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Application-Specific Link Attributes Advertisement Using the Border Gateway Protocol - Link State (BGP-LS)

Abstract

Extensions have been defined for link-state routing protocols that enable distribution of application-specific link attributes for existing as well as newer applications such as Segment Routing (SR). This document defines extensions to the Border Gateway Protocol - Link State (BGP-LS) to enable the advertisement of these application-specific attributes as a part of the topology information from the network.

Status of This Memo

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1. Introduction

The Border Gateway Protocol - Link State (BGP-LS) [RFC7752] enables the distribution of the link-state topology information from link-state routing protocols (viz., IS-IS [RFC1195], OSPFv2 [RFC2328], and OSPFv3 [RFC5340]) to an application like a controller or Path Computation Engine (PCE) via BGP. The controller or PCE gets the end-to-end topology information across IGP domains so it can perform path computations for use cases like end-to-end traffic engineering (TE).

The link-state topology information distributed via BGP-LS includes link attributes that were originally defined for MPLS TE (i.e., using RSVP-TE [RFC3209] or GMPLS [RFC4202] applications). In recent years, applications, such as Segment Routing (SR) Policy [RFC8402] and Loop-Free Alternates (LFA) [RFC5286], which also make use of link attributes, have been introduced. [RFC8919] and [RFC8920] define extensions for IS-IS and OSPF, respectively, that enable advertising application-specific link attributes for these and other future applications. This has resulted in the need for a similar BGP-LS extension to include this additional link-state topology information from the link-state routing protocols.

This document defines the BGP-LS extensions for the advertisement of application-specific link attributes. It describes the advertisement of these link attributes as top-level TLVs (i.e., as TLVs of the BGP-LS Attribute) and as sub-TLVs of the (top-level) Application-Specific Link Attributes (ASLA) TLV. The document also describes the procedures for the advertisement of these attributes from the underlying IGPs and discusses their deployment aspects.

1.1. 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.

2. Application-Specific Link Attributes TLV

BGP-LS [RFC7752] specifies the Link Network Layer Reachability Information (NLRI) for the advertisement of links and their attributes using the BGP-LS Attribute. The ASLA TLV is an optional top-level BGP-LS Attribute TLV that is introduced for Link NLRIs. It is defined such that it may act as a container for certain existing and future link attributes that require application-specific definition.

The format of this TLV is as follows and is similar to the corresponding ASLA sub-TLVs defined for OSPF and IS-IS in [RFC8920] and [RFC8919], respectively.

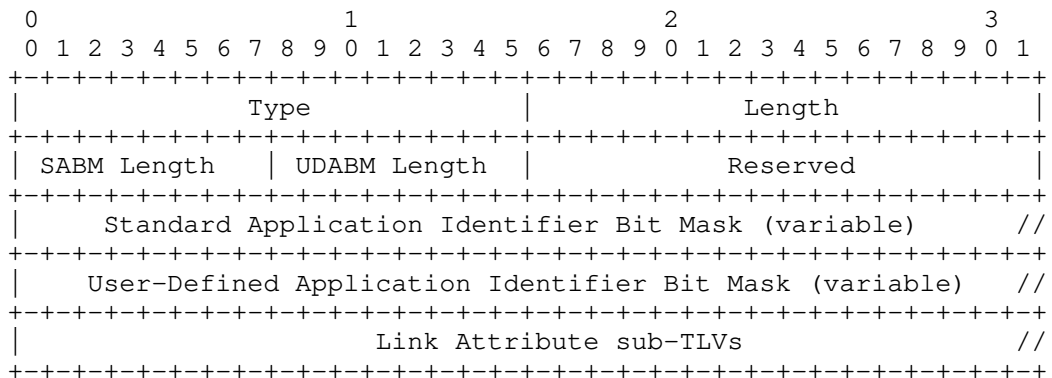


Figure 1: Application-Specific Link Attributes TLV

where:

Type: 1122

Length: variable

SABM Length: 1-octet field that carries the Standard Application Identifier Bit Mask Length in octets as defined in [RFC8920].

UDABM Length: 1-octet field that carries the User-Defined Application Identifier Bit Mask Length in octets as defined in [RFC8920].

Reserved: 2-octet field that MUST be set to zero on transmission and MUST be ignored on reception.

Standard Application Identifier Bit Mask: An optional set of bits (of size 0, 4, or 8 octets as indicated by the SABM Length), where each bit represents a single standard application as defined in [RFC8919].

User-Defined Application Identifier Bit Mask: An optional set of bits (of size 0, 4, or 8 octets as indicated by the UDABM Length), where each bit represents a single user-defined application as defined in [RFC8919] and [RFC8920].

Link Attribute sub-TLVs: BGP-LS Attribute TLVs corresponding to the Link NLRI that are application-specific (including existing ones as specified in Section 3) are included as sub-TLVs of the ASLA TLV.

The semantics associated with the standard and user-defined bit masks as well as the encoding scheme for application-specific attributes are as specified in [RFC8920].

The ASLA TLV and its sub-TLVs can only be added to the BGP-LS Attribute associated with the Link NLRI of the node that originates the underlying IGP link attribute TLVs and sub-TLVs. The procedures for originating link attributes in the ASLA TLV from underlying IGP are specified in Section 4.

3. Application-Specific Link Attributes

Several BGP-LS Attribute TLVs corresponding to the Link NLRI are defined in BGP-LS [RFC7752], and more may be added in the future. Those attributes that have been determined to be, and advertised as, application-specific in the underlying IGP are also encoded similarly in BGP-LS.

The following table lists the currently defined BGP-LS Attribute TLVs corresponding to Link NLRI that can have application-specific semantics based on the underlying IGP specifications [RFC8919] [RFC8920]. These were originally defined with semantics for RSVP-TE and GMPLS applications in BGP-LS by the respective reference documents.

TLV Code Point	Description	Reference Document
1088	Administrative group (color)	[RFC7752]
1092	TE Default Metric	[RFC7752]
1096	Shared Risk Link Group	[RFC7752]
1114	Unidirectional Link Delay	[RFC8571]
1115	Min/Max Unidirectional Link Delay	[RFC8571]

1116	Unidirectional Delay Variation	[RFC8571]
1117	Unidirectional Link Loss	[RFC8571]
1118	Unidirectional Residual Bandwidth	[RFC8571]
1119	Unidirectional Available Bandwidth	[RFC8571]
1120	Unidirectional Utilized Bandwidth	[RFC8571]
1173	Extended Administrative Group	[RFC9104]

Table 1: Existing BGP-LS TLVs Identified as Application-Specific

All the BGP-LS Attribute TLVs listed in the table above are REQUIRED to be advertised as a top-level TLV in the BGP-LS Attribute when used to carry link attributes specific to RSVP-TE.

BGP-LS Attribute TLVs corresponding to Link NLRI that are advertised in the underlying IGP as application-specific are REQUIRED to be encoded within an ASLA TLV.

Link attributes that do not have application-specific semantics MUST NOT be advertised within the ASLA TLV.

When the same application-specific link attributes are advertised both within the ASLA TLV and as top-level TLVs in the BGP-LS Attribute, the attributes advertised within the ASLA TLV take precedence for the applications indicated in the ASLA TLV encoding.

4. Procedures

The BGP-LS originator learns of the association of an application-specific attribute to one or more applications from the underlying IGP protocol Link State Advertisements (LSAs) or Link State Packets (LSPs) from which it is advertising the topology information. [RFC8920] and [RFC8919] specify the mechanisms for advertising application-specific link attributes in OSPF and IS-IS, respectively.

Application-specific link attributes received from an IGP node without the use of ASLA encodings continue to be encoded using the respective BGP-LS top-level TLVs listed in Table 1 as specified in their respective reference documents.

While the ASLA encoding in OSPF is similar to that of BGP-LS, the encoding in IS-IS differs and requires additional procedures when conveying information into BGP-LS. One of these differences arises from the presence of the L-flag in the IS-IS encoding. Another difference arises due to the requirement to collate information from two types of IS-IS encodings for application-specific link information (i.e., the IS-IS ASLA sub-TLV and the IS-IS Application-Specific Shared Risk Link Group (SRLG) TLV) [RFC8919] and to carry them together in the BGP-LS ASLA TLV.

A BGP-LS originator node that is advertising link-state information from the underlying IGP using ASLA encodings determines their BGP-LS encoding based on the following rules:

1. Application-specific link attributes received from an OSPF node using an ASLA sub-TLV or from an IS-IS node using either an ASLA sub-TLV or an Application-Specific SRLG TLV MUST be encoded in the BGP-LS ASLA TLV as sub-TLVs. Exceptions to this rule are specified in (2) (F) and (2) (G) below.

2. In the case of IS-IS, the specific procedures below are to be followed:
 - A. When application-specific link attributes are received from a node with the L-flag set in the IS-IS ASLA sub-TLV and when application bits (other than RSVP-TE) are set in the application bit masks, then the application-specific link attributes advertised in the corresponding legacy IS-IS TLVs and sub-TLVs MUST be encoded within the BGP-LS ASLA TLV as sub-TLVs with the application bits (other than the RSVP-TE bit) copied from the IS-IS ASLA sub-TLV. The link attributes advertised in the legacy IS-IS TLVs and sub-TLVs are also advertised in BGP-LS top-level TLVs as per [RFC7752], [RFC8571], and [RFC9104]. The same procedure also applies for the advertisement of the SRLG values from the IS-IS Application-Specific SRLG TLV.
 - B. When the IS-IS ASLA sub-TLV has the RSVP-TE application bit set, then the link attributes for the corresponding IS-IS ASLA sub-TLVs MUST be encoded using the respective BGP-LS top-level TLVs as per [RFC7752], [RFC8571], and [RFC9104]. Similarly, when the IS-IS Application-Specific SRLG TLV has the RSVP-TE application bit set, then the SRLG values within it MUST be encoded using the top-level BGP-LS SRLG TLV (1096) as per [RFC7752].
 - C. The SRLGs advertised in one or more IS-IS Application-Specific SRLG TLVs and the other link attributes advertised in one or more IS-IS ASLA sub-TLVs are REQUIRED to be collated, on a per-application basis, only for those applications that meet all the following criteria:
 - * their bit is set in the SABM or UDABM in one of the two types of IS-IS encodings (e.g., IS-IS ASLA sub-TLV)
 - * the other encoding type (e.g., IS-IS Application Specific SRLG TLV) has an advertisement with zero-length application bit masks
 - * there is no corresponding advertisement of that other encoding type (following the example, IS-IS Application Specific SRLG TLV) with that specific application bit set

For each such application, its collated information MUST be carried in a BGP-LS ASLA TLV with that application's bit set in the SABM or UDABM. See the illustration in Section 4.1.

 - D. If the resulting set of collated link attributes and SRLG values is common across multiple applications, they MAY be advertised in a common BGP-LS ASLA TLV instance where the bits for all such applications would be set in the application bit mask.
 - E. Both the SRLG values from IS-IS Application-Specific SRLG TLVs and the link attributes from IS-IS ASLA sub-TLVs, with the zero-length application bit mask, MUST be advertised into a BGP-LS ASLA TLV with a zero-length application bit mask, independent of the collation described above.
 - F. [RFC8919] allows the advertisement of the Maximum Link Bandwidth within an IS-IS ASLA sub-TLV even though it is not an application-specific attribute. However, when originating the Maximum Link Bandwidth into BGP-LS, the attribute MUST be encoded only in the top-level BGP-LS Maximum Link Bandwidth TLV (1089) and MUST NOT be advertised within the BGP-LS ASLA TLV.
 - G. [RFC8919] also allows the advertisement of the Maximum Reservable Link Bandwidth and the Unreserved Bandwidth within an IS-IS ASLA sub-TLV even though these attributes are

specific to RSVP-TE application. However, when originating the Maximum Reservable Link Bandwidth and Unreserved Bandwidth into BGP-LS, these attributes MUST be encoded only in the BGP-LS top-level Maximum Reservable Link Bandwidth TLV (1090) and Unreserved Bandwidth TLV (1091), respectively, and not within the BGP-LS ASLA TLV.

These rules ensure that a BGP-LS originator performs the advertisement for all application-specific link attributes from the IGP nodes that support the ASLA extension. Furthermore, it also ensures that the top-level BGP-LS TLVs defined for RSVP-TE and GMPLS applications continue to be used for advertisement of their application-specific attributes.

A BGP-LS speaker would normally advertise all the application-specific link attributes corresponding to RSVP-TE and GMPLS applications as existing top-level BGP-LS TLVs while for other applications they are encoded in the ASLA TLV(s) with appropriate applicable bit mask setting. An application-specific attribute value received via a sub-TLV within the ASLA TLV has precedence over the value received via a top-level TLV.

4.1. Illustration for IS-IS

This section illustrates the procedure for the advertisement of application-specific link attributes from IS-IS into BGP-LS.

Consider the following advertisements for a link in IS-IS. We start with this set:

- a. IS-IS ASLA sub-TLV with the S, F, and X bits set on it that carries certain application-specific link attributes
- b. IS-IS Application-Specific SRLG TLV with zero-length bit masks with a set of application-specific SRLGs
- c. IS-IS Application-Specific SRLG TLV with the X bit set on it with a set of application-specific SRLGs

The corresponding BGP-LS advertisements for that link are determined as follows:

First, based on rule (1), the advertisements are conveyed to BGP-LS to get the following "updated set":

1. ASLA with the S, F, and X bits set on it that carries link attributes from IS-IS advertisement (a)
2. ASLA SRLG with zero-length bit masks with a set of SRLGs from IS-IS advertisement (b)
3. ASLA SRLG with the X bit set on it with a set of SRLGs from IS-IS advertisement (c)

Next, we apply the rules from (2) to this "updated set", because all of them were sourced from IS-IS, to derive a new set.

The next rule that applies is (2)(c), and it is determined that collation is required for applications S and F; therefore, we get the following "final set":

1. ASLA with the S bit set on it that carries link attributes from IS-IS advertisement (a) and SRLGs from IS-IS advertisement (b) (this is collation for application S based on (2)(c))
2. ASLA with the F bit set on it that carries link attributes from IS-IS advertisement (a) and SRLGs from IS-IS advertisement (b) (this is collation for application F based on (2)(c))
3. ASLA with the X bit set on it that carries link attributes from IS-IS advertisement (a) (remaining application not affected by

collation based on (2)(c))

4. ASLA with zero-length bit masks with SRLGs from IS-IS advertisement (b) (not affected by (2)(c) and therefore carried forward unchanged from the "updated set")
5. ASLA with the X bit set on it with SRLGs from IS-IS advertisement (c) (not affected by (2)(c) and therefore carried forward unchanged from the "updated set")

Implementations may optionally perform further consolidation by processing the "final set" above based on (2)(d) to determine the following "consolidated final set":

1. ASLA with the S and F bits set on it that carries application-specific link attributes from IS-IS advertisement (a) and SRLGs from IS-IS advertisement (b) (this is the consolidation of items 1 and 2 of the "final set" based on (2)(d))
2. ASLA with the X bit set on it that carries certain application-specific link attributes from IS-IS advertisement (a) (it is unaffected by this consolidation)
3. ASLA with zero-length bit masks with a set of application-specific SRLGs from IS-IS advertisement (b) (this is retained based on (2)(e) and is unaffected by any further consolidation)
4. ASLA with the X bit set on it with a set of application-specific SRLGs from IS-IS advertisement (c) (it is unaffected by this consolidation)

Further optimization (e.g., combining (2) and (4) from the "consolidated final set" above into a single BGP-LS ASLA TLV) may be possible while ensuring that the semantics are preserved between the IS-IS and BGP-LS advertisements. Such optimizations are outside the scope of this document.

5. Deployment Considerations

BGP-LS sources the link-state topology information (including the extensions introduced by this document) from the underlying link-state IGP protocols. The various deployment aspects related to the advertisement and use of application-specific link attributes are discussed in the Deployment Considerations sections of [RFC8920] and [RFC8919]. The IGP backward-compatibility aspects described in those documents associated with application-specific link attributes along with the BGP-LS procedures specified in this document enable backward compatibility in deployments of existing implementations of [RFC7752], [RFC8571], and [RFC9104] for applications such as RSVP-TE, SR Policy, and LFA.

It is recommended that only nodes supporting this specification are selected as originators of BGP-LS information when advertising the link-state information from the IGPs in deployments supporting application-specific link attributes.

BGP-LS consumers that do not support this specification can continue to use the existing top-level TLVs for link attributes for existing applications as discussed above. However, they would be able to support neither the application-specific link attributes nor newer applications that may be encoded only using the ASLA TLV.

6. IANA Considerations

IANA has assigned a code point from the "BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs" registry as described in the following table. There is no "IS-IS TLV/Sub-TLV" value for this entry.

TLV Code Point	Description	Reference
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1122	Application-Specific Link Attributes	RFC 9294
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Table 2: ASLA TLV Code Point Allocation

7. Manageability Considerations

The protocol extensions introduced in this document augment the existing IGP topology information defined in [RFC7752]. Procedures and protocol extensions defined in this document do not affect the BGP protocol operations and management other than as discussed in the Manageability Considerations section of [RFC7752]. Specifically, the malformed NLRI attribute tests in the Fault Management section of [RFC7752] now encompass the BGP-LS TLVs defined in this document.

The extensions specified in this document do not specify any new configuration or monitoring aspects in BGP or BGP-LS. The specification of BGP models is an ongoing work based on [IDR-BGP-MODEL].

8. Security Considerations

Security considerations for acquiring and distributing BGP-LS information are discussed in [RFC7752]. Specifically, the considerations related to topology information, which are related to traffic engineering, apply.

The TLVs introduced in this document are used to propagate the application-specific link attributes IGP extensions defined in [RFC8919] and [RFC8920]. It is assumed that the IGP instances originating these TLVs will support all the required security (as described in [RFC8919] and [RFC8920]).

This document defines a new way to advertise link attributes. Tampering with the information defined in this document may affect applications using it, including impacting traffic engineering, which uses various link attributes for its path computation. As the advertisements defined in this document limit the scope to specific applications, the impact of tampering is similarly limited in scope. The advertisement of the link attribute information defined in this document presents no significant additional risk beyond that associated with the existing link attribute information already supported in [RFC7752].

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