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OSPF Link Traffic Engineering (TE) Attribute Reuse
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Abstract

Various link attributes have been defined in OSPF in the context of the MPLS Traffic Engineering (TE) and GMPLS. Many of these link attributes can be used for applications other than MPLS Traffic Engineering or GMPLS. This document defines how to distribute such attributes in OSPFv2 and OSPFv3 for applications other than MPLS Traffic Engineering or GMPLS.

Table of Contents

1. Introduction

Various link attributes have been defined in OSPFv2 [RFC2328] and OSPFv3 [RFC5340] in the context of the MPLS traffic engineering and GMPLS. All these attributes are distributed by OSPFv2 as sub-TLVs of the Link-TLV advertised in the OSPFv2 TE Opaque LSA [RFC3630]. In OSPFv3, they are distributed as sub-TLVs of the Link-TLV advertised in the OSPFv3 Intra-Area-TE-LSA as defined in [RFC5329].

Many of these link attributes are useful outside of traditional MPLS Traffic Engineering or GMPLS. This brings its own set of problems,

in particular how to distribute these link attributes in OSPFv2 and OSPFv3 when MPLS TE and GMPLS are not deployed or are deployed in parallel with other applications that use these link attributes.

[RFC7855] discusses use cases/requirements for Segment Routing. Included among these use cases is SRTE. If both RSVP-TE and SRTE are deployed in a network, link attribute advertisements can be used by one or both of these applications. As there is no requirement for the link attributes advertised on a given link used by SRTE to be identical to the link attributes advertised on that same link used by RSVP-TE, there is a clear requirement to indicate independently which link attribute advertisements are to be used by each application.

As the number of applications which may wish to utilize link attributes may grow in the future, an additional requirement is that the extensions defined allow the association of additional applications to link attributes without altering the format of the advertisements or introducing new backwards compatibility issues.

Finally, there may still be many cases where a single attribute value can be shared among multiple applications, so the solution should minimize advertising duplicate link/attribute when possible.

1.1. Requirements notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Advertisement of Link Attributes

This section outlines the solution for advertising link attributes originally defined for MPLS Traffic Engineering or GMPLS when they are used for other applications.

2.1. OSPFv2 Extended Link Opaque LSA and OSPFv3 E-Router-LSA

Extended Link Opaque LSAs as defined in [RFC7684] for OSPFv2 and Extended Router-LSAs [RFC8362] for OSPFv3 are used to advertise link attributes that are used by applications other then MPLS traffic engineering or GMPLS. These LSAs were defined as a generic containers for distribution of the extended link attributes. There are several advantages in using them:

1. Advertisement of the link attributes does not make the link part of the TE topology. It avoids any conflicts and is fully compatible with [RFC3630] and [RFC5329].

2. The OSPFv2 TE Opaque LSA and OSPFv3 Intra-Area-TE-LSA remains truly opaque to OSPFv2 and OSPFv3 as originally defined in [RFC3630] and [RFC5329] respectively. Their contents are not inspected by OSPF, that acts as a pure transport.

3. There is clear distinction between link attributes used by TE and link attributes used by other OSPFv2 or OSPFv3 applications.

4. All link attributes that are used by other applications are advertised in a single LSA, the Extended Link Opaque LSA in OSPFv2 or the OSPFv3 E-Router-LSA [RFC8362] in OSPFv3.

The disadvantage of this approach is that in rare cases, the same link attribute is advertised in both the TE Opaque and Extended Link Attribute LSAs in OSPFv2 or the Intra-Area-TE-LSA and E-Router-LSA in OSPFv3. Additionally, there will be additional standardization effort. However, this could also be viewed as an advantage as the non-TE use cases for the TE link attributes are documented and validated by the LSR working group.

It is RECOMMENDED to use the Extended Link Opaque LSA [RFC7684] and E-Router-LSA [RFC8362] to advertise any link attributes used for non-TE applications in OSPFv2 or OSPFv3 respectively, including those that have been originally defined for TE applications.

It is also RECOMMENDED that TE link attributes used for RSVP-TE/GMPLS continue to use OSPFv2 TE Opaque LSA [RFC3630] and OSPFv3 Intra-Area-TE-LSA [RFC5329].

The format of the link attribute TLVs that have been defined for TE applications will be kept unchanged even when they are used for non-TE applications. Unique code points will be allocated for these TE link attribute TLVs from the OSPFv2 Extended Link TLV Sub-TLV Registry [RFC7684] and from the OSPFv3 Extended LSA Sub-TLV Registry [RFC8362]. For each reused TLV, the code point will be defined in an IETF document along with the expected use-case(s).

3. Advertisement of Application Specific Values

To allow advertisement of the application specific values of the link attribute, a new Application Specific Link Attributes (ASLA) sub-TLV is defined. The ASLA sub-TLV is a sub-TLV of the OSPFv2 Extended Link TLV [RFC7471] and OSPFv3 Router-Link TLV [RFC8362].

The ASLA sub-TLV is an optional sub-TLV and can appear multiple times in the OSPFv2 Extended Link TLV and OSPFv3 Router-Link TLV. It has the following format:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Type             |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     SABML     |     UDABML    |            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Standard Application Bit-Mask                  |
+-                                                             -+
|                            ...                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                User Defined Application Bit-Mask              |
+-                                                             -+
|                            ...                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Link Attribute sub-sub-TLVs              |
+-                                                             -+
|                            ...                                |
```

where:

Type: 10 (OSPFv2), TBD1 (OSPFv3)

Length: variable

SABML: Standard Application Bit-Mask Length. It MUST be a multiple of 4 bytes. If the Standard Application Bit-Mask is not present, the Standard Application Bit-Mask Length MUST be set to 0.

UDABML: User Defined Application Bit-Mask Length. It MUST be a multiple of 4 bytes. If the User Defined Application Bit-Mask is not present, the User Defined Application Bit-Mask Length MUST be set to 0.

Standard Application Bit-Mask: Optional set of bits, where each bit represents a single standard application. Bits are defined in [I-D.ietf-isis-te-app], which also request a new IANA "Link Attribute Applications" registry under "Interior Gateway Protocol (IGP) Parameters" for them. The bits are repeated here for informational purpose:

Bit-0: RSVP Traffic Engineering

Bit-1: Segment Routing Traffic Engineering

Bit-2: Loop Free Alternate (LFA). Includes all LFA types

Bit-3: Flexible Algorithm

User Defined Application Bit-Mask: Optional set of bits, where each bit represents a single user defined application.

Standard Application Bits are defined/sent starting with Bit 0. Additional bit definitions that are defined in the future SHOULD be assigned in ascending bit order so as to minimize the number of octets that will need to be transmitted.

User Defined Application bits have no relationship to Standard Application bits and are NOT managed by IANA or any other standards body. It is recommended that bits are used starting with Bit 0 so as to minimize the number of octets required to advertise all of them.

Undefined bits in both Bit-Masks MUST be transmitted as 0 and MUST be ignored on receipt. Bits that are NOT transmitted MUST be treated as if they are set to 0 on receipt.

If the link attribute advertisement is limited to be used by a specific set of applications, corresponding Bit-Masks MUST be present and application specific bit(s) MUST be set for all applications that use the link attributes advertised in the ASLA sub-TLV.

Application Bit-Masks apply to all link attributes that support application specific values and are advertised in the ASLA sub-TLV.

The advantage of not making the Application Bit-Masks part of the attribute advertisement itself is that we can keep the format of the link attributes that have been defined previously and reuse the same format when advertising them in the ASLA sub-TLV.

When neither the Standard Application Bits nor the User Defined Application bits are set (i.e., both SABML and UDABML are 0) in the ASLA sub-TLV, then the link attributes included in it MUST be considered as being applicable to all applications.

If, however, another advertisement of the same link attribute includes any Application Bit-Mask in the ASLA sub-TLV, applications that are listed in the Application Bit-Masks of such ASLA sub-TLV SHOULD use the attribute advertisement which has the application specific bit set in the Application Bit-Masks.

If the same application is listed in the Application Bit-Masks of more then one ASLA sub-TLV, the application SHOULD use the first advertisement and ignore any subsequent advertisements of the same attribute. This situation SHOULD be logged as an error.

This document defines the initial set of link attributes that MUST use ASLA sub-TLV if advertised in the OSPFv2 Extended Link TLV or in the OSPFv3 Router-Link TLV. If the ASLA sub-TLV includes any link attribute(s) NOT listed below, they MUST be ignored. Documents which define new link attributes MUST state whether the new attributes support application specific values and as such MUST be advertised in an ASLA sub-TLV. The link attributes that MUST be advertised in ASLA sub-TLVs are:

- Shared Risk Link Group

- Unidirectional Link Delay

- Min/Max Unidirectional Link Delay

- Unidirectional Delay Variation

- Unidirectional Link Loss

- Unidirectional Residual Bandwidth

- Unidirectional Available Bandwidth

- Unidirectional Utilized Bandwidth

- Administrative Group

- Extended Administrative Group

- Traffic Engineering Metric

4. Reused TE link attributes

This section defines the use case and code points from the OSPFv2 Extended Link TLV Sub-TLV Registry and OSPFv3 Extended LSA Sub-TLV Registry for some of the link attributes that have been originally defined for TE or GMPLS.

4.1. Shared Risk Link Group (SRLG)

The SRLG of a link can be used in OSPF calculated IPFRR [RFC5714] to compute a backup path that does not share any SRLG group with the protected link.

To advertise the SRLG of the link in the OSPFv2 Extended Link TLV, the same format for the sub-TLV defined in section 1.3 of [RFC4203] is used and TLV type 11 is used. Similarly, for OSPFv3 to advertise the SRLG in the OSPFv3 Router-Link TLV, TLV type TBD2 is used.

4.2. Extended Metrics

[RFC3630] defines several link bandwidth types. [RFC7471] defines extended link metrics that are based on link bandwidth, delay and loss characteristics. All these can be used to compute primary and backup paths within an OSPF area to satisfy requirements for bandwidth, delay (nominal or worst case) or loss.

To advertise extended link metrics in the OSPFv2 Extended Link TLV, the same format for the sub-TLVs defined in [RFC7471] is used with the following TLV types:

12 - Unidirectional Link Delay

13 - Min/Max Unidirectional Link Delay

14 - Unidirectional Delay Variation

15 - Unidirectional Link Loss

16 - Unidirectional Residual Bandwidth

17 - Unidirectional Available Bandwidth

18 - Unidirectional Utilized Bandwidth

To advertise extended link metrics in the OSPFv3 Extended LSA Router-Link TLV, the same format for the sub-TLVs defined in [RFC7471] is used with the following TLV types:

TBD3 - Unidirectional Link Delay

TBD4 - Min/Max Unidirectional Link Delay

TBD5 - Unidirectional Delay Variation

TBD6 - Unidirectional Link Loss

TBD7 - Unidirectional Residual Bandwidth

TBD8 - Unidirectional Available Bandwidth

TBD9 - Unidirectional Utilized Bandwidth

4.3. Administrative Group

[RFC3630] and [RFC7308] define the Administrative Group and Extended Administrative Group sub-TLVs respectively.

One use case where advertisement of the Extended Administrative Group(s) for a link is required is described in [I-D.ietf-lsr-flex-algo].

To advertise the Administrative Group and Extended Administrative Group in the OSPFv2 Extended Link TLV, the same format for the sub-TLVs defined in [RFC3630] and [RFC7308] is used with the following TLV types:

19 - Administrative Group

20 - Extended Administrative Group

To advertise Administrative Group and Extended Administrative Group in the OSPFv3 Router-Link TLV, the same format for the sub-TLVs defined in [RFC3630] and [RFC7308] is used with the following TLV types:

TBD10 - Administrative Group

TBD11 - Extended Administrative Group

4.4. Traffic Engineering Metric

[RFC3630] defines Traffic Engineering Metric.

To advertise the Traffic Engineering Metric in the OSPFv2 Extended Link TLV, the same format for the sub-TLV defined in section 2.5.5 of [RFC3630] is used and TLV type TBD12 is used. Similarly, for OSPFv3 to advertise the Traffic Engineering Metric in the OSPFv3 Router-Link TLV, TLV type TBD13 is used.

5. Maximum Link Bandwidth

Maximum link bandwidth is an application independent attribute of the link that is defined in [RFC3630]. Because it is an application independent attribute, it MUST NOT be advertised in ASLA sub-TLV. Instead, it MAY be advertised as a sub-TLV of the Extended Link Opaque LSA Extended Link TLV in OSPFv2 [RFC7684] or sub-TLV of OSPFv3 E-Router-LSA Router-Link TLV in OSPFv3 [RFC8362].

To advertise the Maximum link bandwidth in the OSPFv2 Extended Link TLV, the same format for sub-TLV defined in [RFC3630] is used with TLV type TBD14.

To advertise the Maximum link bandwidth in the OSPFv3 Router-Link TLV, the same format for sub-TLV defined in [RFC3630] is used with TLV type TBD15.

6. Local Interface IPv6 Address Sub-TLV

The Local Interface IPv6 Address Sub-TLV is an application independent attribute of the link that is defined in [RFC5329]. Because it is an application independent attribute, it MUST NOT be advertised in the ASLA sub-TLV. Instead, it MAY be advertised as a sub-TLV of the OSPFv3 E-Router-LSA Router-Link TLV [RFC8362].

To advertise the Local Interface IPv6 Address Sub-TLV in the OSPFv3 Router-Link TLV, the same format for sub-TLV defined in [RFC5329] is used with TLV type TBD16.

7. Remote Interface IPv6 Address Sub-TLV

The Remote Interface IPv6 Address Sub-TLV is an application independent attribute of the link that is defined in [RFC5329]. Because it is an application independent attribute, it MUST NOT be advertised in the ASLA sub-TLV. Instead, it MAY be advertised as a sub-TLV of the OSPFv3 E-Router-LSA Router-Link TLV [RFC8362].

To advertise the Remote Interface IPv6 Address Sub-TLV in the OSPFv3 Router-Link TLV, the same format for sub-TLV defined in [RFC5329] is used with TLV type TBD17.

8. Deployment Considerations

If link attributes are advertised associated with zero length application bit masks for both standard applications and user defined applications, then that set of link attributes MAY be used by any application. If support for a new application is introduced on any node in a network in the presence of such advertisements, these advertisements MAY be used by the new application. If this is not what is intended, then existing advertisements MUST be readvertised with an explicit set of applications specified before a new application is introduced.

9. Attribute Advertisements and Enablement

This document defines extensions to support the advertisement of application specific link attributes.

Whether the presence of link attribute advertisements for a given application indicates that the application is enabled on that link depends upon the application. Similarly, whether the absence of link attribute advertisements indicates that the application is not enabled depends upon the application.

In the case of RSVP-TE, the advertisement of application specific link attributes implies that RSVP is enabled on that link.

In the case of SRTE, advertisement of application specific link attributes does NOT indicate enablement of SRTE. The advertisements are only used to support constraints which may be applied when specifying an explicit path. SRTE is implicitly enabled on all links which are part of the Segment Routing enabled topology independent of the existence of link attribute advertisements.

In the case of LFA, advertisement of application specific link attributes does NOT indicate enablement of LFA on that link. Enablement is controlled by local configuration.

In the case of Flexible Algorithm, advertisement of application specific link attributes does NOT indicate enablement of Flexible Algorithm on that link. Rather the attributes are used to determine what links are included/excluded in the algorithm specific constrained SPF. This is fully specified in [I-D.ietf-lsr-flex-algo].

If, in the future, additional standard applications are defined to use this mechanism, the specification defining this use MUST define the relationship between application specific link attribute advertisements and enablement for that application.

This document allows the advertisement of application specific link attributes with no application identifiers i.e., both the Standard Application Bit Mask and the User Defined Application Bit Mask are not present (See Section 3). This supports the use of the link attribute by any application. In the presence of an application where the advertisement of link attribute advertisements is used to infer the enablement of an application on that link (e.g., RSVP-TE), the absence of the application identifier leaves ambiguous whether that application is enabled on such a link. This needs to be considered when making use of the "any application" encoding.

10. Backward Compatibility

Link attributes may be concurrently advertised in both the TE Opaque LSA and the Extended Link Opaque LSA in OSPFv2 and the OSPFv3 Intra-Area-TE-LSA and OSPFv3 Extended LSA Router-Link TLV in OSPFv3.

In fact, there is at least one OSPF implementation that utilizes the link attributes advertised in TE Opaque LSAs [RFC3630] for Non-RSVP TE applications. For example, this implementation of LFA and remote LFA utilizes links attributes such as Shared Risk Link Groups (SRLG) [RFC4203] and Admin Group [[RFC3630] advertised in TE Opaque LSAs. These applications are described in [RFC5286], [RFC7490], [RFC7916] and [RFC8102].

When an OSPF routing domain includes routers using link attributes from the OSPFv2 TE Opaque LSAs or the OSPFv3 Intra-Area-TE-LSA for Non-RSVP TE applications such as LFA, OSPF routers in that domain SHOULD continue to advertise such OSPFv2 TE Opaque LSAs or the OSPFv3 Intra-Area-TE-LSA. If there are also OSPF routers using the link attributes described herein for any other application, OSPF routers in the routing domain will also need to advertise these attributes in OSPFv2 Extended Link Attributes LSAs or OSPFv3 E-Router-LSA. In such a deployment, the advertised attributes SHOULD be the same and Non-RSVP application access to link attributes is a matter of local policy.

11. Security Considerations

Existing security extensions as described in [RFC2328], [RFC5340] and [RFC8362] apply to extensions defined in this document. While OSPF is under a single administrative domain, there can be deployments where potential attackers have access to one or more networks in the OSPF routing domain. In these deployments, stronger authentication mechanisms such as those specified in [RFC5709], [RFC7474], [RFC4552] or [RFC7166] SHOULD be used.

Implementations MUST assure that malformed TLV and Sub-TLV defined in this document are detected and do not provide a vulnerability for attackers to crash the OSPF router or routing process. Reception of a malformed TLV or Sub-TLV SHOULD be counted and/or logged for further analysis. Logging of malformed TLVs and Sub-TLVs SHOULD be rate-limited to prevent a Denial of Service (DoS) attack (distributed or otherwise) from overloading the OSPF control plane.

12. IANA Considerations

12.1. OSPFv2

OSPFv2 Extended Link TLV Sub-TLVs registry [RFC7684] defines sub-TLVs at any level of nesting for OSPFv2 Extended Link TLVs. This specification updates OSPFv2 Extended Link TLV sub-TLVs registry with the following TLV types:

10 - Application Specific Link Attributes

11 - Shared Risk Link Group

12 - Unidirectional Link Delay

13 - Min/Max Unidirectional Link Delay

14 - Unidirectional Delay Variation

15 - Unidirectional Link Loss

16 - Unidirectional Residual Bandwidth

17 - Unidirectional Available Bandwidth

18 - Unidirectional Utilized Bandwidth

19 - Administrative Group

20 - Extended Administrative Group

TBD12 (22 Recommended) - Traffic Engineering Metric

TBD14 (21 Recommended) - Maximum Link Bandwidth

12.2. OSPFv3

OSPFv3 Extended LSA Sub-TLV Registry [RFC8362] defines sub-TLVs at any level of nesting for OSPFv3 Extended LSAs. This specification updates OSPFv3 Extended LSA Sub-TLV Registry with the following TLV types:

TBD1 (10 Recommended) - Application Specific Link Attributes

TBD2 (11 Recommended) - Shared Risk Link Group

TBD3 (12 Recommended) - Unidirectional Link Delay

TBD4 (13 Recommended) - Min/Max Unidirectional Link Delay

TBD5 (14 Recommended) - Unidirectional Delay Variation

TBD6 (15 Recommended) - Unidirectional Link Loss

TBD7 (16 Recommended) - Unidirectional Residual Bandwidth

TBD8 (17 Recommended) - Unidirectional Available Bandwidth

TBD9 (18 Recommended) - Unidirectional Utilized Bandwidth

TBD10 (19 Recommended) - Administrative Group

TBD11 (20 Recommended) - Extended Administrative Group

TBD13 (21 Recommended) - Traffic Engineering Metric

TBD15 (22 Recommended) - Maximum Link Bandwidth

TBD16 (23 Recommended) - Local Interface IPv6 Address Sub-TLV

TBD17 (24 Recommended) - Local Interface IPv6 Address Sub-TLV

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