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OSPFv3 LSA Extendibility
draft-acee-ospfv3-lsa-extend-01.txt

Abstract

   OSPFv3 requires functional extension beyond what can be done with the
   fixed Link State Advertisement (LSA) format as described in RFC 5340.
   This document extends the LSA format by allowing the optional
   inclusion of Type-Length-Value (TLV) tuples in the LSAs. It also
   covers all aspects of backward compatibility.

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1. Introduction

   OSPFv3 requires functional extension beyond what can be done with the
   fixed Link State Advertisement (LSA) format as described in RFC 5340
   [OSPFV3]. 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 go to Michael Barnes, Peter Psenak, Mike Dubrovskiy, and Anton
   Smirnov for review of the initial draft version 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 TLVs 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.

```
        LSA function code   LS Type   Description
        ----------------------------------------------------
        33                  0x2021    E-Router-LSA
        34                  0x2022    E-Network-LSA
        35                  0x2023    E-Inter-Area-Prefix-LSA
        36                  0x2024    E-Inter-Area-Router-LSA
        37                  0x4025    E-AS-External-LSA
        38                  N/A       Unused (Not to be allocated)
        39                  0x2027    E-Type-7-LSA
        40                  0x0028    E-Link-LSA
        41                  0x2029    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:

```
    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            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                            Value...                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
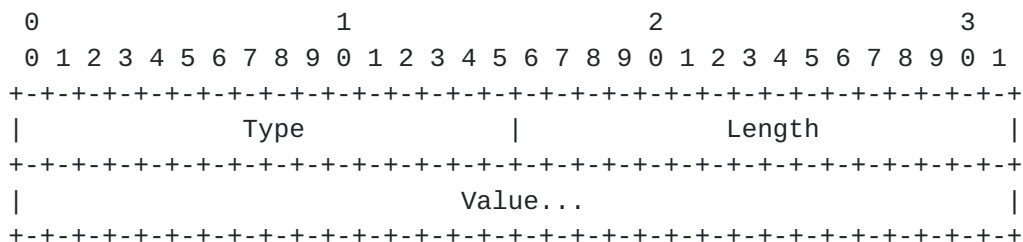
                             TLV Format

   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 0x2021 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.

```
    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
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           LS Age               |0|0|1|          0x21           |
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Link State ID                          |
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Advertising Router                       |
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      LS Sequence Number                       |
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       LS Checksum              |             Length           |
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   0   |Nt|x|V|E|B|           Options                          |
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                               .
   .                           TLVs                                .
   .                                                               .
   +-+-+-+--+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
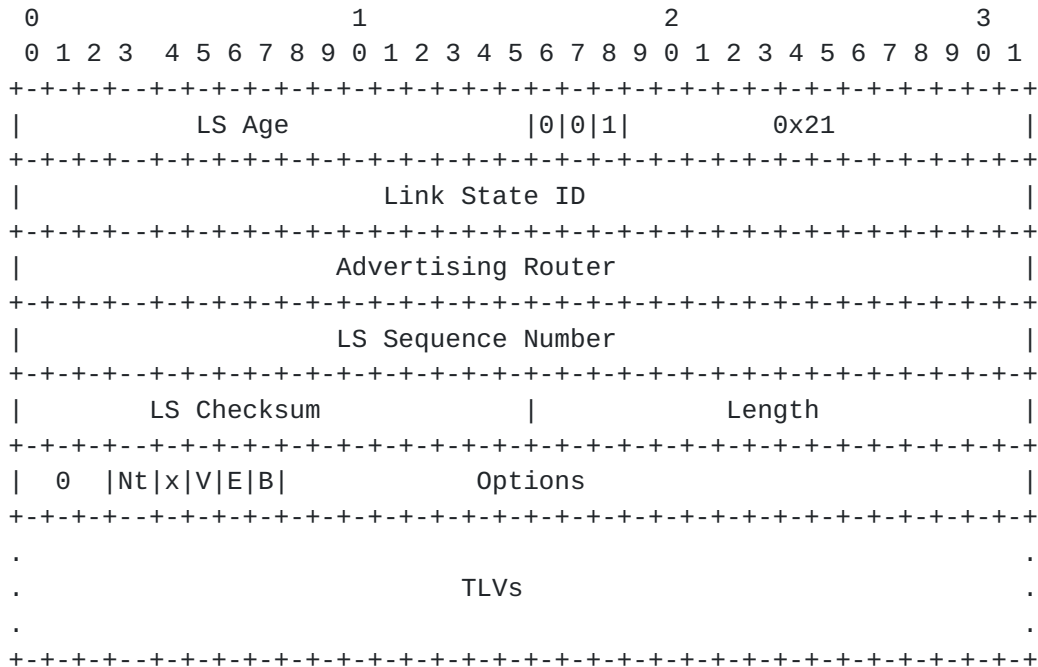
                        Extended Router-LSA

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

   o 0 - Reserved

   o 1 - Router-Link TLV

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           1 (Router-Link)     |           TLV Length          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |       0       |             Metric            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Interface ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Neighbor Interface ID                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Neighbor Router ID                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                          sub-TLVs                             .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                        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 0x2022 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.
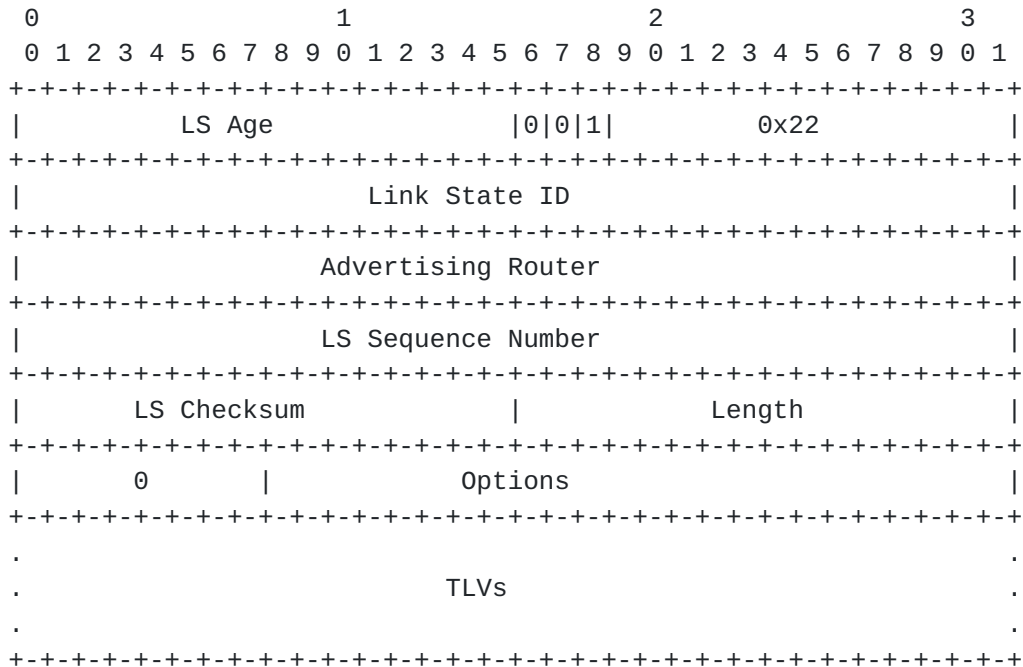
```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |          LS Age            |0|0|1|           0x22            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                         Link State ID                        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                       Advertising Router                     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                       LS Sequence Number                     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        LS Checksum         |             Length              |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |       0       |                  Options                     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    .                                                              .
    .                           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

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |        2 (Attached-Routers)   |        TLV Length            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                 Adjacent Neighbor Router ID                  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    .                                                              .
    .               Additional Adjacent Neighbors                 .
    .                                                              .
```

```
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                            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.

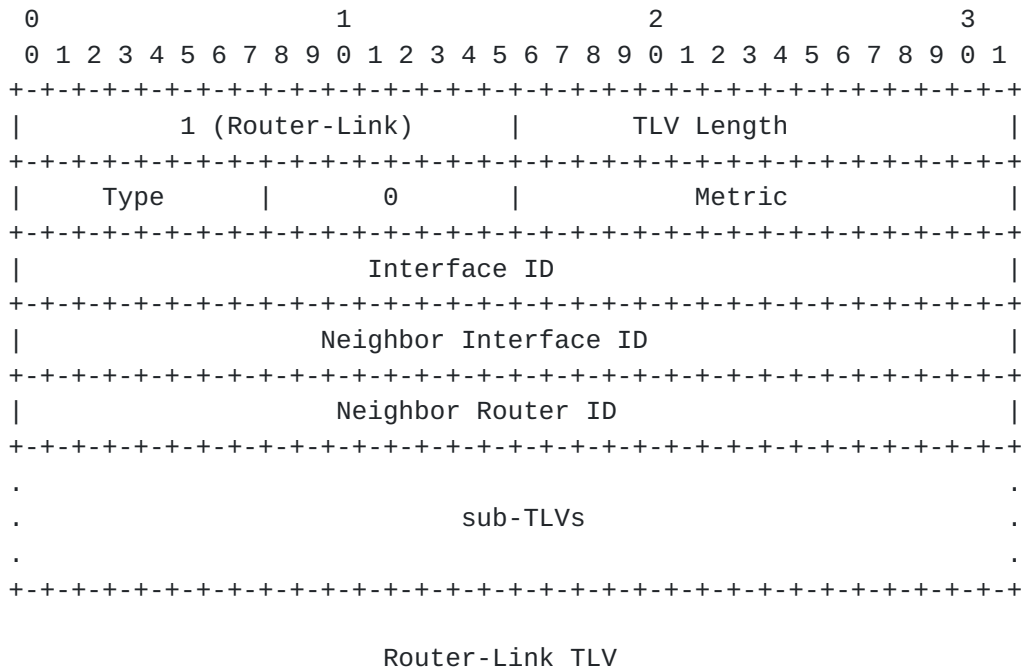## 6. OSPFv3 E-Inter-Area-Prefix-LSA

The E-Inter-Area-Prefix-LSA has an LS Type of 0x2023 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.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           LS Age              |0|0|1|          0x23           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Link State ID                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Advertising Router                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      LS Sequence Number                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        LS Checksum            |             Length           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                              .
   .                            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:

o 3 - Inter-Area Prefix TLV

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       3 (Inter-Area Prefix)   |         TLV Length            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      0        |                  Metric                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | PrefixLength  | PrefixOptions |                 0             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Address Prefix                          |
   |                          ...                                  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                               .
   .                         sub-TLVs                              .
   .                                                               .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                         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.

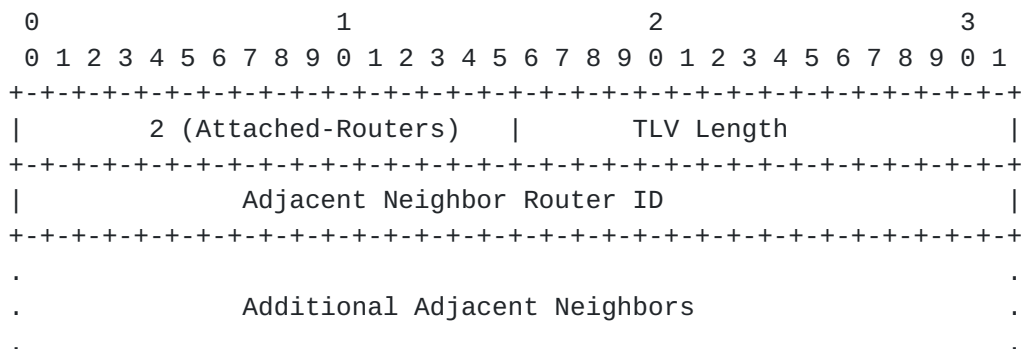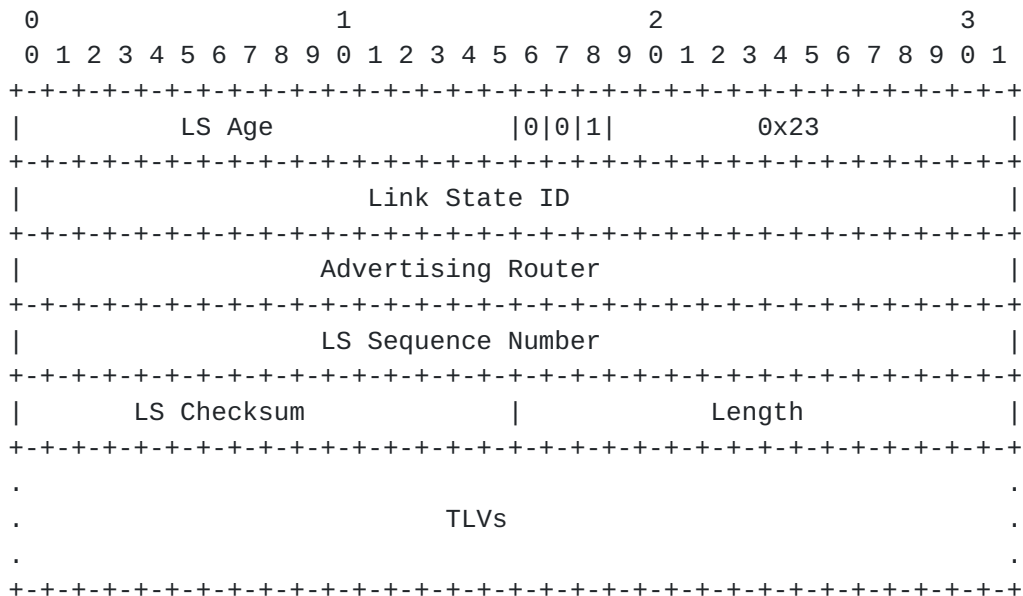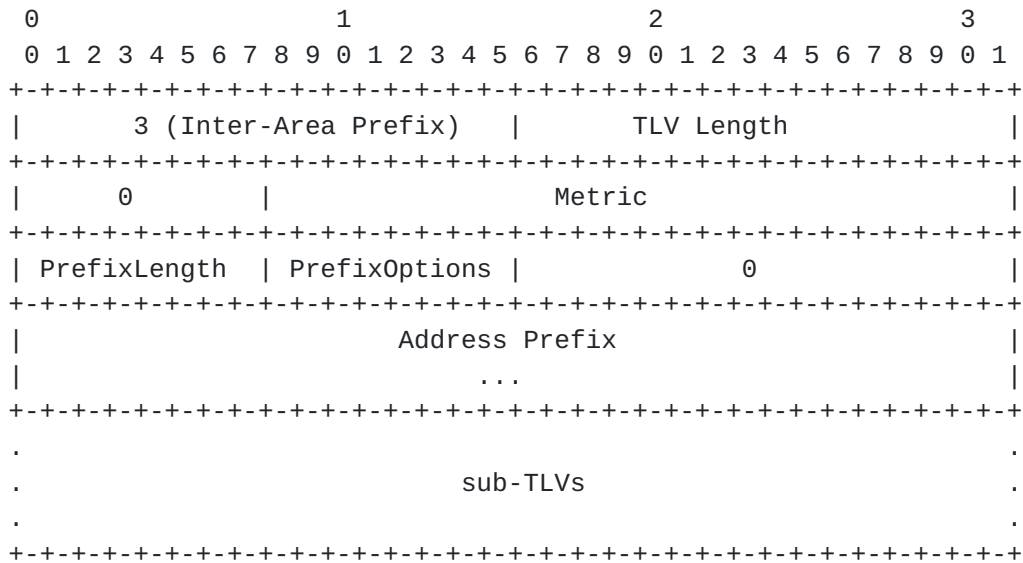## 7. OSPFv3 E-Inter-Area-Router-LSA

   The E-Inter-Area-Router-LSA has an LS Type of 0x2024 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.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |            LS Age              |0|0|1|           0x24         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         Link State ID                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Advertising Router                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       LS Sequence Number                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         LS Checksum           |             Length            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                               .
   .                              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:

   o 4 - Inter-Area Router TLV

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|       3 (Inter-Area Router)   |        TLV Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     0         |                 Options                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     0         |                 Metric                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Router ID                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                                                               .
.                         sub-TLVs                              .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
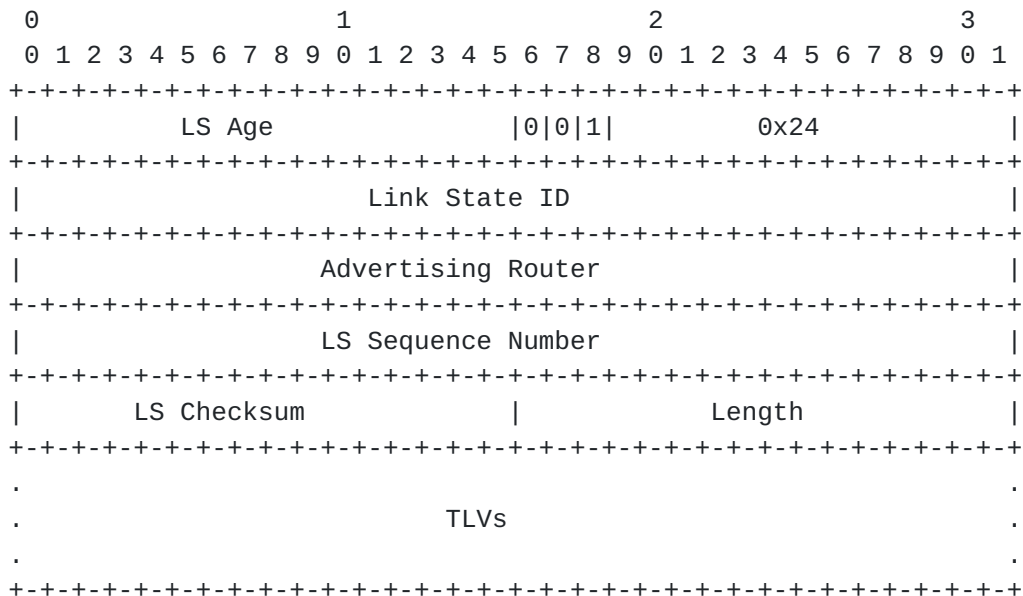
Inter-Area Router TLV

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.
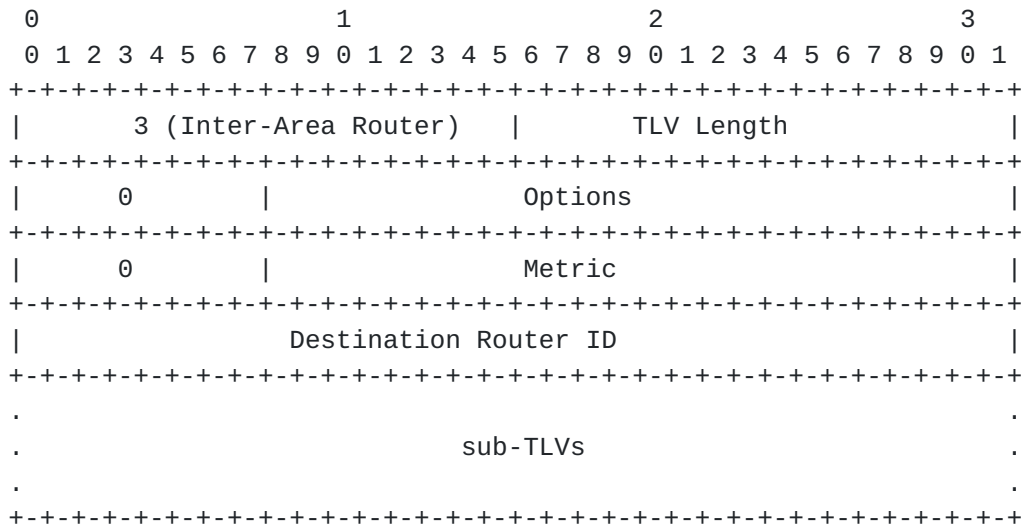Inclusion in other Extended LSAs MUST be ignored.

8. OSPFv3 E-AS-External-LSA

   The E-AS-External-LSA has an LS Type of 0x4025 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.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           LS Age              |0|1|0|          0x25           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Link State ID                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Advertising Router                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      LS Sequence Number                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |       LS Checksum             |             Length           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                              .
   .                            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:

   o 5 - External Prefix TLV
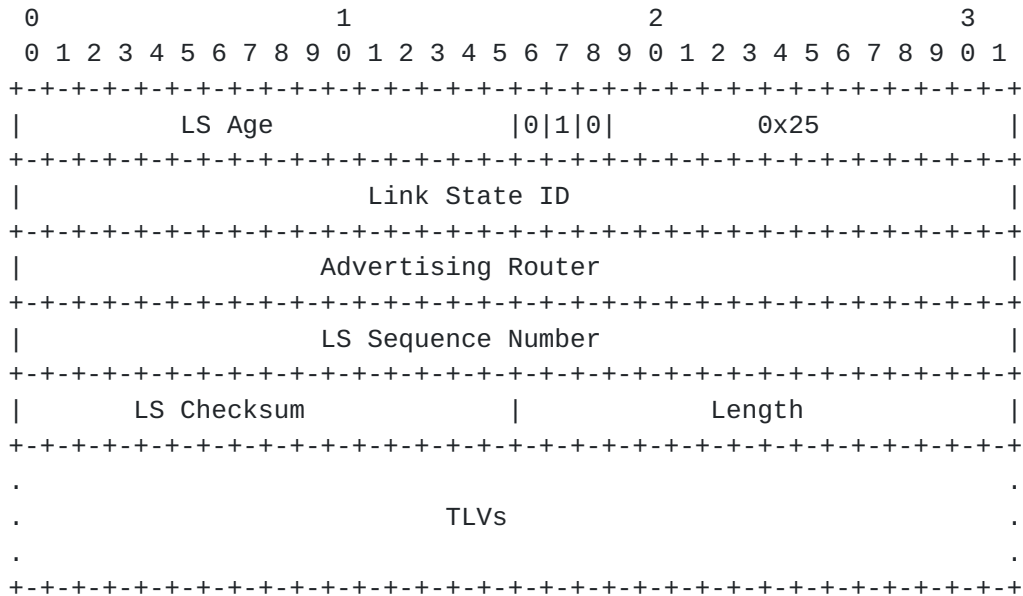
```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |       5 (External Prefix)     |        TLV Length             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |         |E|F|T|                Metric                         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | PrefixLength  | PrefixOptions |              0                |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                         Address Prefix                        |
    |                             ...                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    +-                                                             -+
    |                                                               |
    +-             Forwarding Address (Optional)                   -+
    |                                                               |
    +-                                                             -+
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              External Route Tag (Optional)                    |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    .                                                               .
    .                          sub-TLVs                             .
    .                                                               .
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
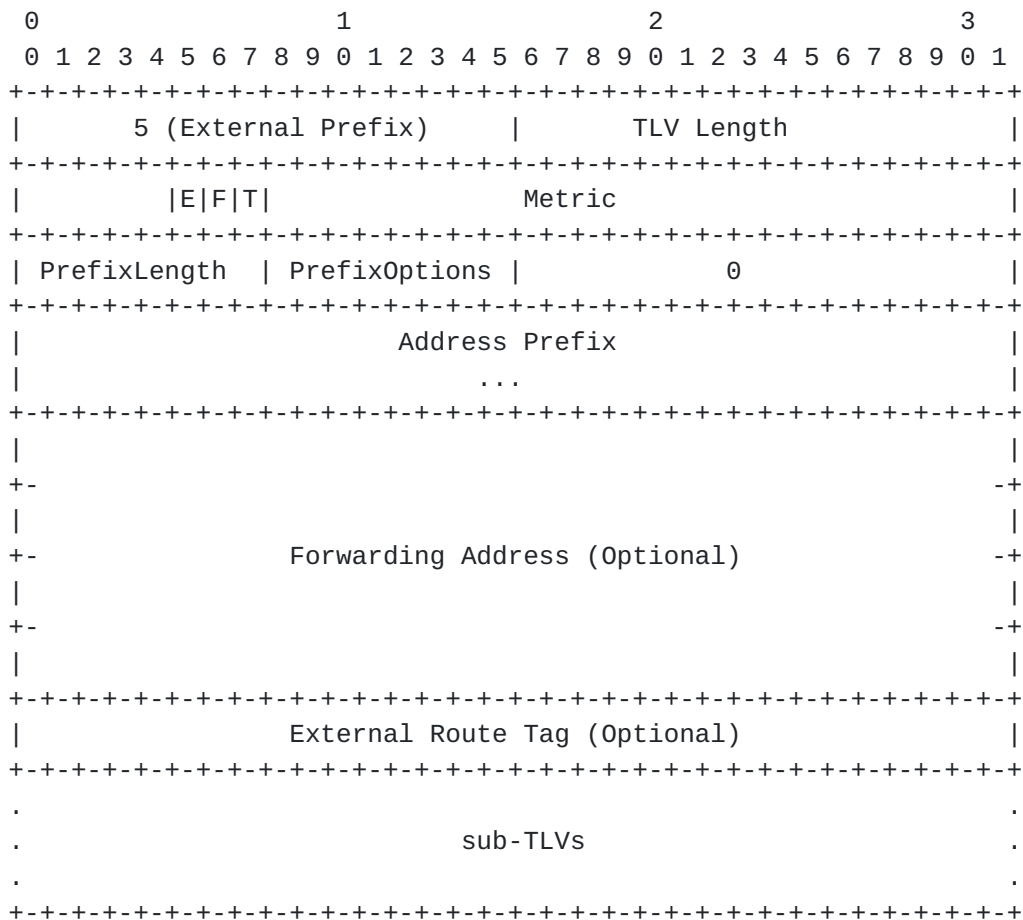
                        External Prefix TLV

   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 functions
   such as incremental SPF computation. 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.
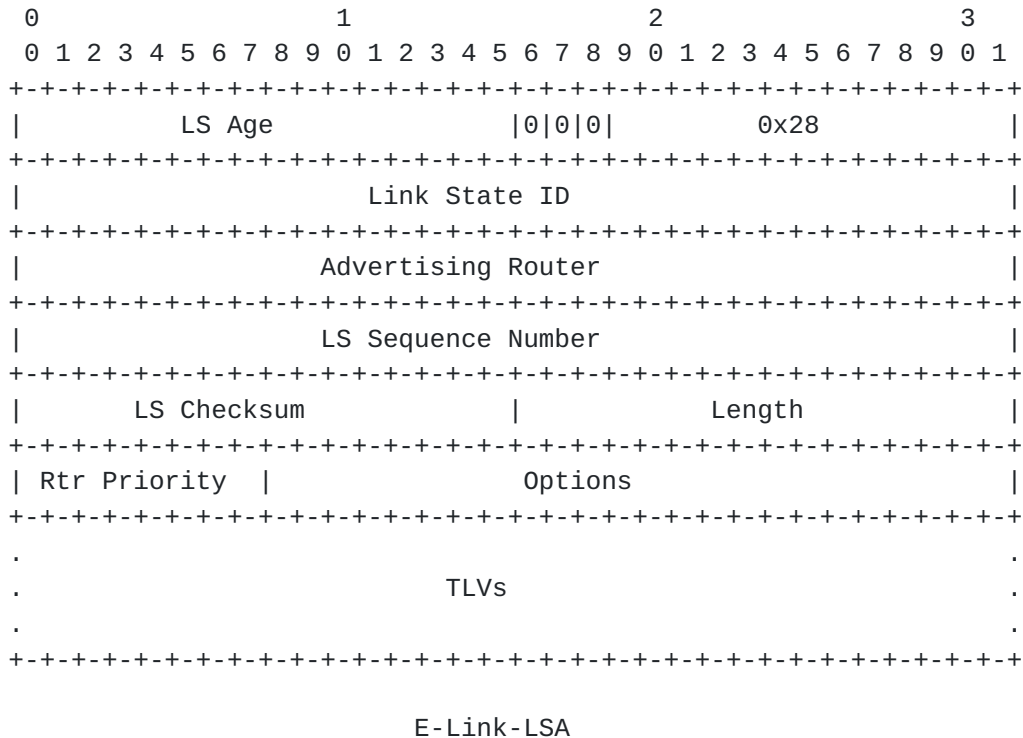   Inclusion in other Extended LSAs MUST be ignored.

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 0x2027 which implies area
   flooding scope. Future requirements may dictate that supported TLVs
   differ between the E-AS-External-LSA and the E-NSSA-TLV. However,
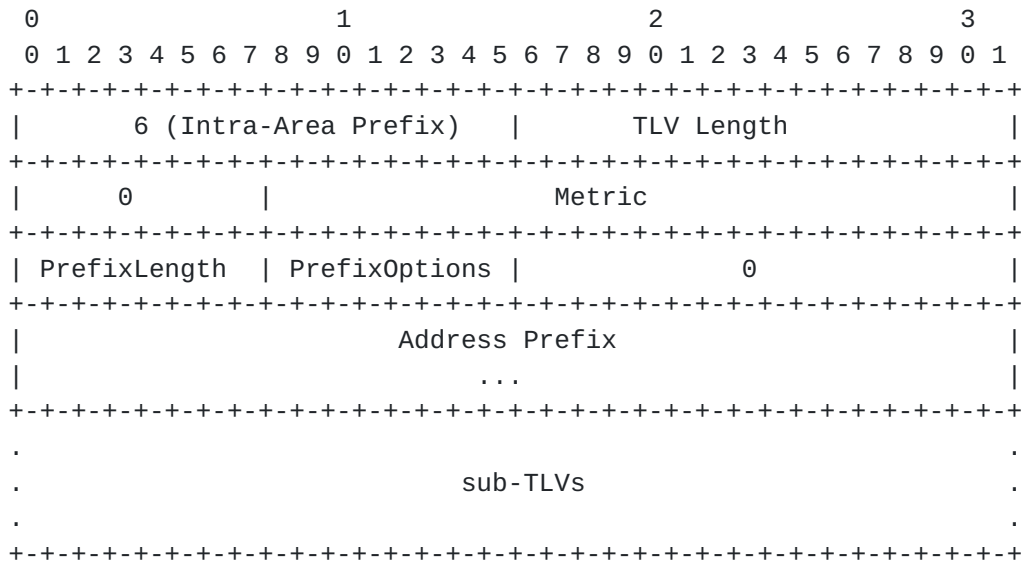   future requirements are beyond the scope of this document.

10. OSPFv3 E-Link-LSA

The E-Link-LSA has an LS Type of 0x0028 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.
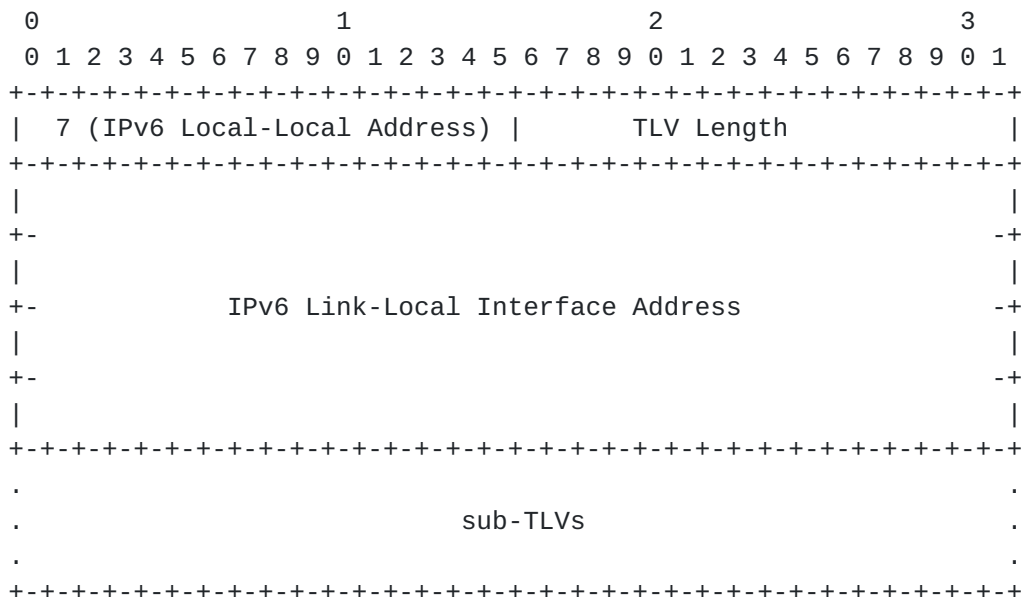
```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |          LS Age               |0|0|0|          0x28           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Link State ID                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Advertising Router                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      LS Sequence Number                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        LS Checksum             |              Length          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Rtr Priority  |                 Options                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                               .
   .                            TLVs                               .
   .                                                               .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

                            E-Link-LSA
```

The following top-level TLVs are defined:

o 6 - Intra-Area Prefix TLV

o 7 - IPv6 Link-Local Address TLV

o 8 - IPv4 Link-Local Address TLV

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |       6 (Intra-Area Prefix)   |          TLV Length           |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |      0        |                   Metric                      |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | PrefixLength  | PrefixOptions |                 0             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                        Address Prefix                         |
    |                           ...                                 |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    .                                                               .
    .                         sub-TLVs                              .
    .                                                               .
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                        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
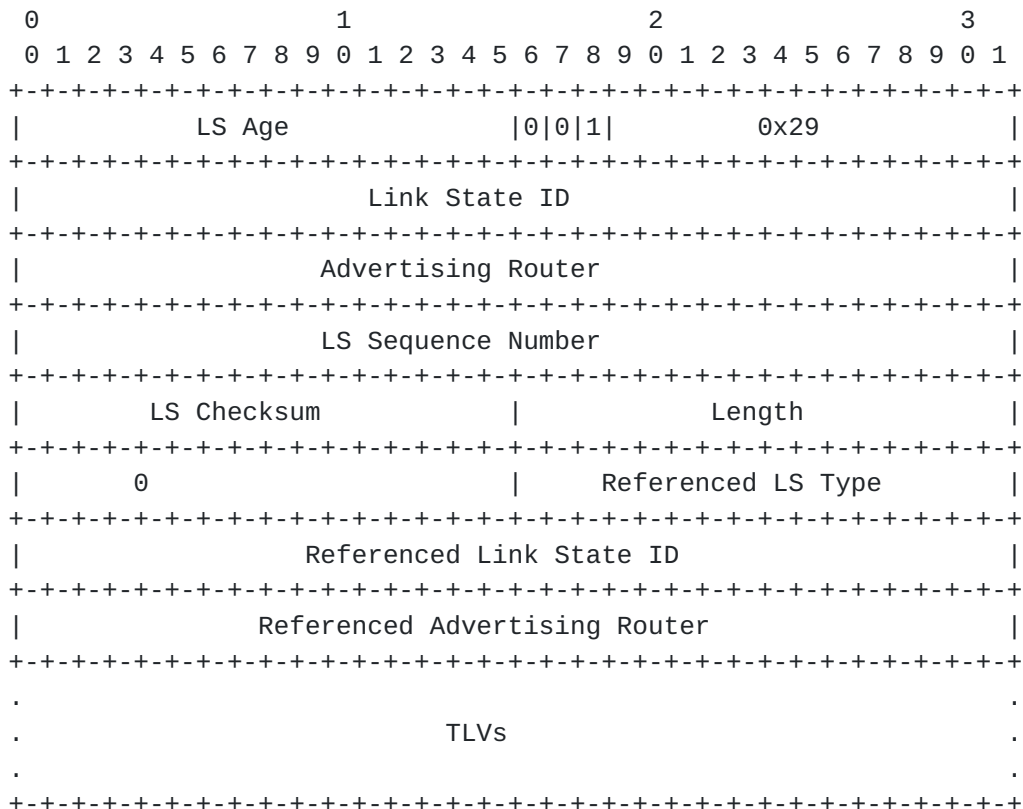   and the E-Intra-Area-Prefix-LSA. Inclusion in other Extended LSAs
   MUST be ignored.

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |  7 (IPv6 Local-Local Address) |          TLV Length           |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    +-                                                             -+
    |                                                               |
    +-            IPv6 Link-Local Interface Address                -+
    |                                                               |
    +-                                                             -+
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    .                                                               .
    .                         sub-TLVs                              .
    .                                                               .
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                      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
preceding 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.

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |  8 (IPv4 Local-Local Address) |        TLV Length             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              IPv4 Link-Local Interface Address                |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    .                                                               .
    .                          sub-TLVs                             .
    .                                                               .
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                    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
preceding the first MUST be ignored. For IPv6 address families as
defined in [OSPFV3-AF]. 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 0x2029 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.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |           LS Age           |0|0|1|          0x29             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Link State ID                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Advertising Router                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      LS Sequence Number                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         LS Checksum        |              Length             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         0                  |         Referenced LS Type      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                   Referenced Link State ID                   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                 Referenced Advertising Router                |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   .                                                              .
   .                           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 basic 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. An OSPFv3 instance will be configured
   to use either the Non-TLV-based LSAs, TLV-based LSAs, or support both
   (Appendix A). 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 "Normal" is specified for
   ExtendedLSASupport, the OSPFv3 router MUST NOT form adjacencieswith
   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.

```
                        1                     2
   0 1 2 3 4 5 6 7 8 9 0 1  2  3 4  5 6 7  8 9 0 1  2  3
  +-+-+-+-+-+-+-+-+-+-+-+-+--+-+--+-+-+-+--+-+-+-+--+--+
  | | | | | | | | | | | | |EL|AT|L|AF|*|*|DC|R|N|x| E|V6|
  +-+-+-+-+-+-+-+-+-+-+-+-+--+-+--+-+-+-+--+-+-+-+--+--+
                    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 mixture of
   OSPFv3 routers supporting and not supporting TLV-based LSAs in the
   same OSPFv3 routing domain. In these deployments, the OSPFv3 routers
   configured with a value of MixedMode for ExtendedLSASupport,
   (Appendix A), MUST originate both the TLV-based and non-TLV-based
   versions of the OSPFv3 LSAs described herein. For the purposes of
   Shortest Path First (SPF) computation, the TLV-based LSAs MUST be
   used by OSPFv3 routers supporting this specification. 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.

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**

   Extendible OSPFv3 LSAs do not introduce any new security concerns
   beyond those described in RFC 5340 [OSPFV3].

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:

o 0 - Reserved

o 1 - Router-Link TLV

o 2 - Attached-Routers TLV

o 3 - Inter-Area Prefix TLV

o 4 - Inter-Area Router TLV

o 5 - External Prefix TLV

o 6 - Intra-Area Prefix TLV

o 7 - IPv6 Link-Local Address TLV

o 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:

o 0 - Reserved

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-toplogy routing in OSPFv3
             (MT-OSPFV3)", draft-ietf-ospf-mt-ospfv3-04.txt (work in
             progress).

Appendix A. Configurable Constants

   An additional global configurable constant 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.

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

      * MixedMode - Both extended and non-extended LSAs will be
         originated. OSPFv3 adjacencies will be formed with OSPFv3
         routers not supporting this specification.

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