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Advertising Layer 2 Bundle Member Link Attributes in IS-IS

Abstract

There are deployments where the Layer 3 interface on which IS-IS operates is a Layer 2 interface bundle. Existing IS-IS advertisements only support advertising link attributes of the Layer 3 interface. If entities external to IS-IS wish to control traffic flows on the individual physical links that comprise the Layer 2 interface bundle, link attribute information about the bundle members is required.

This document introduces the ability for IS-IS to advertise the link attributes of Layer 2 (L2) Bundle Members.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc8668.

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1. Introduction

There are deployments where the Layer 3 interface on which an IS-IS adjacency is established is a Layer 2 interface bundle, for instance, a Link Aggregation Group (LAG) [IEEE802.1AX]. This reduces the number of adjacencies that need to be maintained by the routing protocol in cases where there are parallel links between the neighbors. Entities external to IS-IS such as Path Computation Elements (PCEs) [RFC4655] may wish to control traffic flows on individual members of the underlying Layer 2 bundle. In order to do so, link attribute information about individual bundle members is required. The protocol extensions defined in this document provide the means to advertise this information.

This document introduces a new TLV to advertise link attribute information for each of the L2 Bundle Members that comprise the Layer 3 interface on which IS-IS operates.

[RFC8667] introduces a new link attribute, adjacency segment identifier (Adj-SID), which can be used as an instruction to forwarding to send traffic over a specific link. This document introduces additional sub-TLVs to advertise Adj-SIDs for L2 Bundle Members.

Note that the new advertisements defined in this document are intended to be provided to external (to IS-IS) entities. The following items are intentionally not defined and/or are outside the scope of this document:

* What link attributes will be advertised. This is determined by the needs of the external entities.

* A minimum or default set of link attributes.

* How these attributes are configured.

* How the advertisements are used.

* What impact the use of these advertisements may have on traffic flow in the network.

* How the advertisements are passed to external entities.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. L2 Bundle Member Attributes TLV

A new TLV is introduced to advertise L2 Bundle Member attributes. Although much of the information is identical to and uses the same sub-TLVs included in Extended IS Neighbor advertisements (TLVs 22 and 222), a new TLV is used so that changes to the advertisement of the L2 Bundle Member link attributes do not trigger unnecessary action by the [ISO10589] Decision Process.

Advertisement of this information implies that the identified link is

a member of the L2 Bundle associated with the identified Parent L3 Neighbor and that the member link is operationally up. Therefore, advertisements MUST be withdrawn if the link becomes operationally down or it is no longer a member of the identified L2 Bundle.

This new TLV utilizes the sub-TLV space defined for TLVs 22, 23, 141, 222, and 223.

The following new TLV is introduced:

L2 Bundle Member Attributes

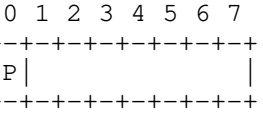
Type: 25

Length: Number of octets to follow

Parent L3 Neighbor Descriptor

L3 Neighbor System ID + pseudonode ID (7 octets)

Flags: 1-octet field of the following flags:



where:

P-Flag: When set to 1, one of the sub-TLVs described in Section 3.1 immediately follows the flags field. If the P-Flag is set to 0, then none of the sub-TLVs described in Section 3.1 are present.

Other bits: MUST be zero when originated and ignored when received.

One or more L2 Bundle Attribute Descriptors (as defined below).

Length of L2 Bundle Attribute Descriptor (1 octet)

NOTE: This includes all fields described below.

Number of L2 Bundle Member Descriptors (1 octet)

L2 Bundle Member Link Local Identifiers
(4 * Number of L2 Bundle Member Descriptors octets)

NOTE: An L2 Bundle Member Descriptor is a Link Local Identifier as defined in [RFC4202].

Sub-TLV(s)
A sub-TLV may define an attribute common to all of the bundle members listed, or it may define an attribute unique to each bundle member. Use of these two classes of sub-TLVs is described in the following sections.

NOTE: Only one Parent L3 Neighbor Descriptor is present in a given TLV. Multiple L2 Bundle Attribute Descriptors may be present in a single TLV.

3.1. Parallel L3 Adjacencies

When there exist multiple L3 adjacencies to the same neighbor, additional information is required to uniquely identify the L3 Neighbor. One and only one of the following three sub-TLVs is used to uniquely identify the L3 adjacency:

* IPv4 Interface Address (sub-TLV 6 defined in [RFC5305])

* IPv6 Interface Address (sub-TLV 12 defined in [RFC6119])

* Link Local/Remote Identifiers (sub-TLV 4 defined in [RFC5307])

When the P-Flag is set in the flags field in the Parent L3 Neighbor Descriptor, one and only one of the above sub-TLVs MUST be present. The chosen sub-TLV MUST immediately follow the flags field described in Section 3.

These sub-TLVs MAY be omitted if no parallel adjacencies to the neighbor exist.

3.2. Shared Attribute Sub-TLVs

These sub-TLVs advertise a single copy of an attribute (e.g., link bandwidth). The attribute applies to all of the L2 Bundle Members in the set advertised under the preceding L2 Bundle Member Attribute Descriptor. No more than one copy of a given sub-TLV in this category may appear in the set of sub-TLVs under the preceding L2 Bundle Member Attribute Descriptor. If multiple copies of a given sub-TLV are present, all copies MUST be ignored.

The set of L2 Bundle Member Descriptors that may be advertised under a single L2 Bundle Member Attribute Descriptor is therefore limited to bundle members that share the set of attributes advertised in the shared attribute sub-TLVs.

All existing sub-TLVs defined in the IANA registry for Sub-TLVs for TLVs 22, 23, 141, 222, and 223 are in the category of shared attribute sub-TLVs unless otherwise specified in this document.

4. Advertising L2 Bundle Member Adj-SIDs

[RFC8667] defines sub-TLVs to advertise Adj-SIDs for L3 adjacencies. However, these sub-TLVs only support the advertisement of a single Adj-SID. As it is expected that each L2 Bundle Member will have unique Adj-SIDs in many deployments, it is desirable to define a new sub-TLV that allows more efficient encoding of a set of Adj-SIDs in a single sub-TLV. Two new sub-TLVs are therefore introduced to support advertising Adj-SIDs for L2 Bundle Members. The format of the new sub-TLVs is similar to that used for L3 adjacencies, but it is optimized to allow advertisement of a set of Adj-SIDs (one per L2 Bundle Member) in a single sub-TLV.

The two new sub-TLVs defined in the following sections do not fall into the category of shared attribute sub-TLVs.

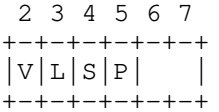
4.1. L2 Bundle Member Adjacency Segment Identifier Sub-TLV

This sub-TLV is used to advertise Adj-SIDs for L2 Bundle Members associated with a parent L3 adjacency that is point-to-point. The following format is defined for this sub-TLV:

Type: 41 (1 octet)

Length: variable (1 octet)

Flags: 1-octet field of the following flags:



where:

F-Flag: Address-Family Flag. If unset, then the Adj-SID refers to an L2 Bundle Member with outgoing IPv4 encapsulation. If set, then the Adj-SID refers to an L2 Bundle Member with outgoing IPv6 encapsulation.

V-Flag: Value Flag. If set, then the Adj-SID carries a value.

By default, the flag is SET.

L-Flag: Local Flag. If set, then the value/index carried by the Adj-SID has local significance. By default, the flag is SET.

S-Flag: Set Flag. When set, the S-Flag indicates that the Adj-SID refers to a set of L2 Bundle Members (and therefore MAY be assigned to other L2 Bundle Members as well).

P-Flag: Persistent Flag. When set, the P-Flag indicates that the Adj-SID is persistently allocated, i.e., the Adj-SID value remains consistent across router restart and/or interface flap.

Other bits: MUST be zero when originated and ignored when received.

NOTE: The flags are deliberately kept congruent to the flags in the L3 ADJ-SID defined in [RFC8667]. * indicates a flag used in the L3 Adj-SID sub-TLV, but one that is NOT used in this sub-TLV. These bits SHOULD be sent as 0 and MUST be ignored on receipt.

Weight: 1 octet. The value represents the weight of the Adj-SID for the purpose of load balancing. The use of the weight is defined in [RFC8402].

NOTE: Flags and weight are shared by all L2 Bundle Members listed in the L2 Bundle Attribute Descriptor.

L2 Bundle Member Adj-SID Descriptors:
There MUST be one descriptor for each of the L2 Bundle Members advertised under the preceding L2 Bundle Member Attribute Descriptor. Each descriptor consists of one of the following fields:

SID/Index/Label: According to the V- and L-Flags, it contains either:

- A 3-octet local label where the 20 rightmost bits are used for encoding the label value. In this case, the V- and L-Flags MUST be set.

- A 4-octet index defining the offset in the SID/Label space advertised by this router. See [RFC8667]. In this case, V- and L-Flags MUST be unset.

4.2. L2 Bundle Member LAN Adjacency SID Sub-TLV

This sub-TLV is used to advertise Adj-SIDs for L2 Bundle Members associated with a parent L3 adjacency that is a LAN adjacency. In LAN subnetworks, the Designated Intermediate System (DIS) is elected and originates the Pseudonode-LSP (PN-LSP) including all neighbors of the DIS. When Segment Routing is used, each router in the LAN MAY advertise the Adj-SID of each of its neighbors on the LAN. Similarly, for each L2 Bundle Member, a router MAY advertise an Adj-SID to each neighbor on the LAN.

The following format is defined for this sub-TLV:

Type: 42 (1 octet)

Length: variable (1 octet)

Neighbor System ID: 6 octets

Flags: 1-octet field of the following flags:

0 1 2 3 4 5 6 7

where:

F-Flag: Address-Family Flag. If unset, then the Adj-SID refers to an L2 Bundle Member with outgoing IPv4 encapsulation. If set, then the Adj-SID refers to an L2 Bundle Member with outgoing IPv6 encapsulation.

V-Flag: Value Flag. If set, then the Adj-SID carries a value. By default, the flag is SET.

L-Flag: Local Flag. If set, then the value/index carried by the Adj-SID has local significance. By default, the flag is SET.

S-Flag: Set Flag. When set, the S-Flag indicates that the Adj-SID refers to a set of L2 Bundle Members (and therefore MAY be assigned to other L2 Bundle Members as well).

P-Flag: Persistent Flag. When set, the P-Flag indicates that the Adj-SID is persistently allocated, i.e., the Adj-SID value remains consistent across router restart and/or interface flap.

Other bits: MUST be zero when originated and ignored when received.

NOTE: The flags are deliberately kept congruent to the flags in the L3 LAN Adjacency SID defined in [RFC8667]. * indicates a flag used in the L3 Adj-SID sub-TLV, but one that is NOT used in this sub-TLV. These bits SHOULD be sent as 0 and MUST be ignored on receipt.

Weight: 1 octet. The value represents the weight of the Adj-SID for the purpose of load balancing. The use of the weight is defined in [RFC8402].

NOTE: Flags and weight are shared by all L2 Bundle Members listed in the L2 Bundle Attribute Descriptor.

L2 Bundle Member LAN Adjacency SID Descriptors:
There MUST be one descriptor for each of the L2 Bundle Members advertised under the preceding L2 Bundle Member Attribute Descriptor. Each descriptor consists of one of the following fields:

SID/Index/Label: According to the V- and L-Flags, it contains either:

- A 3-octet local label where the 20 rightmost bits are used for encoding the label value. In this case, the V- and L-Flags MUST be set.

- A 4-octet index defining the offset in the SID/Label space advertised by this router. See [RFC8667]. In this case, V- and L-Flags MUST be unset.

5. IANA Considerations

This document adds the following new TLV to the IS-IS "TLV Codepoints Registry".

Value: 25

Name: L2 Bundle Member Attributes

The name of the IANA registry for Sub-TLVs for TLVs 22, 23, 141, 222,

and 223 has been changed to include sub-TLV 25. An additional column has been added to the registry to indicate which sub-TLVs may appear in the new L2 Bundle Member Attributes TLV. The column for TLV 25 has one of the following three values:

y sub-TLV may appear in TLV 25 but MUST NOT be shared by multiple L2 Bundle Members

y(s) sub-TLV may appear in TLV 25 and MAY be shared by multiple L2 Bundle Members

n sub-TLV MUST NOT appear in TLV 25

The following table indicates the appropriate settings for all currently defined sub-TLVs with regard to their use in the new L2 Bundle Member Attributes TLV.

Value	Description	TLV 25
3	Administrative group (color)	y(s)
4	Link Local/Remote Identifiers	y(s)
6	IPv4 interface address	y(s)
8	IPv4 neighbor address	y(s)
9	Maximum link bandwidth	y(s)
10	Maximum reservable link bandwidth	y(s)
11	Unreserved bandwidth	y(s)
12	IPv6 Interface Address	y(s)
13	IPv6 Neighbor Address	y(s)
14	Extended Administrative Group	y(s)
18	TE Default metric	y(s)
19	Link-attributes	y(s)
20	Link Protection Type	y(s)
21	Interface Switching Capability Descriptor	y(s)
22	Bandwidth Constraints	y(s)
23	Unconstrained TE LSP Count (sub-)TLV	y(s)
24	remote AS number	n
25	IPv4 remote ASBR Identifier	n
26	IPv6 remote ASBR Identifier	n
27	Interface Adjustment Capability Descriptor (IACD)	y(s)
28	MTU	n
29	SPB-Metric	y(s)
30	SPB-A-OALG	y(s)
33	Unidirectional Link Delay	y
34	Min/Max Unidirectional Link Delay	y

35	Unidirectional Delay Variation	y
36	Unidirectional Link Loss	y
37	Unidirectional Residual Bandwidth	y
38	Unidirectional Available Bandwidth	y
39	Unidirectional Utilized Bandwidth	y
40	RTM Capability	n

Table 1

This document adds the following new sub-TLVs to the above registry.

Type	Description	22	23	25	141	222	223
41	L2 Bundle Member Adj-SID	n	n	y	n	n	n
42	L2 Bundle Member LAN Adj-SID	n	n	y	n	n	n

Table 2

6. Security Considerations

The IS-IS protocol has supported the advertisement of link attribute information, including link identifiers, for many years. The advertisements defined in this document are identical to existing advertisements defined in [RFC4202], [RFC5305], [RFC8570], and [RFC8667], but are associated with L2 links that are part of a bundle interface on which the IS-IS protocol operates. There are therefore no new security issues introduced by the extensions in this document.

As always, if the protocol is used in an environment where unauthorized access to the physical links on which IS-IS Protocol Data Units (PDUs) are sent occurs, then attacks are possible. The use of authentication as defined in [RFC5304] and [RFC5310] is recommended to prevent such attacks.

7. References

7.1. Normative References

[IEEE802.1AX]
IEEE, "IEEE Standard for Local and metropolitan area networks -- Link Aggregation", IEEE 802.1AX, <https://ieeexplore.ieee.org/document/7055197>.

[ISO10589] International Organization for Standardization, "Information technology -- Telecommunications and information exchange between systems -- Intermediate System to Intermediate System intra-domain routeing information exchange protocol for use in conjunction with the protocol for providing the connectionless-mode network service (ISO 8473)", ISO/IEC 10589:2002, Second Edition, November 2002.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC4202] Kompella, K., Ed. and Y. Rekhter, Ed., "Routing Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4202, DOI 10.17487/RFC4202, October 2005, <https://www.rfc-editor.org/info/rfc4202>.

[RFC5304] Li, T. and R. Atkinson, "IS-IS Cryptographic Authentication", RFC 5304, DOI 10.17487/RFC5304, October 2008, <https://www.rfc-editor.org/info/rfc5304>.

[RFC5305] Li, T. and H. Smit, "IS-IS Extensions for Traffic Engineering", RFC 5305, DOI 10.17487/RFC5305, October 2008, <https://www.rfc-editor.org/info/rfc5305>.

[RFC5307] Kompella, K., Ed. and Y. Rekhter, Ed., "IS-IS Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 5307, DOI 10.17487/RFC5307, October 2008, <https://www.rfc-editor.org/info/rfc5307>.

[RFC5310] Bhatia, M., Manral, V., Li, T., Atkinson, R., White, R., and M. Fanto, "IS-IS Generic Cryptographic Authentication", RFC 5310, DOI 10.17487/RFC5310, February 2009, <https://www.rfc-editor.org/info/rfc5310>.

[RFC6119] Harrison, J., Berger, J., and M. Bartlett, "IPv6 Traffic Engineering in IS-IS", RFC 6119, DOI 10.17487/RFC6119, February 2011, <https://www.rfc-editor.org/info/rfc6119>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8570] Ginsberg, L., Ed., Previdi, S., Ed., Giacalone, S., Ward, D., Drake, J., and Q. Wu, "IS-IS Traffic Engineering (TE) Metric Extensions", RFC 8570, DOI 10.17487/RFC8570, March 2019, <https://www.rfc-editor.org/info/rfc8570>.

[RFC8667] Previdi, S., Ed., Ginsburg, L., Ed., Filsfils, C., Bashandy, A., Gredler, H., and B. Decraene, "IS-IS Extensions for Segment Routing", RFC 8667, DOI 10.17487/RFC8667, December 2019, <https://www.rfc-editor.org/info/rfc8667>.

7.2. Informative References

[RFC4655] Farrel, A., Vasseur, JP., and J. Ash, "A Path Computation Element (PCE)-Based Architecture", RFC 4655, DOI 10.17487/RFC4655, August 2006, <https://www.rfc-editor.org/info/rfc4655>.

[RFC8402] Filsfils, C., Ed., Previdi, S., Ed., Ginsberg, L., Decraene, B., Litkowski, S., and R. Shakir, "Segment Routing Architecture", RFC 8402, DOI 10.17487/RFC8402, July 2018, <https://www.rfc-editor.org/info/rfc8402>.

Appendix A. Example Encoding

Below is an example encoding of L2 Bundle advertisements in a case where we have two parallel adjacencies to the same neighbor whose system-id is 1234.1234.1234.00. The two L2 bundles have the following sets of attributes:

L3 Adjacency #1

L3 IPv4 local link address: 192.0.2.1

Four bundle members with the following attributes:

Num	Link Local ID	Bandwidth	Adj-SID/Weight
1	0x11111111	1G	0x11111/1
2	0x11112222	1G	0x11112/1
3	0x11113333	10G	0x11113/1

4	0x11114444	10G	0x11114/1

Table 3

L3 Adjacency #2

L3 IPv4 local link address: 192.0.2.2

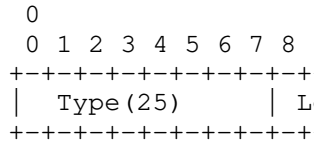
Three bundle members with the following attributes:

Num	Link Local ID	Bandwidth	Adj-SID/Weight
1	0x22221111	10G	22221/1
2	0x22222222	10G	22222/1
3	0x22223333	10G	22223/1

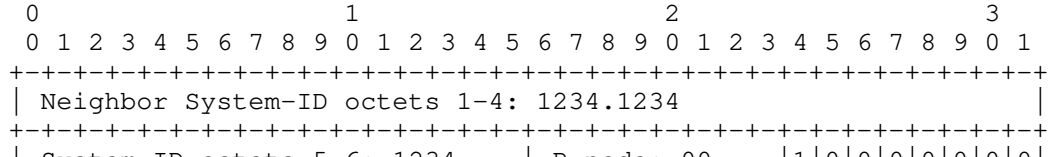
Table 4

This requires two TLVs, one for each L3 adjacency.

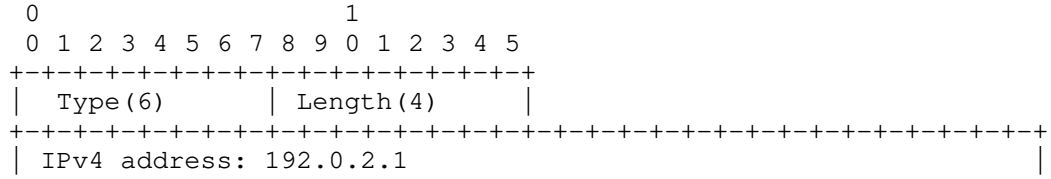
TLV for Adjacency #1:



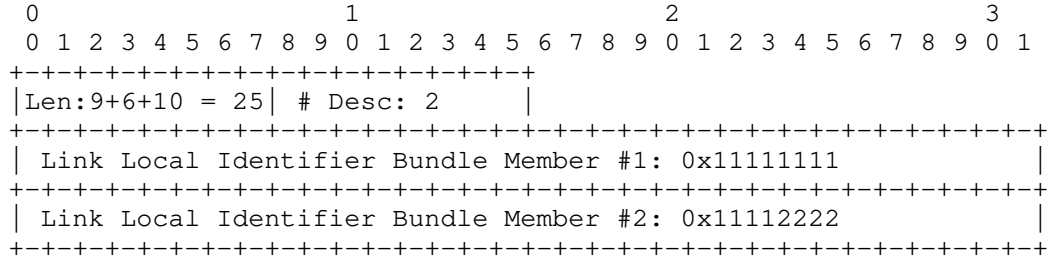
Parent L3 Neighbor Descriptor



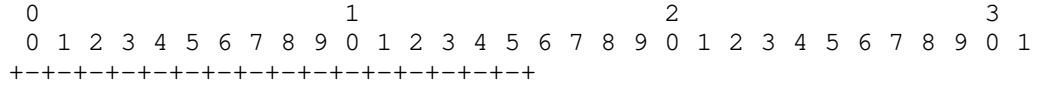
IPv4 Interface Address Sub-TLV

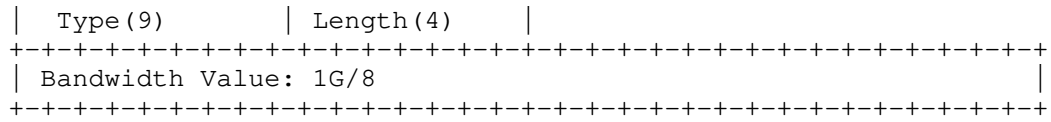


L2 Bundle Attribute Descriptors

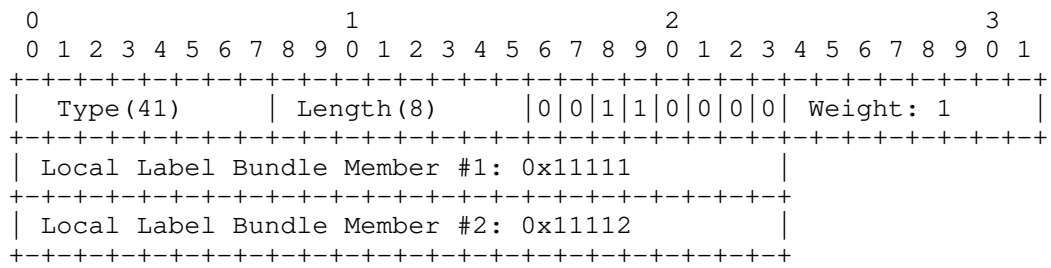


Maximum Link Bandwidth Sub-TLV

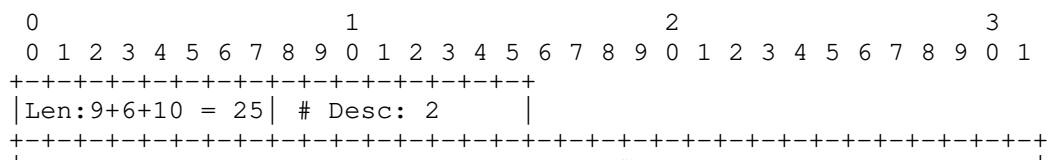




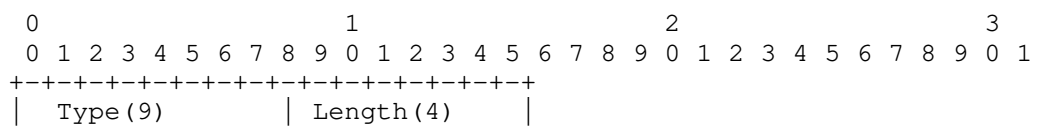
L2 Bundle Member Adj-SID Sub-TLV



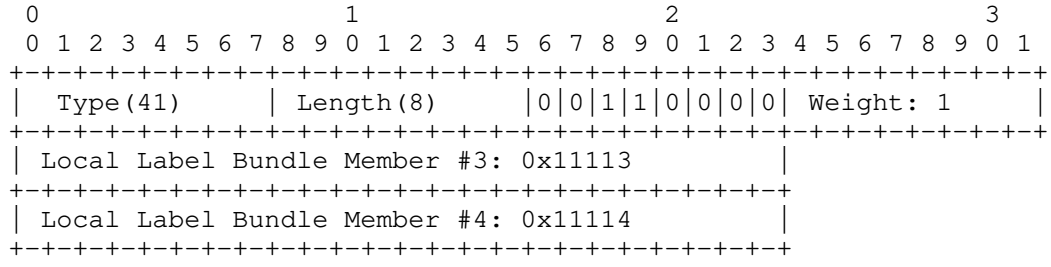
L2 Bundle Attribute Descriptors



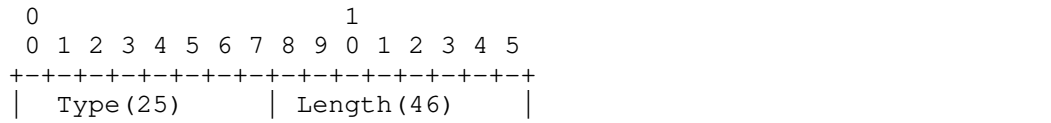
Maximum Link Bandwidth Sub-TLV



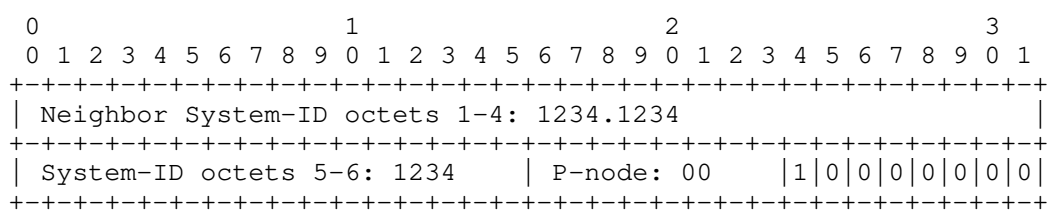
L2 Bundle Member Adj-SID Sub-TLV



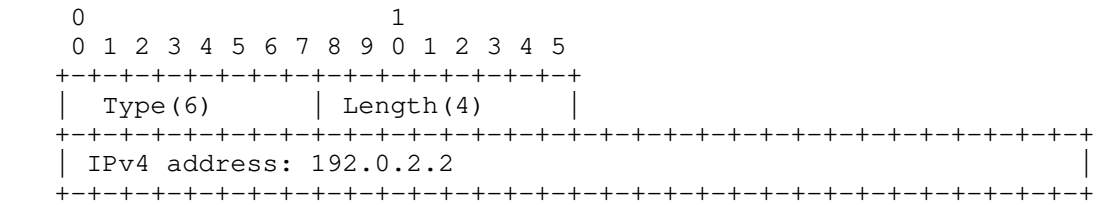
TLV for Adjacency #2:



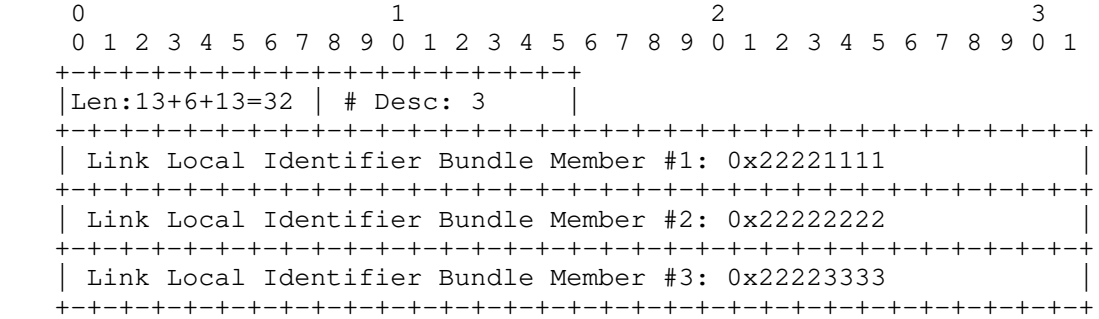
Parent L3 Neighbor Descriptor



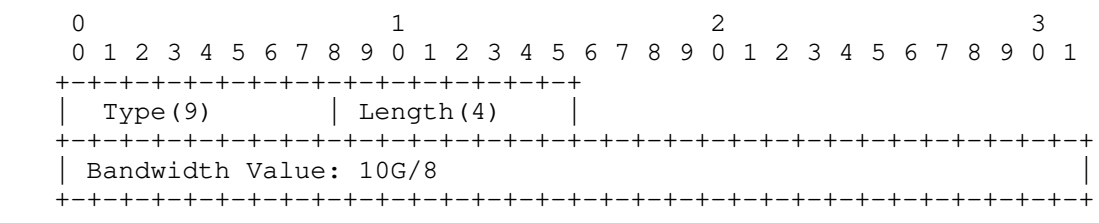
IPv4 Interface Address Sub-TLV



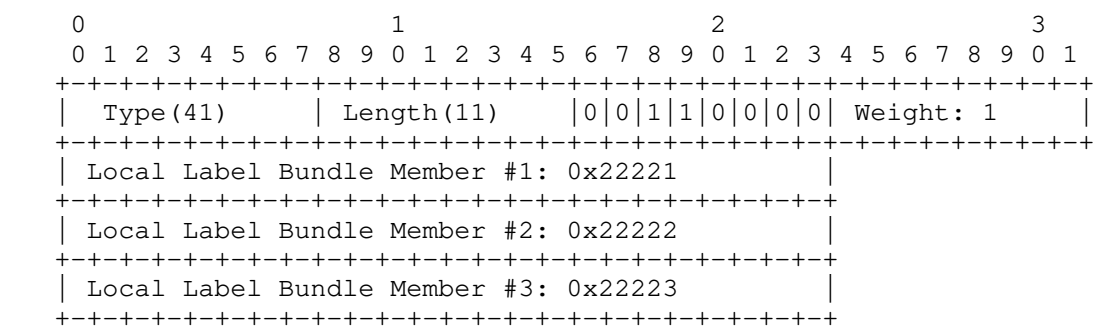
L2 Bundle Attribute Descriptors



Maximum Link Bandwidth Sub-TLV



L2 Bundle Member Adj-SID Sub-TLV



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