

Internet Engineering Task Force (IETF)
Request for Comments: 9492
Obsoletes: 8920
Category: Standards Track
ISSN: 2070-1721

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October 2023

OSPF Application-Specific Link Attributes

Abstract

Existing traffic-engineering-related link attribute advertisements have been defined and are used in RSVP-TE deployments. Since the original RSVP-TE use case was defined, additional applications such as Segment Routing (SR) Policy and Loop-Free Alternates (LFAs) that also make use of the link attribute advertisements have been defined. In cases where multiple applications wish to make use of these link attributes, the current advertisements do not support application-specific values for a given attribute, nor do they support indication of which applications are using the advertised value for a given link. This document introduces link attribute advertisements in OSPFv2 and OSPFv3 that address both of these shortcomings.

This document obsoletes RFC 8920.

Status of This Memo

This is an Internet Standards Track document.

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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/rfc9492>.

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1. Introduction

Advertisement of link attributes by the OSPFv2 [RFC2328] and OSPFv3 [RFC5340] protocols in support of traffic engineering (TE) was introduced by [RFC3630] and [RFC5329], respectively. It has been extended by [RFC4203], [RFC7308], and [RFC7471]. Use of these extensions has been associated with deployments supporting TE over Multiprotocol Label Switching (MPLS) in the presence of the Resource Reservation Protocol (RSVP), more succinctly referred to as RSVP-TE [RFC3209].

For the purposes of this document, an application is a technology

that makes use of link attribute advertisements, examples of which are listed in Section 5.

In recent years, new applications have been introduced that have use cases for many of the link attributes historically used by RSVP-TE. Such applications include SR Policy [RFC9256] and LFAs [RFC5286]. This has introduced ambiguity in that if a deployment includes a mix of RSVP-TE support and SR Policy support, for example, it is not possible to unambiguously indicate which advertisements are to be used by RSVP-TE and which advertisements are to be used by SR Policy. If the topologies are fully congruent, this may not be an issue, but any incongruence leads to ambiguity.

An example of where this ambiguity causes a problem is a network where RSVP-TE is enabled only on a subset of its links. A link attribute is advertised for the purpose of another application (e.g., SR Policy) for a link that is not enabled for RSVP-TE. As soon as the router that is an RSVP-TE head end sees the link attribute being advertised for that link, it assumes RSVP-TE is enabled on that link, even though it is not. If such an RSVP-TE head-end router tries to set up an RSVP-TE path via that link, it will result in a setup failure for the path.

An additional issue arises in cases where both applications are supported on a link but the link attribute values associated with each application differ. Current advertisements do not support advertising application-specific values for the same attribute on a specific link.

This document defines extensions that address these issues. Also, as evolution of use cases for link attributes can be expected to continue in the years to come, this document defines a solution that is easily extensible for the introduction of new applications and new use cases.

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. Requirements Discussion

As stated previously, evolution of use cases for link attributes can be expected to continue. Therefore, any discussion of existing use cases is limited to requirements that are known at the time of this writing. However, in order to determine the functionality required beyond what already exists in OSPF, it is only necessary to discuss use cases that justify the key points identified in the introduction, which are:

1. Support for indicating which applications are using the link attribute advertisements on a link.

2. Support for advertising application-specific values for the same attribute on a link.

[RFC7855] discusses use cases and requirements for SR. Included among these use cases is SR Policy, which is defined in [RFC9256]. If both RSVP-TE and SR Policy are deployed in a network, link attribute advertisements can be used by one or both of these applications. There is no requirement for the link attributes advertised on a given link used by SR Policy to be identical to the link attributes advertised on that same link used by RSVP-TE; thus, there is a clear requirement to indicate independently which link attribute advertisements are to be used by each application.

As the number of applications that 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 backwards-compatibility issues.

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

3. Existing Advertisement of Link Attributes

There are existing advertisements used in support of RSVP-TE. These advertisements are carried in the OSPFv2 TE Opaque Link State Advertisement (LSA) [RFC3630] and OSPFv3 Intra-Area-TE-LSA [RFC5329]. Additional RSVP-TE link attributes have been defined by [RFC4203], [RFC7308], and [RFC7471].

Extended Link Opaque LSAs as defined in [RFC7684] for OSPFv2 and E-Router-LSAs [RFC8362] for OSPFv3 are used to advertise link attributes that are used by applications other than RSVP-TE or GMPLS [RFC4203]. These LSAs were defined as generic containers for distribution of the extended link attributes.

4. Advertisement of Link Attributes

This section outlines the solution for advertising link attributes originally defined for RSVP-TE or GMPLS when they are used for other applications.

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

The following are the advantages of Extended Link Opaque LSAs as defined in [RFC7684] for OSPFv2 and E-Router-LSAs [RFC8362] for OSPFv3 with respect to the advertisement of link attributes originally defined for RSVP-TE when used in packet networks and in GMPLS:

1. Advertisement of the link attributes does not make the link part of the RSVP-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 remain truly opaque to OSPFv2 and OSPFv3 as originally defined in [RFC3630] and [RFC5329], respectively. Their contents are not inspected by OSPF, which instead acts as a pure transport.
3. There is a clear distinction between link attributes used by RSVP-TE and link attributes used by other OSPFv2 or OSPFv3 applications.
4. All link attributes that are used by other applications are advertised in the Extended Link Opaque LSA in OSPFv2 [RFC7684] 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.

The Extended Link Opaque LSA [RFC7684] and E-Router-LSA [RFC8362] are used to advertise any link attributes used for non-RSVP-TE applications in OSPFv2 or OSPFv3, respectively, including those that have been originally defined for RSVP-TE applications (see Section 6).

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

The format of the link attribute TLVs that have been defined for RSVP-TE applications will be kept unchanged even when they are used for non-RSVP-TE applications. Unique codepoints are allocated for these link attribute TLVs from the "OSPFv2 Extended Link TLV Sub-TLVs" registry [RFC7684] and from the "OSPFv3 Extended-LSA Sub-TLVs" registry [RFC8362], as specified in Section 14.

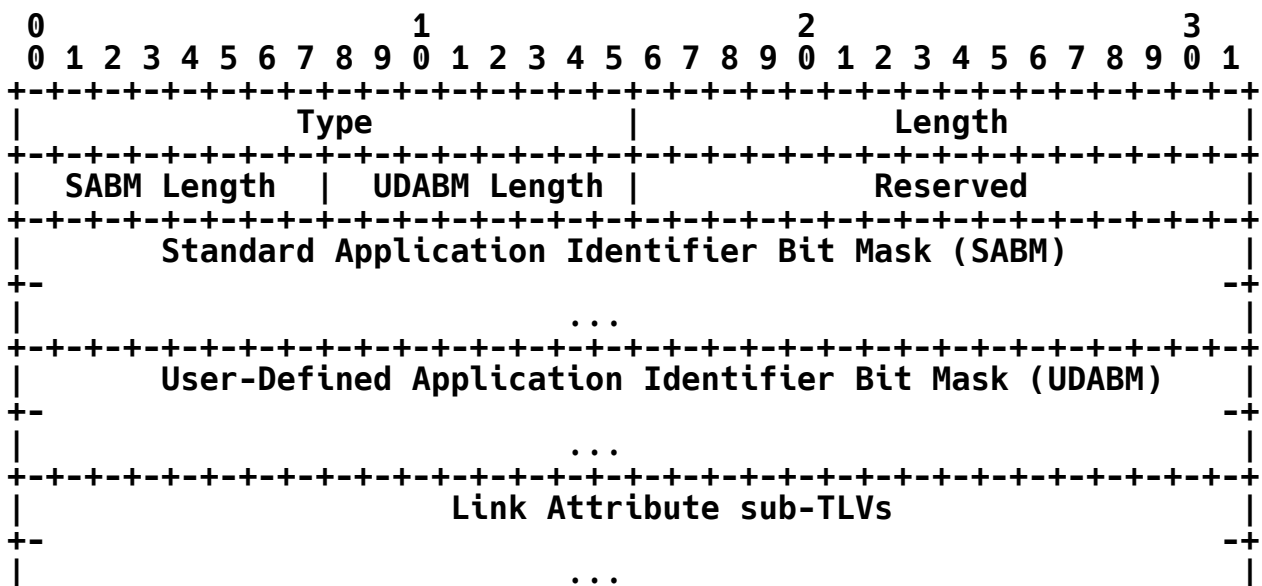
5. Advertisement of Application-Specific Values

To allow advertisement of the application-specific values of the link attribute, an Application-Specific Link Attributes (ASLA) sub-TLV is defined. The ASLA sub-TLV is a sub-TLV of the OSPFv2 Extended Link TLV [RFC7684] and OSPFv3 Router-Link TLV [RFC8362].

In addition to advertising the link attributes for standardized applications, link attributes can be advertised for the purpose of applications that are not standardized. We call such an application a "user-defined application" or "UDA". These applications are not subject to standardization and are outside of the scope of this specification.

The ASLA sub-TLV is an optional sub-TLV of the OSPFv2 Extended Link TLV and OSPFv3 Router-Link TLV. Multiple ASLA sub-TLVs can be present in a parent TLV when different applications want to control different link attributes or when a different value of the same attribute needs to be advertised by multiple applications. The ASLA sub-TLV MUST be used for advertisement of the link attributes listed at the end of this section if these are advertised inside the OSPFv2 Extended Link TLV and OSPFv3 Router-Link TLV. It has the following

format:



where:

Type:

10 (OSPFv2), 11 (OSPFv3)

Length:

Variable

SABM Length:

Standard Application Identifier Bit Mask Length in octets. The value MUST be 0, 4, or 8. If the Standard Application Identifier Bit Mask is not present, the SABM Length MUST be set to 0.

UDABM Length:

User-Defined Application Identifier Bit Mask Length in octets. The value MUST be 0, 4, or 8. If the User-Defined Application Identifier Bit Mask is not present, the UDABM Length MUST be set to 0.

Standard Application Identifier Bit Mask:

Optional set of bits, where each bit represents a single standard application. Bits are defined in the "Link Attribute Application Identifiers" registry, which is defined in [RFC9479]. Current assignments are repeated here for informational purposes:

0	1	2	3	4	5	6	7	...
+	+	+	+	+	+	+	+	...
	R		S		F			...
+	+	+	+	+	+	+	+	...

Bit 0 (R-bit): RSVP-TE.

Bit 1 (S-bit): SR Policy (this is data plane independent).

Bit 2 (F-bit): Loop-Free Alternate (includes all LFA types).

User-Defined Application Identifier Bit Mask:

Optional set of bits, where each bit represents a single user-defined application.

If the SABM or UDABM Length is other than 0, 4, or 8, the ASLA sub-TLV MUST be ignored by the receiver.

Standard Application Identifier Bits are defined and sent starting with bit 0. Undefined bits that are transmitted 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. Bits that are not supported by an implementation MUST be ignored on receipt.

User-Defined Application Identifier Bits have no relationship to Standard Application Identifier Bits and are not managed by IANA or any other standards body. It is recommended that these bits be used starting with bit 0 so as to minimize the number of octets required to advertise all UDAs. Undefined bits that are transmitted 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. Bits that are not supported by an implementation MUST be ignored on receipt.

If the link attribute advertisement is intended to be only used by a specific set of applications, corresponding bit masks MUST be present and one or more application-specific bits MUST be set for all applications that use the link attributes advertised in the ASLA sub-TLV.

Application Identifier 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 Identifier Bit Masks part of the attribute advertisement itself is that the format of any previously defined link attributes can be kept and reused when advertising them in the ASLA sub-TLV.

If the same attribute is advertised in more than one ASLA sub-TLV with the application listed in the Application Identifier Bit Masks, the application SHOULD use the first instance of advertisement and ignore any subsequent advertisements of that attribute.

Link attributes MAY be advertised associated with zero-length Application Identifier Bit Masks for both standard applications and user-defined applications. Such link attribute advertisements MUST be used by standard applications and/or user-defined applications when no link attribute advertisements with a non-zero-length Application Identifier Bit Mask and a matching Application Identifier Bit set are present. Otherwise, such link attribute advertisements MUST NOT be used.

This document defines the initial set of link attributes that MUST use the ASLA sub-TLV if advertised in the OSPFv2 Extended Link TLV or in the OSPFv3 Router-Link TLV. Documents that define new link

attributes MUST state whether the new attributes support application-specific values and, as such, are advertised in an ASLA sub-TLV. The standard link attributes that are advertised in ASLA sub-TLVs are:

- * Shared Risk Link Group [RFC4203]
- * Unidirectional Link Delay [RFC7471]
- * Min/Max Unidirectional Link Delay [RFC7471]
- * Unidirectional Delay Variation [RFC7471]
- * Unidirectional Link Loss [RFC7471]
- * Unidirectional Residual Bandwidth [RFC7471]
- * Unidirectional Available Bandwidth [RFC7471]
- * Unidirectional Utilized Bandwidth [RFC7471]
- * Administrative Group [RFC3630]
- * Extended Administrative Group [RFC7308]
- * TE Metric [RFC3630]

6. Reused TE Link Attributes

This section defines the use case and indicates the codepoints (Section 14) from the "OSPFv2 Extended Link TLV Sub-TLVs" registry and "OSPFv3 Extended-LSA Sub-TLVs" registry for some of the link attributes that have been originally defined for RSVP-TE or GMPLS.

6.1. Shared Risk Link Group (SRLG)

The SRLG of a link can be used in OSPF-calculated IPFRR (IP Fast Reroute) [RFC5714] to compute a backup path that does not share any SRLG 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 with TLV type 11. Similarly, for OSPFv3 to advertise the SRLG in the OSPFv3 Router-Link TLV, TLV type 12 is used.

6.2. Extended Metrics

[RFC3630] defines several link bandwidth types. [RFC7471] defines extended link metrics that are based on link bandwidth, delay, and loss characteristics. All of 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 Router-Link TLV inside the OSPFv3 E-Router-LSA, the same format for the sub-TLVs defined in [RFC7471] is used with the following TLV types:

- 13: Unidirectional Link Delay
- 14: Min/Max Unidirectional Link Delay
- 15: Unidirectional Delay Variation
- 16: Unidirectional Link Loss
- 17: Unidirectional Residual Bandwidth
- 18: Unidirectional Available Bandwidth
- 19: Unidirectional Utilized Bandwidth

6.3. Administrative Group

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

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 the 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:

- 20: Administrative Group
- 21: Extended Administrative Group

6.4. TE Metric

[RFC3630] defines the TE Metric.

To advertise the TE Metric in the OSPFv2 Extended Link TLV, the same format for the sub-TLV defined in Section 2.5.5 of [RFC3630] is used with TLV type 22. Similarly, for OSPFv3 to advertise the TE Metric in the OSPFv3 Router-Link TLV, TLV type 22 is used.

7. 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 the ASLA sub-TLV. Instead, it **MAY** be advertised as a sub-TLV of the Extended Link TLV in the Extended Link Opaque LSA in OSPFv2 [RFC7684] or as a sub-TLV of the Router-Link TLV in the 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 the sub-TLV defined in [RFC3630] is used with TLV type 23.

To advertise the maximum link bandwidth in the OSPFv3 Router-Link TLV, the same format for the sub-TLV defined in [RFC3630] is used with TLV type 23.

8. Considerations for Extended TE Metrics

[RFC7471] defines a number of dynamic performance metrics associated with a link. It is conceivable that such metrics could be measured specific to traffic associated with a specific application. Therefore, this document includes support for advertising these link attributes specific to a given application. However, in practice, it may well be more practical to have these metrics reflect the performance of all traffic on the link regardless of application. In such cases, advertisements for these attributes can be associated with all of the applications utilizing that link. This can be done either by explicitly specifying the applications in the Application Identifier Bit Mask or by using a zero-length Application Identifier Bit Mask. The use of zero-length Application Identifier Bit Mask is further discussed in Section 12.2.

9. 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 Router-Link TLV inside the OSPFv3 E-Router-LSA [RFC8362].

To advertise the Local Interface IPv6 Address sub-TLV in the OSPFv3 Router-Link TLV, the same format for the sub-TLV defined in [RFC5329] is used with TLV type 24.

10. 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 Router-Link TLV inside the OSPFv3 E-Router-LSA [RFC8362].

To advertise the Remote Interface IPv6 Address sub-TLV in the OSPFv3 Router-Link TLV, the same format for the sub-TLV defined in [RFC5329] is used with TLV type 25.

11. Attribute Advertisements and Enablement

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

There are applications where the application enablement on the link is relevant; for example, with RSVP-TE, one needs to make sure that RSVP is enabled on the link before sending an RSVP-TE signaling message over it.

There are applications where the enablement of the application on the link is irrelevant and has nothing to do with the fact that some link attributes are advertised for the purpose of such application. An example of this is LFA.

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 has no implication of RSVP-TE being enabled on that link. The RSVP-TE enablement is solely derived from the information carried in the OSPFv2 TE Opaque LSA [RFC3630] and OSPFv3 Intra-Area-TE-LSA [RFC5329].

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

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

In the future, if 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 SABM and the UDABM are not present (see Section 5). This supports the use of the link attribute by any application. In the presence of an application where the advertisement of link attributes 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.

12. Deployment Considerations

12.1. Use of Legacy RSVP-TE LSA Advertisements

Bit identifiers for standard applications are defined in Section 5. All of the identifiers defined in this document are associated with applications that were already deployed in some networks prior to the writing of this document. Therefore, such applications have been deployed using the RSVP-TE LSA advertisements. The standard applications defined in this document may continue to use RSVP-TE LSA advertisements for a given link so long as at least one of the following conditions is true:

- * The application is RSVP-TE.
- * The application is SR Policy or LFA, and RSVP-TE is not deployed anywhere in the network.
- * The application is SR Policy or LFA, RSVP-TE is deployed in the network, and both the set of links on which SR Policy and/or LFA advertisements are required and the attribute values used by SR Policy and/or LFA on all such links are fully congruent with the links and attribute values used by RSVP-TE.

Under the conditions defined above, implementations that support the extensions defined in this document have the choice of using RSVP-TE LSA advertisements or application-specific advertisements in support of SR Policy and/or LFA. This will require implementations to provide controls specifying which types of advertisements are to be sent and processed on receipt for these applications. Further discussion of the associated issues can be found in Section 12.3.

New applications that future documents define to make use of the advertisements defined in this document **MUST NOT** make use of RSVP-TE LSA advertisements. This simplifies deployment of new applications by eliminating the need to support multiple ways to advertise attributes for the new applications.

12.2. Use of Zero-Length Application Identifier Bit Masks

Link attribute advertisements associated with zero-length Application Identifier Bit Masks for both standard applications and user-defined applications are usable by any application, subject to the restrictions specified in Section 5. If support for a new application is introduced on any node in a network in the presence of such advertisements, the new application will use these advertisements when the aforementioned restrictions are met. If this

is not what is intended, then existing link attribute advertisements **MUST** be readvertised with an explicit set of applications specified before a new application is introduced.

12.3. Interoperability, Backwards Compatibility, and Migration Concerns

Existing deployments of RSVP-TE, SR Policy, and/or LFA utilize the legacy advertisements listed in Section 3. Routers that do not support the extensions defined in this document will only process legacy advertisements and are likely to infer that RSVP-TE is enabled on the links for which legacy advertisements exist. It is expected that deployments using the legacy advertisements will persist for a significant period of time. Therefore, deployments using the extensions defined in this document in the presence of routers that do not support these extensions need to be able to interoperate with the use of legacy advertisements by the legacy routers. The following subsections discuss interoperability and backwards-compatibility concerns for a number of deployment scenarios.

12.3.1. Multiple Applications: Common Attributes with RSVP-TE

In cases where multiple applications are utilizing a given link, one of the applications is RSVP-TE, and all link attributes for a given link are common to the set of applications utilizing that link, interoperability is achieved by using legacy advertisements for RSVP-TE. Attributes for applications other than RSVP-TE **MUST** be advertised using application-specific advertisements. This results in duplicate advertisements for those attributes.

12.3.2. Multiple Applications: Some Attributes Not Shared with RSVP-TE

In cases where one or more applications other than RSVP-TE are utilizing a given link and one or more link attribute values are not shared with RSVP-TE, interoperability is achieved by using legacy advertisements for RSVP-TE. Attributes for applications other than RSVP-TE **MUST** be advertised using application-specific advertisements. In cases where some link attributes are shared with RSVP-TE, this requires duplicate advertisements for those attributes.

12.3.3. Interoperability with Legacy Routers

For the standard applications defined in this document, routers that do not support the extensions defined in this document will send and receive only legacy link attribute advertisements. In addition, the link attribute values associated with these applications are always shared since legacy routers have no way of advertising or processing application-specific values. So long as there is any legacy router in the network that has any of the standard applications defined in this document enabled, all routers **MUST** continue to advertise link attributes for these applications using only legacy advertisements. ASLA advertisements for these applications **MUST NOT** be sent. Once all legacy routers have been upgraded, migration from legacy advertisements to ASLA advertisements can be achieved via the following steps:

- 1) Send new application-specific advertisements while continuing to

advertise using the legacy advertisement (all advertisements are then duplicated). Receiving routers continue to use legacy advertisements.

- 2) Enable the use of the application-specific advertisements on all routers.
- 3) Keep legacy advertisements if needed for RSVP-TE purposes.

When the migration is complete, it then becomes possible to advertise incongruent values per application on a given link.

Documents defining new applications that make use of the application-specific advertisements defined in this document **MUST** discuss interoperability and backwards-compatibility issues that could occur in the presence of routers that do not support the new application.

12.3.4. Use of Application-Specific Advertisements for RSVP-TE

The extensions defined in this document support RSVP-TE as one of the supported applications. It is, however, **RECOMMENDED** to advertise all link attributes for RSVP-TE in the existing OSPFv2 TE Opaque LSA [RFC3630] and OSPFv3 Intra-Area-TE-LSA [RFC5329] to maintain backwards compatibility. RSVP-TE can eventually utilize the application-specific advertisements for newly defined link attributes that are defined as application specific.

Link attributes that are not allowed to be advertised in the ASLA sub-TLV, such as maximum reservable link bandwidth and unreserved bandwidth, **MUST** use the OSPFv2 TE Opaque LSA [RFC3630] and OSPFv3 Intra-Area-TE-LSA [RFC5329] and **MUST NOT** be advertised in the ASLA sub-TLV.

13. 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 ensure that if any of the TLVs and sub-TLVs defined in this document are malformed, they are detected and do not facilitate a vulnerability for attackers to crash or otherwise compromise 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.

This document defines an improved way to advertise link attributes. Tampering with the information defined in this document may have an effect on applications using it, including impacting TE, which uses various link attributes for its path computation. This is similar in

nature to the impacts associated with, for example, [RFC3630]. As the advertisements defined in this document limit the scope to specific applications, the impact of tampering is similarly limited in scope.

14. IANA Considerations

This specification updates two existing registries:

- * the "OSPFv2 Extended Link TLV Sub-TLVs" registry
- * the "OSPFv3 Extended-LSA Sub-TLVs" registry

The values defined in this document have been allocated using the IETF Review procedure as described in [RFC8126].

14.1. OSPFv2

The "OSPFv2 Extended Link TLV Sub-TLVs" registry [RFC7684] defines sub-TLVs at any level of nesting for OSPFv2 Extended Link TLVs. IANA has assigned the following sub-TLV types in the "OSPFv2 Extended Link TLV Sub-TLVs" registry:

- 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
- 22: TE Metric
- 23: Maximum link bandwidth

14.2. OSPFv3

The "OSPFv3 Extended-LSA Sub-TLVs" registry [RFC8362] defines sub-TLVs at any level of nesting for OSPFv3 Extended LSAs. IANA has assigned the following sub-TLV types in the "OSPFv3 Extended-LSA Sub-TLVs" registry:

- 11: Application-Specific Link Attributes
- 12: Shared Risk Link Group
- 13: Unidirectional Link Delay
- 14: Min/Max Unidirectional Link Delay
- 15: Unidirectional Delay Variation
- 16: Unidirectional Link Loss
- 17: Unidirectional Residual Bandwidth
- 18: Unidirectional Available Bandwidth
- 19: Unidirectional Utilized Bandwidth
- 20: Administrative Group
- 21: Extended Administrative Group
- 22: TE Metric
- 23: Maximum link bandwidth
- 24: Local Interface IPv6 Address
- 25: Remote Interface IPv6 Address

15. Changes to RFC 8920

Discussion within the LSR WG indicated that there was confusion regarding the use of ASLA advertisements that had a zero-length SABM/UDABM. The discussion can be seen by searching the LSR WG mailing list archives for the thread "Proposed Errata for RFCs 8919/8920" starting on 15 June 2021.

Changes to Section 5 have been introduced to clarify normative behavior in the presence of such advertisements. [RFC8920] defines advertising link attributes with zero-length SABM and zero-length UDABM as a means of advertising link attributes that can be used by any application. However, the text uses the word "permitted", suggesting that the use of such advertisements is "optional". Such an interpretation could lead to interoperability issues and is not what was intended.

The replacement text makes explicit the specific conditions when such advertisements MUST be used and the specific conditions under which they MUST NOT be used.

A subsection discussing the use of zero-length Application Identifier Bit Masks has been added for greater consistency with [RFC9479]. See Section 12.2.

16. References

16.1. Normative References

- [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>>.
- [RFC2328] Moy, J., "OSPF Version 2", STD 54, RFC 2328, DOI 10.17487/RFC2328, April 1998, <<https://www.rfc-editor.org/info/rfc2328>>.
- [RFC3630] Katz, D., Kompella, K., and D. Yeung, "Traffic Engineering (TE) Extensions to OSPF Version 2", RFC 3630, DOI 10.17487/RFC3630, September 2003, <<https://www.rfc-editor.org/info/rfc3630>>.
- [RFC4203] Kompella, K., Ed. and Y. Rekhter, Ed., "OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4203, DOI 10.17487/RFC4203, October 2005, <<https://www.rfc-editor.org/info/rfc4203>>.
- [RFC5329] Ishiguro, K., Manral, V., Davey, A., and A. Lindem, Ed., "Traffic Engineering Extensions to OSPF Version 3", RFC 5329, DOI 10.17487/RFC5329, September 2008, <<https://www.rfc-editor.org/info/rfc5329>>.
- [RFC5340] Coltun, R., Ferguson, D., Moy, J., and A. Lindem, "OSPF for IPv6", RFC 5340, DOI 10.17487/RFC5340, July 2008, <<https://www.rfc-editor.org/info/rfc5340>>.
- [RFC7308] Osborne, E., "Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE)", RFC 7308, DOI 10.17487/RFC7308, July 2014, <<https://www.rfc-editor.org/info/rfc7308>>.
- [RFC7471] Giacalone, S., Ward, D., Drake, J., Atlas, A., and S. Previdi, "OSPF Traffic Engineering (TE) Metric Extensions", RFC 7471, DOI 10.17487/RFC7471, March 2015, <<https://www.rfc-editor.org/info/rfc7471>>.
- [RFC7684] Psenak, P., Gredler, H., Shakir, R., Henderickx, W., Tantsura, J., and A. Lindem, "OSPFv2 Prefix/Link Attribute Advertisement", RFC 7684, DOI 10.17487/RFC7684, November 2015, <<https://www.rfc-editor.org/info/rfc7684>>.
- [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>>.
- [RFC8362] Lindem, A., Roy, A., Goethals, D., Reddy Vallem, V., and F. Baker, "OSPFv3 Link State Advertisement (LSA) Extensibility", RFC 8362, DOI 10.17487/RFC8362, April 2018, <<https://www.rfc-editor.org/info/rfc8362>>.
- [RFC9479] Ginsberg, L., Psenak, P., Previdi, S., Henderickx, W., and

J. Drake, "IS-IS Application-Specific Link Attributes", RFC 9479, DOI 10.17487/RFC9479, October 2023, <<https://www.rfc-editor.org/info/rfc9479>>.

16.2. Informative References

- [RFC3209] Awduche, D., Berger, L., Gan, D., Li, T., Srinivasan, V., and G. Swallow, "RSVP-TE: Extensions to RSVP for LSP Tunnels", RFC 3209, DOI 10.17487/RFC3209, December 2001, <<https://www.rfc-editor.org/info/rfc3209>>.
- [RFC4552] Gupta, M. and N. Melam, "Authentication/Confidentiality for OSPFv3", RFC 4552, DOI 10.17487/RFC4552, June 2006, <<https://www.rfc-editor.org/info/rfc4552>>.
- [RFC5286] Atlas, A., Ed. and A. Zinin, Ed., "Basic Specification for IP Fast Reroute: Loop-Free Alternates", RFC 5286, DOI 10.17487/RFC5286, September 2008, <<https://www.rfc-editor.org/info/rfc5286>>.
- [RFC5709] Bhatia, M., Manral, V., Fanto, M., White, R., Barnes, M., Li, T., and R. Atkinson, "OSPFv2 HMAC-SHA Cryptographic Authentication", RFC 5709, DOI 10.17487/RFC5709, October 2009, <<https://www.rfc-editor.org/info/rfc5709>>.
- [RFC5714] Shand, M. and S. Bryant, "IP Fast Reroute Framework", RFC 5714, DOI 10.17487/RFC5714, January 2010, <<https://www.rfc-editor.org/info/rfc5714>>.
- [RFC7166] Bhatia, M., Manral, V., and A. Lindem, "Supporting Authentication Trailer for OSPFv3", RFC 7166, DOI 10.17487/RFC7166, March 2014, <<https://www.rfc-editor.org/info/rfc7166>>.
- [RFC7474] Bhatia, M., Hartman, S., Zhang, D., and A. Lindem, Ed., "Security Extension for OSPFv2 When Using Manual Key Management", RFC 7474, DOI 10.17487/RFC7474, April 2015, <<https://www.rfc-editor.org/info/rfc7474>>.
- [RFC7855] Previdi, S., Ed., Filsfils, C., Ed., Decraene, B., Litkowski, S., Horneffer, M., and R. Shakir, "Source Packet Routing in Networking (SPRING) Problem Statement and Requirements", RFC 7855, DOI 10.17487/RFC7855, May 2016, <<https://www.rfc-editor.org/info/rfc7855>>.
- [RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 8126, DOI 10.17487/RFC8126, June 2017, <<https://www.rfc-editor.org/info/rfc8126>>.
- [RFC8920] Psenak, P., Ed., Ginsberg, L., Henderickx, W., Tantsura, J., and J. Drake, "OSPF Application-Specific Link Attributes", RFC 8920, DOI 10.17487/RFC8920, October 2020, <<https://www.rfc-editor.org/info/rfc8920>>.
- [RFC9256] Filsfils, C., Talaulikar, K., Ed., Voyer, D., Bogdanov,

A., and P. Mattes, "Segment Routing Policy Architecture",
RFC 9256, DOI 10.17487/RFC9256, July 2022,
<<https://www.rfc-editor.org/info/rfc9256>>.

Acknowledgments

The following acknowledgments are included in [RFC8920]:

Thanks to Chris Bowers for his review and comments.

Thanks to Alvaro Retana for his detailed review and comments.

For this document, the authors would like to thank Bruno Decraene.

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