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OSPFv3 LSA Extendibility
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Abstract

OSPFv3 requires functional extension beyond what can readily be done with the fixed-format Link State Advertisement (LSA) as described in RFC 5340. Without LSA extension, attributes associated with OSPFv3 links and advertised IPv6 prefixes must be advertised in separate LSAs and correlated to the fixed-format LSA. This document extends the LSA format by allowing the optional inclusion of Type-Length-Value (TLV) tuples in the LSAs. Backward compatibility mechanisms are also described.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on August 14, 2014.

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1. Introduction

OSPFv3 requires functional extension beyond what can readily be done with the fixed-format Link State Advertisement (LSA) as described in RFC 5340 [OSPFV3]. Without LSA extension, attributes associated with OSPFv3 links and advertised IPv6 prefixes must be advertised in separate LSAs and correlated to the fixed-format LSA. This document extends the LSA format by allowing the optional inclusion of Type-Length-Value (TLV) tuples in the LSAs. Backward compatibility mechanisms are also described.

A similar extension was previously proposed in support of multi-topology routing. Additional requirements for OSPFv3 LSA extension include source/destination routing, route tagging, and others.

A final requirement is to limit the changes to OSPFv3 to those necessary for TLV-based LSAs. For the most part, the semantics of existing OSPFv3 LSA are retained for their TLV-based successor LSAs described herein. Additionally, encoding details, e.g., the representation of IPv6 prefixes as described in section A.4.1 in RFC 5340 [OSPFV3], have been retained. This requirement was included to increase the expedience of IETF adoption and deployment.

The following aspects of OSPFv3 LSA extension are described:

1. Extended LSA Types

2. Extended LSA Formats

3. Backward Compatibility

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 [RFC-KEYWORDS].

1.2. Acknowledgments

OSPFv3 TLV-based LSAs were first proposed in "Multi-topology routing in OSPFv3 (MT-OSPFv3)" [MT-OSPFV3].

Thanks for Peter Psenak for significant contributions to the backward compatibility mechanisms.

Thanks go to Michael Barnes, Mike Dubrovsky, and Anton Smirnov for review of the draft versions and discussions of backward compatibility.

The RFC text was produced using Marshall Rose's xml2rfc tool.

2. OSPFv3 Extended LSA Types

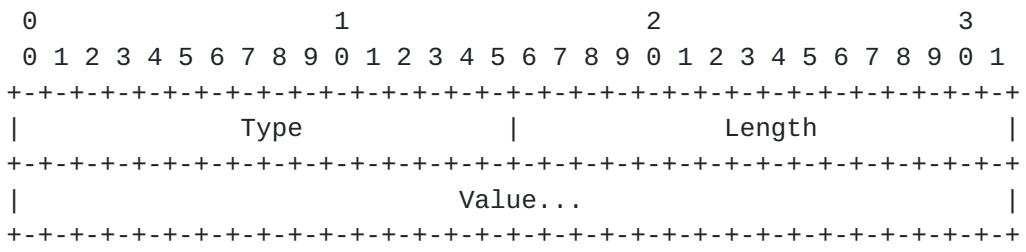
In order to provide backward compatibility, new LSA codes must be allocated. There are eight fixed-format LSAs defined in RFC 5340 [OSPFV3]. For ease of implementation and debugging, the LSA function codes are the same as the fixed-format LSAs only with 32, i.e., 0x20, added. The alternative was to allocate a bit in the LSA Type indicating the new LSA format. However, this would have used one half the LSA function code space for the migration of the eight original fixed-format LSAs. For backward compatibility, the U-bit will be set in LS Type so that the LSAs will be flooded by OSPFv3 routers that do not understand them.

LSA function code	LS Type	Description
33	0xA021	E-Router-LSA
34	0xA022	E-Network-LSA
35	0xA023	E-Inter-Area-Prefix-LSA
36	0xA024	E-Inter-Area-Router-LSA
37	0xC025	E-AS-External-LSA
38	N/A	Unused (Not to be allocated)
39	0xA027	E-Type-7-LSA
40	0x8028	E-Link-LSA
41	0xA029	E-Intra-Area-Prefix-LSA

OSPFv3 Extended LSA Types

3. OSPFv3 Extended LSA TLV

The format of the TLVs within the body of the extended LSAs is the same as the format used by the Traffic Engineering Extensions to OSPF [TE]. The variable TLV section consists of one or more nested Type/ Length/Value (TLV) tuples. The format of each TLV is:

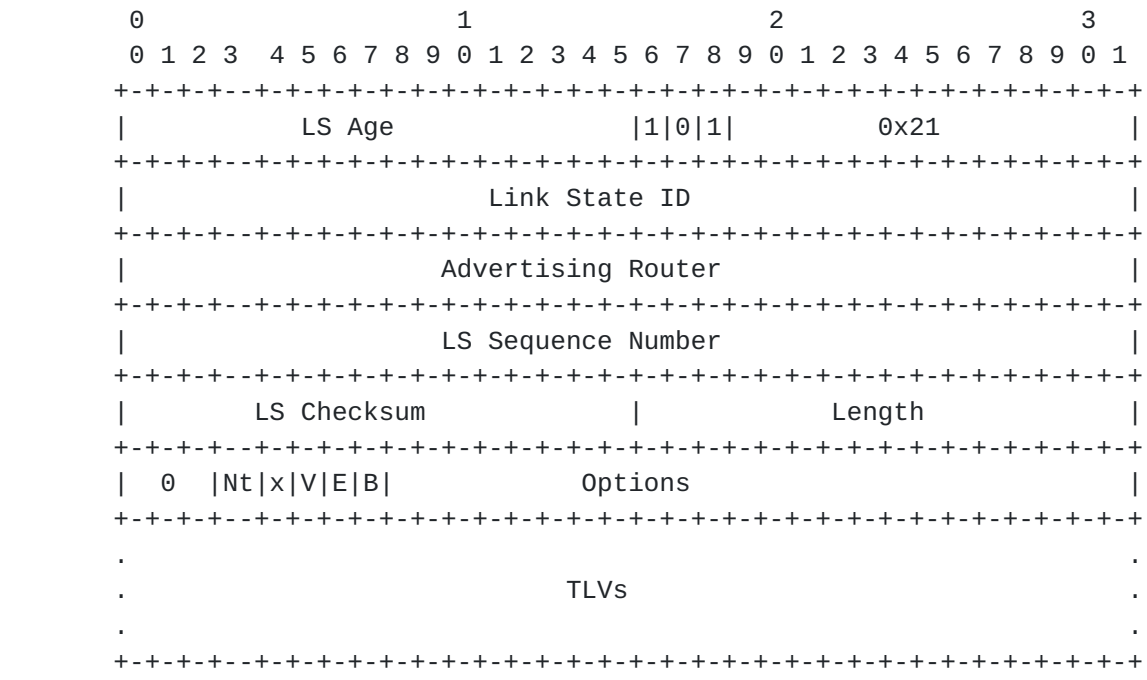


TLV Format

The Length field defines the length of the value portion in octets (thus a TLV with no value portion would have a length of 0). The TLV is padded to 4-octet alignment; padding is not included in the length field (so a 3-octet value would have a length of 3, but the total size of the TLV would be 8 octets). Nested TLVs are also 32-bit aligned. For example, a 1-byte value would have the length field set to 1, and 3 octets of padding would be added to the end of the value portion of the TLV. Unrecognized types are ignored.

4. OSPFv3 E-Router-LSA

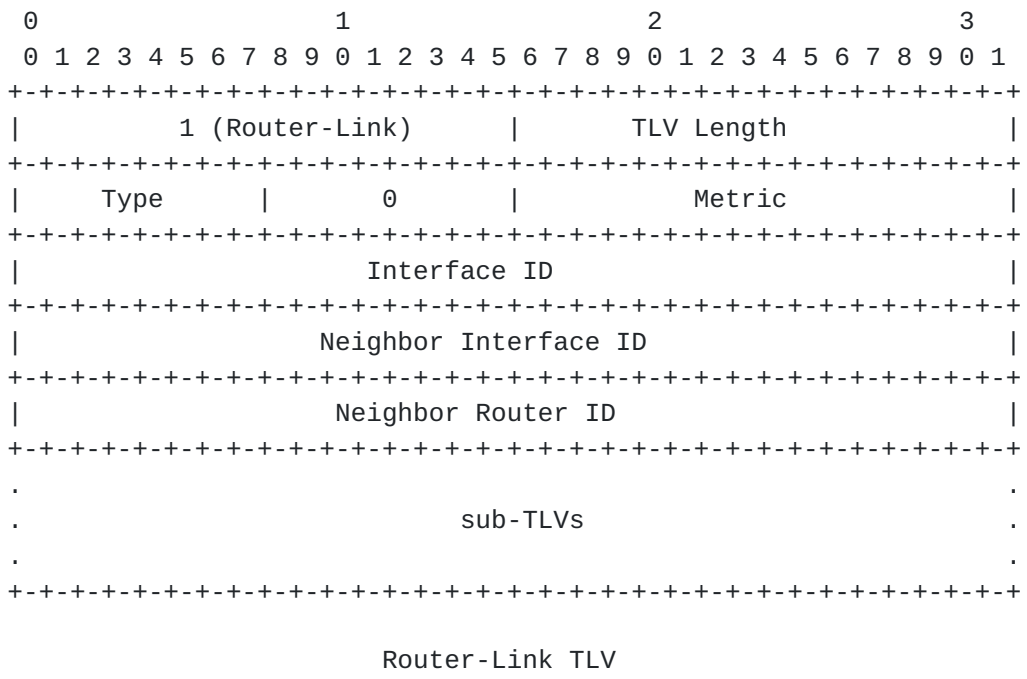
The E-Router-LSA has an LS Type of 0xA021 and has the same base information content as the Router-LSA, section 4.4.3.2 in [OSPFV3]. However, unlike the existing Router-LSA, it is fully extendable and represented as TLVs.



Extended Router-LSA

All LSA Header fields are the same as defined for the Router-LSA. The following top-level TLVs are defined:

- 0 - Reserved
- 1 - Router-Link TLV

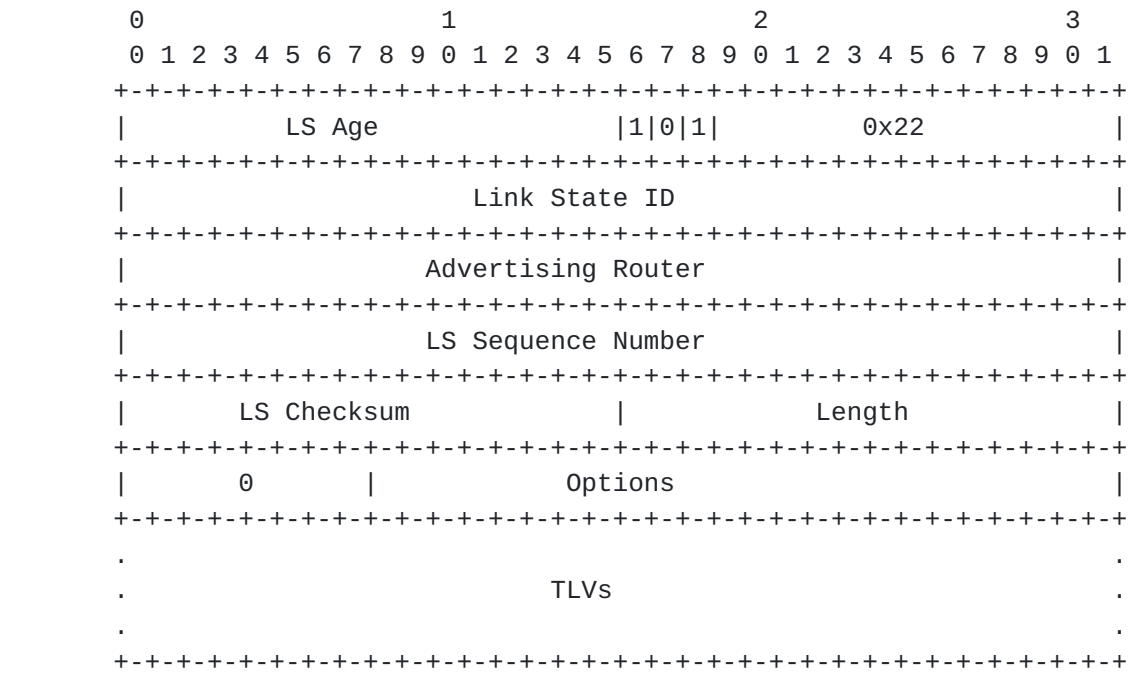


Router-Link TLV

Like the existing Router-LSA, the LSA length is used to determine the end of the LSA including TLVs. The Router-Link TLV is only applicable to the E-Router-LSA. Inclusion in other Extended LSAs MUST be ignored.

5. OSPFv3 E-Network-LSA

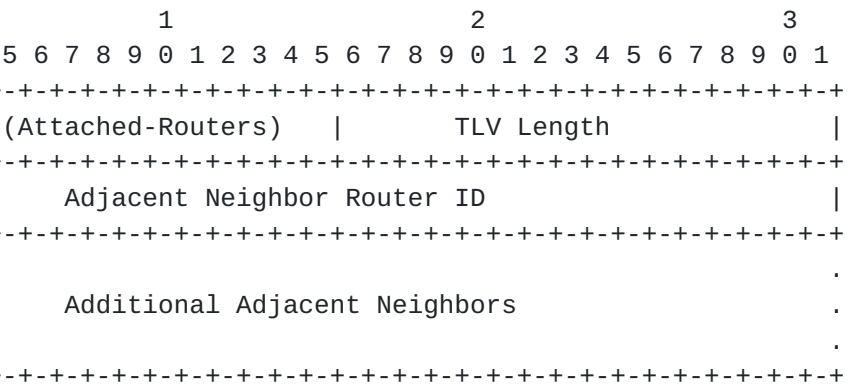
The E-Network-LSA has an LS Type of 0xA022 and has the same base information content as the Network-LSA, section 4.4.3.3 in [OSPFV3]. However, unlike the existing Network-LSA, it is fully extendable and represented as TLVs.



E-Network-LSA

All LSA Header fields are the same as defined for the Network-LSA. The following top-level TLVs are defined:

o 2 - Attached-Routers TLV



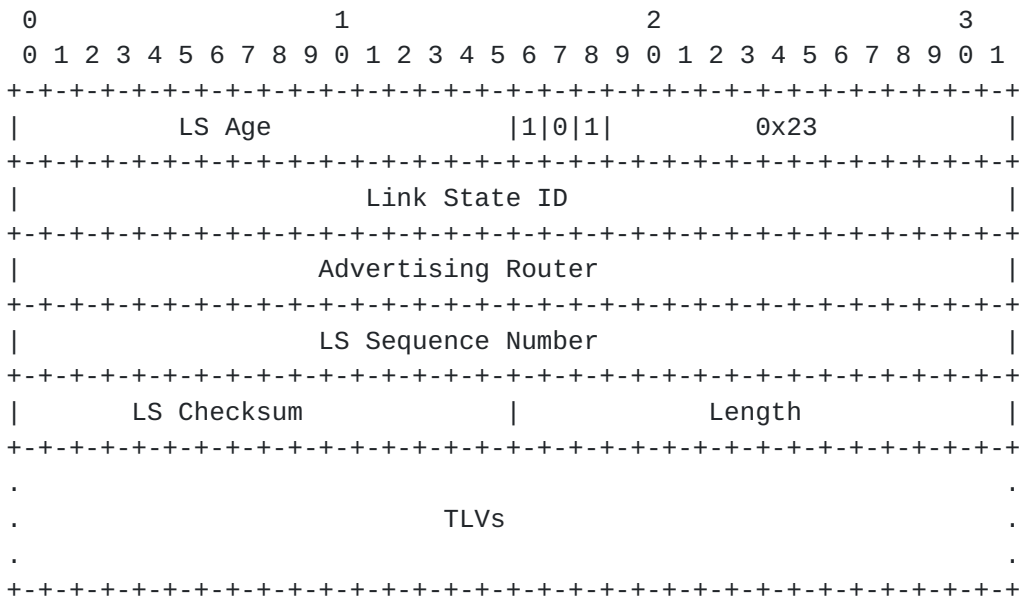
Attached-Routers TLV

There are two reasons for not having a separate TLV or sub-TLV for each adjacent neighbor. The first is to discourage using the E-Network-LSA for more than its current role of solely advertising the routers attached to a multi-access network. The router's metric as well as her attributes of individual attached routers should be advertised in their respective E-Router-LSAs. The second reason is that there is only a single E-Network-LSA per multi-access link with the Link State ID set to the Designated Router's Interface ID and, consequently, compact encoding has been chosen to decrease the likelihood of the size of the E-Network-LSA requiring IPv6 fragmentation when advertised in an OSPFv3 Link State Update packet.

Like the existing Network-LSA, the LSA length is used to determine the end of the LSA including TLVs. The Attached-Routers TLV is only applicable to the E-Network-LSA. Inclusion in other Extended LSAs MUST be ignored.

6. OSPFv3 E-Inter-Area-Prefix-LSA

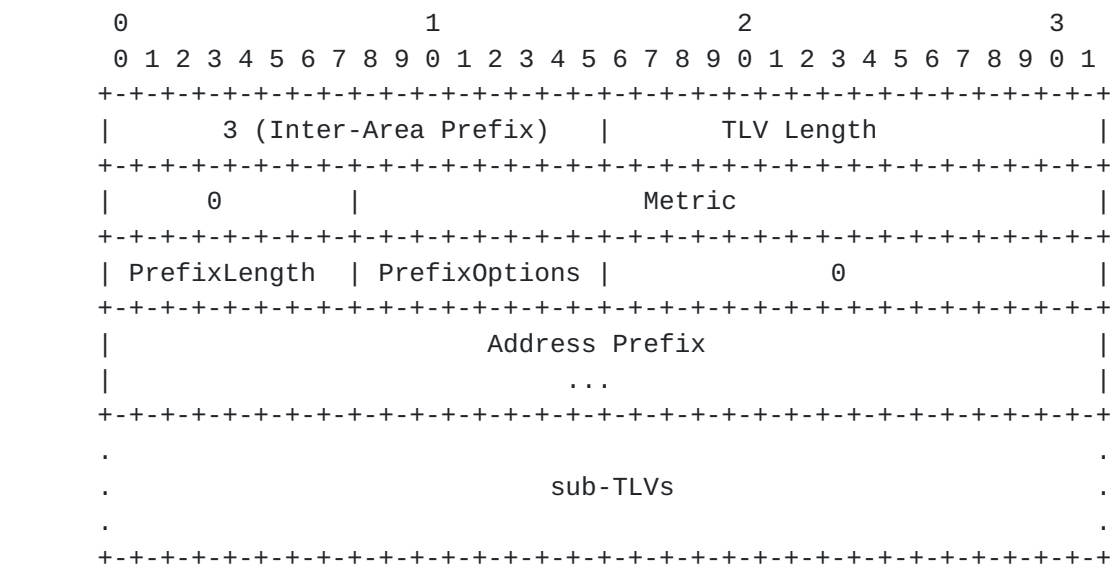
The E-Inter-Area-Prefix-LSA has an LS Type of 0xA023 and has the same base information content as the Inter-Area-Prefix-LSA, section 4.4.3.4 in [OSPFV3]. However, unlike the existing Inter-Area-Prefix-LSA, it is fully extendable and represented as TLVs.



E-Inter-Area-Prefix-LSA

All LSA Header fields are the same as defined for the Network-LSA. The following top-level TLVs are defined:

- 3 - Inter-Area Prefix TLV



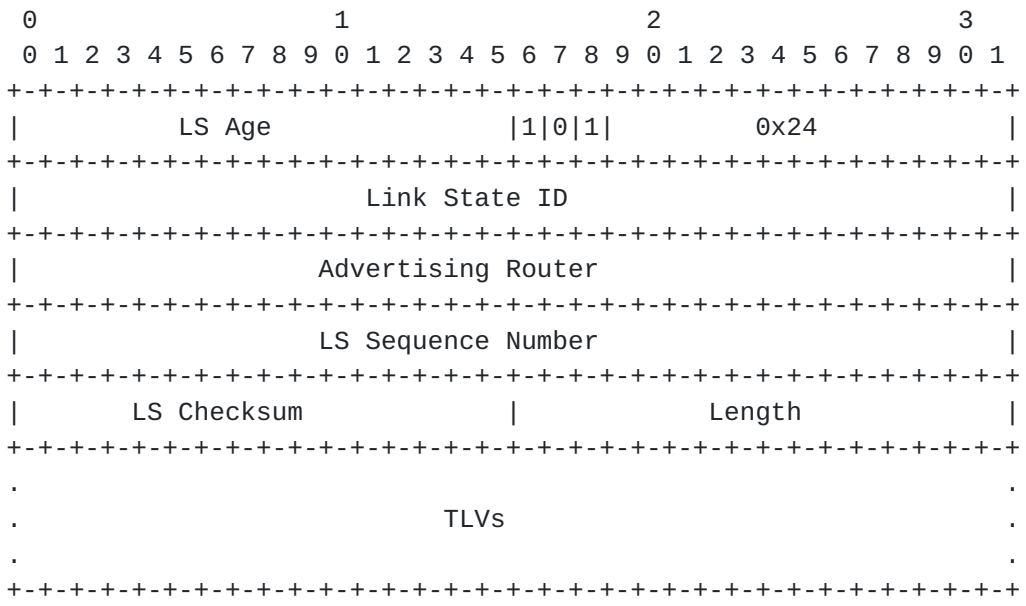
Inter-Area Prefix TLV

In order to retain compatibility and semantics with the current OSPFv3 specification, each LSA MUST contain a single Inter-Area Prefix TLV. This will facilitate migration and avoid changes to functions such as incremental SPF computation.

Like the existing Inter-Area-Prefix-LSA, the LSA length is used to determine the end of the LSA including TLV. The Inter-Area-Prefix TLV is only applicable to the E-Inter-Area-Prefix-LSA. Inclusion in other Extended LSAs MUST be ignored.

7. OSPFv3 E-Inter-Area-Router-LSA

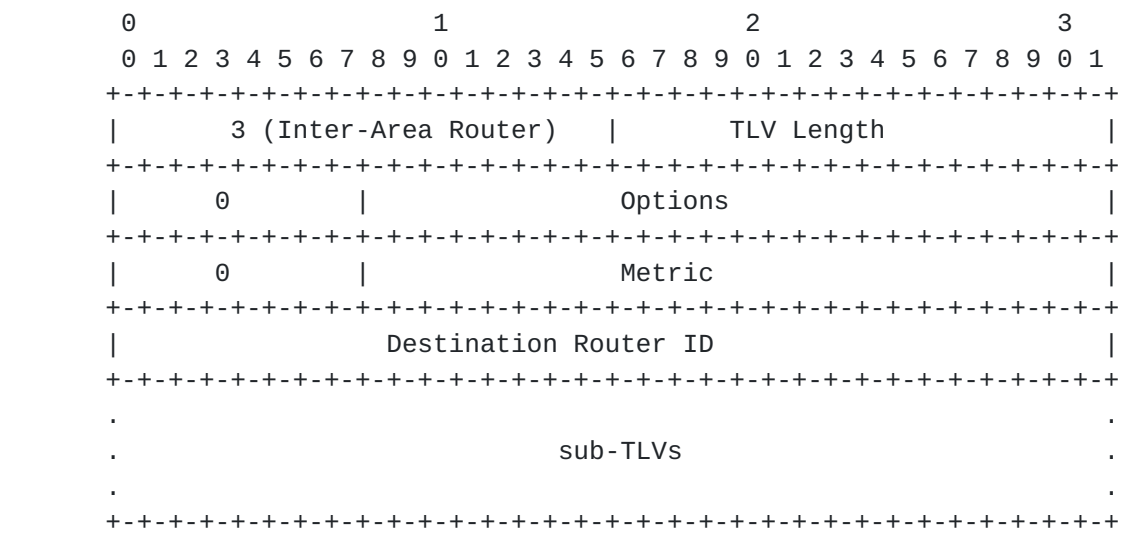
The E-Inter-Area-Router-LSA has an LS Type of 0xA024 and has the same base information content as the Inter-Area-Router-LSA, section 4.4.3.5 in [OSPFV3]. However, unlike the Inter-Area-Router-LSA, it is fully extendable and represented as TLVs.



E-Inter-Area-Router-LSA

All LSA Header fields are the same as defined for the Inter-Area-Router-LSA. The following top-level TLVs are defined:

- 4 - Inter-Area Router TLV



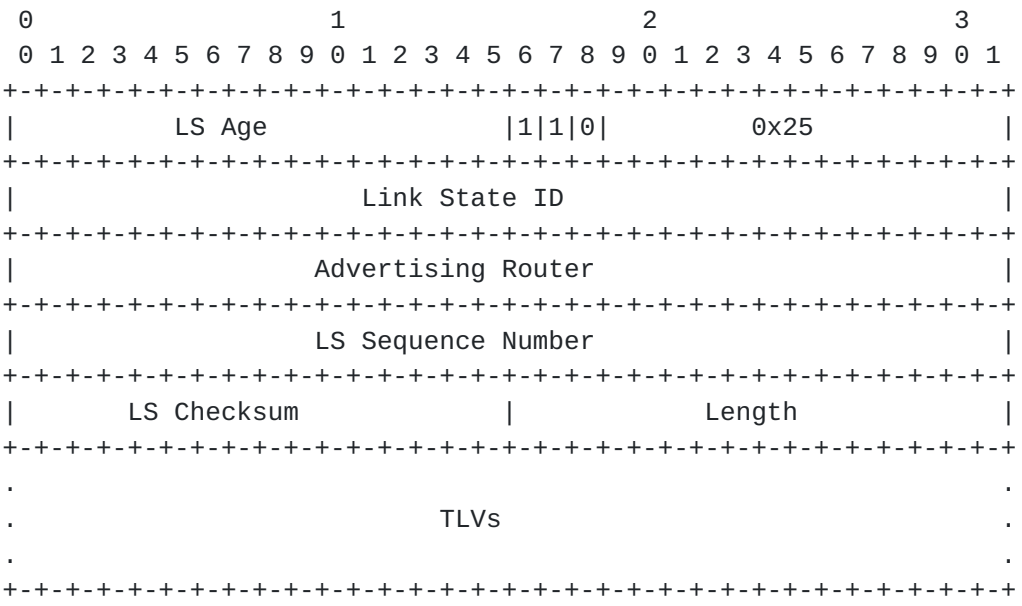
Inter-Area Router TLV

In order to retain compatibility and semantics with the current OSPFv3 specification, each LSA MUST contain a single Inter-Area Router TLV. This will facilitate migration and avoid changes to functions such as incremental SPF computation.

Like the existing Inter-Area-Router-LSA, the LSA length is used to determine the end of the LSA including sub-TLVs. The Inter-Area-Router TLV is only applicable to the E-Inter-Area-Router-LSA. Inclusion in other Extended LSAs MUST be ignored.

8. OSPFv3 E-AS-External-LSA

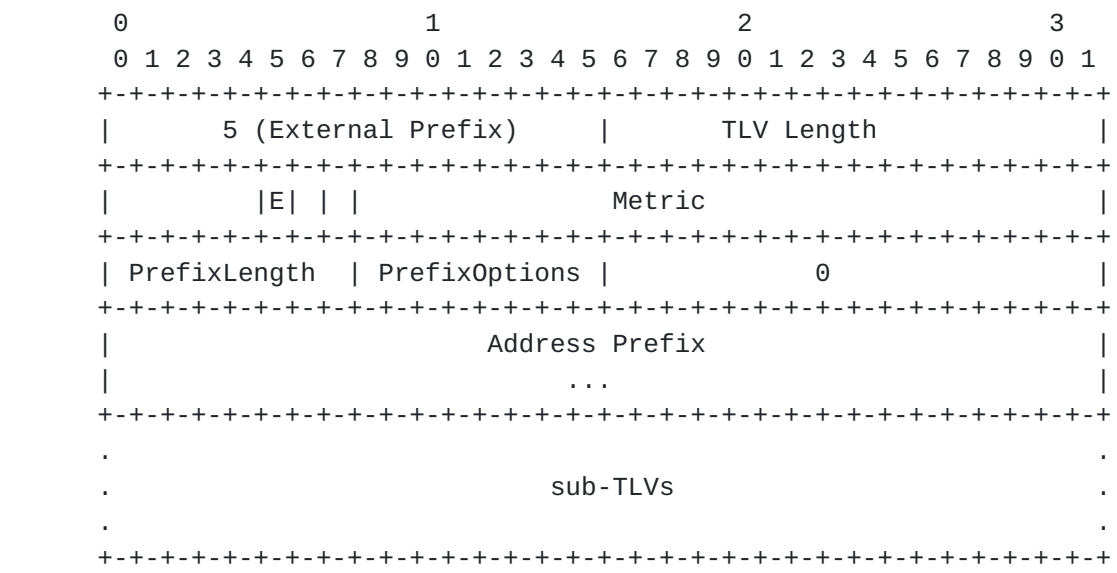
The E-AS-External-LSA has an LS Type of 0xC025 and has the same base information content as the AS-External-LSA, section 4.4.3.6 in [OSPFV3]. However, unlike the existing AS-External-LSA, it is fully extendable and represented as TLVs.



E-AS-External-LSA

All LSA Header fields are the same as defined for the AS-External-LSA. The following top-level TLVs are defined:

- 5 - External Prefix TLV



External Prefix TLV

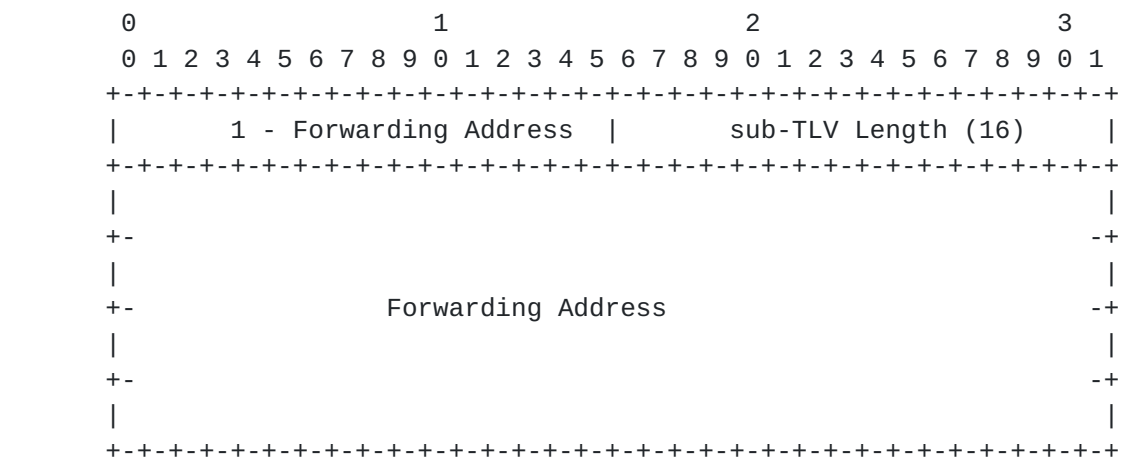
In order to retain compatibility and semantics with the current OSPFv3 specification, each LSA MUST contain a single External Prefix TLV. This will facilitate migration and avoid changes to OSPFv3 processes such as incremental SPF computation. In External Prefix TLV, the optional Forwarding Address and External Route Tag are now sub-TLVs. Given the Referenced LS type and Referenced Link State ID from the AS-External-LSA have never been used or even specified, they have been omitted from the External Prefix TLV. If there were ever a requirement for a referenced LSA, it could be satisfied with a sub-TLV.

Like the existing AS-External-LSA, the LSA length is used to determine the end of the LSA including sub-TLVs. The External-Prefix TLV is only applicable to the E-AS-External-LSA and the E-NSSA-LSA. Inclusion in other Extended LSAs MUST be ignored.

The following sub-TLVs are defined for the External Prefix TLV:

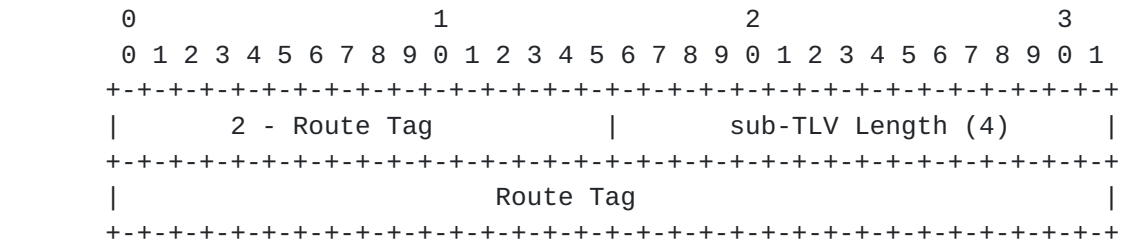
- 1 - Forwarding Address sub-TLV

- 2 - Route Tag sub-TLV



External Route Tag Sub-TLV

The optional Forwarding Address sub-TLV has identical semantics to the optional forwarding address in section 4.4.3.6 of [OSPFV3]. The Forwarding Address sub-TLV is applicable to the External-Prefix TLV. Specification as a sub-TLV of other TLVs is not defined herein. The sub-TLV is optional and the first specified instance is used as the Forwarding Address as defined in [OSPFV3]. Instances subsequent to the first are ignored.



Route Tag Sub-TLV

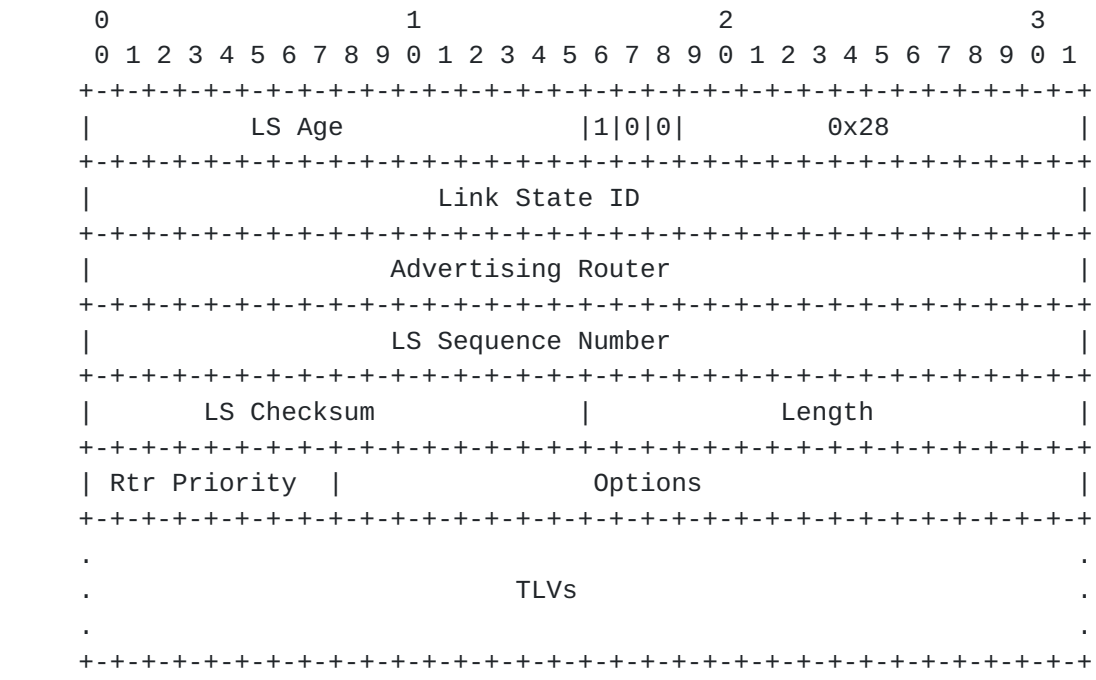
The optional Route Tag sub-TLV has identical semantics to the optional External Route Tag in section 4.4.3.6 of [OSPFV3]. The Route Tag sub-TLV is applicable to the External-Prefix TLV. Specification as a sub-TLV of other TLVs is not defined herein. The sub-TLV is optional and the first specified instance is used as the Route Tag as defined in [OSPFV3]. Instances subsequent to the first are ignored.

9. OSPFv3 E-NSSA-LSA

The E-NSSA-LSA will have the same format and TLVs as the Extended AS-External-LSA Section 8. This is the same relationship as exists between the NSSA-LSA, section 4.4.3.7 in [OSPFV3], and the AS-External-LSA. The NSSA-LSA will have type 0xA027 which implies area flooding scope. Future requirements may dictate that supported TLVs differ between the E-AS-External-LSA and the E-NSSA-LSA. However, future requirements are beyond the scope of this document.

10. OSPFv3 E-Link-LSA

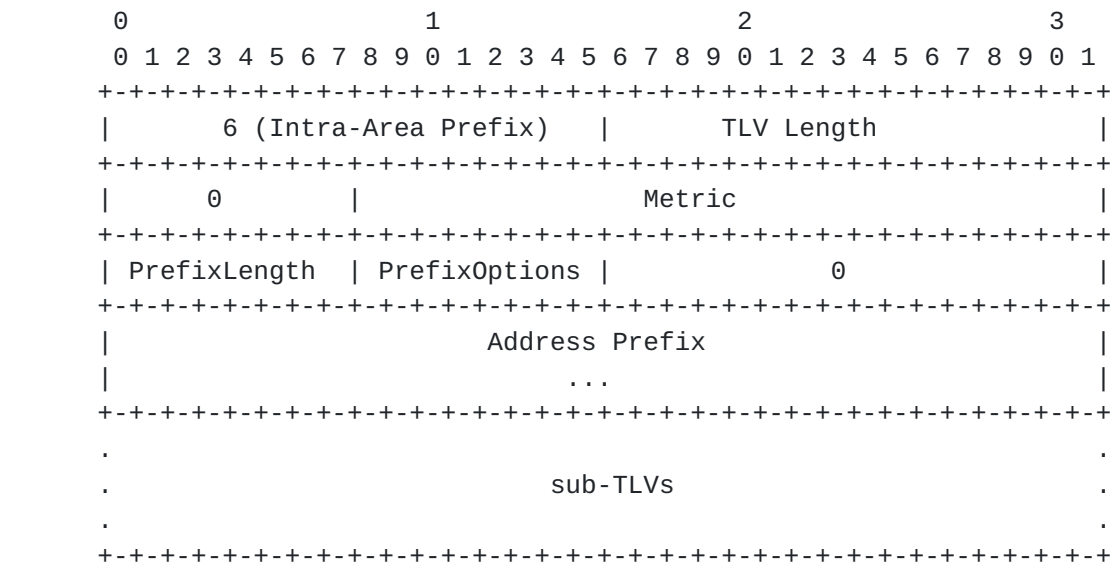
The E-Link-LSA has an LS Type of 0x8028 and will have the same base information content as the Link-LSA, section 4.4.3.8 in [OSPFV3]. However, unlike the existing Link-LFA, it is extendable and represented as TLVs.



E-Link-LSA

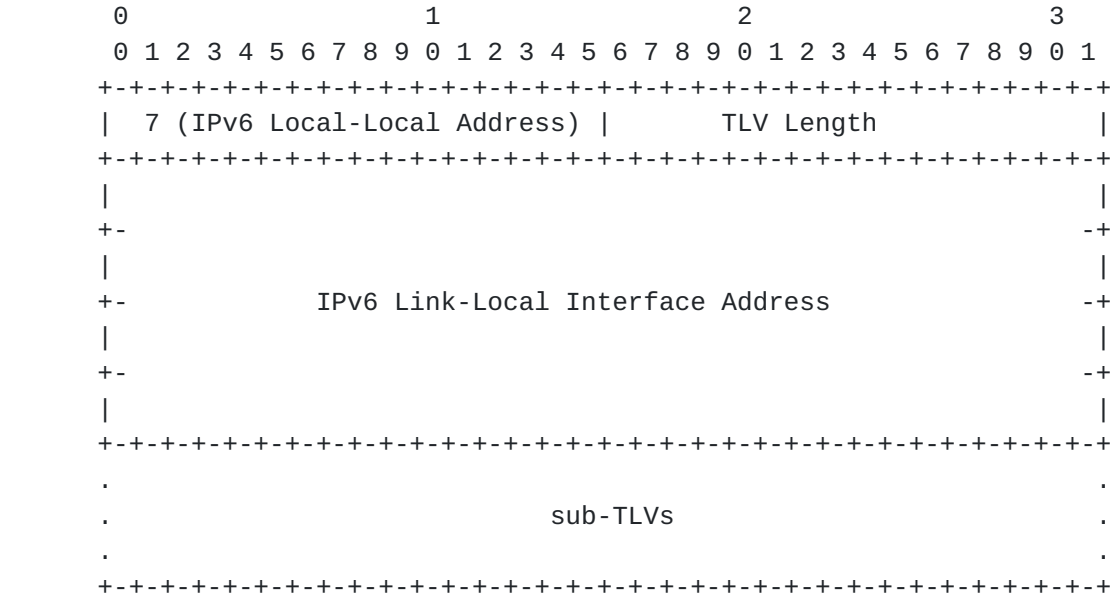
The following top-level TLVs are defined:

- 6 - Intra-Area Prefix TLV
- 7 - IPv6 Link-Local Address TLV
- 8 - IPv4 Link-Local Address TLV



Intra-Area Prefix TLV

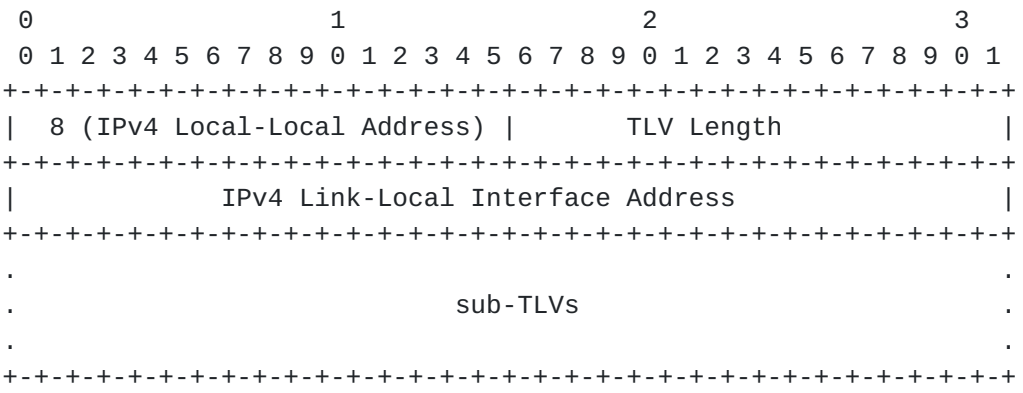
Like the Link-LSA, the E-Link-LSA affords advertisement of multiple intra-area prefixes. Hence, multiple Intra-Area Prefix TLVs may be specified and the LSA length defines the end of the LSA including all TLVs. The Intra-Area-Prefix TLV is only applicable to the E-Link-LSA and the E-Intra-Area-Prefix-LSA. Inclusion in other Extended LSAs MUST be ignored.



IPv6 Link-Local Address TLV

The IPv6 Link-Local Address TLV is to be used with IPv6 address

families as defined in [OSPFV3-AF]. The IPv6 Link-Local Address TLV is only applicable to the E-Link-LSA. Inclusion in other Extended LSAs MUST be ignored. Only a single instance of the IPv6 Link-Local Address family SHOULD be included in the E-Link-LSA. Instances following the first MUST be ignored. For IPv4 address families as defined in [OSPFV3-AF], this TLV SHOULD be ignored. Future specifications may support advertisement of routing and topology information for multiple address families. However, this is beyond the scope of this document.

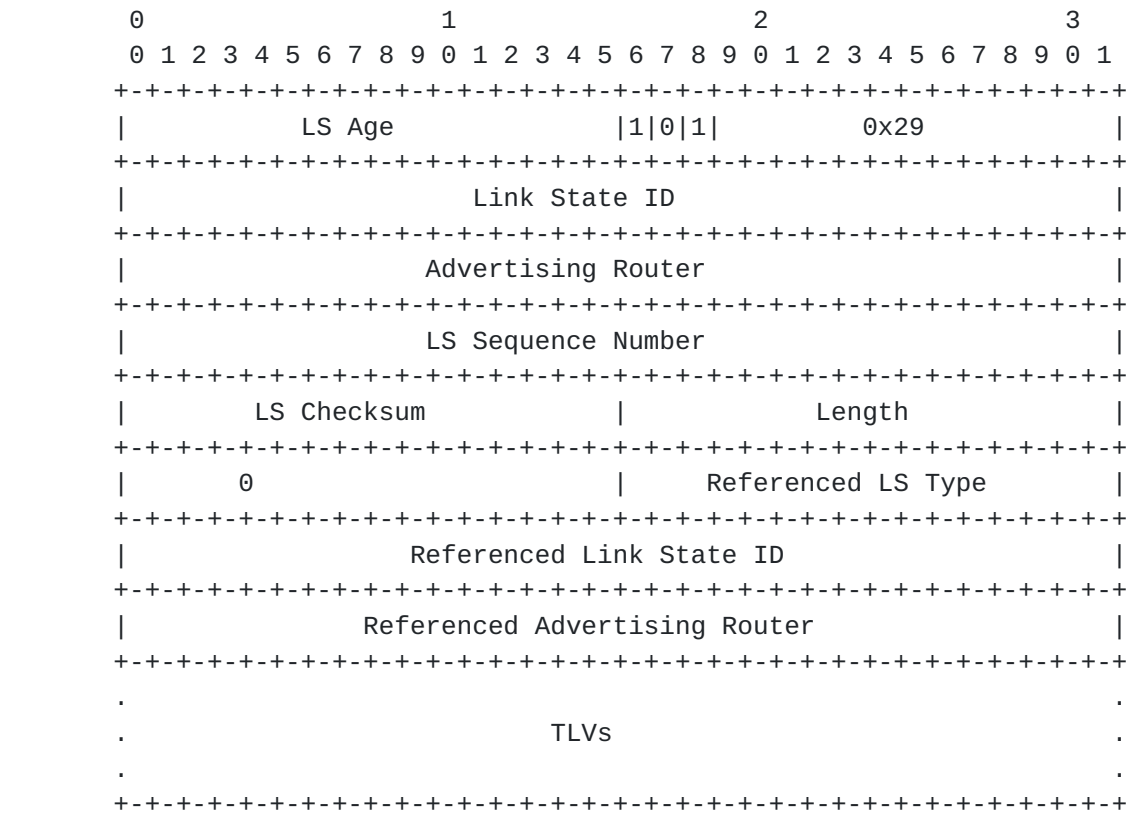


IPv4 Link-Local Address TLV

The IPv4 Link-Local Address TLV is to be used with IPv4 address families as defined in [OSPFV3-AF]. The IPv4 Link-Local Address TLV is only applicable to the E-Link-LSA. Inclusion in other Extended LSAs MUST be ignored. Only a single instance of the IPv4 Link-Local Address family SHOULD be included in the E-Link-LSA. Instances following the first MUST be ignored. For OSPFv3 IPv6 address families as defined in [OSPFV3-AF], this TLV MUST be ignored. Future specifications may support advertisement of routing and topology information for multiple address families. However, this is beyond the scope of this document.

11. OSPFv3 E-Intra-Area-Prefix-LSA

The E-Intra-Area-Prefix-LSA has an LS Type of 0xA029 and has the same base information content as the Intra-Area-Prefix-LSA, section 4.4.3.9 in [OSPFV3]. However, unlike the Intra-Area-Prefix-LSA, it is fully extendable and represented as TLVs.



E-Intra-Area-Prefix-LSA

All LSA Header fields are the same as defined for the Intra-Area-Prefix-LSA. The following top-level TLVs are defined:

o 6 - Intra-Area-Prefix TLV (defined in Section 10)

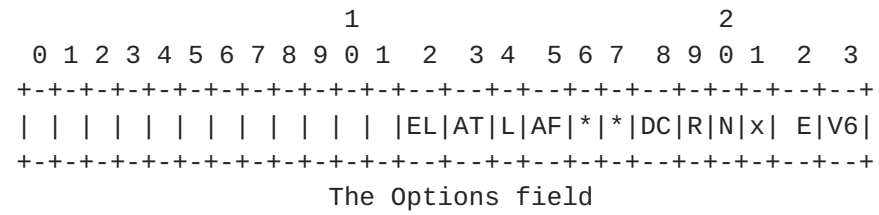
Like the Intra-Area-Prefix-LSA, the E-Intra-Area-Link-LSA affords advertisement of multiple intra-area prefixes. Hence, multiple Intra-Area Prefix TLVs may be specified and the LSA length defines the end of the LSA including all TLVs.

12. LSA Extension Backward Compatibility

In the context of this document, backward compatibility is solely related to the capability of an OSPFv3 router to receive, process, and originate the TLV-based LSAs defined herein. Backward compatibility for future OSPFv3 extensions utilizing the TLV-based LSAs is out of scope and must be covered in the documents describing those extensions. Both full and, if applicable, partial deployment should be covered for future OSPFv3 LSA extensions.

For simplicity and to avoid the scaling impact of maintaining both TLV and non-TLV based versions of the same LSA within a routing domain, the base backward compatibility mode will not allow mixing of LSA formats. Different formats could still be supported with multiple OSPFv3 instances and separate OSPFv3 routing domains. Additionally, a more complex mode is provided in Section 12.1, where both formats of LSA coexist. In order to facilitate backward compatibility, the OSPFv3 options field (as described in Appendix A.2 of RFC 5340 [OSPFV3]), will contain an additional options bits. The EL-bit will be used to indicate that the advertising OSPFv3 Router can receive, process, and originate TLV-based LSAs. An OSPFv3 router configured to support TLV-based LSAs WILL set its option field EL-bit in OSPFv3 Hello and Database Description packets. If Full is specified for ExtendedLSASupport, the OSPFv3 router MUST NOT form adjacencies with OSPFv3 Routers sending OSPFv3 Hello and Database Description packets with the options field EL-bit clear. In this manner, OSPFv3 routing domains utilizing the new encoding will be completely isolated from those using the RFC 5340 encodings.

If MixedModeOriginateOnly, MixedModeOriginateSPF, or Full is specified for ExtendedLSASupport, (Appendix A), or AreaExtendedLSASupport (Appendix B) the EL-bit will be set in the OSPFv3 Hello and Database Description packet options field.



The Options field

EL-bit
This bit is indicates whether or not the OSPFv3 router supports the Extended LSA format with the bit set condition indicating support.

Options Field EL-bit

12.1. Extended LSA Mixed-Mode Backward Compatibility

An implementation MAY support configuration allowing a graceful transition from the non-extended (non-TLV-based) LSAs to the extended (TLV-based) LSAs in an OSPFv3 routing domain. In these routing domains, the OSPFv3 routers configured with a value of MixedModeOriginateOnly or MixedModeOriginateSPF for ExtendedLSASupport, (Appendix A), MUST originate both the extended and non-extended versions of the OSPFv3 LSAs described herein. For the purposes of Shortest Path First (SPF) computation, the non-exteneded versions of the OSPFv3 LSAs are used for SPF computation when MixedModeOrignateOnly is configured and the extended versions are used when MixedModeOriginateSPF is specified. The extended LSAs MAY be used for functions other than routing computation as long as backward compatility is described in the documents describing those functions. OSPFv3 routers configured for mixed mode operation also MUST form adjacencies with OSPFv3 Routers sending OSPFv3 Hello and Database Description packets with the options field EL-bit clear.

In this manner, OSPFv3 routing domains utilizing the new encodings can be gradually migrated with a worst-case cost of approximately doubling the number of LSAs in the routing domain. The transition within an OSPFv3 routing domain would progress as follows:

1. Configure OSPFv3 Router ExtendedLSASupport to MixedModeOriginateOnly so that routers orginate the extended LSAs.

2. When all the OSPFv3 Routers have been reconfigured to MixedModeOriginateOnly, gradually reconfigure OSPFv3 Routers to use the extended LSAs by configuring ExtendedLSASupport to MixedModeOriginateSPF. This can be done on a small subset of OSPFv3 Routers and the route tables can be verified.

3. When all the OSPFv3 Routers have been reconfigured to MixedModeOriginateSPF and the routing has been verified, reconfigure OSPFv3 Routers to purge or simply not refresh the non-extended OSPFv3 LSA by configuring ExtendedLSASupport to Full.

12.1.1. Area Extended LSA Mixed-Mode Backward Compatibility

An implemenation MAY also support configuration allowing graceful transition from the non-extended LSAs to the extended LSAs within a single area. In these area, the parameter AreaExtendedLSASupport (Appendix B) may be configured to take precedence over the global parameter ExtendedLSASupport. However, the AreaExtendedLSASupport will only apply to link and area scoped LSAs within the area and area

based SPF calculations. The default is for the AreaExtendedLSASupport to be inherited from the ExtendedLSASupport.

12.2. LSA TLV Processing Backward Compatibility

This section defines the general rules for processing LSA TLVs. To ensure compatibility of future TLV-based LSA extensions, all implementations MUST adhere to these rules:

1. Unrecognized TLVs and sub-TLVs are ignored when parsing or processing Extended-LSAs.

2. Whether or not partial deployment of a given TLV is supported MUST be specified.

3. If partial deployment is not supported, mechanisms to ensure the corresponding feature are not deployed MUST be specified in the document defining the new TLV or sub-TLV.

4. If partial deployment is supported, backward compatibility and partial deployment MUST be specified in the document defining the new TLV or sub-TLV.

13. Security Considerations

In general, extendible OSPFv3 LSAs are subject to the same security concerns as those described in RFC 5340 [OSPFV3]. Additionally, implementations must assure that malformed TLV and Sub-TLV permutations do not result in errors which cause hard OSPFv3 failures.

If there were ever a requirement to digitally sign OSPFv3 LSAs as described for OSPFv2 LSAs in RFC 2154 [OSPF-DIGITAL-SIGNATURE], the mechanisms described herein would greatly simplify the extension.

14. IANA Considerations

This specification defines nine OSPFv3 Extended LSA types as described in Section 2.

This specification also creates two registries OSPFv3 Extended-LSAs TLVs and sub-TLVs. The TLV and Sub-TLV code-points in these registries are common to all Extended-LSAs and their respective definitions must define where they are applicable.

The OSPFv3 Extend-LSA TLV registry will define top-level TLVs for Extended-LSAs and should be placed in the existing OSPFv3 IANA registry. New values can be allocated via IETF Consensus or IESG Approval.

Nine initial values are allocated:

- 0 - Reserved
- 1 - Router-Link TLV
- 2 - Attached-Routers TLV
- 3 - Inter-Area Prefix TLV
- 4 - Inter-Area Router TLV
- 5 - External Prefix TLV
- 6 - Intra-Area Prefix TLV
- 7 - IPv6 Link-Local Address TLV
- 8 - IPv4 Link-Local Address TLV

The OSPFv3 Extend-LSA sub-TLV registry will define sub-TLVs at any level of nesting for Extended-LSAs and should be placed in the existing OSPFv3 IANA registry. New values can be allocated via IETF Consensus or IESG Approval.

One initial value is allocated:

- 0 - Reserved
- 1 - Forwarding Address
- 2 - Route Tag

15. References

15.1. Normative References

[OSPFV3] Coltun, R., Ferguson, D., Moy, J., and A. Lindem, "OSPF for IPv6", RFC 5340, July 2008.

[OSPFV3-AF] Lindem, A., Mirtorabi, S., Roy, A., Barnes, M., and R. Aggarwal, "Support of Address Families in OSPFv3", RFC 5838, April 2010.

[RFC-KEYWORDS] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", RFC 2119, March 1997.

[TE] Katz, D., Yeung, D., and K. Kompella, "Traffic Engineering Extensions to OSPF", RFC 3630, September 2003.

15.2. Informative References

[MT-OSPFV3] Mirtorabi, S. and A. Roy, "Multi-topology routing in OSPFv3 (MT-OSPFV3)", draft-ietf-ospf-mt-ospfv3-04.txt (work in progress).

[OSPF-DIGITAL-SIGNATURE] Murphy, S., Badger, M., and B. Wellington, "OSPF with Digital Signatures", RFC 2154, June 1997.

Appendix A. Global Configuration Parameters

An additional global configurable parameter will be added to the OSPFv3 protocol.

ExtendedLSASupport

This is an enumeration type indicating the extent to which the OSPFv3 instance supports the TLV format described herein for Extended LSAs. The valid value for the enumeration are:

* None - Non-extended LSAs will not be originated or used in the SPF calculation. This is the default.

* MixedModeOriginateOnly - Both extended and non-extended LSAs will be originated. OSPFv3 adjacencies will be formed with OSPFv3 routers not supporting this specification. The non-extended LSAs are used for the SPF computation.

* MixedModeOriginateSPF - Both extended and non-extended LSAs will be originated. OSPFv3 adjacencies will be formed with OSPFv3 routers not supporting this specification. The extended LSAs are used for the SPF computation.

* Full - Extended LSAs will be originated and adjacencies will not be formed with OSPFv3 routers not supporting this specification. Only Extended LSAs will be originated.

Appendix B. Area Configuration Parameters

An additional area configurable parameter will be added to the OSPFv3 protocol.

AreaExtendedLSASupport

This is an enumeration type indicating the extent to which the OSPFv3 area supports the TLV format described herein for Extended LSAs. The valid value for the enumeration are:

* InheritGlobal - The AreaExtendedLSASupport will be inherited from ExtendedLSASupport. This is the default.

* None - Non-extended LSAs will not be originated or used in the SPF calculation.

* MixedModeOriginateOnly - Both extended and non-extended link and area scoped LSAs will be originated. OSPFv3 adjacencies will be formed with OSPFv3 routers not supporting this specification. The non-extended LSAs are used for the SPF computation.

* MixedModeOriginateSPF - Both extended and non-extended link and area scoped LSAs will be originated. OSPFv3 adjacencies will be formed with OSPFv3 routers not supporting this specification. The extended LSAs are used for the area SPF computation.

* Full - Link and area scoped extended LSAs will be originated and adjacencies will not be formed with OSPFv3 routers not supporting this specification. Only Extended LSAs will be originated.

For regular areas, i.e., areas where AS scoped LSAs are flooded, configuring None or MixedModeOriginateOnly for AreaExtendedLSASupport when Full is specified for ExtendedLSASupport is contradictory and MAY be prohibited by the implementation.

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