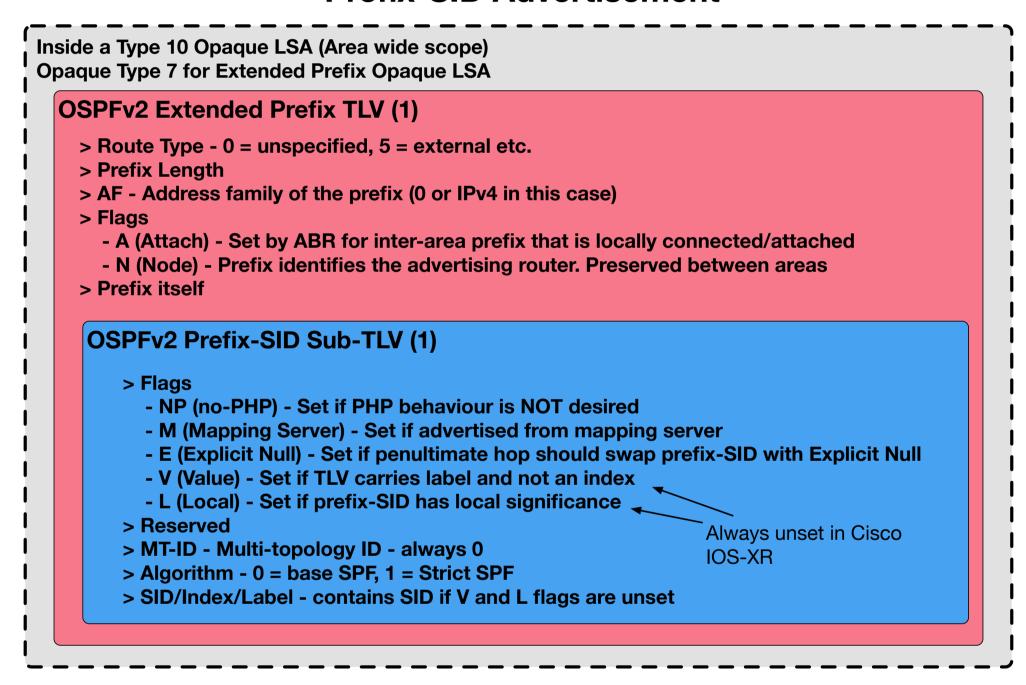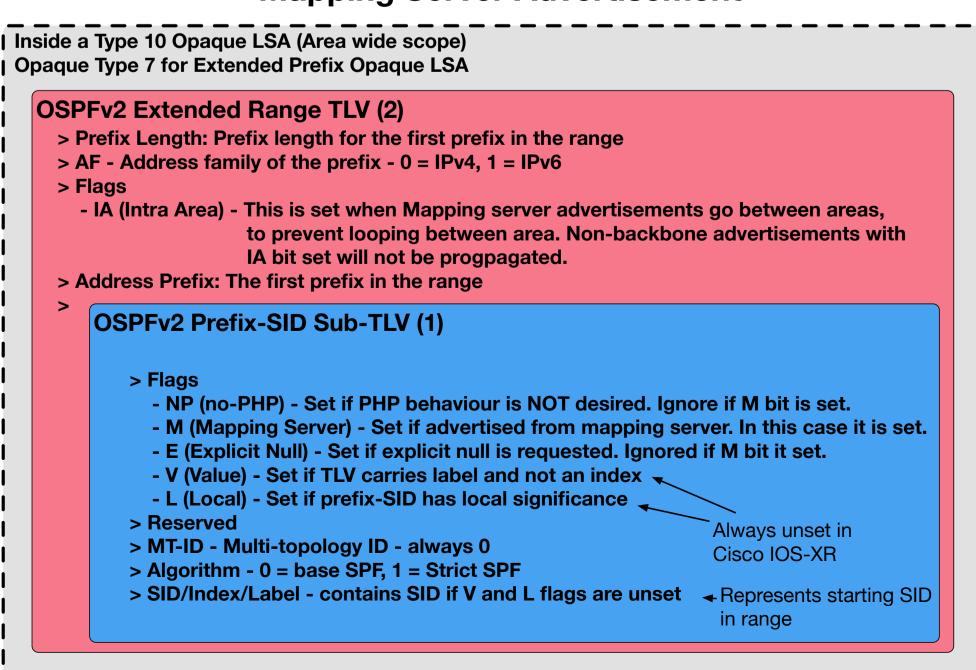# Segment Routing IGP Extensions
OSPFv2

SR Capabilities

Inside a Type 10 Opaque LSA (Area wide scope)
Opaque Type 4 for Router Information

OSPFv2 SID/Label Range TLV (9)
> Range Size - number of labels in the SRGB
> Reserved

SID/Label Sub-TLV (1)
> SID/Label ← In this case this represents the base label.

In OSPF the SR-AIrgorithm Sub-TLV will be attached to the same Type 10 Opaque LSA

SR-Algorithm Sub-TLV (19)
> Algorithm 1
> Algorithm 2
....
> Algorithm n

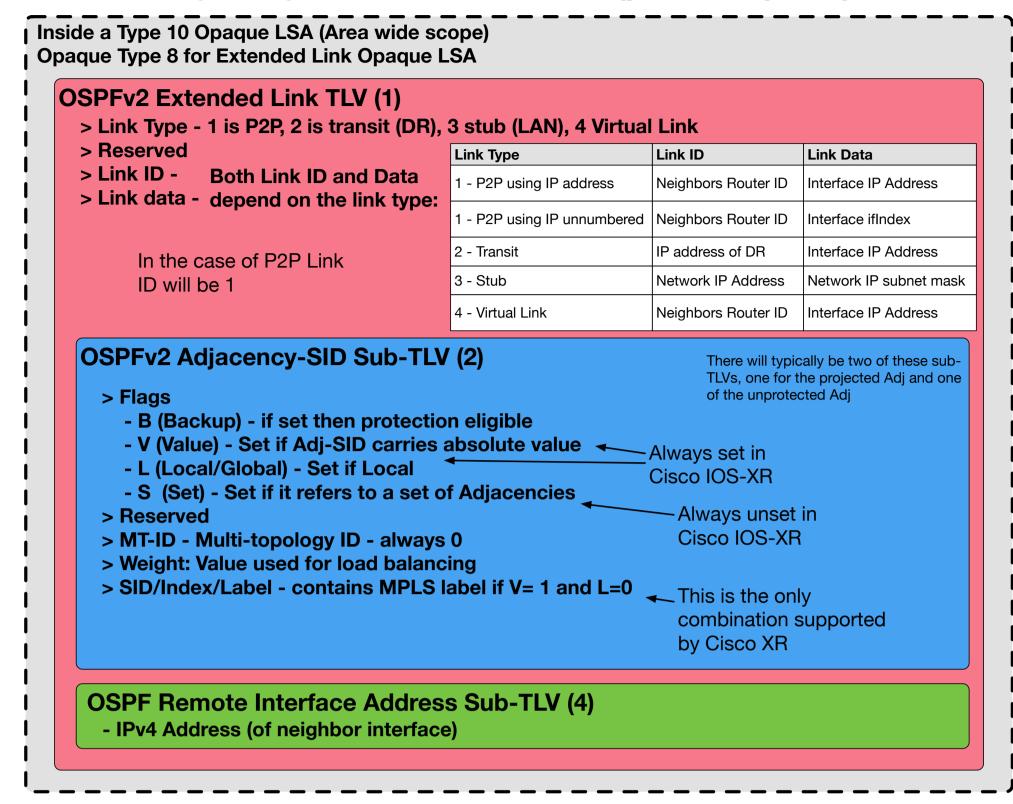The Router Information TLV will also be attached to this Type 4 Opaque LSA
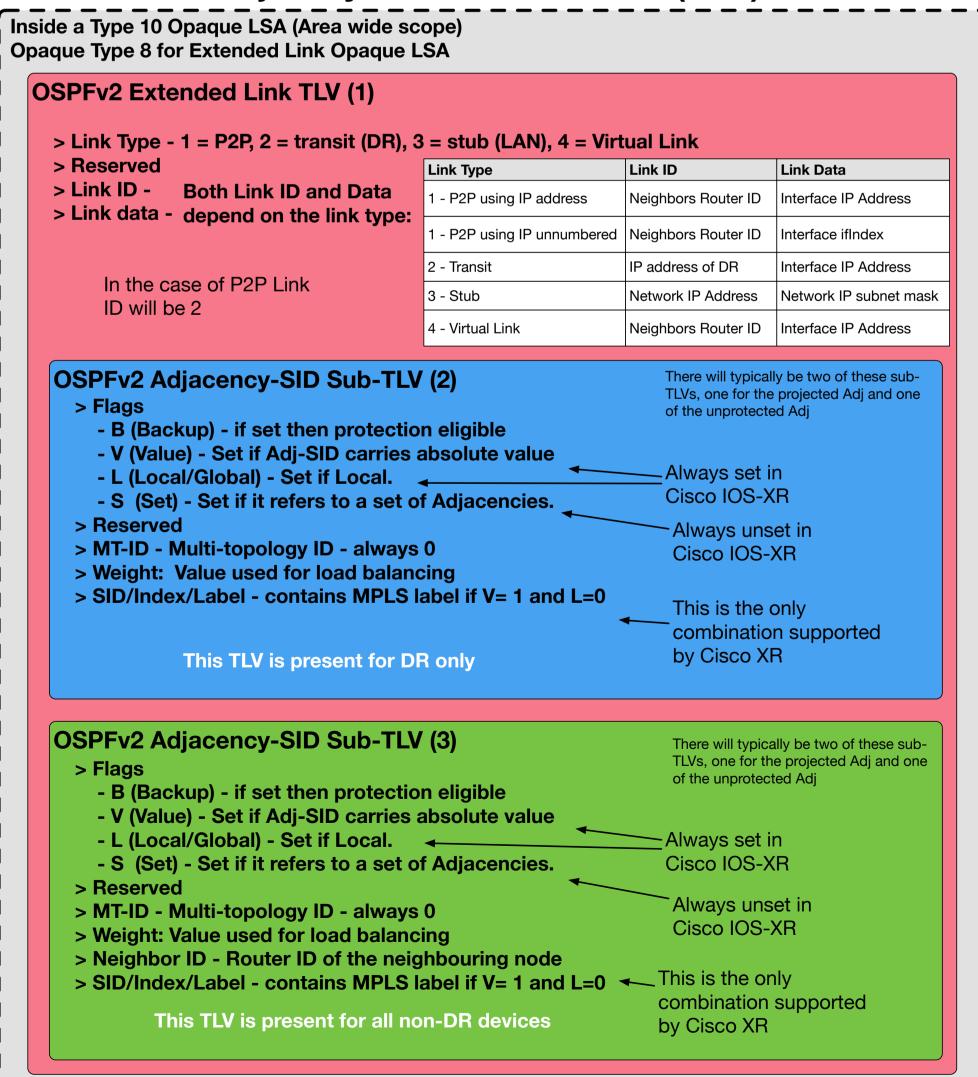
Prefix-SID Advertisement

Inside a Type 10 Opaque LSA (Area wide scope)
Opaque Type 7 for Extended Prefix Opaque LSA

OSPFv2 Extended Prefix TLV (1)
> Route Type - 0 = unspecified, 5 = external etc.
> Prefix Length
> AF - Address family of the prefix (0 or IPv4 in this case)
> Flags
   - A (Attach) - Set by ABR for inter-area prefix that is locally connected/attached
   - N (Node) - Prefix identifies the advertising router. Preserved between areas
> Prefix itself

OSPFv2 Prefix-SID Sub-TLV (1)
> Flags
   - NP (no-PHP) - Set if PHP behaviour is NOT desired
   - M (Mapping Server) - Set if advertised from mapping server
   - E (Explicit Null) - Set if penultimate hop should swap prefix-SID with Explicit Null
   - V (Value) - Set if TLV carries label and not an index
   - L (Local) - Set if prefix-SID has local significance
> Reserved   Always unset in Cisco IOS-XR
> MT-ID - Multi-topology ID - always 0
> Algorithm - 0 = base SPF, 1 = Strict SPF
> SID/Index/Label - contains SID if V and L flags are unset

Mapping Server Advertisement

Inside a Type 10 Opaque LSA (Area wide scope)
Opaque Type 7 for Extended Prefix Opaque LSA

OSPFv2 Extended Range TLV (2)
> Prefix Length: Prefix length for the first prefix in the range
> AF - Address family of the prefix - 0 = IPv4, 1 = IPv6
> Flags
   - IA (Intra Area) - This is set when Mapping server advertisements go between areas, to prevent looping between area. Non-backbone advertisements with IA bit set will not be progpagated.
> Address Prefix: The first prefix in the range
>

OSPFv2 Prefix-SID Sub-TLV (1)
> Flags
   - NP (no-PHP) - Set if PHP behaviour is NOT desired. Ignore if M bit is set.
   - M (Mapping Server) - Set if advertised from mapping server. In this case it is set.
   - E (Explicit Null) - Set if explicit null is requested. Ignored if M bit it set.
   - V (Value) - Set if TLV carries label and not an index
   - L (Local) - Set if prefix-SID has local significance
> Reserved   Always unset in Cisco IOS-XR
> MT-ID - Multi-topology ID - always 0
> Algorithm - 0 = base SPF, 1 = Strict SPF
> SID/Index/Label - contains SID if V and L flags are unset   Represents starting SID in range

Adjaceny-SID Advertisement (point-to-point)

Inside a Type 10 Opaque LSA (Area wide scope)
Opaque Type 8 for Extended Link Opaque LSA

OSPFv2 Extended Link TLV (1)
> Link Type - 1 is P2P, 2 is transit (DR), 3 stub (LAN), 4 Virtual Link
> Reserved
> Link ID -   Both Link ID and Data
> Link data -   depend on the link type:

In the case of P2P Link ID will be 1

Link Type	Link ID	Link Data
1 - P2P using IP address	Neighbors Router ID	Interface IP Address
1 - P2P using IP unnumbered	Neighbors Router ID	Interface ifIndex
2 - Transit	IP address of DR	Interface IP Address
3 - Stub	Network IP Address	Network IP subnet mask
4 - Virtual Link	Neighbors Router ID	Interface IP Address

OSPFv2 Adjacency-SID Sub-TLV (2)
There will typically be two of these sub-TLVs, one for the projected Adj and one of the unprotected Adj
> Flags
   - B (Backup) - if set then protection eligible
   - V (Value) - Set if Adj-SID carries absolute value
   - L (Local/Global) - Set if Local   Always set in Cisco IOS-XR
   - S (Set) - Set if it refers to a set of Adjacencies   Always unset in Cisco IOS-XR
> Reserved
> MT-ID - Multi-topology ID - always 0
> Weight: Value used for load balancing
> SID/Index/Label - contains MPLS label if V= 1 and L=0   This is the only combination supported by Cisco XR

OSPF Remote Interface Address Sub-TLV (4)
   - IPv4 Address (of neighbor interface)

Adjaceny-SID Advertisement (LAN)

Inside a Type 10 Opaque LSA (Area wide scope)
Opaque Type 8 for Extended Link Opaque LSA

OSPFv2 Extended Link TLV (1)
> Link Type - 1 = P2P, 2 = transit (DR), 3 = stub (LAN), 4 = Virtual Link
> Reserved
> Link ID -   Both Link ID and Data
> Link data -   depend on the link type:

In the case of P2P Link ID will be 2

Link Type	Link ID	Link Data
1 - P2P using IP address	Neighbors Router ID	Interface IP Address
1 - P2P using IP unnumbered	Neighbors Router ID	Interface ifIndex
2 - Transit	IP address of DR	Interface IP Address
3 - Stub	Network IP Address	Network IP subnet mask
4 - Virtual Link	Neighbors Router ID	Interface IP Address

OSPFv2 Adjacency-SID Sub-TLV (2)
There will typically be two of these sub-TLVs, one for the projected Adj and one of the unprotected Adj
> Flags
   - B (Backup) - if set then protection eligible
   - V (Value) - Set if Adj-SID carries absolute value
   - L (Local/Global) - Set if Local.   Always set in Cisco IOS-XR
   - S (Set) - Set if it refers to a set of Adjacencies.   Always unset in Cisco IOS-XR
> Reserved
> MT-ID - Multi-topology ID - always 0
> Weight: Value used for load balancing
> SID/Index/Label - contains MPLS label if V= 1 and L=0   This is the only combination supported by Cisco XR

This TLV is present for DR only

OSPFv2 Adjacency-SID Sub-TLV (3)
There will typically be two of these sub-TLVs, one for the projected Adj and one of the unprotected Adj
> Flags
   - B (Backup) - if set then protection eligible
   - V (Value) - Set if Adj-SID carries absolute value
   - L (Local/Global) - Set if Local.   Always set in Cisco IOS-XR
   - S (Set) - Set if it refers to a set of Adjacencies.   Always unset in Cisco IOS-XR
> Reserved
> MT-ID - Multi-topology ID - always 0
> Weight: Value used for load balancing
> Neighbor ID - Router ID of the neighbouring node
> SID/Index/Label - contains MPLS label if V= 1 and L=0   This is the only combination supported by Cisco XR

This TLV is present for all non-DR devices

Segment Routing IGP Extensions
ISIS

SR Capabilities

Attached to LSP

ISIS Router Capability TLV (242)
- > Router-ID
- > Flags
  - - D (Down) - set if TLV has been leaked from L2 to L1
  - - S (Scope) - set if should be flooded across domain

Always unset so not advertised across level boundaries

SR Capability Sub-TLV (2)
- > Flags
  - - I (MPLS IPv4) - Capable of processing SR MPLS Encapsulated IPv4 packets
  - - V (MPLS IPv6) - Capable of processing SR MPLS Encapsulated IPv6 packets
  - - H (SRv6) - Capable of processing SRv6 header
- > SRGB Descriptor
  - - SRBG Range Size
  - -

SID/Label Sub-TLV (1)
- - SRGB Label Base
- - SRBG Label Range

There could be multiple of these if SR is using multiple blocks.

SR-Algorithm Sub-TLV (19)
- > Algorithm 1
- > Algorithm 2
- ….
- > Algorithm n

Adjaceny-SID Advertisement (point-to-point)

Attached to LSP

IS Reachability TLV (22 for IS Extended Reachability, TLV 222 for Multi-topology IS Reachability TLV)
- > System ID and Pseudonode number (of the neighbor)
- > Default Metric
- > Length of Sub-TLVs

ISIS Adjacency-SID Sub-TLV (31)
- > Flags
  - - F (Address-Family) - unset = IPv4. Set = IPv6
  - - B (Backup) - If set this adjacency SID is protection-elgibile
  - - V (Value) - Set if Adj-SID carries absolute value
  - - L (Local/Global) - Set if Local.
  - - S (Set) - Set if it refers to a set of Adjacencies.
- > Weight: Value used for load balancing
- > SID/Index/Label - contain MPLS label if V= 1 and L=0

There will typically be two of these sub-TLVs, one for the projected Adj and one of the unprotected Adj

Always set in Cisco IOS-XR

Always unset in Cisco IOS-XR

This is the only combination supported by Cisco

IPv4 Interface Address sub-TLV (6)
- - IPv4 Address (of local interface)

IPv4 Neighbor Address sub-TLV (8)
- - IPv4 Address (of neighbor interface)

Prefix-SID Advertisement

Attached to LSP

IP Reachability TLV (135 for IPv4, 235 (MT-IPv4), 236 (IPv6), 237 (MT-IPv6)
- > Metric
- > U/D
- > Sub TLV presence
- > Prefix Length
- > Prefix
- > Prefix Atttibute Flags:
  - - X (eXternal): Set if externally redistributed
  - - R (Re-advertisement): Set if leaked from L2 to L1
  - - N (Node): The prefix indentifies the advertising router

The attribute flags shown here (X,R and N) are only present if RFC 7794 has been implemented. These attribute flags will likely obsolete the R flags in the Prefix-SID sub-TLV at some point

ISIS Prefix-SID Sub-TLV (3)
- > Flags
  - - R (Re-advertisement) - Set if redistributed from another protocol or level
  - - N (Node SID) - Set if this is a Node SID
  - - P (PHP-off) - Set if PHP behaviour is NOT desired
  - - E (Explicit Null) - Set if penultimate hop should swap prefix-SID with Explicit Null
  - - V (Value) - Set if TLV carries label and not an index
  - - L (Local) - Set if prefix-SID has local significance
- > Algorithm
- > SID/Index/Label - contains SID if V and L flags are unset

Always unset in Cisco IOS-XR

LAN Adjaceny-SID Advertisement (on LAN)

Attached to LSP

IS Reachability TLV (22 for IS Extended Reachability, TLV 222 for Multi-topology IS Extended Reachability TLV)
- > System ID and Pseudonode number (of the neighbor)
- > Default Metric
- > Length of Sub-TLVs

In LAN segments the IS Reachability TLV will reference the Pseudonode LSP originated by the DIS

ISIS LAN Adjacency-SID Sub-TLV (32)
- > Flags
  - - F (Address-Family) - unset = IPv4, Set = IPv6
  - - B (Backup) - If set this adjacency SID is protection-elgibile
  - - V (Value) - Set if Adj-SID carries absolute value
  - - L (Local/Global) - Set if Local
  - - S (Set) - Set if it refers to a set of Adjacencies
- > Weight: Value used for load balancing
- > System-ID: Refers to the system ID of the neighbors
- > SID/Index/Label - contains MPLS label if V= 1 and L=0

There will typically be two of these sub-TLVs, one for the projected Adj and one of the unprotected Adj

Always set in Cisco IOS-XR

Always unset in Cisco IOS-XR

This is the only combination supported by Cisco XR

Mapping Server Advertisement

Attached to LSP

ISIS SID/Label Binding TLV (149)
- > Flags:
  - - F (Address-Family) - unset = IPv4, Set = IPv6
  - - M (Mirror Context): Set if SID/path corresponds to mirrored context
  - - S (Scope): If unset must not be propagated between levels
  - - D (Down) - set if TLV has been leaked from L2 to L1
  - - A (Attached) - set if prefix attached to originator
- > Weight: Value used for load balancing
- > Range: Number of prefix-SID mappings in the mapping range
- > Prefix Length: Prefix length for the first prefix in the range
- > Prefix: The first prefix in the range
- >

Always unset in Cisco IOS-XR

Cisco IOS-XR default is unset

ISIS Prefix-SID Sub-TLV (3)
- > Flags
  - - R - not used
  - - N (Node SID) - Set if this is a Node SID
  - - P - not used
  - - E - not used
  - - V - not used
  - - L - not used
- > Algorithm
- > SID/Index/Label - contains SID if V and L flags are unset

Same sub-TLV used in IP Reachability TLVs, but not all flags are used.

Always unset in Cisco IOS-XR in this context