

OSPFv3 (RFC 2740)



OSPFv3 and v2 Differences

- Protocol processing per-link, not per-subnet
- Removal of addressing semantics
- Addition of Flooding scope
- Explicit support for multiple instances per link
- Use of IPv6 link-local addresses
- Authentication method changes
- Packet format, LSA's header format changes
- Handling of unknown LSA types

OSPFv3 and v2 Similarities

packet type	Description
1	Hello
2	Database Description
3	Link State Request
4	Link State Update
5	Link State Acknowledgment

- **OSPFv3 has the same 5 packet type but some fields have been changed.**
- **Mechanisms for neighbor discovery and adjacency formation**
- **Interface types**
 - P2P, P2MP, Broadcast, NBMA, Virtual
- **LSA flooding and aging**
- **Nearly identical LSA types**

OSPFv3 and v2 header comparison

Version	Type	Packet Length
Router ID		
Area ID		
Checksum	Autype	
Authentication		
Authentication		

Version	Type	Packet Length
Router ID		
Area ID		
Checksum	Instance ID	0

- **Size of the header is reduced from 24 bytes to 16**
- **Router ID & Area ID are still a 32 bit numbers**
- **Instance ID is a new field that is used to have multiple OSPF process' instance per link. In order for 2 instances talk to each other they need to have the same instance ID. **By default it is 0** and for any additional instance it is increased, Instance ID has local link significance only**
- **Authentication fields have been suppressed – RFC 4552 talks about the authentication implementation in OSPFv3**

OSPFv3 LSA Details



OSPFv3 & v2 LSA Header Comparison

LS age	Options	LS type
Link State ID		
Advertising Router		
LS sequence number		
LS checksum	Length	

LS age	LS type
Link State ID	
Advertising Router	
LS sequence number	
LS checksum	Length

- Option field is removed from the header to the body of the LSA
- LS type field in the LSA header has increased from 1 byte to 2 bytes. It indicates the function performed by the LSA (more on next slide)
- The behavior of assigning Link State ID value has changed from v4 to v6, we will talk about the change of behavior as we go to each of the LSA
- Advertising router still contain the RID of the LSA originator

OSPFv3 LSA Types

- Here is the list of LSA in OSPFv3

LSA Name	LS Type code	Flooding scope	LSA Function code
Router LSA	0x2001	Area scope	1
Network LSA	0x2002	Area scope	2
Inter-Area-Prefix-LSA	0x2003	Area scope	3
Inter-Area-Router-LSA	0x2004	Area scope	4
AS-External-LSA	0x4005	AS scope	5
Group-membership-LSA	0x2006	Area scope	6
Type-7-LSA	0x2007	Area scope	7
Link-LSA	0x0008	Link-local scope	8
Intra-Area-Prefix-LSA	0x2009	Area scope	9

OSPFv3 and v2 Router LSA comparison

00000VEB	0	# Links
Link ID		
Link Data		
Type	# TOS	metric
.....		
TOS	0	TOS metric

000NtxVEB	Options	
Type	0	Metric
Interface ID		
Neighbor Interface ID		
Neighbor Router ID		

- New bit (removed in latest specs)**

bit Nt: This is from RFC 3101, when set, the router is an NSSA ABR

bit x: This used to be W bit for MOSPF and has been reclaimed in the latest OSPFv3 RFC

Router interface information may be spread across multiple Router LSAs. Receivers must concatenate all the Router-LSAs originated by a given router when running the SPF calculation.

The Options field and Nt, V, E and B bits should be the same in all Router LSAs from a single originator.

In the case of a mismatch the values in the LSA with the lowest Link State ID take precedence.

OSPFv3(Router LSA of R3 for Area 1)

```
R3#show ipv6 ospf database router self
```

Router Link States (Area 1)

LS age: 0

Options: (V6-Bit E-Bit R-bit DC-Bit)

LS Type: Router Links

Link State ID: 0

Advertising Router: 3.3.3.3

Checksum: 0x146B

Length: 56

Area Border Router

Link connected to: a Transit Network

Link Metric: 1

Local Interface ID: 3

Neighbor (DR) Interface ID: 3

Neighbor (DR) Router ID: 1.1.1.1

Always 0 at origination

This is an IPv6 router

This is a router LSA

First Fragment

Router ID of R3

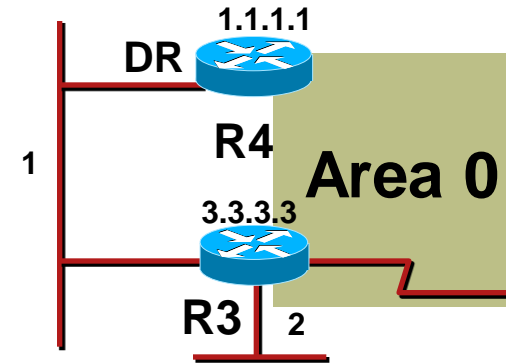
bit B = 1

Cost to reach the interface

Could be IfIndex of the local interface

Could be IfIndex of the neighbor int

Router ID of R1



OSPFv3 and vs Network LSA comparison

Network Mask
Attached Router
.....

0	Options
Attached Router	
.....	

- Function code **0x2002** – Area Wide flooding scope
- In OSPFv2, Link State ID in the header contain DR IP address of Transit link and the mask was inside the type 2 LSA. This combination was used to install the IP address of the transit link.
- In OSPFv3 IP address are carried in intra-area-prefix-LSA (FC 9) therefore the mask field has been removed from network LSA also **Link State ID in the LSA header contain DR's Interface ID**

OSPFv3 (Network LSA by R4)

```
R3#show ipv6 ospf database network 3
Network Link States (Area 1)
```

LS age: 992

Options: (V6-Bit E-Bit R-bit DC-Bit)

LS Type: Network Links

Link State ID: 3

Advertising Router: 4.4.4.4

Checksum: 0x146B

Length: 40

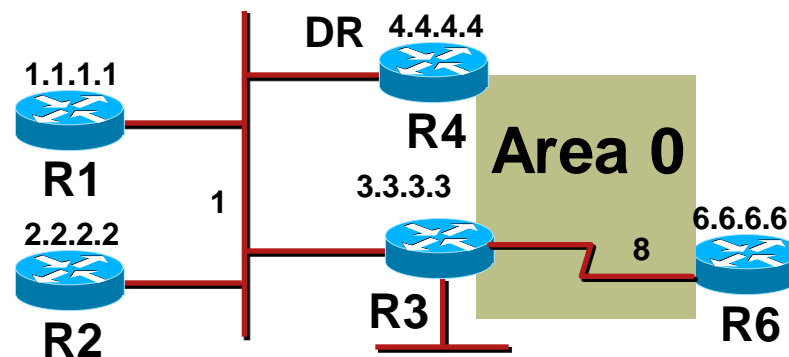
Attached Router: 1.1.1.1

Attached Router: 2.2.2.2

Attached Router: 3.3.3.3

Attached Router: 4.4.4.4

This is a Network LSA
Interface ID of the DR
RID of the DR



OSPFv3 (Link LSA Details) - NEW

- Function Code of **0x0008** - Link local flooding scope.
- This is a new LSA in OSPFv3 and it is used to advertise one or more IPv6 prefixes on a given link
- Link LSA's are generated for every link that has **2 or more routers**
- Note, in OSPFv2 link address information (routers' interface ip address) was carried in Router LSA's "Link Data" field. This information was used for the next hop calculation
- Link LSA **MUST** not be originated for Virtual links.
- LinkLSASupression (new in the latest specs)

OSPFv3 (Link LSA Details)

Rtr Pri	Options	
Link-local Interface address (128-bit)		
# prefixes		
PrefixLength	PrefixOptions	0
Address prefix (128-bit)		

- **Rtr Pri** is The Router Priority of the interface attaching the originating router to the link.
- **# prefixes** is the number of prefix advertised
- **Link-local interface address** is used for next hop calculation.
- Link-LSA also advertise a list of IPv6 prefixes identified by **{Address prefix, PrefixLength, PrefixOptions}** to other attached router. For example a DR will include this list of IPv6 prefix advertised by a router in its intra-area-prefix-LSA
- Link State ID in the header of the Link-LSA is set to router's Interface ID on the link therefore, size of this LSA is not limited.

OSPFv3 (Link LSA in Area 1)

```
R3#show ip ospf database link
```

Link (Type-8) Link States (Area 1)

LS age: 1

Options: (V6-Bit E-Bit R-bit DC-Bit)

LS Type: Link-LSA (Interface: Ethernet0)

Link State ID: 1 (Interface ID)

Advertising Router: 3.3.3.3

LS Seq Number: 8000002E

Checksum: 0xD7B3

Length: 64

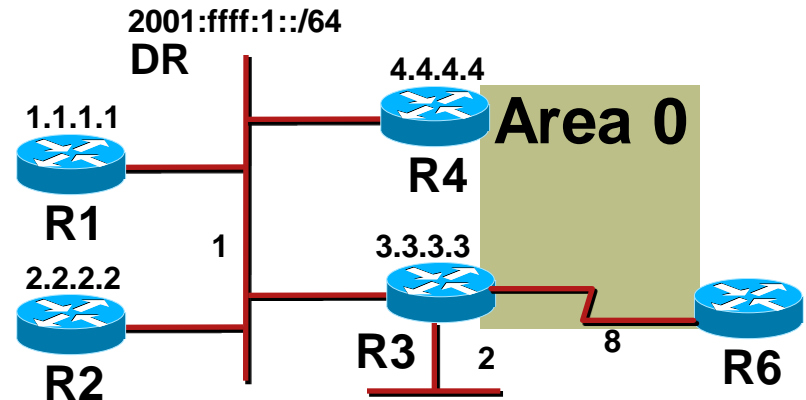
Router Priority: 1

Link Local Address: FE80::204:C1FF:FEDB:2FA0

Number of Prefixes: 1

Prefix Address: 2001:FFFF:1::

Prefix Length: 64, Options: None



interface ID of Ethernet0 on R3

Copied from int pri of the Eth0
Link Local address of R3 Eth0

Prefix assigned on Eth0

OSPFv3 (Link LSA in Area 0)

```
R3#show ip ospf database link
```

Link (Type-8) Link States (Area 0)

LS age: 1936

Options: (V6-Bit E-Bit R-bit DC-Bit)

LS Type: Link-LSA (Interface: Serial0)

Link State ID: 3 (Interface ID)

Advertising Router: 3.3.3.3

LS Seq Number: 8000000E

Checksum: 0xD7B3

Length: 64

Router Priority: 1

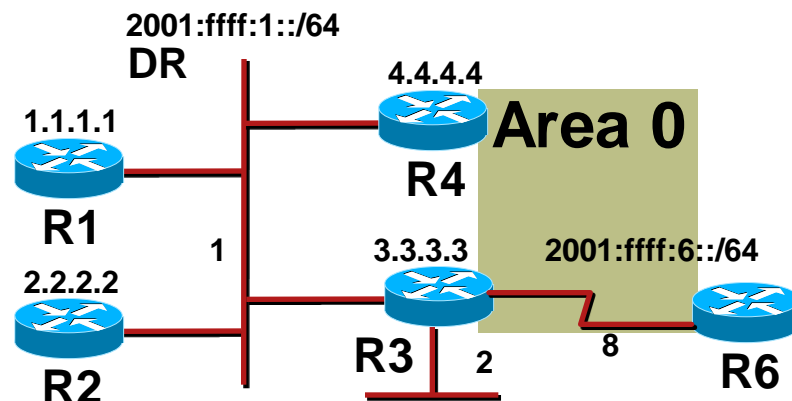
serial0

Link Local Address: FE80::104:C1FF:FEDB:2FA0

Number of Prefixes: 1

Prefix Address: 2001:FFFF:6::

Prefix Length: 64, Options: None



Interface ID of Serial 0 on R3

Copied from Int pri on the

Link Local address of R3 Serial0

Prefix assigned on Serial0

OSPFv3 (Intra-area-prefix LSA Details) - **NEW**

- Function code **0x2009** – Area wide scope
- This is a new LSA in OSPFv3 and used in order to advertise one or more IPv6 prefixes. The prefixes are associated with router segment, Stub network segment or transit network segment.
- In OSPFv2 the intra area prefix information was carried in the Router and Network LSA's

OSPFv3 (Intra-area-prefix LSA Details)

# Prefixes	Referenced LS type	
Referenced Link State ID		
Referenced Advertising Router		
PrefixLength	PrefixOptions	Metric
Address Prefix (128-bit)		

- # prefixes is the number of prefixes advertised
- Each IPv6 address is associate with { Address prefix, PrefixLength, PrefixOptions }
- The three field { Referenced LS type, Referenced Link State ID, Referenced Advertising Router } identifies the Router LSA or Network LSA that the Intra-Area-Prefix-LSA should be associated with.

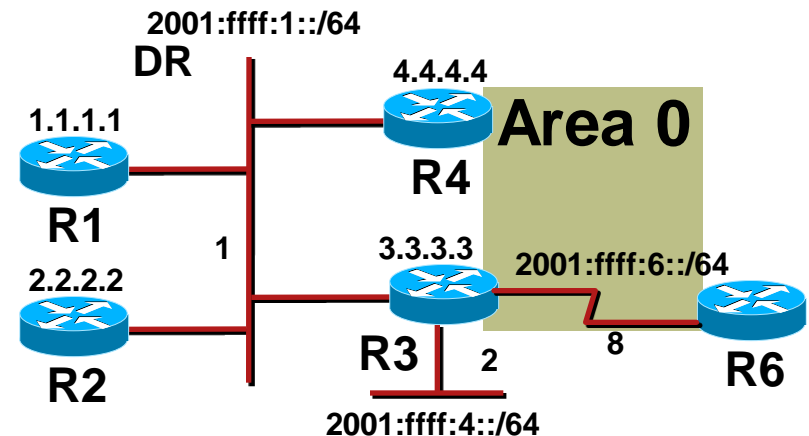
OSPFv3 (Intra-area-prefix LSA Ref 2001)

R3#show ipv6 ospf database prefix
Intra Area Prefix Link States (Area 0)

Routing Bit Set on this LSA

LS age: 1431
LS Type: Intra-Area-Prefix-LSA
Link State ID: 177
Advertising Router: 3.3.3.3
LS Seq Number: 80000006
Checksum: 0x4005
Length: 56

Referenced LSA Type: 2001
Referenced Link State ID: 0
Referenced Advertising Router: 3.3.3.3
Number of Prefixes: 1
Prefix Address: 2001:FFFF:6::
Prefix Length: 64, Options: None, Metric: 8



Router LSA
0 for Router LSA
Originating router's RID

prefix configured on S0
Metric is copied from the Interface

OSPFv3 (Inter-area-prefix LSA Details)

Network Mask	
0	metric
TOS	TOS metric

0	metric	
PrefixLength	PrefixOptions	0
Address Prefix 128-bit		

- Function code **0x2003** – Area wide flooding scope
- Inter-Area-Prefix-LSA announce destinations outside of the area (type 3 in OSPFv2)
- All TOS field have been suppressed
- In OSPFv2 Link State ID in the LSA header contain IP destination outside of the area and the mask is in the body of the LSA
- In OSPFv3 Link State ID is just a fragment number and the prefix is moved into the body of the LSA
- All Prefix in OSPFv3 is defined by 3 fields {Address Prefix, PrefixLength, PrefixOptions}

OSPFv3 (Inter-area-prefix LSA Details)

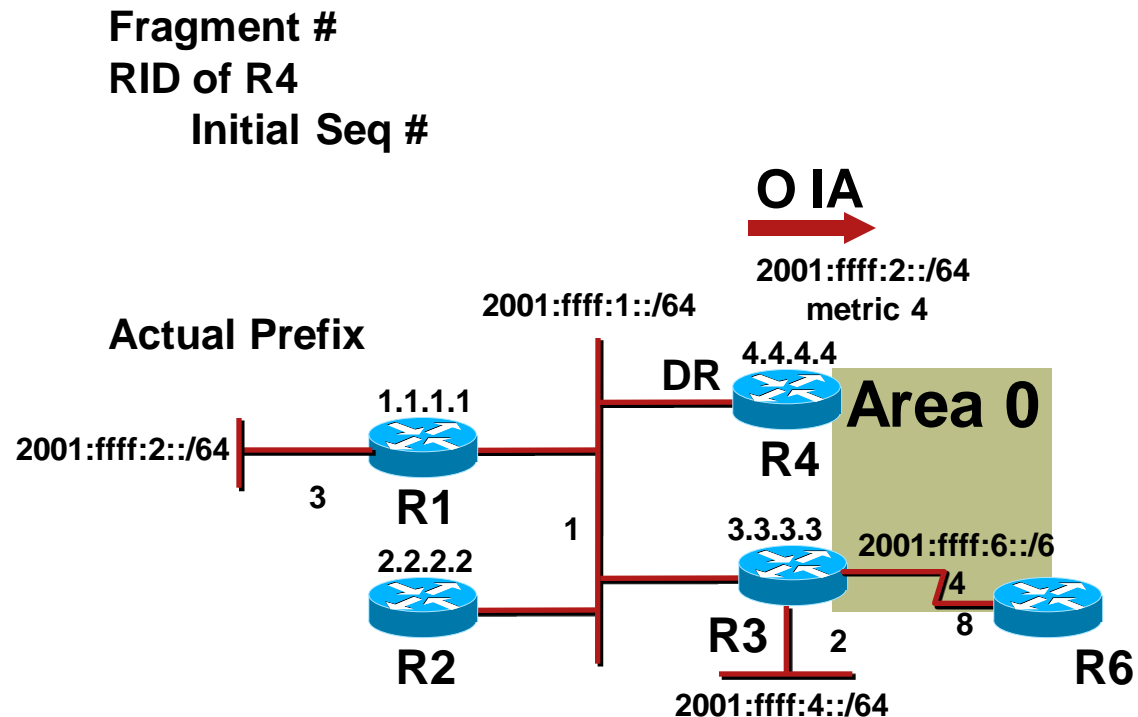
```
R3#sh ipv6 ospf database inter-area prefix 2001:FFFF:3::/64
```

Inter Area Prefix Link States (Area 0)

Routing Bit Set on this LSA

LS age: 81
LS Type: Inter Area Prefix Links
Link State ID: 5
Advertising Router: 4.4.4.4
LS Seq Number: 80000001
Checksum: 0xFC68
Length: 44

Metric: 4
Prefix Address: 2001:FFFF:2::
Prefix Length: 64, Options: None



OSPFv3 (Inter-Area-Router-LSA Details)

Network Mask	
0	metric
TOS	TOS metric

0	Options
0	Metric
Destination Router ID	

- Function code **0x2004** – Area wide flooding scope
- Inter-Area-Router-LSA announce the location of ASBR (type 4 in OSPFv2)
- In OSPFv2 the mask field is not used for type 4 and contains zero so suppressed in OSPFv3
- In OSPFv2 Link State ID in the header contain the Router ID of the ASBR. In OSPFv3 Link State ID is just a fragment number and ASBR Router ID is inside the body of LSA.
- Note, Cisco implementation converts the ASBR RID in decimal and put it under Link State ID

OSPFv3(Inter-area Router LSA Details)

R3#show ipv6 ospf database inter-area router 117901063

Inter Area Router Link States (Area 1)

LS age: 60

Options: (V6-Bit E-Bit R-bit DC-Bit)

LS Type: Inter Area Router Links

Link State ID: 117901063

Advertising Router: 4.4.4.4

LS Seq Number: 80000001

Checksum: 0xFC68

Length: 44

Metric: 16

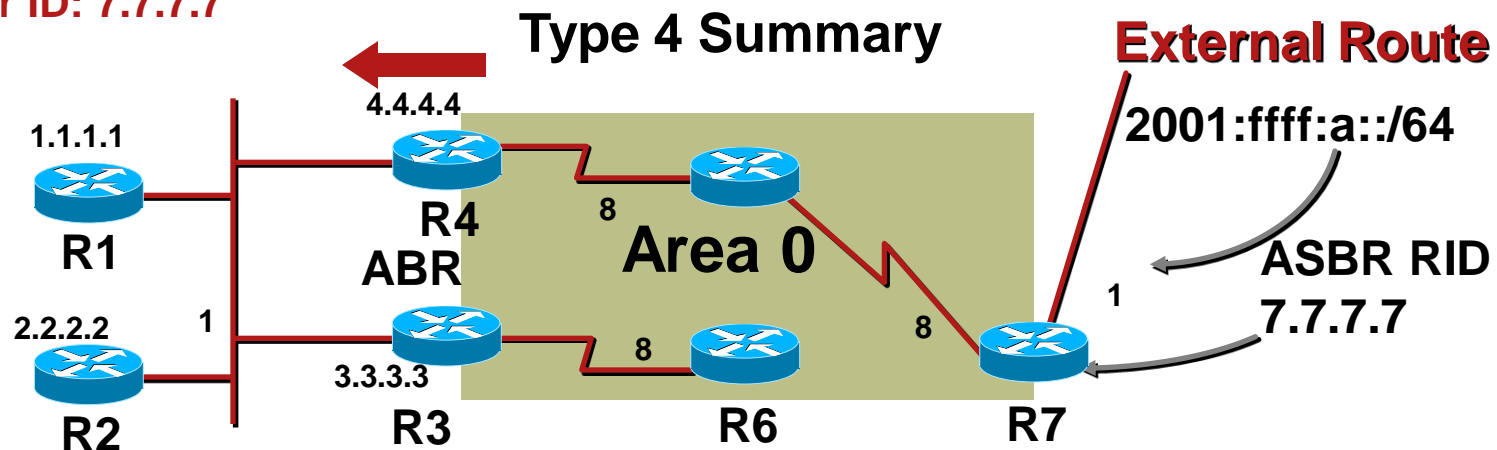
Destination Router ID: 7.7.7.7

Function Type 2004

Frag # - RID of ASBR (Cisco)

RID of ABR (R4)

Initial Seq #



OSPFv3 & v2 External LSA Difference

Network Mask	
E0000000	Metric
Forwarding Address	
External Route Tag	
E TOS	TOS metric

0 0 0 0 0 E FT	metric	
PrefixLength	PrefixOptions	Referenced LS Type(opt)
Address Prefix 128-bit		
Forwarding address (optional) 128-bit		
External Route Tag (optional)		
Referenced Link State ID (optional)		

- Function Type code **0x4005** – AS wide flooding scope
- There are two new fields in OSPFv3, **Referenced LS type and Referenced Link State ID**. The Referenced Link State ID field would present **ONLY** if Referenced LS Type is non-zero
- If a router advertising an As-External-LSA wants to announce additional information regarding external route that is not used by OSPF itself (for example BGP external route attribute) it sets Referenced LS type and Referenced Link State ID in order to announce additional information.
- Fwd address is now **optional** – must NOT be set to :: or link-local

OSPFv3 (External LSA Details)

R3#show ip ospf database external

Routing Bit Set on this LSA

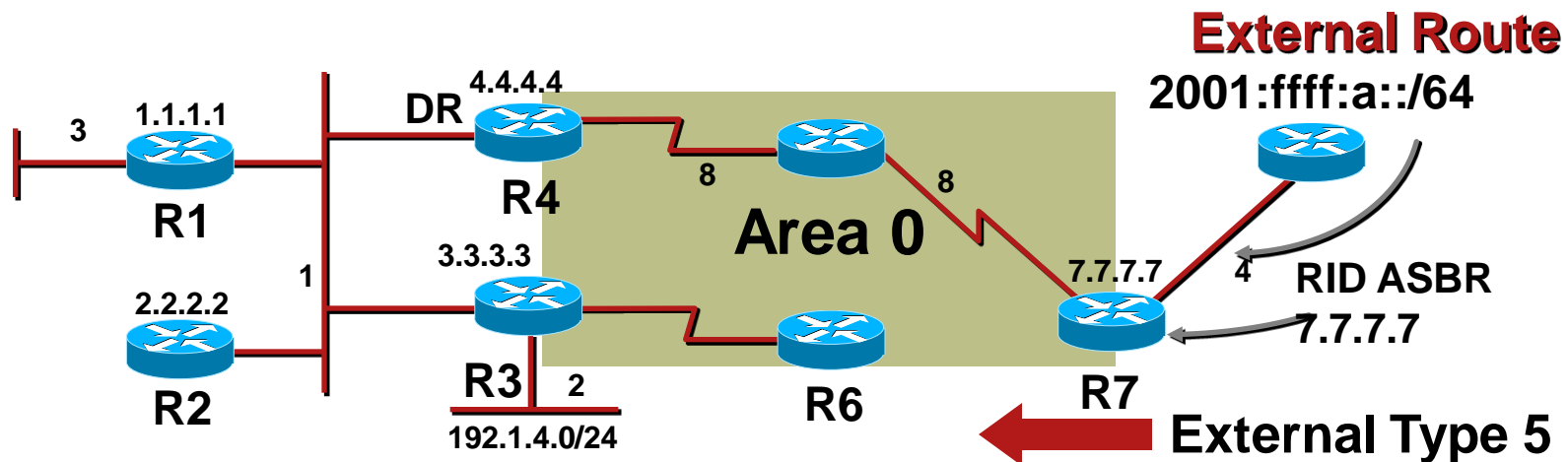
LS age: 473
LS Type: AS External Link
Link State ID: 5
Advertising Router: 7.7.7.7
LS Seq Number: 80000001
Checksum: 0x77AB
Length: 36

Prefix Address: 2001:FFFF:A::
Prefix Length: 64,
Metric Type: 2
Metric: 20

Frag #
RID of ASBR
Initial Seq #

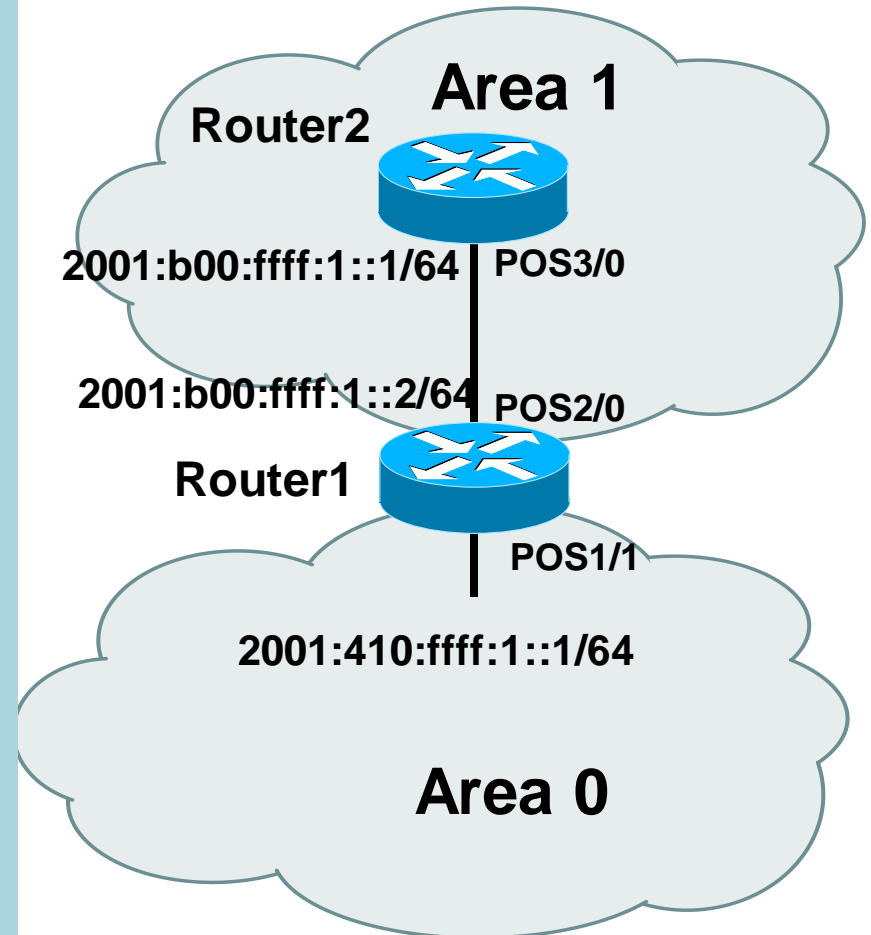
External Prefix

bit E = 1 -> O E2 (Default)



OSPFv3 Configuration Example

```
Router1#  
interface POS1/1  
  ipv6 address 2001:410:FFFF:1::1/64  
  ipv6 enable  
  ipv6 ospf 100 area 0  
  
interface POS2/0  
  ipv6 address 2001:B00:FFFF:1::2/64  
  ipv6 enable  
  ipv6 ospf 100 area 1  
  
ipv6 router ospf 100  
  router-id 10.1.1.3  
  
Router2#  
interface POS3/0  
  ipv6 address 2001:B00:FFFF:1::1/64  
  ipv6 enable  
  ipv6 ospf 100 area 1  
  
ipv6 router ospf 100  
  router-id 10.1.1.4
```



OSPFv3 Show Commands

```
Router2#sh ipv6 ospf int pos 3/0
POS3/0 is up, line protocol is up
  Link Local Address FE80::290:86FF:FE5D:A000, Interface ID 7
  Area 1, Process ID 100, Instance ID 0, Router ID 10.1.1.4
  Network Type POINT_TO_POINT, Cost: 1
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:02
  Index 1/1/1, flood queue length 0
  Next 0x0(0)/0x0(0)/0x0(0)
  Last flood scan length is 3, maximum is 3
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1, Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.1.3
  Suppress hello for 0 neighbor(s)
```

OSPFv3 Show Commands

```
Router2#sh ipv6 ospf neighbor detail
```

```
Neighbor 10.1.1.3
```

```
  In the area 1 via interface POS3/0
```

```
Neighbor: interface-id 8, link-local address FE80::2D0:FFFF:FE60:DFFF
```

```
Neighbor priority is 1, State is FULL, 12 state changes
```

```
Options is 0x630C34B9
```

```
Dead timer due in 00:00:33
```

```
Neighbor is up for 00:49:32
```

```
Index 1/1/1, retransmission queue length 0, number of retransmission 1
```

```
First 0x0(0)/0x0(0)/0x0(0) Next 0x0(0)/0x0(0)/0x0(0)
```

```
Last retransmission scan length is 2, maximum is 2
```

```
Last retransmission scan time is 0 msec, maximum is 0 msec
```

OSPFv3 Show Commands

```
Router2#sh ipv6 route
IPv6 Routing Table - 5 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
OI 2001:410:FFFF:1::/64 [110/2]
   via FE80::2D0:FFFF:FE60:DFFF, POS3/0
C 2001:B00:FFFF:1::/64 [0/0]
  via ::, POS3/0
L 2001:B00:FFFF:1::1/128 [0/0]
  via ::, POS3/0
L FE80::/10 [0/0]
  via ::, Null0
L FF00::/8 [0/0]
  via ::, Null0
```

