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Routing extensions for discovery of Multiprotocol (MPLS) Label Switch Router (LSR) Traffic Engineering (TE) mesh membership
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Abstract

The set up of a full mesh of Multi-Protocol Label Switching (MPLS) Traffic Engineering (TE) Label Switched Paths (LSP) among a set of Label Switch Routers (LSR) is a common deployment scenario of MPLS Traffic Engineering either for bandwidth optimization, bandwidth guarantees or fast rerouting with MPLS Fast Reroute. Such deployment may require the configuration of potentially a large number of TE LSPs (on the order of the square of the number LSRs). This document specifies Interior Gateway Protocol (IGP) routing extensions for Intermediate System-to-Intermediate System (IS-IS) and Open Shortest Path First (OSPF) so as to provide an automatic discovery of the set of LSRs members of a mesh in order to automate the creation of such mesh of TE LSPs.

Requirements Language

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 2119 [RFC2119].

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1. Terminology

Terminology used in this document

IGP: Interior Gateway Protocol.

IGP Area: OSPF area or IS-IS level.

IS-IS: Intermediate System-to-Intermediate System (IS-IS).

LSR: Label Switch Router.

OSPF: Open Shortest Path First (OSPF).

OSPF LSA: OSPF Link State Advertisement.

TE LSP: Traffic Engineering Label Switched Path.

TE LSP head-end: head/source of the TE LSP.

TE LSP tail-end: tail/destination of the TE LSP.

TLV: Type Lenght Value

2. Introduction

There are two well-known approaches in deploying MPLS Traffic Engineering:

(1) The so-called "strategic" approach that consists of setting up a full mesh of TE LSPs between a set of LSRs,

(2) The so-called "tactical" approach where a set of TE LSPs are provisioned on well identified "hot spots" in order to alleviate a congestion resulting for instance from an unexpected traffic growth in some parts of the network.

The set up of a full mesh of TE LSPs among a set of LSRs is a common deployment scenario of MPLS Traffic Engineering either for bandwidth optimization, bandwidth guarantees or fast rerouting with MPLS Fast Reroute. Setting up a full mesh of TE LSPs between N LSRs requires the configuration of a potentially large number of TE LSPs (O(N^2)). Furthermore, the addition of any new LSR in the mesh requires the configuration of N additional TE LSPs on the new LSR and one new TE LSP on every LSR of the existing mesh destined to this new LSR, which gives a total of 2*N TE LSPs to be configured. Such operation is not only time consuming but also a risky operation (prone to

misconfiguration) for Service Providers. Hence, an automatic mechanism for setting up TE LSPs meshes is desirable and requires the ability to automatically discover the set of LSRs that belong to the mesh. This document specifies routing extensions so as to automatically discover the members of a mesh, also referred to as a "TE mesh-group". Note that the mechanism(s) needed for the dynamic creation of TE LSPs is implementation specific and outside the scope of this document.

Routing extensions have been defined in [I-D.ietf-ospf-cap] and [I-D.ietf-isis-caps] in order to advertise router capabilities. This document specifies IGP (OSPF and IS-IS) TE Mesh Group (Type Lenght Value) TLVs allowing for the automatic discovery of a TE mesh-group members, to be carried in the OSPF Router Information (Link State Advertisement) LSA [I-D.ietf-ospf-cap] and IS-IS Router Capability TLV [I-D.ietf-isis-caps]. The routing extensions specified in this document provide the ability to signal multiple TE mesh groups. An LSR may belong to more than one TE mesh-group(s).

There are relatively tight real-time constraints on the operation of IGPs (such as OSPF and IS-IS). For this reason some care needs to be applied when proposing to carry additional information in an IGP. The information described in this document is both relatively small in total volume (compared with other information already carried in IGPs), and also relatively stable (ie, changes are based on configuration changes, but not based on dynamic events within the network, and not based on dynamic triggers such as the leaking of information from other routing protocols or routing protocol instances).

3. Description of a TE Mesh-Group

A TE mesh-group is defined as a group of LSRs that are connected by a full mesh of TE LSPs. Routing extensions are specified in this document allowing for dynamic discovery of the TE mesh-group members. Procedures are also specified for a member to join and leave a TE mesh-group. For each TE mesh-group membership announced by an LSR, the following information is avdertized:

- A mesh-group number identifying the TE mesh-group the LSR belongs to,

- A Tail-end address (used as the TE LSP Tail-end address by other LSRs belonging to the same mesh-group),

- A Tail-end name: a display string that is allocated to the Tail-end used to ease the TE-LSP naming.

4. TE-MESH-GROUP TLV formats

4.1. OSPF TE-MESH-GROUP TLV format

The TE-MESH-GROUP TLV is used to advertise the desire of an LSR to join/leave a given TE mesh-group. No sub-TLV is currently defined for the TE-MESH-GROUP TLV.

The OSPF TE-MESH-GROUP TLV (advertised in an OSPF router information LSA defined in [I-D.ietf-ospf-cap]) 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            |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                                                               |
  //                            Value                            //
  |                                                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1 - OSPF TE-MESH-GROUP TLV format

Where
   Type: identifies the TLV type
   Length: length of the value field in octets

The format of the OSPF TE-MESH-GROUP TLV is the same as the TLV format used by the Traffic Engineering Extensions to OSPF (see[RFC3630]). The TLV is padded to four-octet alignment; padding is not included in the length field (so a three octet value would have a length of three, but the total size of the TLV would be eight octets). Nested TLVs are also 32-bit aligned. Unrecognized types are ignored. All types between 32768 and 65535 are reserved for vendor-specific extensions. All other undefined type codes are reserved for future assignment by IANA.

The OSPF TE-MESH-GROUP TLV format for IPv4 (figure 2) and IPv6 (figure 3) is as follows:
TYPE: To be assigned by IANA (Suggested Value: 3)
LENGTH: Variable

```
   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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      mesh-group-number 1                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Tail-end IPv4 address 1                   |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Name length  |              Tail-end name 1                  |
```

```
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     //                                                              //
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                      mesh-group-number n                      |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                     Tail-end IPv4 address n                   |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Name length  |               Tail-end name n                 |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2 - OSPF TE-MESH-GROUP TLV format (IPv4 Address)

TYPE: To be assigned by IANA (Suggested Value: 4)
LENGTH: Variable

```
      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
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                    mesh-group-number 1                        |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                                                               |
      |                   Tail-end IPv6 address 1                     |
      |                                                               |
      |                                                               |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Name length  |             Tail-end name 1                   |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     //                                                              //
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                    mesh-group-number n                        |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                                                               |
      |                   Tail-end IPv6 address n                     |
      |                                                               |
      |                                                               |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |  Name length  |             Tail-end name n                   |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3 - OSPF TE-MESH-GROUP TLV format (IPv6 Address)

The OSPF TE-MESH-GROUP TLV may contain one or more mesh-group entries where each entry correspond to a TE mesh-group and is made of the following fields:

- A mesh-group-number that identifies the mesh-group number,

- A Tail-end address: an IPv4 or IPv6 IP address to be used as a tail-end TE LSP address by other LSRs belonging to the same mesh-group,

- A Tail-end name: A display string that is allocated to the Tail-end. The field is of variable length field and is used to facilitate the TE LSP identification. - Name length field: An integer, expressed in octets, that indicates the length of the Tail-end name before padding.

4.2. IS-IS TE-MESH-GROUP sub-TLV format

The TE-MESH-GROUP sub-TLV is used to advertise the desire of an LSR to join/leave a given TE mesh-group. No sub-TLV is currently defined for the TE-MESH-GROUP sub-TLV.

The IS-IS TE-MESH-GROUP sub-TLV (advertised in the IS-IS CAPABILITY TLV defined in [I-D.ietf-isis-caps]) is composed of 1 octet for the type, 1 octet specifying the TLV length and a value field. The format of the TE-MESH-GROUP sub-TLV is identical to the TLV format used by the Traffic Engineering Extensions for IS-IS [RFC3784].

The IS-IS TE-MESH-GROUP sub-TLV format for IPv4 (figure 4) and IPv6 (figure 5) is as follows:
TYPE: To be assigned by IANA (Suggested value: 3).
LENGTH: Variable

```
 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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                     mesh-group-number 1                       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                   Tail-end IPv4 address  1                    |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |  Name length  |             Tail-end name 1                   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//                                                               //
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                     mesh-group-number n                       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                   Tail-end IPv4 address n                     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |  Name length  |             Tail-end name n                   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4 - IS-IS TE-MESH-GROUP sub-TLV format (IPv4 Address)

TYPE: To be assigned by IANA (Suggested Value: 4)
LENGTH: Variable

```
  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
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                      mesh-group-number 1                      |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                                                               |
  |                    Tail-end IPv6 address 1                    |
  |                                                               |
  |                                                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |  Name length  |            Tail-end name 1                    |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 //                                                               //
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                      mesh-group-number n                      |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                                                               |
  |                    Tail-end IPv6 address n                    |
  |                                                               |
  |                                                               |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |  Name length  |            Tail-end name n                    |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5 - IS-IS TE-MESH-GROUP sub-TLV format (IPv6 Address)

The IS-IS TE-MESH-GROUP sub-TLV may contain one or more mesh-group entries where each entry correspond to a TE mesh-group and is made of the following fields:

- A mesh-group-number that identifies the mesh-group number,

- A Tail-end address: an IPv4 or IPv6 IP address to be used as a tail-end TE LSP address by other LSRs belonging to the same mesh-group,

- A Tail-end name: A display string that is allocated to the Tail-end. The field is of variable length field and is used to facilitate the TE LSP identification. - Name length field: An integer, expressed in octets, that indicates the length of the Tail-end name before padding.

5. Elements of procedure

The OSPF TE-MESH-GROUP TLV is carried within the OSPF Routing

Information LSA and the TE-MESH-GROUP sub-TLV is caried within the IS-IS Router capability TLV. As such, elements of procedure are inherited from those defined in [I-D.ietf-ospf-cap] and [I-D.ietf-isis-caps] for OSPF and IS-IS respectively. Specifically, a router MUST originate a new LSA/LSP whenever the content of this information changes, or whenever required by regular routing procedure (e.g. update).

The TE-MESH-GROUP TLV is OPTIONAL and MUST NOT include more than one of each of the IPv4 instance or the IPv6 instance. If either the IPv4 or the IPv6 OSPF TE-MESH-GROUP TLV occurs more than once within the OSPF Router Information LSA, only the first instance is processed, subsequent TLV(s) SHOULD be silently ignored. Similarly, if either the IPv4 or the IPv6 IS-IS TE-MESH-GROUP sub-TLV occurs more than once within the ISIS Router capability TLV, only the first instance is processed, subsequent TLV(s) SHOULD be silently ignored.

5.1. OSPF

The TE-MESH-GROUP TLV is advertised within an OSPF Router Information opaque LSA (opaque type of 4, opaque ID of 0) for OSPFv2 ([RFC2328]) and within a new LSA (Router Information LSA) for OSPFv3 ([RFC2740]). The Router Information LSAs for OSPFv2 and OSPFv3 are defined in ([I-D.ietf-ospf-cap]).

A router MUST originate a new OSPF router information LSA whenever the content of the any of the advertised TLV changes or whenever required by the regular OSPF procedure (LSA update (every LSRefreshTime)). If an LSR desires to join or leave a particular TE mesh group, it MUST originate a new OSPF Router Information LSA comprising the updated TE-MESH-GROUP TLV. In the case of a join, a new entry will be added to the TE-MESH-GROUP TLV; conversely, if the LSR leaves a mesh-group the corresponding entry will be removed from the TE-MESH-GROUP TLV. Note that both operations can be performed in the context of a single LSA update. An implementation SHOULD be able to detect any change to a previously received TE-MESH-GROUP TLV from a specific LSR.

As defined in [RFC2370] for OSPVv2 and in [RFC2740] for OSPFv3, the flooding scope of the Router Information LSA is determined by the LSA Opaque type for OSPFv2 and the values of the S1/S2 bits for OSPFv3.

For OSPFv2 Router Information opaque LSA:

- Link-local scope: type 9;

- Area-local scope: type 10;

- Routing-domain scope: type 11. In this case, the flooding scope is equivalent to the Type 5 LSA flooding scope.

For OSPFv3 Router Information LSA:

- Link-local scope: OSPFV3 Router Information LSA with the S1 and S2 bits cleared;

- Area-local scope: OSPFV3 Router Information LSA with the S1 bit set and the S2 bit cleared;

- Routing-domain scope: OSPFv3 Router Information LSA with S1 bit cleared and the S2 bit set.

A router may generate multiple OSPF Router Information LSAs with different flooding scopes.

The TE-MESH-GROUP TLV may be advertised within an Area-local or Routing-domain scope Router Information LSA depending on the MPLS TE mesh group profile:

- If the MPLS TE mesh-group is contained within a single area (all the LSRs of the mesh-group are contained within a single area), the TE-MESH-GROUP TLV MUST be generated within an Area-local Router Information LSA.

- If the MPLS TE mesh-group spans multiple OSPF areas, the TE mesh-group TLV MUST be generated within a Routing-domain scope router information LSA.

5.2. IS-IS

The TE-MESH-GROUP sub-TLV is advertised within the IS-IS Router CAPABILITY TLV defined in [I-D.ietf-isis-caps]. An IS-IS router MUST originate a new IS-IS LSP whenever the content of the any of the advertised sub-TLV changes or whenever required by regular IS-IS procedure (LSP update). If an LSR desires to join or leave a particular TE mesh group, it MUST originate a new LSP comprising the refreshed IS-IS Router capability TLV comprising the updated TE-MESH-GROUP sub-TLV. In the case of a join, a new entry will be added to the TE-MESH-GROUP sub-TLV; conversely, if the LSR leaves a mesh-group the corresponding entry will be deleted from the TE-MESH-GROUP sub-TLV. Note that both operations can be performed in the context of a single update. An implementation SHOULD be able to detect any change to a previously received TE-MESH-GROUP sub-TLV from a specific LSR.

If the flooding scope of an MPLS Traffic Engineering capability is limited to an IS-IS level/area, the sub-TLV MUST not be leaked across

level/area and the S flag of the Router CAPABILITY TLV MUST be cleared. Conversely, if the flooding scope of an MPLS Traffic Engineering capability is the entire routing domain, the TLV MUST be leaked across IS-IS levels/areas, and the S flag of the Router CAPABILITY TLV MUST be set. In both cases the flooding rules specified in [I-D.ietf-isis-caps] apply.

As specified in [I-D.ietf-isis-caps], a router may generate multiple IS-IS Router CAPABILITY TLVs within an IS-IS LSP with different flooding scopes.

6. Backward compatibility

The TE-MESH-GROUP TLVs defined in this document do not introduce any interoperability issue. For OSPF, a router not supporting the TE-MESH-GROUP TLV SHOULD just silently ignore the TLV as specified in [RFC2370]. For IS-IS a router not supporting the TE-MESH-GROUP sub-TLV SHOULD just silently ignore the sub-TLV.

7. IANA Considerations

7.1. OSPF

Once a registry for the Router Information LSA defined in [I-D.ietf-ospf-cap] will have been assigned, IANA will assign a new OSPF TLV code-point for the TE-MESH-GROUP TLVs carried within the Router Information LSA.

Value	Sub-TLV	References
3	TE-MESH-GROUP TLV (IPv4)	draft-ietf-ospf-cap (to be replaced by RFC number)
4	TE-MESH-GROUP TLV (IPv6)	draft-ietf-ospf-cap (to be replaced by RFC number)

7.2. IS-IS

Once a registry for the Router Capability TLV defined in [I-D.ietf-isis-caps] will have been assigned, IANA will assign a new IS-IS sub-TLV code-point for the TE-MESH-GROUP sub-TLVs carried within the IS-IS Router Capability TLV.

Value	Sub-TLV	References
3	TE-MESH-GROUP TLV (IPv4)	draft-ietf-isis-caps (to be replaced by RFC number)
4	TE-MESH-GROUP TLV (IPv6)	draft-ietf-isis-caps (to be replaced by RFC number)

8. Security Considerations

The function described in this document does not create any new security issues for the OSPF and the IS-IS protocols. Security considerations are covered in [RFC2328] and [RFC2740] for the base OSPF protocol and in [RFC1195] for IS-IS. It must be noted that the advertisement of "fake" TE Mesh Group membership(s) by a mis-configured or malicious LSR Y would not have any major impact on the network (other than overloading the IGP) such as triggering the set up of new MPLS TE LSP: indeed for a new TE LSP originated by another LSR X destined to LSR Y to be set up, the same TE Mesh group membership must be configured on both LSRs. Thus such fake advertisement could not amplify any DoS attack.

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