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               OSPFv2 Link Traffic Engineering (TE) Attribute Reuse
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Abstract

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

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1. Introduction

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

   Many of these link attributes are useful outside of the traditional
   MPLS Traffic Engineering or GMPLS. This brings its own set of
   problems, in particular how to distribute these link attributes in
   OSPFv2 when MPLS TE or GMPLS are not deployed or are deployed in
   parallel with other applications that use these link attributes.

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

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

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

1.1. Requirements notation

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

2. Link attributes examples

   This section lists some of the link attributes originally defined for
   MPLS Traffic Engineering that can be used for other purposes in
   OSPFv2. The list doesn't necessarily contain all the required
   attributes.

   1. Remote Interface IP address [RFC3630] - OSPFv2 currently cannot
       distinguish between parallel links between two OSPFv2 routers.
       As a result, the two-way connectivity check performed during SPF

      may succeed when the two routers disagree on which of the links
      to use for data traffic.

   2. Link Local/Remote Identifiers - [RFC4203] - Used for the two-way
       connectivity check for parallel unnumbered links. Also used for
       identifying adjacencies for unnumbered links in Segment Routing
       traffic engineering.

   3. Shared Risk Link Group (SRLG) [RFC4203] - In IPFRR, the SRLG is
       used to compute diverse backup paths [RFC5714].

   4. Unidirectional Link Delay/Loss Metrics [RFC7471] - Could be used
       for the shortest path first (SPF) computation using alternate
       metrics within an OSPF area.

3. Advertising Link Attributes

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

3.1. TE Opaque LSA

   One approach for advertising link attributes is to continue to use TE
   Opaque LSA ([RFC3630]). There are several problems with this
   approach:

   1. Whenever the link is advertised in a TE Opaque LSA, the link
       becomes a part of the TE topology, which may not match IP routed
       topology. By making the link part of the TE topology, remote
       nodes may mistakenly believe that the link is available for MPLS
       TE or GMPLS, when, in fact, MPLS is not enabled on the link.

   2. The TE Opaque LSA carries link attributes that are not used or
       required by MPLS TE or GMPLS. There is no mechanism in a TE
       Opaque LSA to indicate which of the link attributes are passed to
       MPLS TE application and which are used by other applications
       including OSPFv2 itself.

   3. Link attributes used for non-TE purposes are partitioned across
       multiple LSAs - the TE Opaque LSA and the Extended Link Opaque
       LSA. This partitioning will require implementations to lookup
       multiple LSAs to extract link attributes for a single link,
       bringing needless complexity to OSPFv2 implementations.

   The advantage of this approach is that there is no additional
   standardization requirement to advertise the TE/GMPL attributes for
   other applications. Additionally, link attributes are only

advertised once when both OSPF TE and other applications are deployed
on the same link. This is not expected to be a common deployment
scenario.

3.2. Extended Link Opaque LSA

An alternative approach for advertising link attributes is to use
Extended Link Opaque LSAs as defined in [RFC7684]. This LSA was
defined as a generic container for distribution of the extended link
attributes. There are several advantages in using Extended Link LSA:

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

   2. The TE Opaque LSA remains truly opaque to OSPFv2 as originally
       defined in [RFC3630]. Its content is not inspected by OSPFv2 and
       OSPFv2 acts as a pure transport.

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

   4. All link attributes that are used by OSPFv2 applications are
       advertised in a single LSA, the Extended Link Opaque LSA.

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

3.3. Selected Approach

It is RECOMMENDED to use the Extended Link Opaque LSA ([RFC7684] to
advertise any link attributes used for non-TE purposes in OSPFv2,
including those that have been originally defined for TE purposes.
TE link attributes used for TE purposes continue to use TE Opaque LSA
([RFC3630]).

It is also RECOMMENDED to keep the format of the link attribute TLVs
that have been defined for TE purposes unchanged even when they are
used for non-TE purposes.

Finally, it is RECOMMENDED to allocate unique code points for link
attribute TLVs that have been defined for TE purposes for the OSPFv2
Extended Link TLV Sub-TLV Registry as defined in [RFC7684]. For each

   reused TLV, the code point will be defined in an IETF document along
   with the expected usecase(s).

4. Reused TE link attributes

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

4.1. Remote interface IP address

   The OSPFv2 description of an IP numbered point-to-point adjacency
   does not include the remote IP address. As described in Section 2,
   this makes the two-way connectivity check ambiguous in the presence
   of the parallel point-to-point links between two OSPFv2 routers.

   The Remote IP address of the link can also be used for Segment
   Routing traffic engineering to identify the link in a set of parallel
   links between two OSPFv2 routers
   [I-D.ietf-ospf-segment-routing-extensions]. Similarly, the remote IP
   address is useful in identifying individual parallel OSPF links
   advertised in BGP Link-State as described in
   [I-D.ietf-idr-ls-distribution].

   To advertise the Remote interface IP address in the OSPFv2 Extended
   Link TLV, the same format of the sub-TLV as defined in section 2.5.4.
   of [RFC3630] is used and TLV type TBD1 is used.

4.2. Link Local/Remote Identifiers

   The OSPFv2 description of an IP unnumbered point-to-point adjacency
   does not include the remote link identifier. As described in
   Section 2, this makes the two-way connectivity check ambiguous in the
   presence of the parallel point-to-point IP unnumbered links between
   two OSPFv2 routers.

   The local and remote link identifiers can also be used for Segment
   Routing traffic engineering to identify the link in a set of parallel
   IP unnumbered links between two OSPFv2 routers
   [I-D.ietf-ospf-segment-routing-extensions]. Similarly, these
   identifiers are useful in identifying individual parallel OSPF links
   advertised in BGP Link-State as described in
   [I-D.ietf-idr-ls-distribution].

   To advertise the link Local/Remote identifiers in the OSPFv2 Extended
   Link TLV, the same format of the sub-TLV as defined in section 1.1.
   of [RFC4203] is used and TLV type TBD2 is used.

4.3. Shared Risk Link Group (SRLG)

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

   To advertise the SRLG of the link in the OSPFv2 Extended Link TLV,
   the same format of the sub-TLV as defined in section 1.3. of
   [RFC4203] is used and TLV type TBD3 is used.

4.4. Extended Metrics

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

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

      TBD4 - Unidirectional Link Delay

      TBD5 - Min/Max Unidirectional Link Delay

      TBD6 - Unidirectional Delay Variation

      TBD7 - Unidirectional Link Loss

      TBD8 - Unidirectional Residual Bandwidth

      TBD9 - Unidirectional Available Bandwidth

      TBD10 - Unidirectional Utilized Bandwidth

5. Advertisement of Application Specific Values

   Multiple applications can utilize link attributes that are flooded by
   OSPFv2. Some examples of applications using the link attributes are
   Segment Routing Traffic Engineering and LFA [RFC5286].

   In some cases the link attribute only has a single value that is
   applicable to all applications. An example is a Remote interface IP
   address [Section 4.1] or Link Local/Remote Identifiers [Section 4.2].

   In some cases the link attribute MAY have different values for
   different applications. An example could be SRLG [Section 4.3],

where values used by LFA could be different then the values used by
Segment Routing Traffic Engineering.

To allow advertisement of the application specific values of the link
attribute, a new Extended Link Attribute sub-TLV of the Extended Link
TLV [RFC7471] is defined. The Extended Link Attribute sub-TLV is an
optional sub-TLV and can appear multiple times in the Extended Link
TLV. It 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     SABML      |     UDABML    |            Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Standard Application Bit-Mask                   |
+-                                                            -+
|                             ...                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              User Defined Application Bit-Mask                |
+-                                                            -+
|                             ...                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 Link Attribute sub-sub-TLVs                   |
+-                                                            -+
|                             ...                               |
```
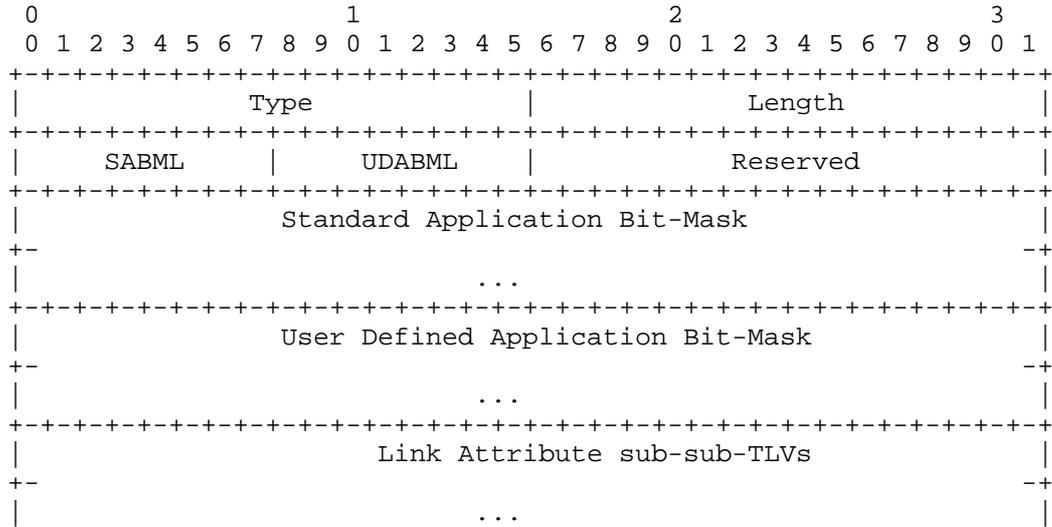
where:

    Type: TBD11, suggested value 14

    Length: variable

    SABML: Standard Application Bit-Mask Length. If the Standard
    Application Bit-Mask is not present, the Standard Application Bit-
    Mask Length MUST be set to 0.

    UDABML: User Defined Application Bit-Mask Length. If the User
    Defined Application Bit-Mask is not present, the User Defined
    Application Bit-Mask Length MUST be set to 0.

    Standard Application Bit-Mask: Optional set of bits, where each
    bit represents a single standard application. The following bits
    are defined by this document:

        Bit-0: RSVP Traffic Engineering

Bit-1: Segment Routing Traffic Engineering

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

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

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

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

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

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

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

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

If the link attribute is advertised and there is no Application Bit-
Mask present in the Extended Link Attribute Sub-TLV, the link
attribute advertisement MAY be used by any application. If, however,
another advertisement of the same link attribute includes any
Application Bit-Mask in the Extended Link Attribute sub-TLV,
applications that are listed in the Application Bit-Masks of such
Extended Link Attribute sub-TLV SHOULD use the attribute
advertisement which has the application specific bit set in the
Application Bit-Masks.

If the same application is listed in the Application Bit-Masks of
more then one Extended Link Attribute sub-TLV, the application SHOULD

use the first advertisement and ignore any subsequent advertisements
of the same attribute. This situation SHOULD be logged as an error.

This document defines the set of link attributes for which the
Application Bit-Masks may be advertised. If any of the Application
Bit-Masks is included in the Extended Link Attribute sub-TLV that
advertises any link attribute(s) NOT listed below, the Application
Bit-Masks MUST NOT be used for such link attribute(s). It MUST be
used for those attribute(s) that support application specific values.
Documents which define new link attributes MUST state whether the new
attributes support application specific values. The link attributes
to which the Application Bit-Masks may apply are:

   - Shared Risk Link Group

   - Unidirectional Link Delay

   - Min/Max Unidirectional Link Delay

   - Unidirectional Delay Variation

   - Unidirectional Link Loss

   - Unidirectional Residual Bandwidth

   - Unidirectional Available Bandwidth

   - Unidirectional Utilized Bandwidth

6. Deployment Considerations

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

7. Attribute Advertisements and Enablement

   This document defines extensions to support the advertisement of
   application specific link attributes. The presence or absence of
   link attribute advertisements for a given application on a link does
   NOT indicate the state of enablement of that application on that

link. Enablement of an application on a link is controlled by other
means.

For some applications, the concept of enablement is implicit. For
example, SRTE implicitly is enabled on all links which are part of
the Segment Routing enabled topology. Advertisement of link
attributes supports constraints which may be applied when specifying
an explicit path through that topology.

For other applications enablement is controlled by local
configuration. For example, use of a link as an LFA can be
controlled by local enablement/disablement and/or the use of
administrative tags.

It is an application specific policy as to whether a given link can
be used by that application even in the absence of any application
specific link attributes.

8. Backward Compatibility

Link attributes may be concurrently advertised in both the TE Opaque
LSA [RFC3630] and the Extended Link Opaque LSA [RFC7684].

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

When an OSPF routing domain includes routers using link attributes
from TE Opaque LSAs for Non-RSVP TE applications such as LFA, OSPF
routers in that domain should continue to advertise such TE Opaque
LSAs. If there are also OSPF routers using the link attributes
described herein for any application, OSPF routers in the routing
domain will also need to advertise these attributes in OSPF Extended
Link Attributes LSAs [RFC7684]. In such a deployment, the advertised
attributes SHOULD be the same and Non-RSVP application access to link
attributes is a matter of local policy.

9. Security Considerations

Implementations must assure that malformed TLV and Sub-TLV
permutations do not result in errors that cause hard OSPFv2 failures.

10. IANA Considerations

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

      TBD1 (4 Recommended) - Remote interface IP address

      TBD2 (5 Recommended) - Link Local/Remote Identifiers

      TBD3 (6 Recommended) - Shared Risk Link Group

      TBD4 (7 Recommended) - Unidirectional Link Delay

      TBD5 (8 Recommended) - Min/Max Unidirectional Link Delay

      TBD6 (9 Recommended) - Unidirectional Delay Variation

      TBD7 (10 Recommended) - Unidirectional Link Loss

      TBD8 (11 Recommended) - Unidirectional Residual Bandwidth

      TBD9 (12 Recommended) - Unidirectional Available Bandwidth

      TBD10 (13 Recommended) - Unidirectional Utilized Bandwidth

      TBD11 (14 Recommended) - Extended Link Attribute

   This specification defines a new Link-Attribute-Applicability
   Application Bits registry and defines following bits:

      Bit-0 - Segment Routing Traffic Engineering

      Bit-1 - LFA

11. Acknowledgments

   Thanks to Chris Bowers for his review and comments.

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