                OSPFv2 Prefix/Link Attribute Advertisement

Abstract

   OSPFv2 requires functional extension beyond what can readily be done
   with the fixed-format Link State Advertisements (LSAs) as described
   in RFC 2328. This document defines OSPFv2 Opaque LSAs based on Type-
   Length-Value (TLV) tuples that can be used to associate additional
   attributes with prefixes or links. Depending on the application,
   these prefixes and links may or may not be advertised in the fixed-
   format LSAs. The OSPFv2 Opaque LSAs are optional and fully backward
   compatible.

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1. Introduction

   OSPFv2 requires functional extension beyond what can readily be done
   with the fixed-format Link State Advertisements (LSAs) as described
   in RFC 2328 [OSPFV2]. This document defines OSPFv2 Opaque LSAs based
   on Type-Length-Value (TLV) tuples that can be used to associate
   additional attributes with prefixes or links. Depending on the
   application, these prefixes and links may or may not be advertised in
   the fixed-format LSAs. The OSPFv2 Opaque LSAs are optional and fully
   backward compatible. This is in contrast to the approach taken in
   OSPFv3 [OSPFv3-EXTEND] where the existing LSAs will be replaced by
   TLV-based extended LSAs.

   New requirements such as source/destination routing, route tagging,
   and segment routing necessitate this extension.

   This specification defines the following OSPFv2 Opaque LSAs:

   1. OSPFv2 Extended Prefix Opaque LSA - Allows advertisement of
       additional attributes for prefixes advertised in Router-LSAs,
       Network-LSAs, Summary-LSAs (IP network), NSSA-LSAs, and
       AS-external-LSAs [OSPFV2][RFC3101].

   2. OSPFv2 Extended Link Opaque LSA - Allows advertisement of
       additional attributes for links advertised in Router-LSAs.

   Additionally, the following TLVs are defined:

   1. OSPFv2 Extended Prefix TLV - Top-level TLV advertising attributes
       for a prefix in the OSPFv2 Extended Prefix Opaque LSA.

   2. OSPFv2 Extended Link TLV - Top-level TLV advertising attributes
       for a link in the OSPFv2 Extended Link Opaque LSA.

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 [KEYWORDS].

2. OSPFv2 Extended Prefix Opaque LSA

   The OSPFv2 Extended Prefix Opaque LSA is used to advertise additional
   prefix attributes. Opaque LSAs are described in [OPAQUE].

   Multiple OSPFv2 Extended Prefix Opaque LSAs can be advertised by an
   OSPFv2 router. The flooding scope of the OSPFv2 Extended Prefix
   Opaque LSA depends on the scope of the advertised prefixes and is

under the control of the advertising router. In some cases (e.g.,
mapping server deployment [SEGMENT-ROUTING]), the LSA flooding scope
may be greater than the scope of the corresponding prefixes.

The format of the OSPFv2 Extended Prefix Opaque LSA is as follows:

```
 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              |    Options    |   LS Type     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Opaque Type  |               Opaque ID                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Advertising Router                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    LS sequence number                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        LS checksum            |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+-                            TLVs                             -+
|                             ...                               |
```
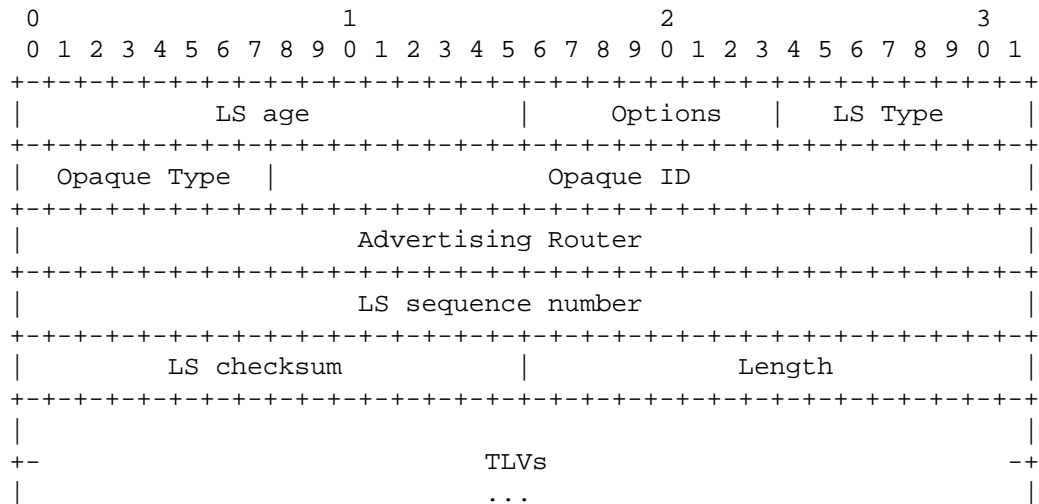
OSPFv2 Extended Prefix Opaque LSA

The Opaque Type used by the OSPFv2 Extended Prefix Opaque LSA is 7.
The Opaque Type is used to differentiate the various types of OSPFv2
Opaque LSAs and is described in Section 3 of [OPAQUE]. The LS Type
may be 10 or 11, indicating that the Opaque LSA flooding scope is
area-local (10) or AS-wide (11) [OPAQUE]. The LSA Length field
[OSPFV2] represents the total length (in octets) of the Opaque LSA,
including the LSA header and all TLVs (including padding).

The Opaque ID field is an arbitrary value used to maintain multiple
OSPFv2 Extended Prefix Opaque LSAs. For OSPFv2 Extended Prefix
Opaque LSAs, the Opaque ID has no semantic significance other than to
differentiate OSPFv2 Extended Prefix Opaque LSAs originated by the
same OSPFv2 router. If multiple OSPFv2 Extended Prefix Opaque LSAs
include the same prefix, the attributes from the Opaque LSA with the
lowest Opaque ID SHOULD be used.

The format of the TLVs within the body of the OSPFv2 Extended Prefix
Opaque LSA is the same as the format used by the Traffic Engineering
Extensions to OSPFv2 [TE]. The variable TLV section consists of one
or more nested TLV tuples. Nested TLVs are also referred to as sub-
TLVs. 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                              |
                                 o
                                 o
                                 o
  |                                                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
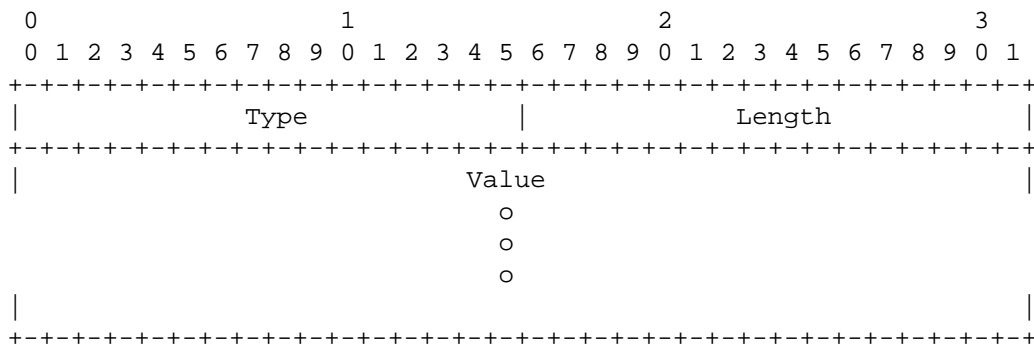
                              TLV Format

   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. The padding is composed of zeros.

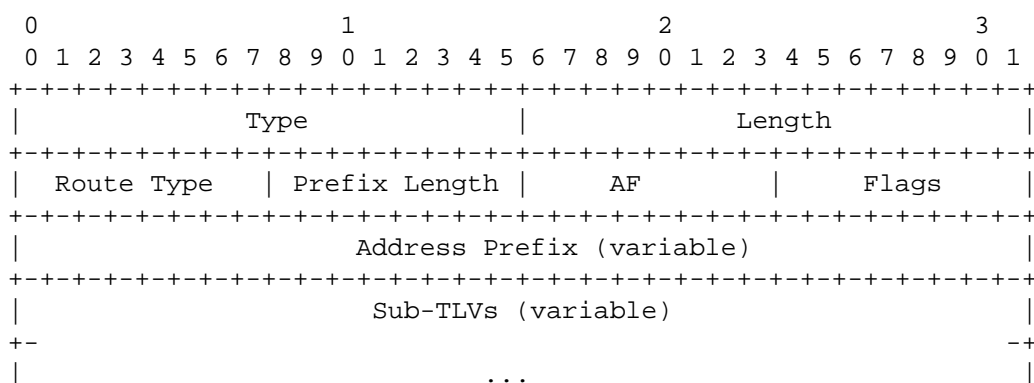2.1. OSPFv2 Extended Prefix TLV

   The OSPFv2 Extended Prefix TLV is used to advertise additional
   attributes associated with the prefix. Multiple OSPFv2 Extended
   Prefix TLVs MAY be advertised in each OSPFv2 Extended Prefix Opaque
   LSA. However, since the Opaque LSA type defines the flooding scope,
   the LSA flooding scope MUST satisfy the application-specific
   requirements for all the prefixes included in a single OSPFv2
   Extended Prefix Opaque LSA. The OSPFv2 Extended Prefix TLV has the
   following format:

```
   0                   1                   2                   3
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |              Type             |             Length            |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |  Route Type   | Prefix Length |       AF      |     Flags     |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                    Address Prefix (variable)                  |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                     Sub-TLVs (variable)                       |
  +-                                                             -+
  |                             ...                               |
```

                     OSPFv2 Extended Prefix TLV

Type
   The TLV type. The value is 1 for this TLV type.

Length
   Variable, dependent on sub-TLVs.

Route Type
   The type of the OSPFv2 route. If the route type is 0
   (Unspecified), the information inside the OSPFv2 External Prefix
   TLV applies to the prefix regardless of prefix's route type. This
   is useful when prefix-specific attributes are advertised by an
   external entity that is not aware of the route type associated
   with the prefix. Supported types are:

      0 - Unspecified

      1 - Intra-Area

      3 - Inter-Area

      5 - Autonomous System (AS) External

      7 - Not-So-Stubby Area (NSSA) External

   These route types correspond directly to the OSPFv2 LSAs types as
   defined in the "OSPFv2 Link State (LS) Type" registry in
   <http://www.iana.org/assignments/ospfv2-parameters>.
   Specification of route types other than those defined will prevent
   correlation with existing OSPFv2 LSAs and is beyond the scope of
   this specification.

Prefix Length
   Length of prefix in bits.

AF
   Address family for the prefix. Currently, the only supported
   value is 0 for IPv4 unicast. The inclusion of address family in
   this TLV allows for future extension.

Flags
   This one-octet field contains flags applicable to the prefix.
   Supported Flags include:

      0x80 - A-Flag (Attach Flag): An Area Border Router (ABR)
      generating an OSPFv2 Extended Prefix TLV for an inter-area
      prefix that is locally connected or attached in another
      connected area SHOULD set this flag.

0x40 - N-Flag (Node Flag): Set when the prefix identifies the
advertising router, i.e., the prefix is a host prefix
advertising a globally reachable address typically associated
with a loopback address. The advertising router MAY choose to
not set this flag even when the above conditions are met. If
the flag is set and the prefix length is not a host prefix,
then the flag MUST be ignored. The flag is preserved when the
OSPFv2 Extended Prefix Opaque LSA is propagated between areas.

Address Prefix
   For the address family IPv4 unicast, the prefix itself is encoded
   as a 32-bit value. The default route is represented by a prefix
   of length 0. Prefix encoding for other address families is beyond
   the scope of this specification.

If this TLV is advertised multiple times for the same prefix in the
same OSPFv2 Extended Prefix Opaque LSA, only the first instance of
the TLV is used by receiving OSPFv2 routers. This situation SHOULD
be logged as an error.

If this TLV is advertised multiple times for the same prefix in
different OSPFv2 Extended Prefix Opaque LSAs originated by the same
OSPFv2 router, the OSPFv2 advertising router is re-originating OSPFv2
Extended Prefix Opaque LSAs for multiple prefixes and is most likely
repacking Extended-Prefix-TLVs in OSPFv2 Extended Prefix Opaque LSAs.
In this case, the Extended-Prefix-TLV in the OSPFv2 Extended Prefix
Opaque LSA with the smallest Opaque ID is used by receiving OSPFv2
routers. This situation may be logged as a warning.

It is RECOMMENDED that OSPFv2 routers advertising OSPFv2 Extended
Prefix TLVs in different OSPFv2 Extended Prefix Opaque LSAs
re-originate these LSAs in ascending order of Opaque ID to minimize
the disruption.

If this TLV is advertised multiple times for the same prefix in
different OSPFv2 Extended Prefix Opaque LSAs originated by different
OSPFv2 routers, the application using the information is required to
determine which OSPFv2 Extended Prefix Opaque LSA is used. For
example, the application could prefer the LSA providing the best path
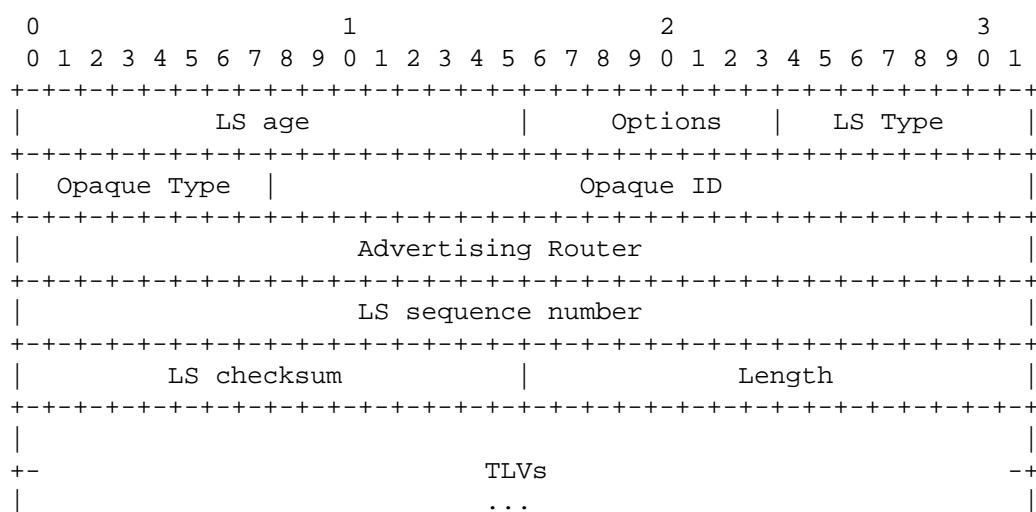to the prefix.

This document creates a registry for OSPFv2 Extended Prefix sub-TLVs
in Section 6.

3. OSPFv2 Extended Link Opaque LSA

   The OSPFv2 Extended Link Opaque LSA is used to advertise additional
   link attributes. Opaque LSAs are described in [OPAQUE].

   The OSPFv2 Extended Link Opaque LSA has an area flooding scope.
   Multiple OSPFv2 Extended Link Opaque LSAs can be advertised by a
   single router in an area.

   The format of the OSPFv2 Extended Link Opaque LSA is as follows:

```
    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              |    Options    |   LS Type     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Opaque Type  |               Opaque ID                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Advertising Router                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     LS sequence number                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |         LS checksum           |             Length            |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   +-                           TLVs                              -+
   |                            ...                                |
```

                OSPFv2 Extended Link Opaque LSA

   The Opaque Type used by the OSPFv2 Extended Link Opaque LSA is 8.
   The LS Type is 10, indicating that the Opaque LSA flooding scope is
   area-local [OPAQUE]. The Opaque Type is used to differentiate the
   various types of OSPFv2 Opaque LSAs and is described in Section 3 of
   [OPAQUE]. The LSA Length field [OSPFV2] represents the total length
   (in octets) of the Opaque LSA, including the LSA header and all TLVs
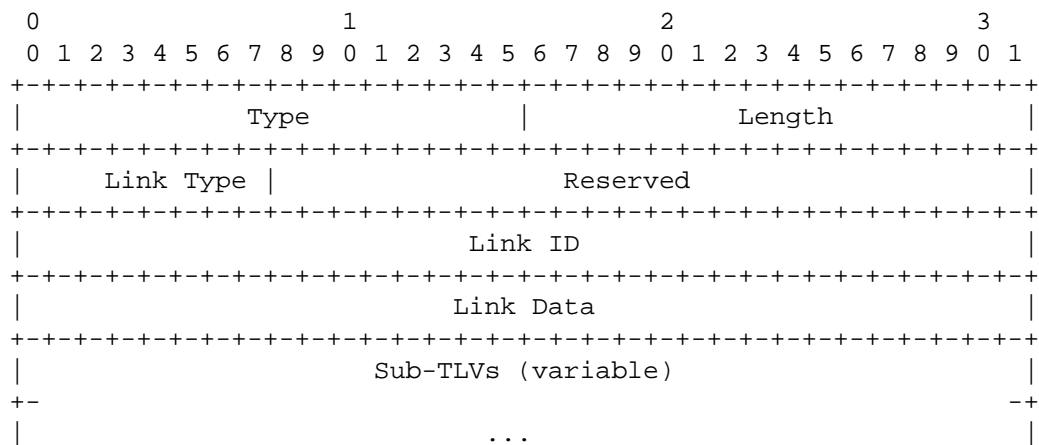   (including padding).

   The Opaque ID field is an arbitrary value used to maintain multiple
   OSPFv2 Extended Prefix Opaque LSAs. For OSPFv2 Extended Link Opaque
   LSAs, the Opaque ID has no semantic significance other than to
   differentiate OSPFv2 Extended Link Opaque LSAs originated by the same
   OSPFv2 router. If multiple OSPFv2 Extended Link Opaque LSAs include
   the same link, the attributes from the Opaque LSA with the lowest
   Opaque ID will be used.

   The format of the TLVs within the body of the OSPFv2 Extended Link
   Opaque LSA is the same as described in Section 2.

3.1. OSPFv2 Extended Link TLV

   The OSPFv2 Extended Link TLV is used to advertise various attributes
   of the link. It describes a single link and is constructed of a set
   of sub-TLVs. There are no ordering requirements for the sub-TLVs.
   Only one OSPFv2 Extended Link TLV SHALL be advertised in each OSPFv2
   Extended Link Opaque LSA, allowing for fine granularity changes in
   the topology.

   The OSPFv2 Extended Link TLV has following format:

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |              Type             |             Length            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |   Link Type   |                  Reserved                     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                            Link ID                            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                           Link Data                          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                       Sub-TLVs (variable)                    |
    +-                                                            -+
    |                              ...                             |
```

                     OSPFv2 Extended Link TLV

   Type
      The TLV type. The value is 1 for this TLV type.

   Length
      Variable, dependent on sub-TLVs.

   Link Type
      Link Type is defined in Section A.4.2 of [OSPFV2] and in the
      "OSPFv2 Router LSA Link Type (Value 1)" registry at
      <http://www.iana.org/assignments/ospfv2-parameters>.
      Specification of link types other than those defined will prevent
      correlation with existing OSPFv2 Router-LSA links and is beyond
      the scope this specification.

   Link ID
      Link ID is defined in Section A.4.2 of [OSPFV2].

   Link Data
      Link Data is defined in Section A.4.2 of [OSPFV2].

If this TLV is advertised multiple times in the same OSPFv2 Extended
Link Opaque LSA, only the first instance of the TLV is used by
receiving OSPFv2 routers. This situation SHOULD be logged as an
error.

If this TLV is advertised multiple times for the same link in
different OSPFv2 Extended Link Opaque LSAs originated by the same
OSPFv2 router, the OSPFv2 Extended Link TLV in the OSPFv2 Extended
Link Opaque LSA with the smallest Opaque ID is used by receiving
OSPFv2 routers. This situation may be logged as a warning.

It is RECOMMENDED that OSPFv2 routers advertising OSPFv2 Extended
Link TLVs in different OSPFv2 Extended Link Opaque LSAs re-originate
these LSAs in ascending order of Opaque ID to minimize the
disruption.

This document creates a registry for OSPFv2 Extended Link sub-TLVs in
Section 6.

4. Backward Compatibility

Since Opaque OSPFv2 LSAs are optional and backward compatible
[OPAQUE], the extensions described herein are fully backward
compatible. However, future OSPFv2 applications utilizing these
extensions MUST address backward compatibility of the corresponding
functionality.

5. Security Considerations

In general, new LSAs defined in this document are subject to the same
security concerns as those described in [OSPFV2] and [OPAQUE].

OSPFv2 applications utilizing these OSPFv2 extensions must define the
security considerations relating to those applications in the
specifications corresponding to those applications.

Additionally, implementations must assure that malformed TLV and sub-
TLV permutations are detected and do not provide a vulnerability for
attackers to crash the OSPFv2 router or routing process. Malformed
LSAs MUST NOT be stored in the Link State Database (LSDB),
acknowledged, or reflooded. Reception of malformed LSAs SHOULD be
counted and/or logged for further analysis. In this context, a
malformed LSA is one that cannot be parsed due to a TLV or sub-TLV
overrunning the end of the subsuming LSA, TLV, or sub-TLV or where
there is data remaining to be parsed but the length of the remaining
data is less than the size of a TLV header.

6. IANA Considerations

   This specification updates the "Opaque Link-State Advertisements
   (LSA) Option Types" registry with the following values:

   o 7 - OSPFv2 Extended Prefix Opaque LSA

   o 8 - OSPFv2 Extended Link Opaque LSA

   This specification also creates five new registries:

   o OSPFv2 Extended Prefix Opaque LSA TLVs

   o OSPFv2 Extended Prefix TLV Sub-TLVs

   o OSPFv2 Extended Prefix TLV Flags

   o OSPFv2 Extended Link Opaque LSA TLVs

   o OSPFv2 Extended Link TLV Sub-TLVs

6.1. OSPFv2 Extended Prefix Opaque LSA TLVs Registry

   The "OSPFv2 Extend Prefix Opaque LSA TLVs" registry defines top-level
   TLVs for OSPFv2 Extended Prefix Opaque LSAs and has been added to the
   "Open Shortest Path First v2 (OSPFv2) Parameters" registry. New
   values can be allocated via IETF Review or IESG Approval [RFC5226].

   The following initial values have been allocated:

   o 0 - Reserved

   o 1 - OSPFv2 Extended Prefix TLV

   Types in the range 32768-33023 are for Experimental Use; these will
   not be registered with IANA and MUST NOT be mentioned by RFCs.

   Types in the range 33024-65535 are not to be assigned at this time.
   Before any assignments can be made in the 33024-65535 range, there
   MUST be an IETF specification that specifies IANA considerations
   covering the range being assigned.

6.2. OSPFv2 Extended Prefix TLV Sub-TLVs Registry

   The "OSPFv2 Extended Prefix TLV Sub-TLVs" registry defines sub-TLVs
   at any level of nesting for OSPFv2 Extended Prefix TLVs and has been
   added to the "Open Shortest Path First v2 (OSPFv2) Parameters"
   registry. New values can be allocated via IETF Review or IESG
   Approval.

   The following initial value has been allocated:

   o 0 - Reserved

   Types in the range 32768-33023 are for Experimental Use; these will
   not be registered with IANA and MUST NOT be mentioned by RFCs.

   Types in the range 33024-65535 are not to be assigned at this time.
   Before any assignments can be made in the 33024-65535 range, there
   MUST be an IETF specification that specifies IANA considerations
   covering the range being assigned.

6.3. OSPFv2 Extended Prefix TLV Flags Registry

   The "OSPFv2 Extended Prefix TLV Flags" registry defines the bits in
   the 8-bit OSPFv2 Extended Prefix TLV Flags (Section 2.1). This
   specification defines the A (0x80) and N (0x40) bits. This registry
   has been added to the "Open Shortest Path First v2 (OSPFv2)
   Parameters" registry. New values can be allocated via IETF Review or
   IESG Approval.

6.4. OSPFv2 Extended Link Opaque LSA TLVs Registry

   The "OSPFv2 Extended Link Opaque LSA TLVs" registry defines top-level
   TLVs for OSPFv2 Extended Link Opaque LSAs and has been added to the
   "Open Shortest Path First v2 (OSPFv2) Parameters" registry. New
   values can be allocated via IETF Review or IESG Approval.

   The following initial values have been allocated:

   o 0 - Reserved

   o 1 - OSPFv2 Extended Link TLV

   Types in the range 32768-33023 are for Experimental Use; these will
   not be registered with IANA and MUST NOT be mentioned by RFCs.

   Types in the range 33024-65535 are not to be assigned at this time.
   Before any assignments can be made in the 33024-65535 range, there
   MUST be an IETF specification that specifies IANA considerations
   covering the range being assigned.

6.5. OSPFv2 Extended Link TLV Sub-TLVs Registry

   The "OSPFv2 Extended Link TLV Sub-TLVs" registry defines sub-TLVs at
   any level of nesting for OSPFv2 Extended Link TLVs and has been added
   to the "Open Shortest Path First v2 (OSPFv2) Parameters" registry.
   New values can be allocated via IETF Review or IESG Approval.

   The following initial value has been allocated:

   o 0 - Reserved

   Types in the range 32768-33023 are for Experimental Use; these will
   not be registered with IANA and MUST NOT be mentioned by RFCs.

   Types in the range 33024-65535 are not to be assigned at this time.
   Before any assignments can be made in the 33024-65535 range, there
   MUST be an IETF specification that specifies IANA considerations
   covering the range being assigned.

7. References

7.1. Normative References

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              DOI 10.17487/RFC2119, March 1997,
              <http://www.rfc-editor.org/info/rfc2119>.

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              (TE) Extensions to OSPF Version 2", RFC 3630,
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7.2. Informative References

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   [RFC3101] Murphy, P., "The OSPF Not-So-Stubby Area (NSSA) Option",
             RFC 3101, DOI 10.17487/RFC3101, January 2003,
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