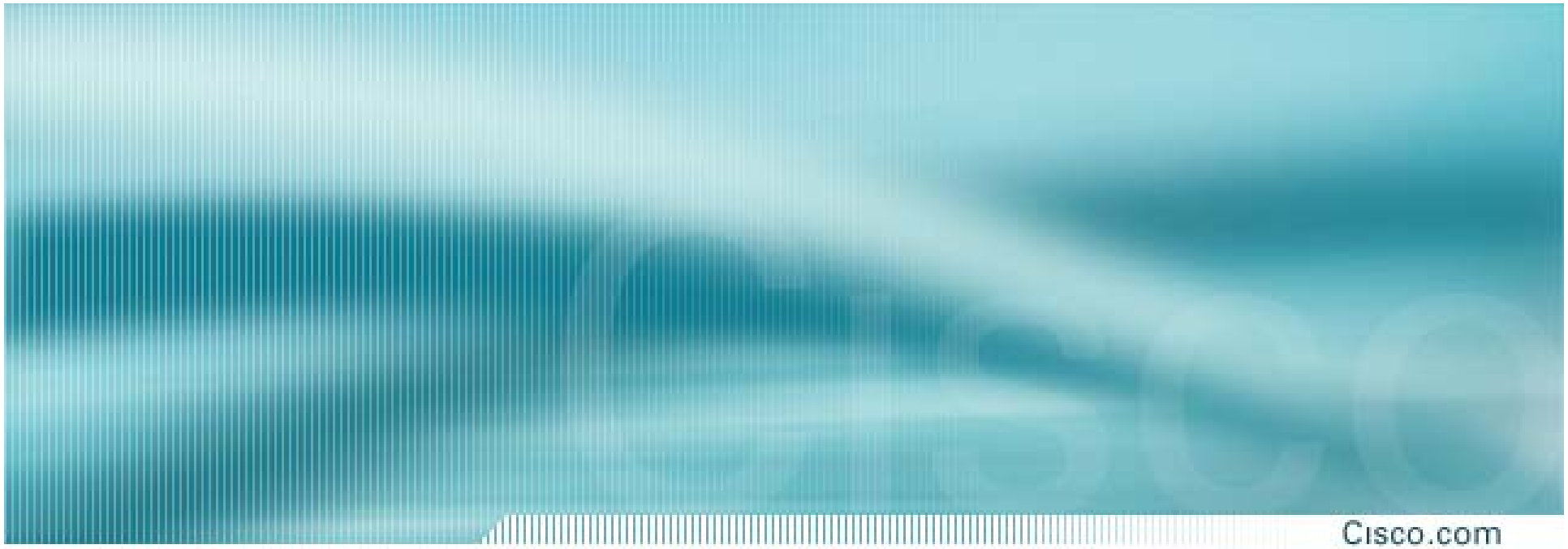


OSPF

Khalid Raza

sraza@cisco.com

OSPF

- **Differences with IPv4**
  - **-Protocol processing per-link, not per-subnet**
  - **-Removal of addressing semantics**
  - **-Addition of Flooding scope**
  - **-Explicit support for multiple instances per link**
  - **-Use of link-local addresses**

OSPF

- **Difference with IPv4**
  - **-Authentication changes**
  - **-Packet format changes**
  - **-LSA format changes**
  - **-Handling unknown LSA types**
  - **-Stub area support**
  - **-Identifying neighbors by Router ID**

OSPF

- **Protocol processing per-link, not per-subnet**
  - **-IPv6 uses the term "link" to indicate communication**
  - **-Interfaces connect to links**
  - **-Multiple IP subnets can be assigned to a single link, and two nodes can talk directly over a single link, even if they do not share a common IP subnet**

OSPF

- **Protocol processing per-link, not per-subnet**
  - **-OSPF for IPv6 runs per-link instead of the IPv4 behavior of per-IP-subnet**
  - **-The terms network and subnet used in the IPv4 OSPF specification is replaced by link**
  - **-Change affects the receiving of OSPF protocol packets, and the contents of Hello Packets and Network-LSAs**

OSPFv3 / OSPFv2 Similarities

- **Basic packet types**
  - **Hello, DBD, LSR, LSU, LSA**
- **Mechanisms for neighbor discovery and adjacency formation**
- **Interface types**
  - **P2P, P2MP, Broadcast, NBMA, Virtual**
- **LSA flooding and aging**
- **Nearly identical LSA types**

OSPFv3 packet type

- **OSPFv3 will have the same 5 packet type but some fields have been changed.**
- **All OSPFv3 packets have a 16 byte header VS the 24 byte header in OSPFv2**

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

OSPF

- **Let us start with basic header**

- **OSPFv2**

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

- **OSPFv3**

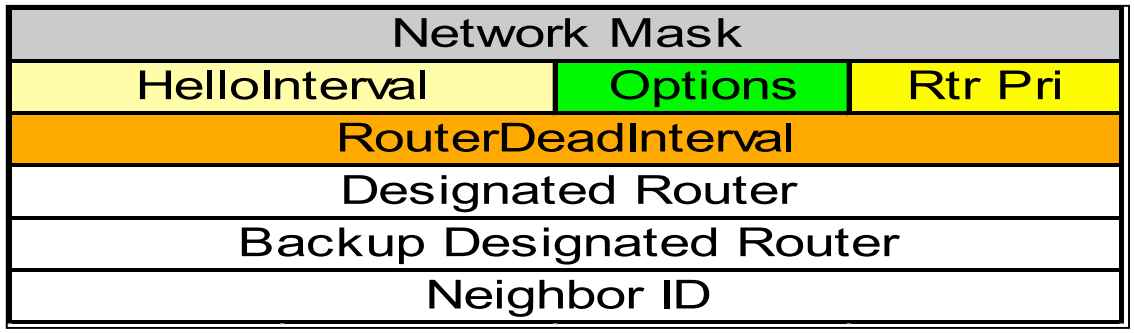
Version	Type	Packet Length
Router ID		
Area ID		
Checksum	Instance ID	0

OSPF

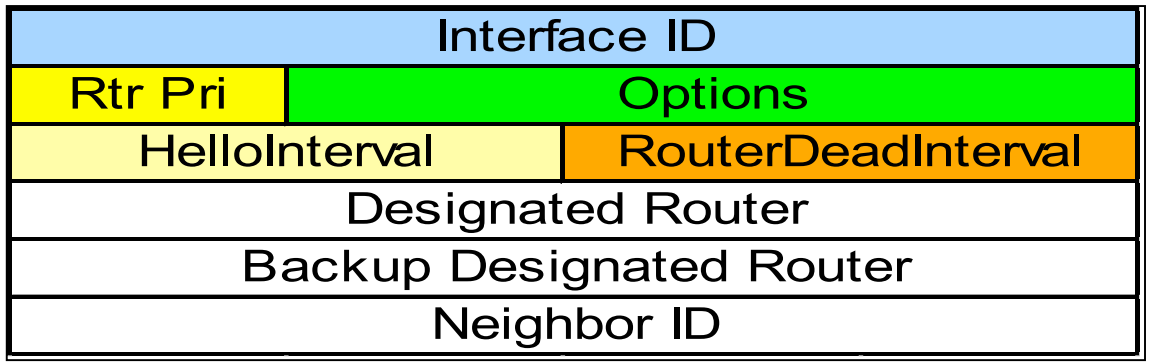
- Size of the header is reduced from 24 bytes to 16
- Router ID is still a 32 bit number uniquely identifying a router in the domain
- Instance ID is a new field that is used to have multiple OSPF process instance per link. In order that 2 instance talk to each other they need to have the same instance 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

Hello Packet
(OSPF header is not represented)

- **OSPFv2**



- **OSPFv3**



OSPF

- **Hello**

  Packet type 1

  Send periodically on all OSPF configured interfaces and on virtual links to establish maintain neighbor relationship

  Hello Packets are multicast on those links having a multicast or broadcast capability, enabling dynamic discovery of neighboring routers

  All routers connected to a common link must agree on certain parameters (Hello Interval and Router Dead Interval).

  Hello packets advertise these intervals, so that differences can inhibit the forming of neighbor relationships

OSPF

- **Hello**

  Mask field has been replaced by Interface ID which is a 32-bit number uniquely identify an interface, virtual link gets its own interface ID

  Option field has been increased to 24-bit from 8-bits

  Hello and Dead intervals have been reduced to 16 bits from 32

  DR and BDR are still 32-bit field and contain the Router ID of DR /BDR instead of IP address. Router Id and Link ID uniquely identify the DR on an interface

OSPF

- **Processing Hello Packet in v3**
  - **Interface ID is copied into the hello packet**
  - **Network mask is not needed adjacency is formed on the link local as v6 runs on per link instead of per subnet**
  - **The choice of DR and BDR in hello is indicated by the router ID instead of their IP interface address on the link**
  - **Neighbors IP address is set to the IPv6 source address in the IPv6 header of the received hello packet.**

IPv6 multicast address

- The multicast address AllSPFRouters is FF02::5 note that 02 means that this is a permanent address and has link scope.
- The multcast address ALLDRouters is FF02::6

OSPF

- **Database Description packet**
- **OSPFv2**

Interface MTU	Options	00000IMMS
DD Sequence number		
LSA Header		

- **OSPFv3**

0	Options	
Interface MTU	0	00000IMMS
DD Sequence number		
LSA Header		

OSPF

• Database Description packet

- These packets are exchanged when an adjacency is being initialized.
- They describe the contents of the link-state database
- The DD packet has been increased by 4 byte compared to OSPFv2
- The Option field is now 24-bit
- All the other field are the same and behave the same way as for OSPFv2

OSPF

- **Database Description packet**

- **Options We will talk about later**
- **Interface MTU The size in bytes of the largest IPv6 datagram that can be sent out the associated interface, without fragmentation.**
- **Bits**

  I-bit The Init bit. When set to 1, this packet is the first in the sequence of Database Description Packets.

  M-bit The More bit. When set to 1, it indicates that more Database Description Packets are to follow.

  MS-bit The Master/Slave bit. When set to 1, it indicates that the router is the master during the Database Exchange process. Otherwise, the router is the slave.

OSPF

- **Link State Request**
- **OSPFv2**

LS Type
Link State ID
Advertising Router

- **OSPFv3**

0	LS type
Link State ID	
Advertising Router	

- **Link State Request**

  After exchanging Database Description packets with a neighboring router, a router may find that parts of its link-state database are out-of-date

  The Link State Request packet is used to request the pieces of the neighbor's database that are more up-to-date

- **Link State Request**

  Every LSA is uniquely identified by { LS type, Link State ID, Advertising router }

  OSPFv3 has the same field as OSPFv2 note that LS Type field is now 2 bytes and it has different coding as for OSPFv2 since there are 2 bits that indicates the flooding scope. (later on flooding)

OSPF

- **Link State update**

  Nothing has changed

  Update

LSAs
LSA (header + body)

OSPF

- **Link State update**

  IPv4 and IPv6, the steps for sending a Link State Update packet are the same

  However the list of eligible interfaces out which to flood the LSA is different

OSPF

- **Link State Update**

  For IPv6, the eligible interfaces are selected based on the following factors:

  The LSA's flooding scope (will talk more later)

  Whether the LSA has a recognized LS type.

  The setting of the U-bit in the LS type. If the U-bit is set to 0, unrecognized LS types are treated as having link-local scope. If set to 1, unrecognized LS types are stored and flooded as if they were recognized.

OSPF

- **Link Sate Acknowledgement**

  Each newly received LSA must be acknowledged.

  This is usually done by sending Link State Acknowledgment packets.

  Acknowledgments can also be accomplished implicitly by sending Link State Update packets

- **Link Sate Acknowledgement**

  Nothing has changed

OSPF

- **Options**

  The OSPF Options field is present in OSPF Hello packets, Database Description packets and all LSAs.

  The Options field enables OSPF routers to support (or not support) optional capabilities, and to communicate their capability level to other OSPF routers

OSPF

- **Options**

  In OSPFv2 Option field was a 8-bit field in Hello packet, DD packet and LSA header (we will talk separately about this in the LSA section).

  In OSPFv3 option field has been increased into 24-bit and moved to the body of certain LSA (see detail later)

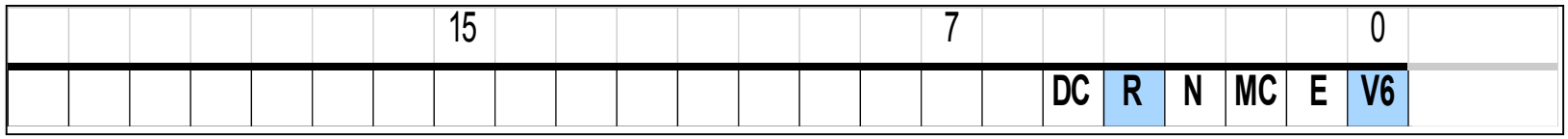
  The option field in Hello and DD packet has been also increased to 24-bit.

  Unused bits have been suppressed and two new bit have been introduced.

- **Options**

IPv4

IPv6



OSPF

- **IPv4 options details**

  DC bit: This bit describes the router's handling of demand circuits

  EA bit: This bit describes the router's willingness to receive and forward External-Attributes-LSAs

  N/P bit:This bit describes the handling of Type-7 LSAs

  MC bit:This bit describes whether IP multicast datagrams are forwarded

  E bit:This bit describes the way AS-external-LSAs are flooded

  O bit: This bit describes the router's willingness to receive and forward Opaque-LSAs

OSPF

- **IPv6 option details**
- **V6 bit : If this bit is cleared the router should be excluded from IPv6 routing calculation. The router can participate in topology distribution but not for forwarding IPV6.**
- **R bit :This bit (the `Router' bit) indicates whether the originator is an active router. If the router bit is cleared then the router cannot be a transit . Clearing the router bit would be appropriate for a multi-homed host that wants to participate in routing, but does not want to forward non-locally addressed packets**

OSPF

- **Flooding**

  OSPFv2 had two flooding scope, AS wide and area wide. In OSPFv3 there are three flooding scope

  AS scope, LSA is flooded through out the AS

  Area scope, LSA is flooded only within an area

  Link-local scope, LSA is flooded only on the local link.

  We will come back to flooding after the LSA discussion

OSPF (LSA Header)

- **OSPFv2**

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

- **OSPFv3**

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

OSPF

- **LSA Header**

  All LSAs begin with a common 20 byte header just like v4 only one change

  LS type field in the LSA header has increased from 1 byte to 2 bytes, since option field is now removed to the body of the LSA and three new bit have been defined

- **LSA Header**

  LS age: The time in seconds since the LSA was originated

  LS type: The LS type field indicates the function performed by the LSA. The high-order three bits of LS type encode generic properties of the LSA, while the remainder (called LSA function code) indicate the LSA's specific functionality (more later)

OSPF

- **LSA Header**

  Link state ID:

  This field identifies the piece of the routing domain that is being described by the LSA. Depending on the LSA's LS type, the Link State ID takes on its value

  The behavior of assigning this 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: ID of the router originating the packet.

OSPF

- **LSA Header**

  LS sequence number: Detects old or duplicate LSAs. Successive instances of an LSA are given successive LS sequence numbers.

OSPF

- **LSA Header**

  The size of the LS type has been increased and 3 new bits have been introduced as mentioned before two bits (S2, S1) for flooding scope and 1 bit (U) for handling unrecognized LSA

OSPF

- **LSA type function codes**
- **S2 / S1 bit indicates the three flooding scopes**

S2	S1	Flooding scope
0	0	Link-Local flooding scope
0	1	Area flodding scope
1	0	AS flooding scope
1	1	Reserved

- **U (unrecognized) bit is used to indicate a router how to handle a LSA if it doesn't recognize it**

U-bit	LSA Handling
0	Treat this LSA as if it has link-local Scope
1	Store and flood this LSA as if type understood

OSPFv3 LSA Type

- In OSPFv3 the LSA are rather called by their name since there are 2 bits indicating the flooding scope and for example Router LSA is not any more coded as 0x01 but 0x2001

- However there is also LSA function code which match the same LSA type as in OSPFv2
- type 3 is recalled Inter-Area-Prefix-LSA
- Type 4 is recalled Inter-Area-Router-LSA
- Two new LSA type have been added

OSPF

- **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

OSPF

- **Router LSA**

  In IPv4 router LSA was type 1

  In IPv6 Router-LSAs have LS type equal to 0x2001 but if you take out the scope which are the S1 and S2 bits and only take the function codes then it is still 1.

  Each router in an area originates one or more router-LSAs.

  The complete collection of router-LSAs originated by the router describe the state and cost of the router's interfaces to the area

OSPF

- **Router LSA**

  Link State ID for v4 in case of the router LSA is the router ID of the originating router.

  For IPv6 Link State ID has shed any addressing semantics. For example, an IPv6 router originating multiple Router-LSAs could start by assigning the first a Link State ID of 0.0.0.1, the second a Link State ID of 0.0.0.2

OSPF

- **Router LSA**

  In IPv4 router could only originate a single router LSA, fragmentation was up to the IP process so the link state ID was set to single value

  For IPv6 a single router may originate one or more Router LSAs, distinguished by their Link-State IDs (which are chosen arbitrarily by the originating router).

OSPF

- **Router LSA**

  The Options field and 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.

  When more than one Router LSA is received from a single router, the links are processed as if concatenated into a single LSA

OSPF (Router LSA)

- **OSPFv2**

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

- **OSPFv3**

0000W VEB	Options	
Type	0	Metric
Interface ID		
Neighbor Interface ID		
Neighbor Router ID		

OSPF

- **Router LSA**

  bit V :When set, the router is an endpoint of one or more fully adjacent virtual links

  bit E: When set, the router is an AS boundary router

  bit B: When set, the router is an area border router (B is for border)

  bit W: This is new, when set, the router is a wild-card multicast receiver. When running MOSPF, these routers receive all multicast datagrams, regardless of destination

OSPF

- **Router LSA**

  Options we talked about earlier are same V6, E MC, R, DC, N. V6 and R bit should be always set in case of Router LSA, all others are dependent on the support

  Next five fields is what you call the link descriptions fields, these are in total 16 bytes long. These include Type, Metric, Interface ID, Neighbor Interface ID and Neighbor Router ID

OSPF

- **Router LSA**
  - **Type**
  - **Interface ID**
  - **Neighbor Interface ID**
  - **Neighbor Router ID**

OSPF

- **Router LSA**
- **Type**

  Describes the type of link there are 3 types of links not like v4 where there were 4 types.

Type	Description
1	Point-to-point
2	Connection to a transit network
3	Reserved
4	Virtual link

- **Since Router LSA announce only topology information link type 3 (Stub link) has been suppressed**

OSPF(Router LSA)

- **Interface ID**

  Every interface is assigned an Interface ID, which uniquely identifies the interface with the router

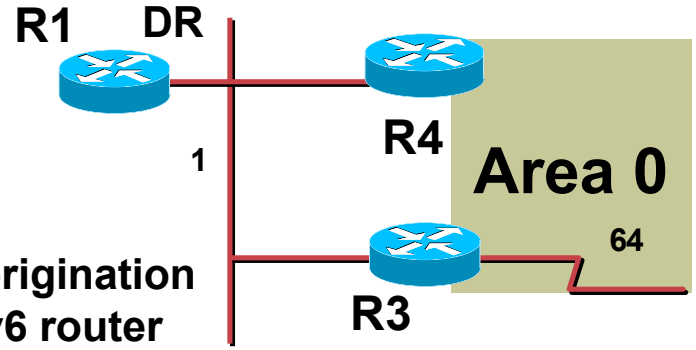
- **Neighbor Interface ID**

  The Interface ID the neighbor router (or the attached link's Designated Router, for Type 2 interfaces) has been advertising in hello packets sent on the attached link

- **Neighbor Router ID**

  The Router ID the neighbor router

OSPF(Router LSA of R3 for Area)



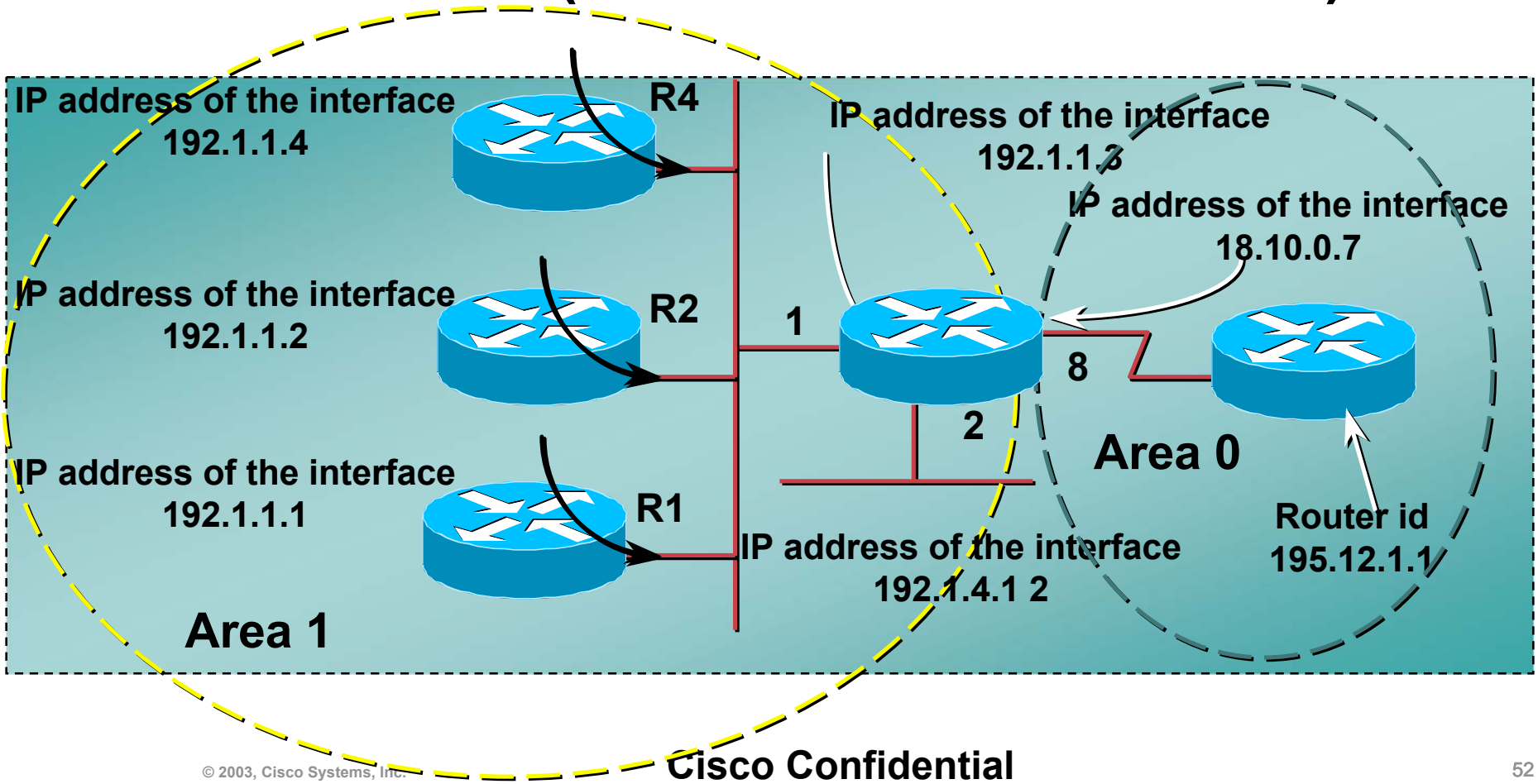
R3#show ip ospf database router

Router Link States (Area 1)

LS age: 0	**Always 0 at origination**
Options: (V6-Bit E-Bit R-bit DC-Bit)	**This is an IPv6 router**
LS Type: Router Links	**This is a router LSA**
Link State ID: 0	
Advertising Router: 26.50.0.2	**Router ID of R3**
Area Border Router	**bit B = 1**
Number of Links: 1	
Link connected to: a Transit Network	
Link Metric: 1	**Cost to reach the interface**
Local Interface ID: 3	**IfIndex**
Neighbor (DR) Interface ID: 3	**IfIndex**
Neighbor (DR) Router ID: 26.50.0.1	**Router ID of R1**

Router LSA for IPv4 (sample network)

- Router LSA (Where the link is transit)



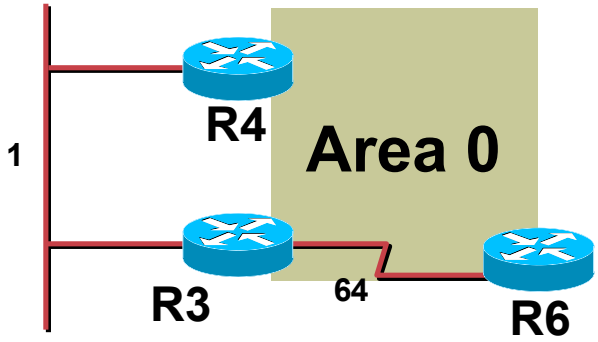
Router LSA of R3 for Area 1(Broadcast network)

- **Router LSA of R3 for area 1**

LS age = 0	Always 0 at origination
Options = (E-bit)	
LS type = 1	This is a router LSA
Link State ID = 192.1.1.3	Router ID of R3
Advertising Router = 192.1.1.3	Router ID of R3
bit E = 0	Not an ASBR
bit B = 1	This is an ABR
# links = 2	
Link ID = 192.1.1.4	IP address of the DR
Link Data = 192.1.1.3	Interface address of this router
Type = 2	This is a transit network
# TOS metrics = 0	
metric = 1	Cost to reach the interface
Link ID = 192.1.4.0	IP network number
Link Data = 255.255.255.0	Subnet mask of the interface
Type = 3	Stub network
# TOS metrics = 0	
metric = 2	

Router LSA of R3 for Area 0

R3#show ip ospf database router



Router Link States (Area 1)

LS age: 249
Options: (V6-Bit E-Bit R-bit DC-Bit)
LS Type: Router Links
Link State ID: 0
Advertising Router: 26.50.0.2
Area Border Router — **bit B = 1**

Link connected to: another Router (point-to-point)
Link Metric: 64 — **Cost to reach the interface**
Local Interface ID: 5 — **IfIndex**
Neighbor Interface ID: 5 — **IfIndex**
Neighbor Router ID: 72.0.0.1 — **Router ID of R6**

Router LSAs IPv4

- **Router LSA of R3 On point to point link**

```
LS age  =  0
Options  =  (E-bit)
LS type  =  1
Link State ID  =  192.1.1.3
Advertising Router   =  192.1.1.3
bit E  =  0
bit B  =  1
# links  =  1
     Link ID  =  195.12.1.1          Router id of the neighbor
     Link Data  =  18.10.0.7         IP interface address of the router
     Type  =  1                      This is a point-to-point link
      # TOS metrics  =  0
     metric  =  8
```

OSPF (Network LSA)

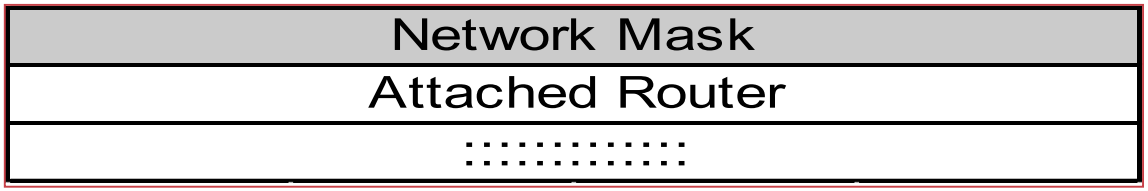
- The LS type of a network-LSA is set to the value 0x2002
- Network- LSAs have area flooding scope
- A network-LSA is originated for every broadcast or NBMA link having two or more attached routers, by the link's Designated Router
- The network-LSA lists all routers attached to the link.

Network LSA

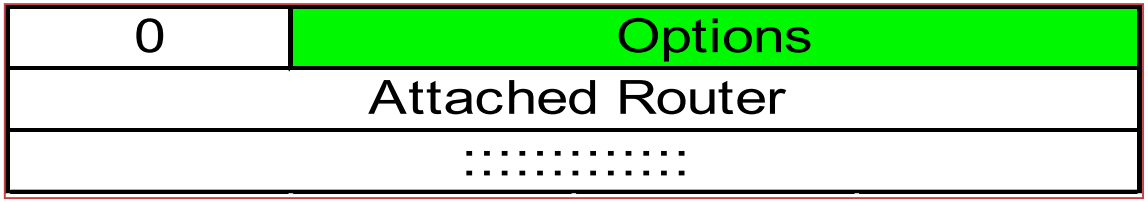
- The procedure for originating network-LSAs in IPv6 is the same as the IPv4 procedure with the following exceptions
  - An IPv6 network-LSA's Link State ID is set to the Interface ID of the Designated Router on the link
  - IPv6 network-LSAs do not contain a Network Mask
  - All addressing information formerly contained in the IPv4 network-LSA has now been consigned to intra-Area-Prefix-LSAs
  - The Options field in the network-LSA is set to the logical OR of the Options fields contained within the link's associated link- LSAs In this way, the network link exhibits a capability when at least one of the link's routers requests that the capability be asserted.

Network LSA

- **OSPFv2**



- **OSPFv3**



OSPF (Network LSA)

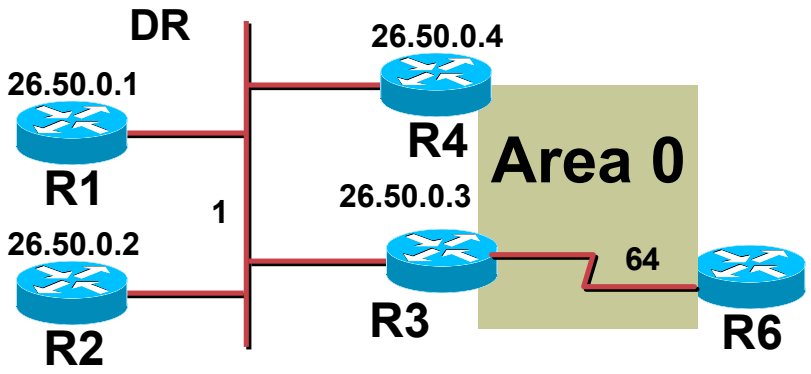
- In OSPFv2, Link State ID in the header contain DR IP address of Transit link and the mask was inside the type 2 LSA. This combination was used to install the IP address of the transit link.
- In OSPFv3 IP address are carried in intra-area-prefix-LSA (FC 9) therefore the mask field has been removed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

OSPF (Network LSA)

R3#show ip ospf database network

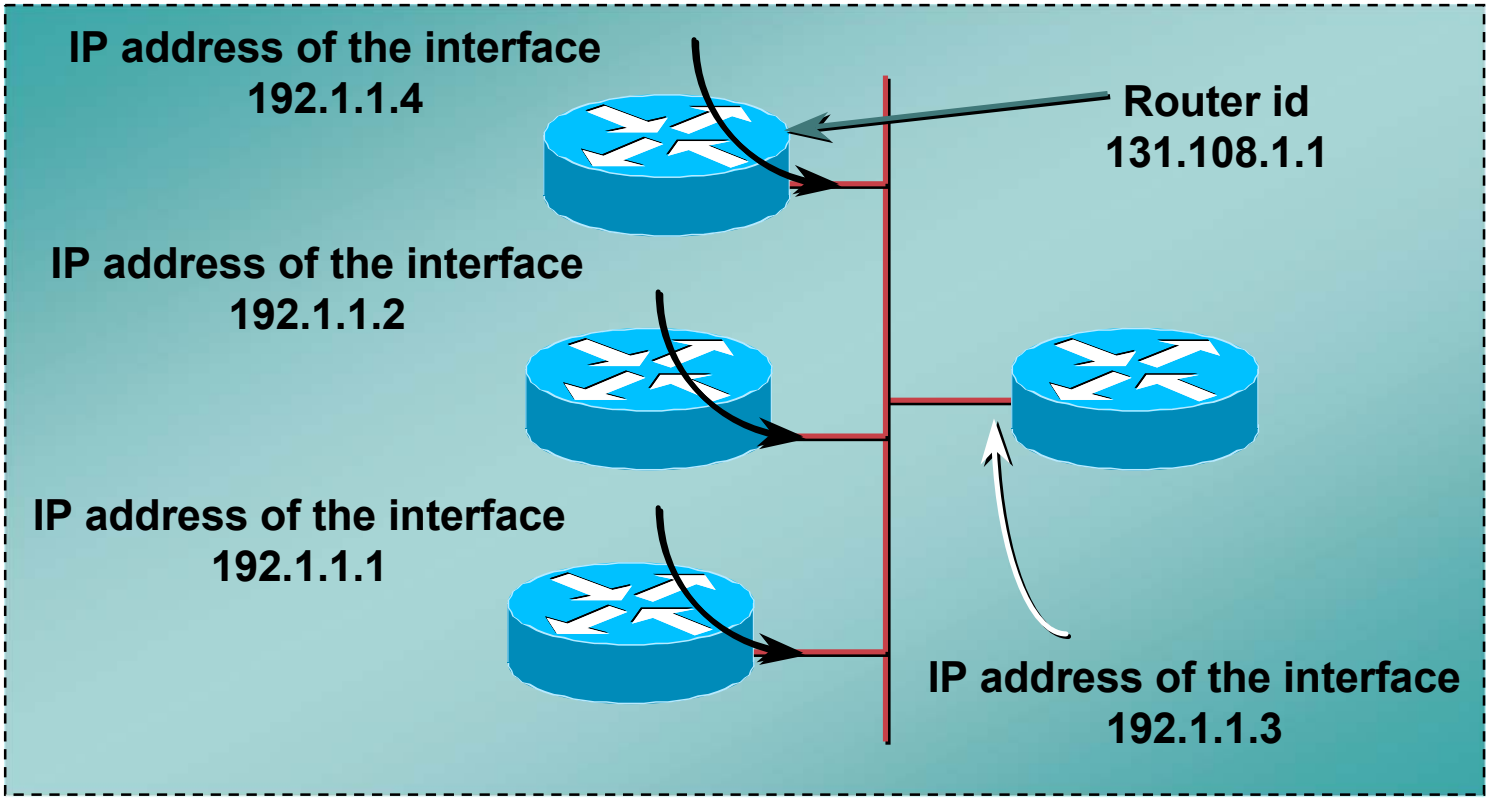
LS age: 992
Options: (V6-Bit E-Bit R-bit DC-Bit)
LS Type: Network Links
Link State ID: 3 (Interface ID of Designated Router)
Advertising Router: 26.50.0.1

Attached Router: 26.50.0.1
Attached Router: 26.50.0.2
Attached Router: 26.50.0.4
Attached Router: 26.50.0.3



OSPF (Network LSA)

Network diagram



OSPF(Network LSA)

- **Network LSA for 192.1.1.0**

LS age = 0
Options = (E-bit)
LS type = 2
Link State ID = 192.1.1.4 — IP interface address of DR
Advertising Router = 131.108.1.1 — Router ID of DR
Network Mask = 255.255.255.0
Attached Router = 192.1.1.4
Attached Router = 192.1.1.3
Attached Router = 192.1.1.2
Attached Router = 192.1.1.1

OSPF (Intra-area prefix LSA)

- Function code 9 it is represented as 0X2009
- 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 link address information was carried in Router and Network LSA

OSPF (Intra-area prefix LSA)

- **OSPFv3**

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

OSPF (Intra-area prefix LSA)

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

OSPF (Intra area prefix LSA)

- **Note that Link State ID in the LSA header of Intra-Area-Prefix-LSA is just a fragment and since a router which act as DR will have the same Advertising Router field for Router LSA and Network LSA there is no way of associating the intra-area-prefix-LSA with Router LSA or Network LSA of a given router that is the reason the referenced field are used.**

OSPF (Intra Area prefix LSA)

- **For Router LSA**

  Referenced LS type = 1
  Referenced Link State ID = 0
  Referenced Advertising Router = router's router ID

- **For Network LSA**

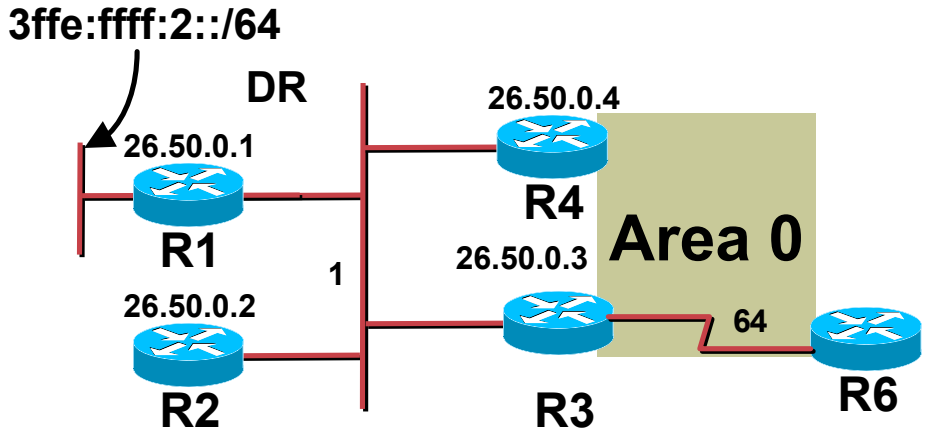
  Referenced LS type = 2
  Referenced Link State ID = Interface ID of DR
  Referenced Advertising Router = router's router ID

OSPF(Intra-Area LSA Stub)

R1#show ip ospf database prefix

Intra Area Prefix Link States (Area 1)

Routing Bit Set on this LSA
LS age: 1431
LS Type: Intra-Area-Prefix-LSA
Link State ID: 0
Advertising Router: 26.50.0.1
LS Seq Number: 80000006
Checksum: 0x4005
Length: 56
Referenced LSA Type: 2001
Referenced Link State ID: 0
Referenced Advertising Router: 26.50.0.1
Number of Prefixes: 1
Prefix Address: 3FFE:FFFF:2::
Prefix Length: 64, Options: None, Metric: 10

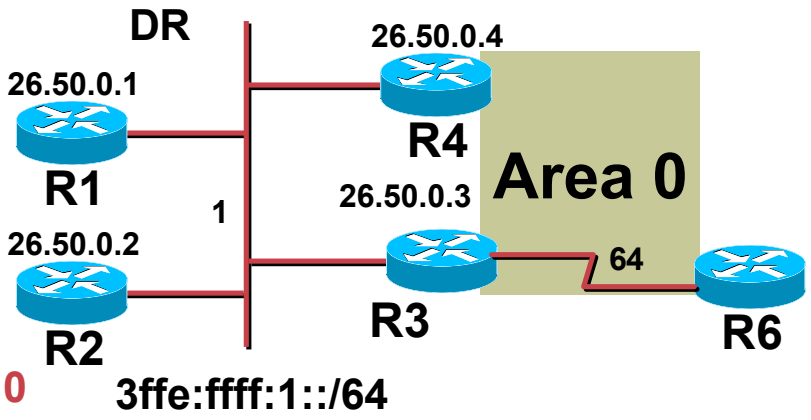


OSPF(Intra-Area LSA Transit)

R3#show ip ospf database prefix

Net Link States (Area 1)

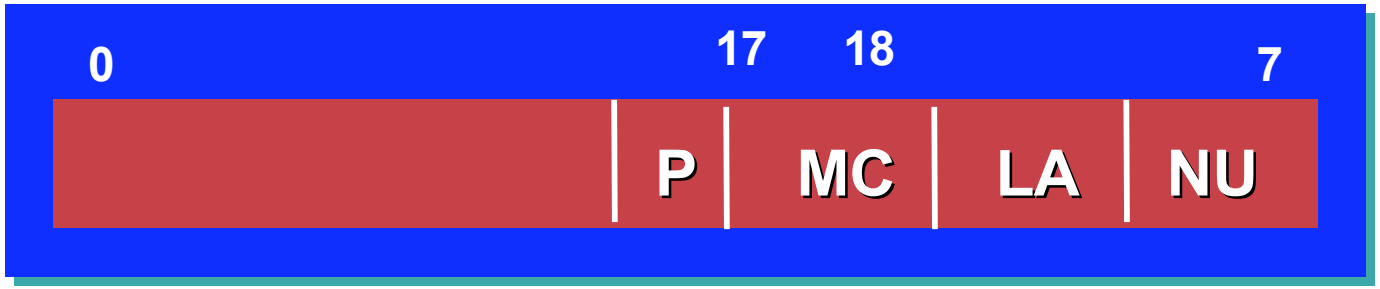
Routing Bit Set on this LSA
LS age: 428
LS Type: Intra-Area-Prefix-LSA
Link State ID: 1003
Advertising Router: 26.50.0.1
LS Seq Number: 80000009
Checksum: 0x5899
Length: 44
Referenced LSA Type: 2002
Referenced Link State ID: 3
Referenced Advertising Router: 26.50.0.1
Number of Prefixes: 1
Prefix Address: 3FFE:FFFF:1::
Prefix Length: 64, Options: None, Metric: 0



OSPF (Intra area prefix LSA)

- Each IPv6 address is associate with { Address prefix, PrefixLength, PrefixOptions }
- First address and prefix length are straight forward
- Prefix options define the capabilities of the prefix

OSPF(Intra area prefix LSA)



- **Prefix Options**

  This is a 8 bit field

  These serve as input to the various routing calculations

  NU-bit: The "no unicast" capability bit. If set, the prefix should be excluded from IPv6 unicast calculations, otherwise it should be included.

OSPF (Intra area prefix LSA)

- **Prefix options**
- **LA: "local address" capability bit**

  If set, the /128 prefix is actually an IPv6 interface address of the advertising router

- **MC: the "multicast" capability bit; if set, the prefix should be included in IPv6 multicast routing calculations**
- **P: The "propagate" bit; set on NSSA area prefixes that should be re-advertised at the NSSA area border**

OSPF (Link LSA)

- **Link-LSA is a new LSA with FC 8 and is represented as 2008in OSPFv3 which is generated for every link and flooded only on a given link. It has the following three purposes**

  I- Since LSA FC 1&2 only announce topology information, Link-LSA announce the link-local address of a router to all other routers attached to the link this is needed for next hop calculation

  II- Link-LSA announce to other routers attached to the link a list of IPv6 prefixes associated with the link. Note that a link can have more than one IPv6 address. This is used for a router attached to a …

OSPF (Link LSA)

LAN to announce its prefix to the DR and DR will include the IPv6 list in its intra-area-prefix-LSA

- lll- on a Multi-access network Link-LSA will announce the options capability of a given router to DR this will allow the DR to sets it's options capabilities in Network LSA as OR options of all attached router.
- In OSPFv2 link-Data field in Router LSA contains router's interface IP address which is used for next hop calculation,

OSPF (Link LSA)

- **OSPFv3**

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

OSPF (Link LSA)

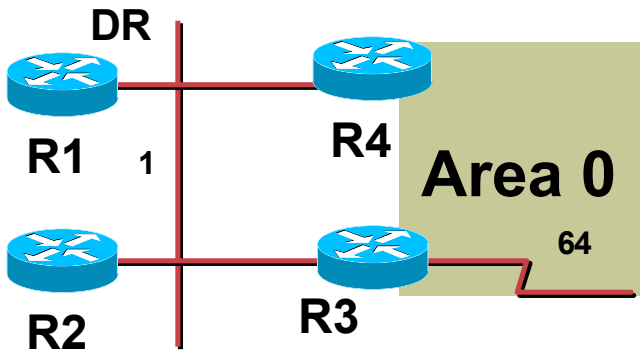
- # prefixes is the number of prefix advertised
- Link-local interface address is used for next hop calculation. Link-LSA also can advertise a list of IPv6 prefixes identified by { Address prefix, PrefixLength, PrefixOptions } to other attached router. For example a DR will include this list of IPv6 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.

OSPF(Link LSA)

- 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 link address information was carried in Router and Network LSA.

Link LSA of R3 For LAN1

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: FastEthernet0/0)
Link State ID: 3 (Interface ID)
Advertising Router: 26.50.0.3
LS Seq Number: 8000002E
Checksum: 0xD7B3
Length: 68
Router Priority: 1
Link Local Address: FE80::204:C1FF:FEDB:2FA0
Number of Prefixes: 2
Prefix Address: 3FFE:FFFF:1:: **Your interface**
Prefix Length: 64, Options: None
Prefix Address: 3FFE:FFFF:1:: **Remote interface**

OSPF (Inter area LSA)

- 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 out side 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 }

OSPF (Inter-Area-Prefix-LSA)

- **OSPFv2**

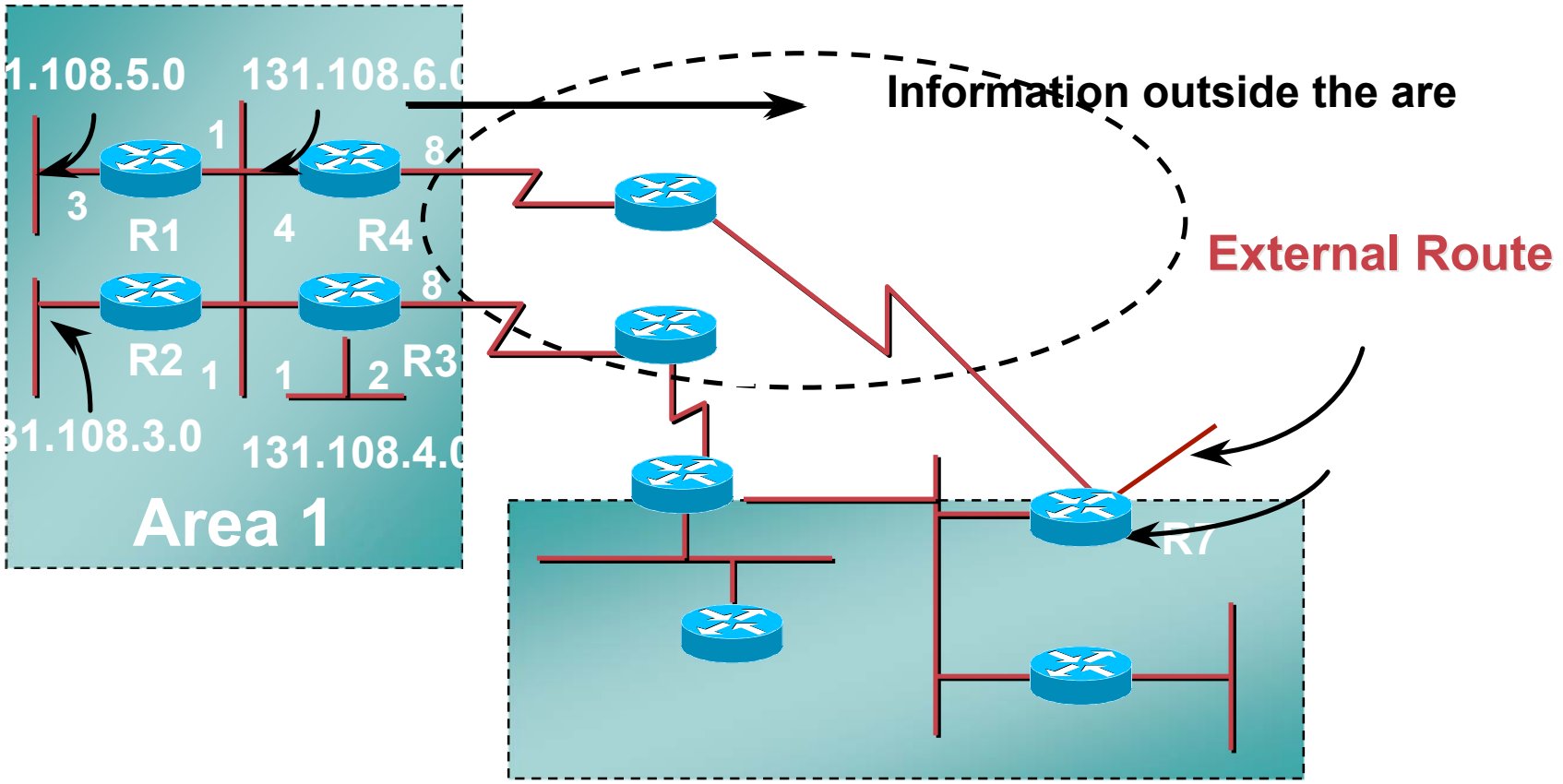
Network Mask	
0	metric
TOS	TOS metric

- **OSPFv3**

0	metric	
PrefixLength	PrefixOptions	0
Adress Prefix 128-bit		

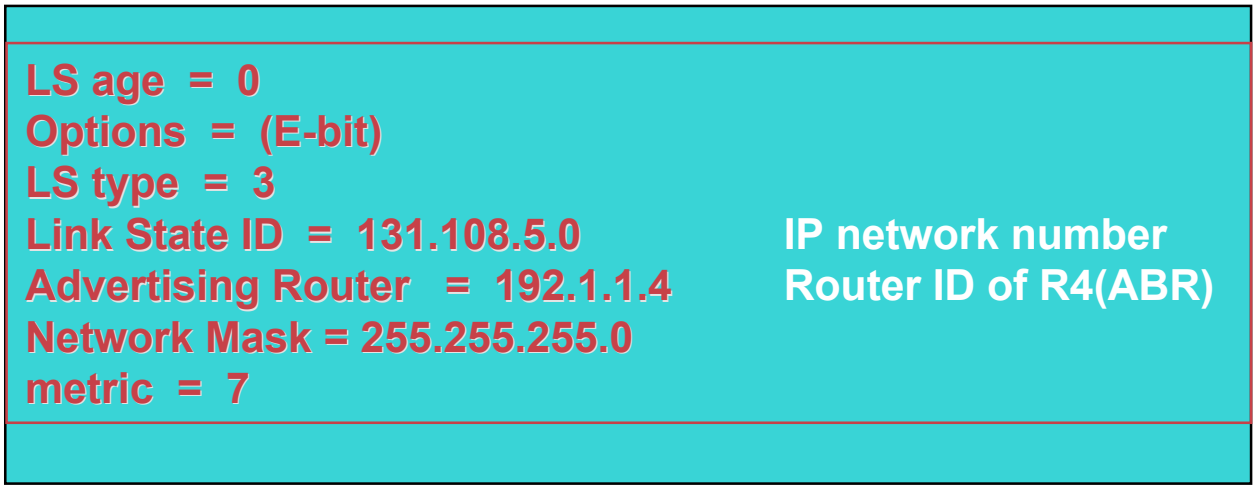
OSPFv2 (summary type 3)

- **Summary (Types 3)**



OSPF Summary type 3

- **Summary LSA Type 3 originated by R4 for Network 192.1.2.0**

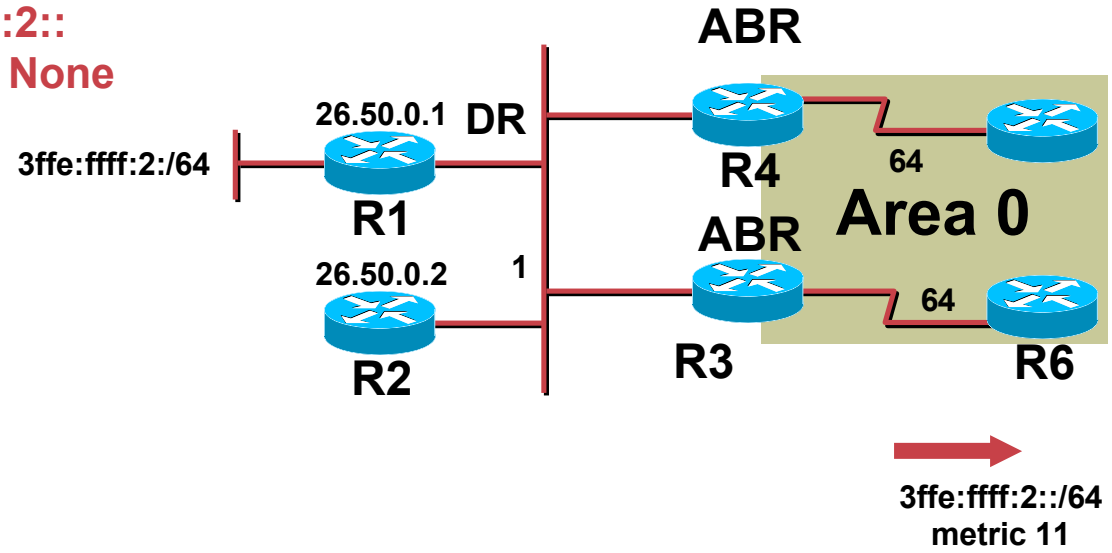


Inter-area Prefix LSA

R6#sh ipv6 ospf database inter-area prefix 3FFE:FFFF:2::/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: 26.50.0.3
Metric: 65
Prefix Address: 3FFE:FFFF:2::
Prefix Length: 64, Options: None



OSPF (Inter-Area-Router-LSA)

- Inter-Area-Router-LSA announce the location of ASBR (type 4 in OSPFv2)
- 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 that in OSPFv2 the mask field is not used for type 4 and contains zero so suppressed in OSPFv3

OSPF (Inter-area-Router-LSA)

- **OSPFv2**

Network Mask	
0	metric
TOS	TOS metric

- **OSPFv3**

0	Options
0	Metric
Destination Router ID	

OSPFv2 (Summary type 4)

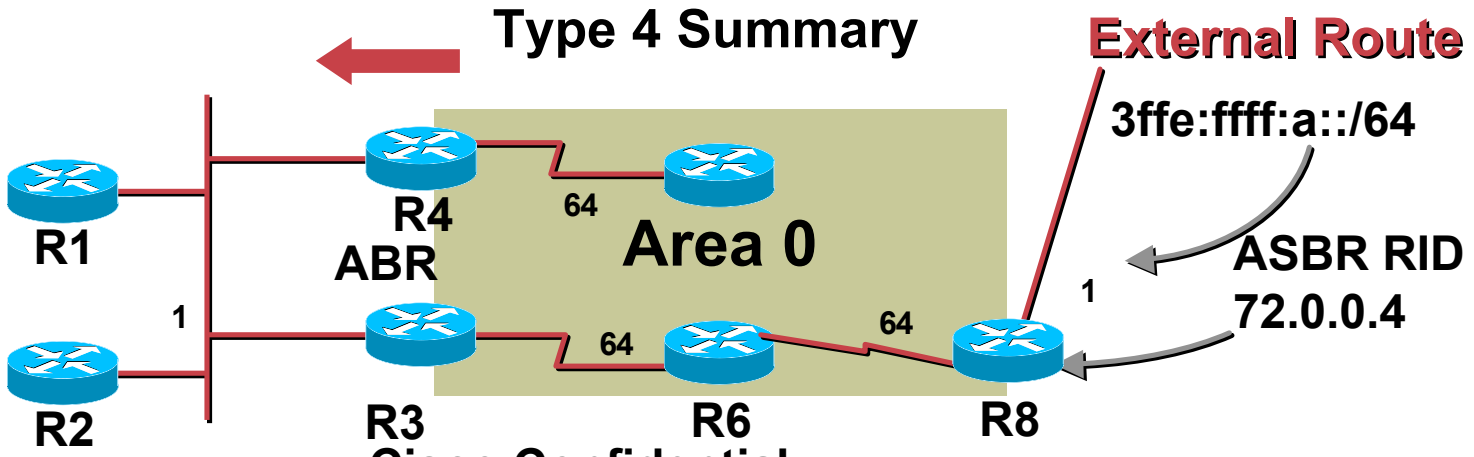
- **Route to the ASBR**

```
LS age  =  0
Options  =  (E-bit)
LS type  =  4
Link State ID  =  131.108.1.1          Router ID of ASBR
Advertising Router   =  192.1.1.4      Router ID of R4(ABR)
Network Mask = 0.0.0.0
metric  =  14
```

OSPF(Inter-area Router LSA Details on R3)

R3#show ipv6 ospf database inter-area router

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: 1207959556
Advertising Router: 26.50.0.3
Metric: 128
Destination Router ID: 72.0.0.4



OSPF (External LSA)

- AS-external-LSAs have LS type equal to 0x4005
- AS- external-LSAs have AS flooding scope
- These describe destinations external to the AS
- The procedure for originating AS-external-LSAs in IPv6 is the same as the IPv4

OSPF (External LSA)

- Few exceptions

1. The Link State ID of an AS-external-LSA has lost all of its addressing semantics, it is used just to distinguish between multiple external LSA originated by the same ASBR
2. The prefix is described by the PrefixLength, PrefixOptions and Address Prefix fields embedded within the LSA body. Network Mask is no longer specified

OSPF (External LSA)

3. Link-local addresses can never be advertised in AS-external-LSAs
4. The forwarding address is present in the AS-external-LSA if and only if the AS-external-LSA's bit F is set.
5. The external route tag is present in the AS-external-LSA if and only if the AS-external-LSA's bit T is set

OSPF (External LSA)

- **OSPFv2**

Network Mask	
E0000000	Metric
Forwarding Adress	
External Route Tag	
E| TOS	TOS metric

- **OSPFv3**

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

OSPF (External LSA)

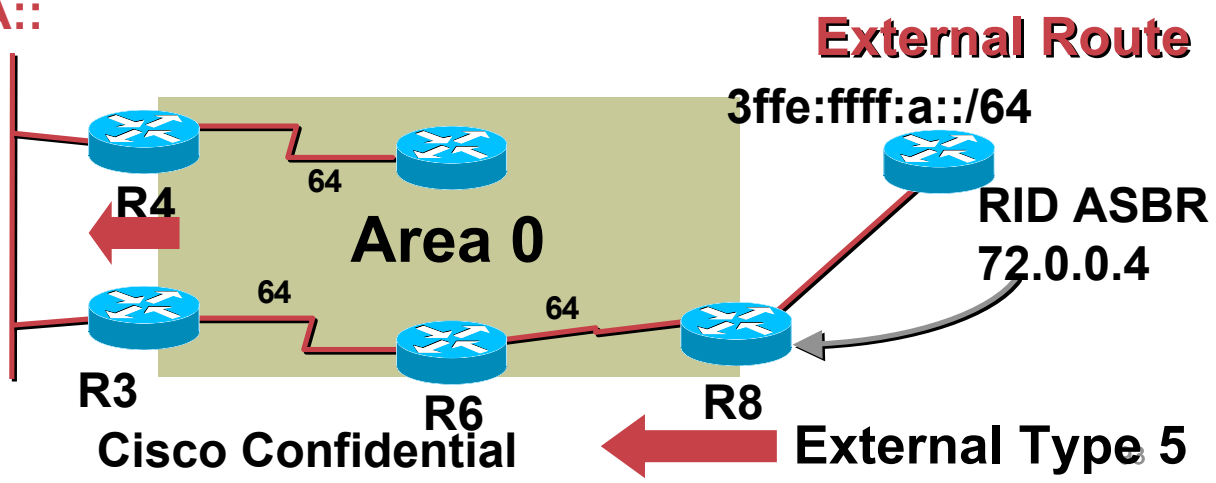
- There are two new fields in OSPFv3, Referenced LS type and Referenced Link State ID
- If a router advertising an As-External-LSA wants to announce additional information regarding external route that is not used by OSPF itself (for example BGP external route attribute) it sets Referenced LS type and Referenced Link State ID in order to announce additional information.

OSPF (External LSA Details)

R3#show ip ospf database external

Type-5 AS External Link States

Routing Bit Set on this LSA
LS age: 473
LS Type: AS External Link
Link State ID: 5
Advertising Router: 72.0.0.4
LS Seq Number: 80000001
Checksum: 0x77AB
Length: 36
Prefix Address: 3FFE:FFFF:A::
Prefix Length: 64,
Metric Type: 2/1
Metric: 20 type2 /148 type1



OSPF (External LSA)

- **External LSA for Network 140.10.0.0**

LS age = 0
Options = (E-bit)
LS type = 5
Link State ID = 140.10.0.0 — IP network number
Advertising Router = 131.108.1.1 — Router ID of R7
Network Mask = 255.255.0.0
bit E = 1; — Type 2 metric
metric = 4
Forwarding address = 0.0.0.0

OSPF (Data Structures)

- OSPFv3 will have the same data structure as OSPFv2 (interface, neighbor, area, link-state database, routing table) however there are few modification to the different data structure.
- We will show what has been added to different data structure in OSPFv3

OSPF (Data Structure)

- Interface data structure will contain all the LSA with link-local scope and all the LSA with unknown type and U bit = 0. This is new as in OSPFv2 all the LSA are in global or area data structure and unknown LSA are discarded.
- Interface data structure contain Interface ID and Instance ID. Interface ID is used in Hello packet, Router LSA and Link-LSA it also identify a DR and appears in Link State ID of network LSA. Instance ID used in the LSA header is used to support multiple OSPF instance on a link.

OSPF (Data Structure)

- In OSPFv3 the neighbor data structure contains neighbor's Interface ID. This is learned though Hello packet received from the neighbor and used in Router LSA to announce the adjacency to the neighbor.
- Neighbor's IPv6 address is a link-local Ipv6 address learned through Link-LSA except for virtual link which is a global or site IPv6 address.

OSPF (Area Data Structure)

- The following LSA are kept in the area data structure: Router LSA, Network LSA, Intra-Area-Prefix-LSA, Inter-Area-Prefix-LSA and Inter-Area-Router-LSA
- In OSPFv3 we will keep all the unknown LSA that has an area flooding scope and the U bit =1. Note that in OSPFv2 unknown LSA are discarded