OSPF Extensions in Support of
Generalized Multi-Protocol Label Switching (GMPLS)

Status of This Memo

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Abstract

   This document specifies encoding of extensions to the OSPF routing
   protocol in support of Generalized Multi-Protocol Label Switching
   (GMPLS).

1. Introduction

   This document specifies extensions to the OSPF routing protocol
   [OSPF] in support of carrying link state information for Generalized
   Multi-Protocol Label Switching (GMPLS). The set of required
   enhancements to OSPF are outlined in [GMPLS-ROUTING].

   In this section, we define the enhancements to the Traffic
   Engineering (TE) properties of GMPLS TE links that can be announced
   in OSPF TE LSAs. The TE LSA, which is an opaque LSA with area
   flooding scope [OSPF-TE], has only one top-level Type/Length/Value
   (TLV) triplet and has one or more nested sub-TLVs for extensibility.
   The top-level TLV can take one of two values (1) Router Address or
   (2) Link. In this document, we enhance the sub-TLVs for the Link TLV
   in support of GMPLS. Specifically, we add the following sub-TLVs to
   the Link TLV:

```
Sub-TLV Type       Length      Name
            11            8     Link Local/Remote Identifiers
            14            4     Link Protection Type
            15     variable     Interface Switching Capability Descriptor
            16     variable     Shared Risk Link Group
```

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 BCP 14, RFC 2119
[RFC2119].

1.1. Link Local/Remote Identifiers

Link Local/Remote Identifiers is a sub-TLV of the Link TLV. The type
of this sub-TLV is 11, and length is eight octets. The value field
of this sub-TLV contains four octets of Link Local Identifier
followed by four octets of Link Remote Identifier (see Section
"Support for unnumbered links" of [GMPLS-ROUTING]). If the Link
Remote Identifier is unknown, it is set to 0.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Link Local Identifier                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Link Remote Identifier                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

A node can communicate its Link Local Identifier to its neighbor
using a link local Opaque LSA, as described in Section "Exchanging
Link Local TE Information".

1.2. Link Protection Type

The Link Protection Type is a sub-TLV of the Link TLV. The type of
this sub-TLV is 14, and length is four octets.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Protection Cap |                   Reserved                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The first octet is a bit vector describing the protection
capabilities of the link (see Section "Link Protection Type" of
[GMPLS-ROUTING]). They are:

    0x01 Extra Traffic

      0x02 Unprotected

      0x04 Shared

      0x08 Dedicated 1:1

      0x10 Dedicated 1+1

      0x20 Enhanced

      0x40 Reserved

      0x80 Reserved

   The remaining three octets SHOULD be set to zero by the sender, and
   SHOULD be ignored by the receiver.

   The Link Protection Type sub-TLV may occur at most once within the
   Link TLV.

1.3. Shared Risk Link Group (SRLG)

   The SRLG is a sub-TLV (of type 16) of the Link TLV. The length is
   the length of the list in octets. The value is an unordered list of
   32 bit numbers that are the SRLGs that the link belongs to. The
   format of the value field is as shown below:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Shared Risk Link Group Value                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       ...........                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Shared Risk Link Group Value                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   This sub-TLV carries the Shared Risk Link Group information (see
   Section "Shared Risk Link Group Information" of [GMPLS-ROUTING]).

   The SRLG sub-TLV may occur at most once within the Link TLV.

1.4. Interface Switching Capability Descriptor

   The Interface Switching Capability Descriptor is a sub-TLV (of type
   15) of the Link TLV. The length is the length of value field in
   octets. The format of the value field is as shown below:

```
  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
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  | Switching Cap |   Encoding    |           Reserved            |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 0               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 1               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 2               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 3               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 4               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 5               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 6               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                 Max LSP Bandwidth at priority 7               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |        Switching Capability-specific information              |
  |                      (variable)                              |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Switching Capability (Switching Cap) field contains one of the
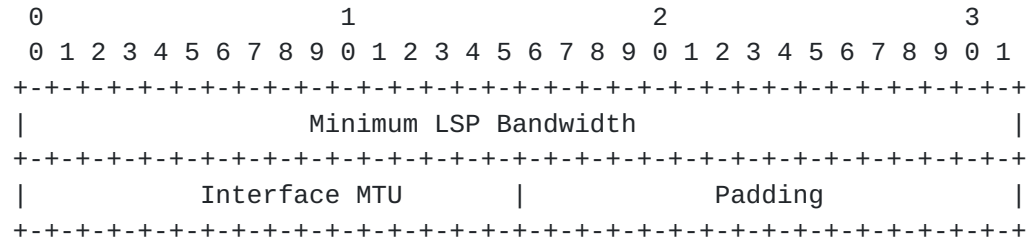following values:

       1   Packet-Switch Capable-1 (PSC-1)
       2   Packet-Switch Capable-2 (PSC-2)
       3   Packet-Switch Capable-3 (PSC-3)
       4   Packet-Switch Capable-4 (PSC-4)
      51   Layer-2 Switch Capable (L2SC)
     100   Time-Division-Multiplex Capable (TDM)
     150   Lambda-Switch Capable   (LSC)
     200   Fiber-Switch Capable   (FSC)

The Encoding field contains one of the values specified in Section
3.1.1 of [GMPLS-SIG].

Maximum LSP Bandwidth is encoded as a list of eight 4 octet fields in
the IEEE floating point format [IEEE], with priority 0 first and
priority 7 last. The units are bytes (not bits!) per second.

The content of the Switching Capability specific information field
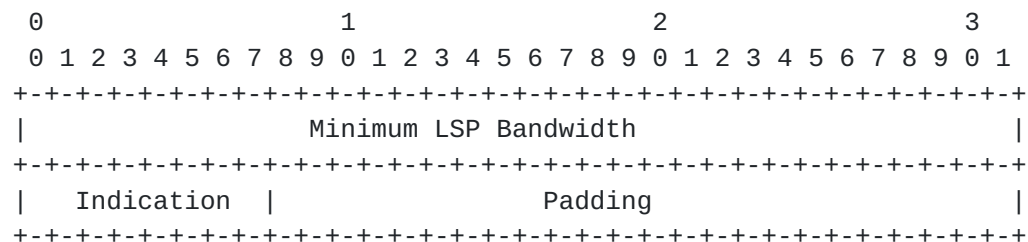depends on the value of the Switching Capability field.

When the Switching Capability field is PSC-1, PSC-2, PSC-3, or PSC-4,
the Switching Capability specific information field includes Minimum
LSP Bandwidth, Interface MTU, and padding.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Minimum LSP Bandwidth                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Interface MTU         |             Padding          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Minimum LSP Bandwidth is encoded in a 4 octets field in the IEEE
floating point format. The units are bytes (not bits!) per second.
The Interface MTU is encoded as a 2 octets integer. The padding is 2
octets, and is used to make the Interface Switching Capability
Descriptor sub-TLV 32-bits aligned. It SHOULD be set to zero by the
sender and SHOULD be ignored by the receiver.

When the Switching Capability field is L2SC, there is no Switching
Capability specific information field present.

When the Switching Capability field is TDM, the Switching Capability
specific information field includes Minimum LSP Bandwidth, an
indication whether the interface supports Standard or Arbitrary
SONET/SDH, and padding.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Minimum LSP Bandwidth                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Indication  |                   Padding                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Minimum LSP Bandwidth is encoded in a 4 octets field in the IEEE
floating point format. The units are bytes (not bits!) per second.
The indication whether the interface supports Standard or Arbitrary
SONET/SDH is encoded as 1 octet. The value of this octet is 0 if the
interface supports Standard SONET/SDH, and 1 if the interface
supports Arbitrary SONET/SDH. The padding is 3 octets, and is used
to make the Interface Switching Capability Descriptor sub-TLV 32-bits
aligned. It SHOULD be set to zero by the sender and SHOULD be
ignored by the receiver.

When the Switching Capability field is LSC, there is no Switching
Capability specific information field present.

To support interfaces that have more than one Interface Switching
Capability Descriptor (see Section "Interface Switching Capability
Descriptor" of [GMPLS-ROUTING]) the Interface Switching Capability
Descriptor sub-TLV may occur more than once within the Link TLV.

2. Implications on Graceful Restart

The restarting node should follow the OSPF restart procedures
[OSPF-RESTART], and the RSVP-TE restart procedures [GMPLS-RSVP].

When a restarting node is going to originate its TE LSAs, the TE LSAs
containing Link TLV should be originated with 0 unreserved bandwidth,
Traffic Engineering metric set to 0xffffffff, and if the Link has LSC
or FSC as its Switching Capability then also with 0 as Max LSP
Bandwidth, until the node is able to determine the amount of
unreserved resources taking into account the resources reserved by
the already established LSPs that have been preserved across the
restart. Once the restarting node determines the amount of
unreserved resources, taking into account the resources reserved by
the already established LSPs that have been preserved across the
restart, the node should advertise these resources in its TE LSAs.

In addition in the case of a planned restart prior to restarting, the
restarting node SHOULD originate the TE LSAs containing Link TLV with
0 as unreserved bandwidth, and if the Link has LSC or FSC as its
Switching Capability then also with 0 as Max LSP Bandwidth. This
would discourage new LSP establishment through the restarting router.

Neighbors of the restarting node should continue advertise the actual
unreserved bandwidth on the TE links from the neighbors to that node.

Regular graceful restart should not be aborted if a TE LSA or TE
topology changes. TE graceful restart need not be aborted if a TE
LSA or TE topology changes.

3. Exchanging Link Local TE Information

It is often useful for a node to communicate some Traffic Engineering
information for a given interface to its neighbors on that interface.
One example of this is a Link Local Identifier. If nodes X and Y are
connected by an unnumbered point-to-point interface I, then X's Link
Local Identifier for I is Y's Link Remote Identifier for I. X can
communicate its Link Local Identifier for I by exchanging with Y a TE
link local opaque LSA described below. Note that this information
need only be exchanged over interface I, hence the use of a link
local Opaque LSA.

A TE Link Local LSA is an opaque LSA of type 9 (link-local flooding
scope) with Opaque Type 1 (TE LSA) and Opaque ID of 0.

```
 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   |      9        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Opaque Type  |                Opaque ID                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Advertising Router                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     LS sequence number                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         LS checksum           |              length           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+-                             TLVs                           -+
|                              ...                              |
```

The format of the TLVs that make up the body of the TE Link Local LSA
is the same as that of the TE TLVs: a 2-octet Type field followed by
a 2-octet Length field which indicates the length of the Value field
in octets. The Top Level Type for the Link Local TLV is 4. The
Value field is zero-padded at the end to a four octet boundary.

The only TLV defined here is the Link Local Identifier TLV, with Type
1, Length 4 and Value the 32 bit Link Local Identifier for the link
over which the TE Link Local LSA is exchanged.

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6. Security Considerations

   This document specifies the contents of Opaque LSAs in OSPFv2. As
   Opaque LSAs are not used for SPF computation or normal routing, the
   extensions specified here have no direct effect on IP routing.
   Tampering with GMPLS TE LSAs may have an effect on the underlying
   transport (optical and/or SONET-SDH) network. [OSPF-TE] suggests
   mechanisms such as [OSPF-SIG] to protect the transmission of this
   information, and those or other mechanisms should be used to secure
   and/or authenticate the information carried in the Opaque LSAs.

7. IANA Considerations

   The memo introduces four new sub-TLVs of the TE Link TLV in the TE
   Opaque LSA for OSPF v2; [OSPF-TE] says that the sub-TLVs of the TE
   Link TLV in the range 10-32767 must be assigned by Expert Review, and
   must be registered with IANA.

   The memo has four suggested values for the four sub-TLVs of the TE
   Link TLV; it is strongly recommended that the suggested values be
   granted, as there are interoperable implementations using these
   values.

   Finally, a new Top Level Type for OSPF TE LSAs for the Link Local TLV
   has been allocated from the Standards Action space.

8. References

8.1. Normative References

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