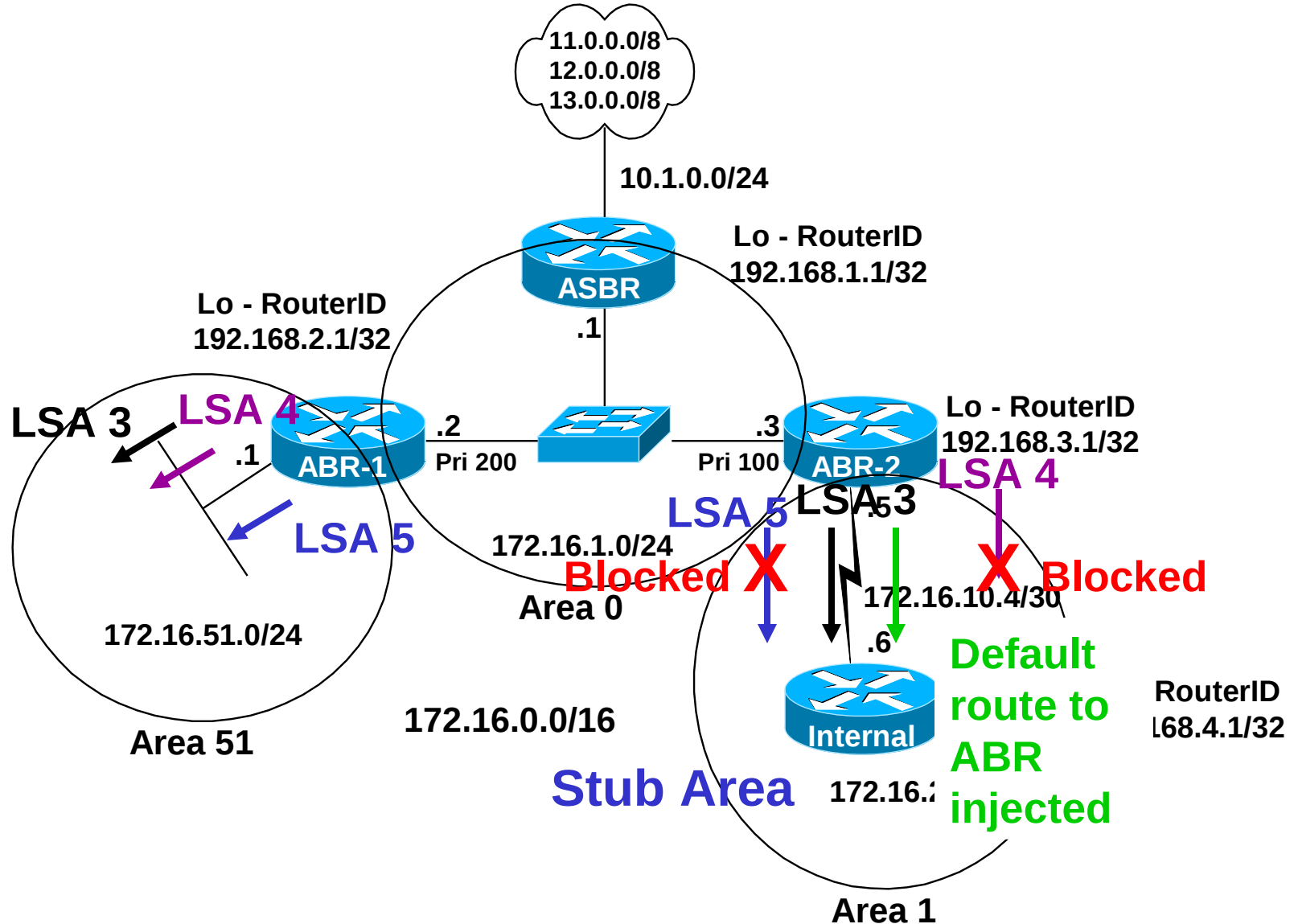
Internal

```
router ospf 1
 network 172.16.0.0 0.0.255.255 area 1
 area 1 stub << Command: area area stub
```

- All routers in the area must be configured as “**stub**” including the ABR



- LSA 3s (Inter-Area routes) are propagated by the ABR.
- ABR blocks all LSA 4s (reachability to ASBR) and LSA 5s (External routes)
- The ABR injects a default route into the stub area, pointing to the ABR. (This does not mean the ABR has a default route of its own.)
- Essentially, internal routers in a Stub Area only see Inter-Area OSPF routes and the default route to the ABR – No External routes.



- Changes in External routes no longer affect Stub Area routing tables.

Stub Areas

Internal

Internal# show ip route

Gateway of last resort is 172.16.10.5 to network 0.0.0.0

172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks

O IA 172.16.51.1/32 [110/783] via 172.16.10.5, 00:03:08, Serial0

C 172.16.20.0/24 is directly connected, FastEthernet0

C 172.16.10.4/30 is directly connected, Serial0

O IA 172.16.1.0/24 [110/782] via 172.16.10.5, 00:03:08, Serial0

192.168.4.0/32 is subnetted, 1 subnets

C 192.168.4.1 is directly connected, Loopback0

O*IA 0.0.0.0/0 [110/782] via 172.16.10.5, 00:03:08, Serial0

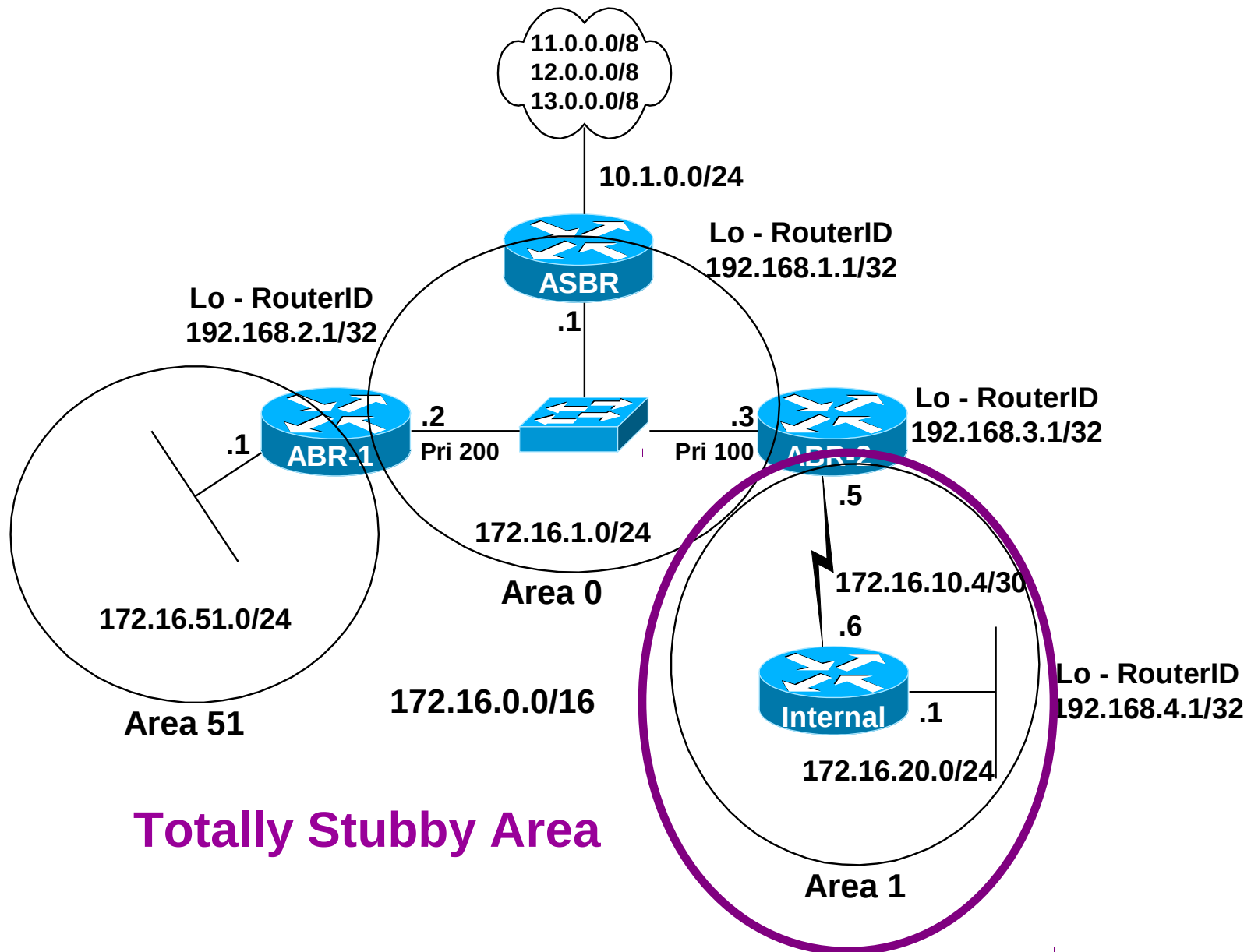
NOTE on default route:

- ABR will advertise a default route with a cost of 1
- cost of 65 = 1 + 64 (serial link)
- **Using bandwidth of 128K, not 64K: $782 = (100,000,000/128,000) + 1$**

Totally Stubby Areas

Same considerations as with Stub areas:

- An area could be qualified a stub when there is a single exit point (a single ABR) from that area or if routing to outside of the area does not have to take an optimal path.
- The ASBR is not within the stub area
- The area is not the backbone area (area 0)
- Stub areas will result in memory and processing savings depending upon the size of the network. - This is even more true with Totally Stubby areas



Totally Stubby Areas

Receives routes from within A.S.:

- Only from within the local area - LSA 1s and LSA 2s (if appropriate)
- Does **not** receive routes from other areas (Inter-Area) - LSA 3s

Does **not** receive routes from External A.S. (External Routes)

ABR:

- ABR blocks all LSA 4s and LSA 5s.
- ABR blocks all LSA 3s, except propagating a default route.
- Default route is injected into totally stubby area by ABR.

Configuring:

- All routers must be configured as “**stub**”
- ABR must be configured as “**stub no-summary**”

Totally Stubby Areas

ABR-2

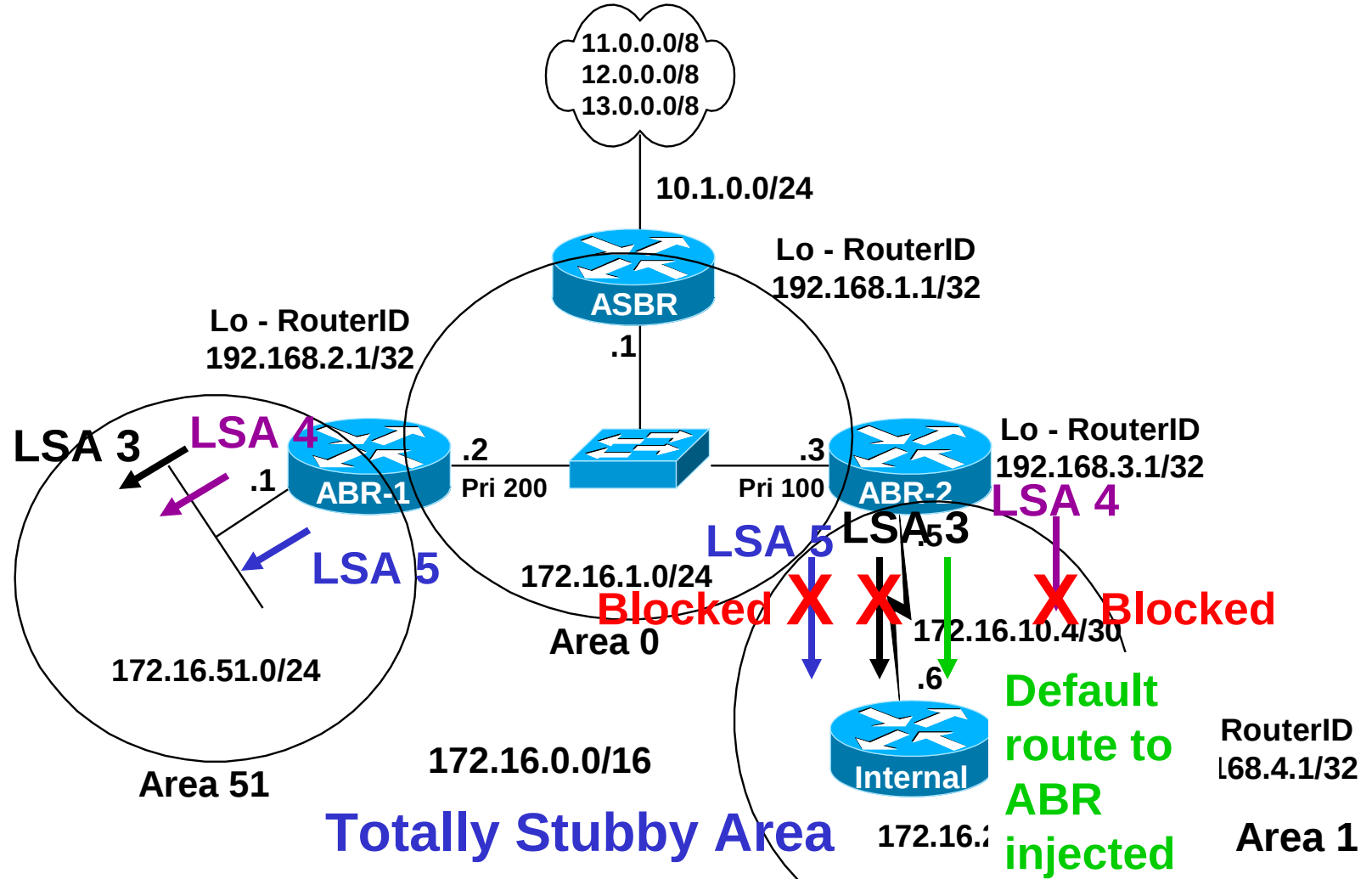
```
router ospf 1
 network 172.16.1.0 0.0.0.255 area 0
 network 172.16.10.4 0.0.0.3 area 1
 area 1 stub no-summary
```

^^ Command: **area area stub no-summary**

Internal

```
router ospf 1
 network 172.16.0.0 0.0.255.255 area 1
 area 1 stub
```

^^ Command: **area area stub**



- LSA 3s (Inter-Area routes) are blocked by the ABR.
- ABR blocks all LSA 4s (reachability to ASBR) and LSA 5s (External routes)
- The ABR injects a default route (LSA 3) into the stub area, pointing to the ABR. (This does not mean the ABR has a default route of its own.)
- Essentially, internal routers in a Totally Stubby Area only see the default route to the ABR.

Totally Stubby Areas

Internal

```
Internal# show ip ospf database
```

```
Summary Net Link States (Area 1)
```

```
LSA 3 - Generated by the ABR.
```

```
Describes links between ABR and Internal Routers of the Local Area
```

Link ID	ADV Router	Age	Seq#	Checksum
Default Route - Advertised by ABR-2				
0.0.0.0	192.168.3.1	205	0x80000003	0x8648

Default Route injected by ABR (LSA 3)

- Default route is injected into totally stubby area by ABR for all other networks (inter-area and external routes)
- Does **not** receive routes from other areas (Inter-Area)
- Does **not** receive routes from External A.S. (External Routes)

Totally Stubby Areas

Internal

```
Internal# show ip route
```

```
Gateway of last resort is 172.16.10.5 to network 0.0.0.0
```

```
172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
```

```
C      172.16.20.0/24 is directly connected, FastEthernet0
```

```
C      172.16.10.4/30 is directly connected, Serial0
```

```
192.168.4.0/32 is subnetted, 1 subnets
```

```
C      192.168.4.1 is directly connected, Loopback0
```

```
0*IA 0.0.0.0/0 [110/782] via 172.16.10.5, 00:03:09, Serial0
```

- Default route is injected into totally stubby area by ABR for all other networks (inter-area and external routes)
- Does **not** receive routes from other areas (Inter-Area)
- Does **not** receive routes from External A.S. (External Routes)

OSPF design considerations

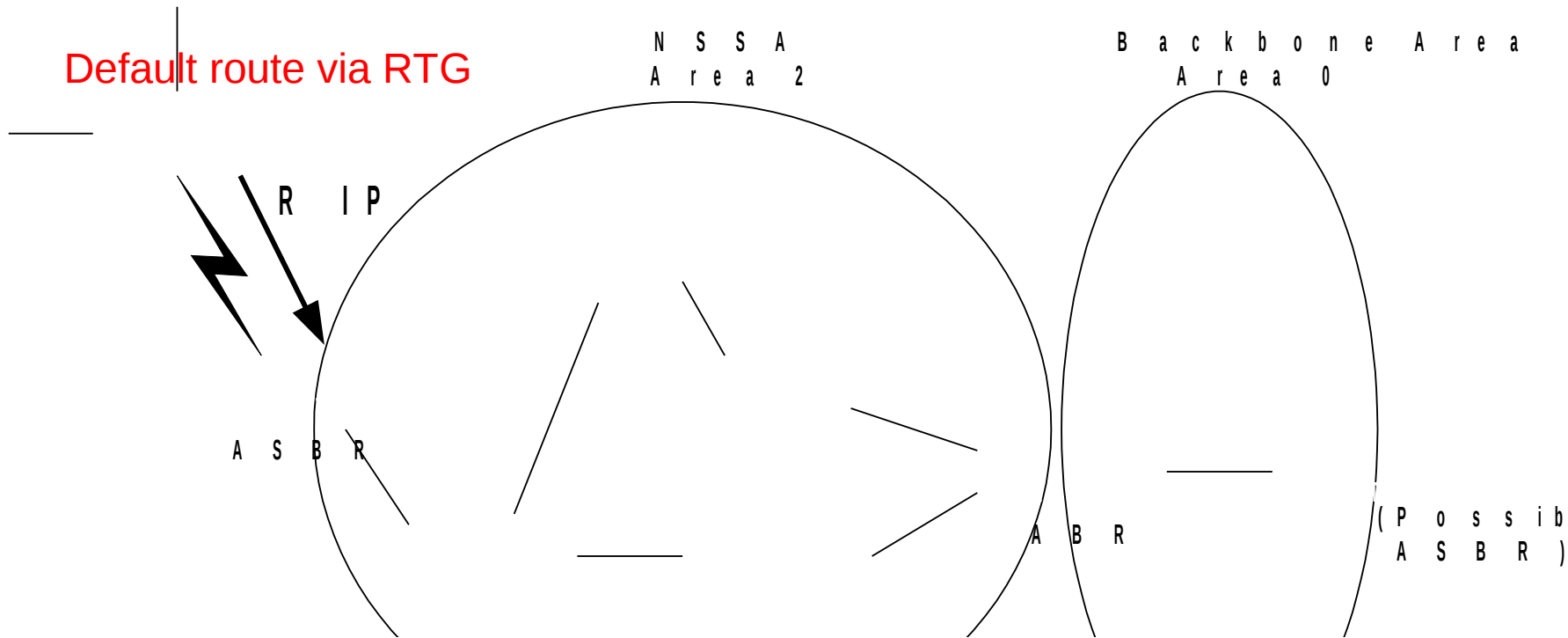
Stub and Totally Stubby Areas:

- An area could be qualified a stub when there is a single exit point (a single ABR) from that area or if routing to outside of the area does not have to take an optimal path.
- The ASBR is not within the stub area
- The area is not the backbone area (area 0)
- Stub areas will result in memory and processing savings depending upon the size of the network. - This is even more true with Totally Stubby areas
- Totally Stubby areas is a Cisco enhancement.

NSSA (Not So Stubby Area)

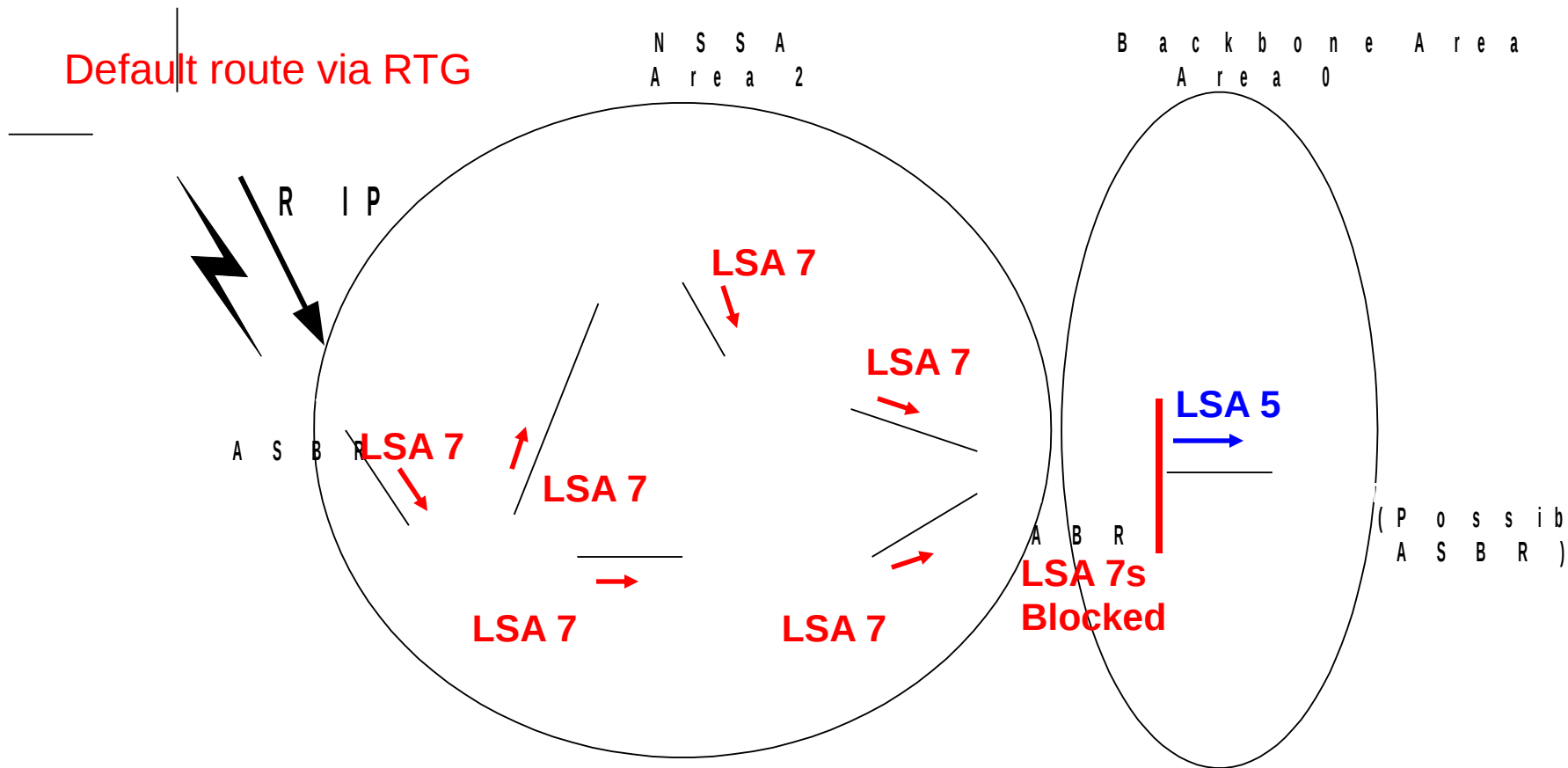
- NSSA allows an area to remain a stub area, but carry external routing information (Type 7 LSAs) from its stubby end back towards the OSPF backbone.
- ASBR in NSSA injects external routing information into the backbone and the NSSA area, but rejects external routing information coming from the ABR.
- The ABR does not inject a default route into the NSSA.
 - This is true for a NSSA Stub, but a default route is injected for a NSSA Totally Stubby area.
- Following scenario is only example of how NSSA works. For the purposes of learning about NSSAs, don't get hung up on the why's and what if's.

Default route via RTG



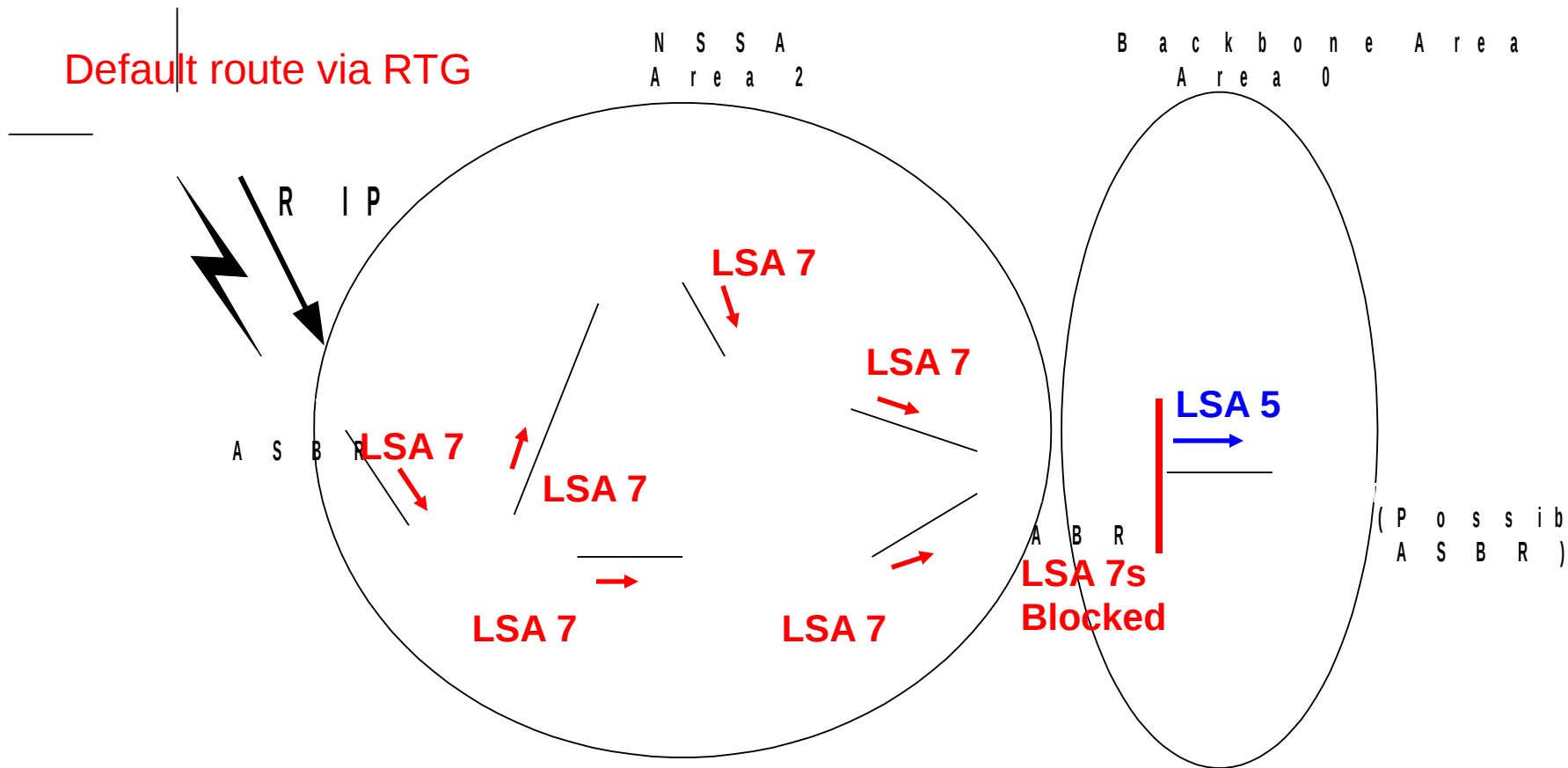
NSSA Stub Area

- Area 2 would like to be a stub network.
- RTH only supports RIP, so RTG will run RIP and redistribute those routes in OSPF.
- Unfortunately, this makes the area 2 router, RTG, an ASBR and therefore area 2 can no longer be a stub area.
- RTH does not need to learn routes from OSPF, a default route to RTG is all it needs.
- But all OSPF routers must know about the networks attached to the RIP router, RTH, to route packets to them.



NSSA Stub Area (cont.)

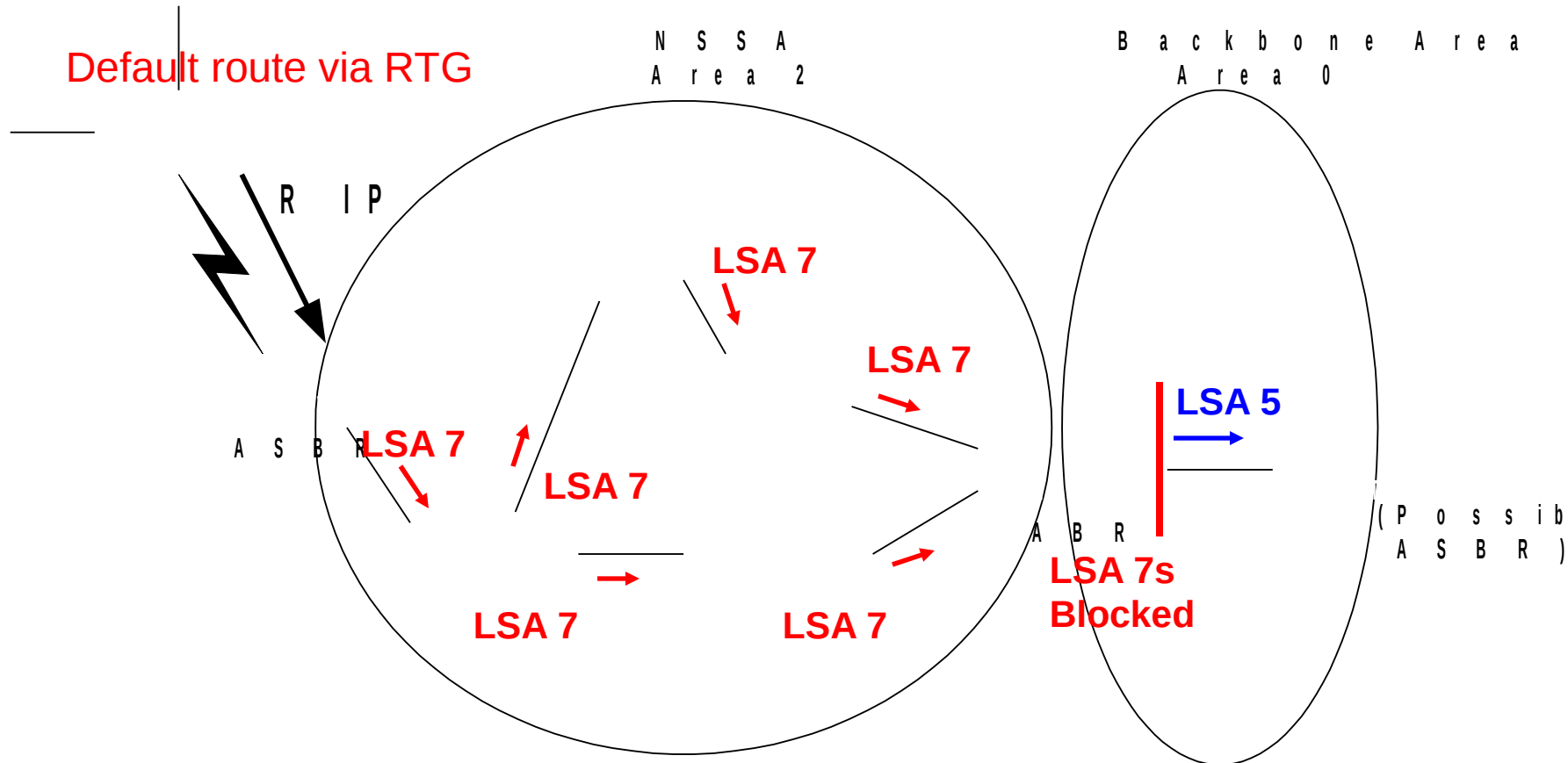
- NSSA allow external routes to be advertised into the OSPF AS while retaining the characteristics of a stub area to the rest of the OSPF AS.
- ASBR RTG will originate Type-7 LSAs to advertise the external destinations.
- These LSA 7s are flooded through the NSSA but are blocked by the NSSA ABR.
- The NSSA ABR translates LSA 7s into LSA 5s and flood other areas.



Type 7 LSA NSSA External Link Entry

- Originated by an ASBR connected to an NSSA.
- Type 7 messages can be flooded throughout NSSAs and translated into LSA Type 5 messages by ABRs.
- Routes learned via Type-7 LSAs are denoted by either a default "N1" or an "N2" in the routing table. (Relative to E1 and E2).

NSSA Generic



Configuring NSSA Stub Area

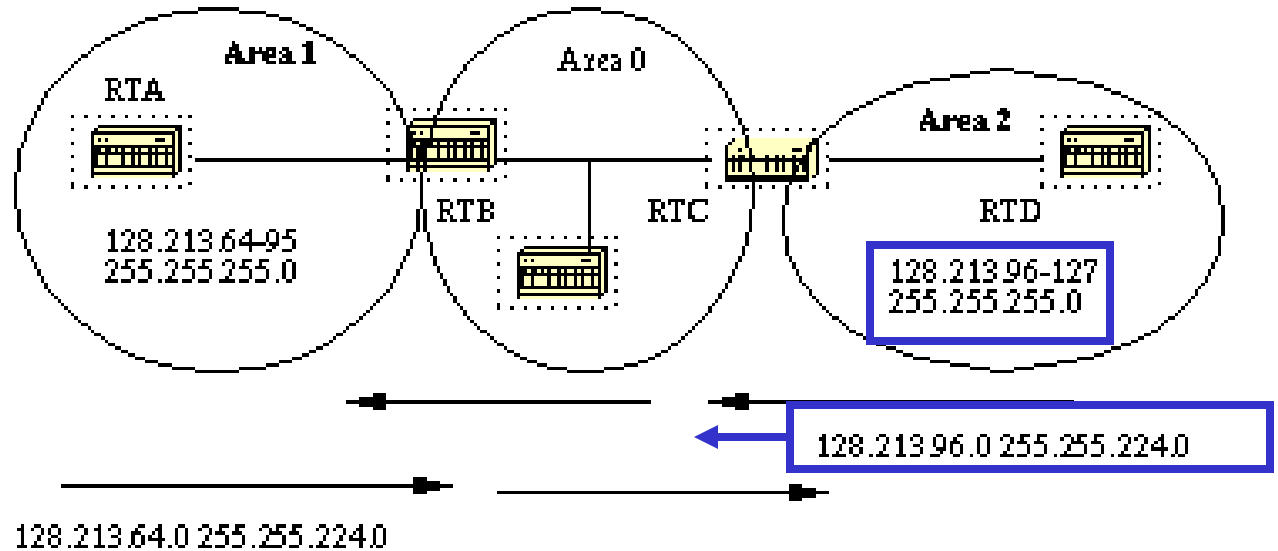
Configured for all routers in Area 2:

```
router ospf 1
```

```
network 172.16.2.0 0.0.0.255 area 2
```

```
area 2 nssa
```

Route Summarization



128.213.96.0/24 - 011 00000

128.213.127.0/24 - 011 11111

128.213.96.0/19 - 01100000

RTC

router ospf 100

area 2 range 128.213.96.0 255.255.224.0

Injecting Default Routes into OSPF

- By default, 0.0.0.0/0 route is not propagated from the ASBR to other routers.
- An autonomous system boundary router (ASBR) can be forced to generate a default route into the OSPF domain.
- As discussed earlier, a router becomes an ASBR whenever routes are redistributed into an OSPF domain.
- However, an ASBR does not, by default, generate a default route into the OSPF routing domain.

Injecting Default Routes into OSPF

The way that OSPF generates default routes (0.0.0.0) varies depending on the type of area the default route is being injected into.

Stub and Totally Stubby Areas

- For stub and totally stubby areas, the area border router (ABR) to the stub area generates a summary link-state advertisement (LSA) with the link-state ID 0.0.0.0.
- This is true even if the ABR doesn't have a default route.
- In this scenario, you don't need to use the **default-information originate** command.

Injecting Default Routes into OSPF

To have OSPF generate a default route use the following:

```
router ospf 10
default-information originate [always] [metric metric-value]
                             [metric-type type-value] [route-map map-name]
```

Injecting Default Routes into OSPF

There are two ways to generate a default.

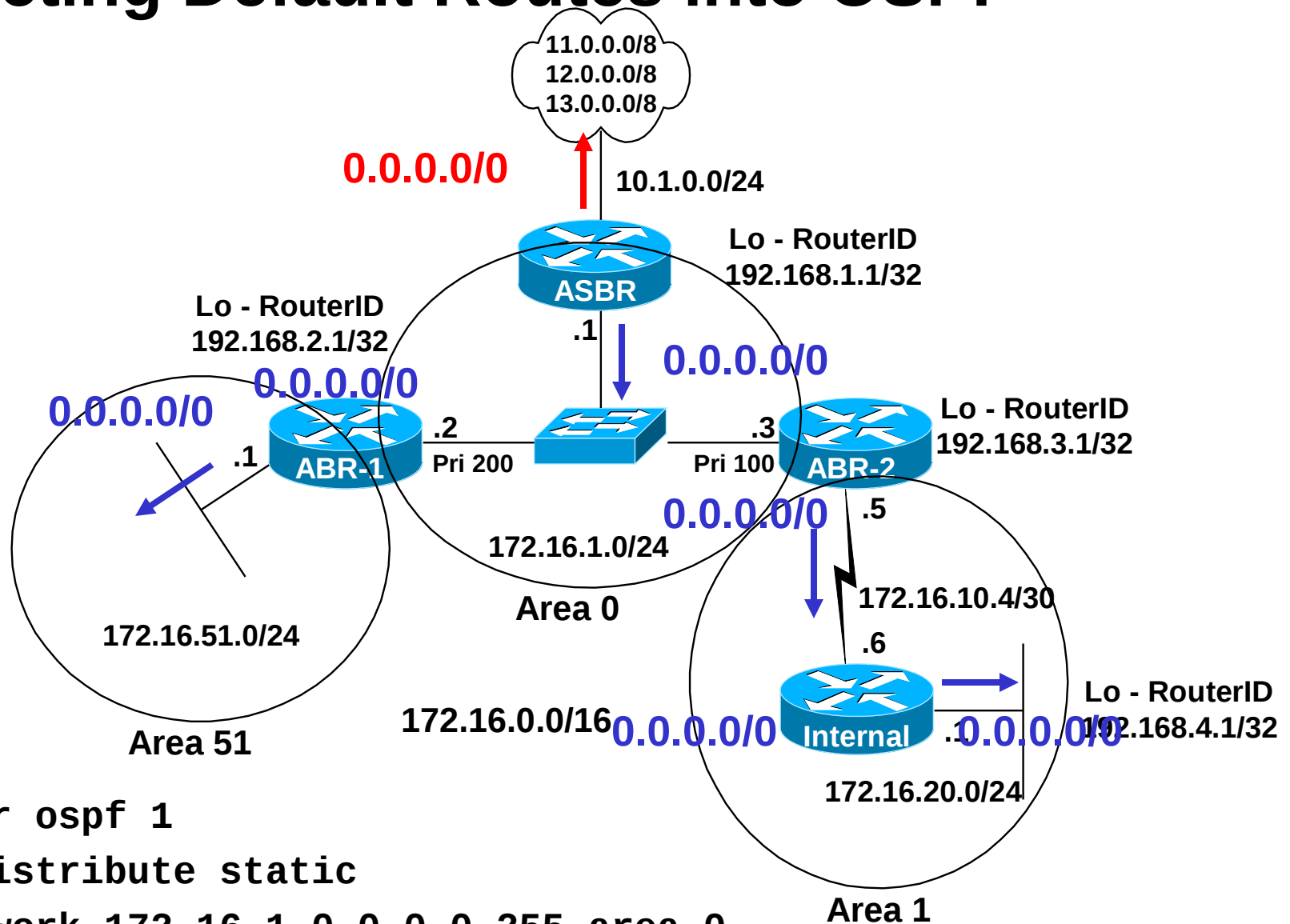
1) **default-information originate**

- If the ASBR already has the default route (ip route 0.0.0.0 0.0.0.0), you can advertise 0.0.0.0 into the area.

2) **default-information originate always**

- If the ASBR doesn't have the route (ip route 0.0.0.0 0.0.0.0), you can add the keyword **always** to the **default-information originate** command, and then advertise 0.0.0.0.
- You should be careful when using the **always** keyword. If your router advertises a default (0.0.0.0) inside the domain and does not have a default itself or a path to reach the destinations, routing will be broken.

Injecting Default Routes into OSPF



ASBR

```
router ospf 1
```

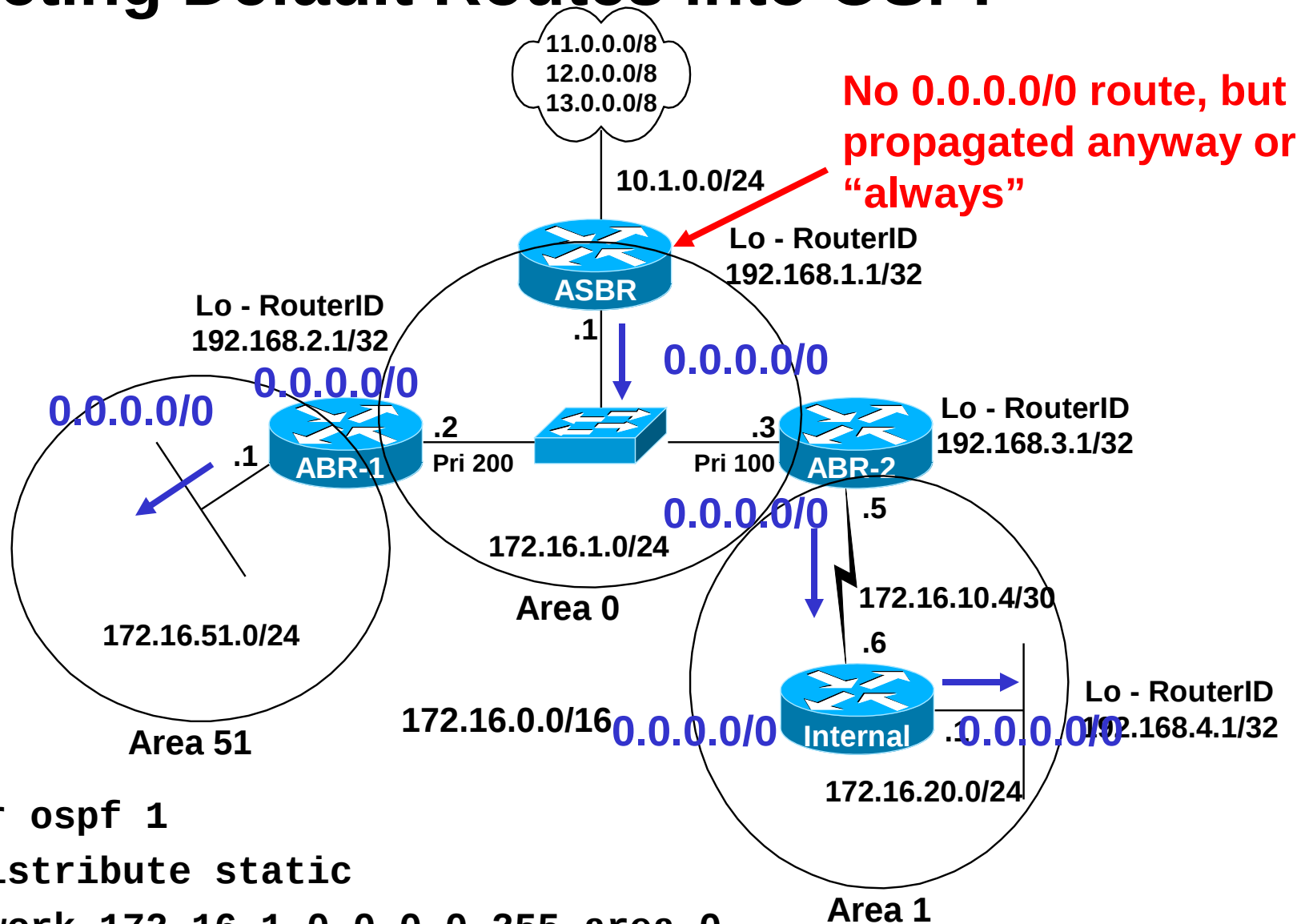
```
redistribute static
```

```
network 172.16.1.0 0.0.0.255 area 0
```

```
default-information originate
```

```
ip route 0.0.0.0 0.0.0.0 10.0.0.2
```

Injecting Default Routes into OSPF



ASBR

router ospf 1

redistribute static

network 172.16.1.0 0.0.0.255 area 0

default-information originate always

~~ip route 0.0.0.0 0.0.0.0 10.0.0.2~~

Redistributing External Routes

E1 vs. E2 External Routes

- External routes fall under two categories, external type 1 and external type 2.
- The difference between the two is in the way the cost (metric) of the route is being calculated.
- A **type 1 (E1)** cost is the addition of the external cost and the internal cost used to reach that route.
- The cost of a **type 2 (E2)** route is always the external cost, irrespective of the interior cost to reach that route.
- ***Type 2 (E2) is the default!***

show ip ospf database

Internal#show ip ospf data

OSPF Router with ID (192.168.4.1) (Process ID 1)

Router Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum	Link count
192.168.3.1	192.168.3.1	898	0x80000003	0xCE56	2
192.168.4.1	192.168.4.1	937	0x80000003	0xFD44	3

Summary Net Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
172.16.1.0	192.168.3.1	848	0x80000005	0xD339
172.16.51.1	192.168.3.1	843	0x80000001	0xB329

Summary ASB Link States (Area 1)

Link ID	ADV Router	Age	Seq#	Checksum
192.168.1.1	192.168.3.1	912	0x80000003	0x93CC

Type-5 AS External Link States

Link ID	ADV Router	Age	Seq#	Checksum	Tag
11.0.0.0	192.168.1.1	1302	0x80000001	0x3FEA	0
12.0.0.0	192.168.1.1	1303	0x80000001	0x32F6	0
13.0.0.0	192.168.1.1	1303	0x80000001	0x2503	0

Router Link States (LSA 1)

- Router Link States (LSA1's) should display all the RouterIDs of routers in that area, including its own.
- Link State ID is always the same as the Advertising Router.
- ADV Router is the Router ID of the router that created this LSA 1.

Net Link States (LSA 2)

- Net Link States (LSA2's) should display the RouterIDs of the DRs on all multi-access networks in the area and their IP addresses.
- Link ID is the IP address of DR on MultiAccess Network.
- ADV Router is the Router ID of the DR.

Summary Link States (LSA 3)

- Should see networks in other areas and the ABR advertising that route.
- Link ID is the IP network addresses of networks in other areas.
- ADV Router is the ABR Router ID sending the LSA-3.

Summary ASB Link States (LSA 4)

- Routers in non-area 0, should see Router ID of ASBR and its ABR to get there.
- Link ID is the Router ID of ASBR
- ADV Router is the Router ID of the ABR advertising route

Type-5 AS External Link States (LSA 5)

- All Routers should see External networks and the Router ID of ASBR to get there
- Link ID is the External Network
- ADV Router is the Router ID of ASBR advertising the LSA 5.