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Generalized Multi-Protocol Label Switching (GMPLS) Protocol Extensions for Multi-Layer and Multi-Region Networks (MLN/MRN)

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Abstract

There are specific requirements for the support of networks comprising Label Switching Routers (LSR) participating in different data plane switching layers controlled by a single Generalized Multi Protocol Label Switching (GMPLS) control plane instance, referred to as GMPLS Multi-Layer Networks/ Multi-Region Networks (MLN/MRN).

This document defines extensions to GMPLS routing and signaling protocols so as to support the operation of GMPLS Multi-Layer/ Multi-Region Networks. It covers the elements of a single GMPLS control plane instance controlling multiple LSP regions or layers within a single TE domain.

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Conventions used in this document

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].

In addition the reader is assumed to be familiar with [RFC3945], [RFC3471], [RFC4201], [RFC4202], [RFC4203], [RFC4206], and [RFC5307].

1. Introduction

Generalized Multi-Protocol Label Switching (GMPLS) [RFC3945] extends MPLS to handle multiple switching technologies: packet switching (PSC), layer-two switching (L2SC), TDM switching (TDM), wavelength switching (LSC) and fiber switching (FSC). A GMPLS switching type (PSC, TDM, etc.) describes the ability of a node to forward data of a particular data plane technology, and uniquely identifies a control plane Label Switched Path (LSP) region. LSP Regions are defined in [RFC4206]. A network comprised of multiple switching types (e.g. PSC and TDM) controlled by a single GMPLS control plane instance is called a Multi-Region Network (MRN).

A data plane layer is a collection of network resources capable of terminating and/or switching data traffic of a particular format. For example, LSC, TDM VC-11 and TDM VC-4-64c represent three different layers. A network comprising transport nodes participating in different data plane switching layers

controlled by a single GMPLS control plane instance is called a Multi-Layer Network (MLN).

The applicability of GMPLS to multiple switching technologies provides the unified control and operations for both LSP provisioning and recovery. This document covers the elements of a single GMPLS control plane instance controlling multiple layers within a given TE domain. A TE domain is defined as group of Label Switching Routers (LSR) that enforces a common TE policy. A Control Plane (CP) instance can serve one, two or more layers. Other possible approaches such as having multiple CP instances serving disjoint sets of layers are outside the scope of this document.

The next sections provide the procedural aspects in terms of routing and signaling for such environments as well as the extensions required to instrument GMPLS to provide the capabilities for MLM/MRN unified control. The rationales and requirements for Multi-Layer/Region networks are set forth in [RFC5212]. These requirements are evaluated against GMPLS protocols in [RFC5339] and several areas where GMPLS protocol extensions are required are identified.

This document defines GMPLS routing and signaling extensions so as to cover GMPLS MLN/MRN requirements.

2. Summary of the Requirements and Evaluation

As identified in [RFC5339], most MLN/MRN requirements rely on mechanisms and procedures (such as local procedures and policies, or specific TE mechanisms and algorithms) that are outside the scope of the GMPLS protocols, and thus do not require any GMPLS protocol extensions.

Four areas for extensions of GMPLS protocols and procedures have been identified in [RFC5339]:

- o GMPLS routing extensions for the advertisement of the internal adjustment capability of hybrid nodes. See Section 3.2.2 of [RFC5339].

- o GMPLS signaling extensions for constrained multi-region signaling (Switching Capability inclusion/exclusion). See Section 3.2.1 of [RFC5339]. An additional eXclude Route Object (XRO) Label subobject is also defined since absent from [RFC4874].

o GMPLS signaling extensions for the setup/deletion of Virtual TE-links (as well as exact trigger for its actual provisioning). See Section 3.1.1.2 of [RFC5339].

o GMPLS routing and signaling extensions for graceful TE-link deletion. See Section 3.1.1.3 of [RFC5339].

The first three requirements are addressed in Sections 3, 4, and 5 of this document, respectively. The fourth requirement is addressed in [GMPLS-RR] with additional context provided by [GR-TELINK].

3. Interface adjustment capability descriptor (IACD)

In the MRN context, nodes that have at least one interface that supports more than one switching capability are called Hybrid nodes [RFC5212]. The logical composition of a hybrid node contains at least two distinct switching elements that are interconnected by "internal links" to provide adjustment between the supported switching capabilities. These internal links have finite capacities that MUST be taken into account when computing the path of a multi-region TE-LSP. The advertisement of the internal adjustment capability is required as it provides critical information when performing multi-region path computation.

3.1. Overview

In an MRN environment, some LSRs could contain multiple switching capabilities such as PSC and TDM, or PSC and LSC, all under the control of a single GMPLS instance,

These nodes, hosting multiple Interface Switching Capabilities (ISC) [RFC4202], are required to hold and advertise resource information on link states and topology, just like other nodes (hosting a single ISC). They may also have to consider some portions of internal node resources use to terminate hierarchical LSPs, since in circuit-switching technologies (such as TDM, LSC, and FSC) LSPs require the use of resources allocated in a discrete manner (as pre-determined by the switching type). For example, a node with PSC+LSC hierarchical switching capability can switch a lambda LSP, but cannot terminate the Lambda LSP if there is no available (i.e., not already in use) adjustment capability between the LSC and the PSC switching components. Another example occurs when L2SC

(Ethernet) switching can be adapted in LAPS X.86 and GFP for instance before reaching the TDM switching matrix. Similar circumstances can occur, if a switching fabric that supports both PSC and L2SC functionalities is assembled with LSC interfaces enabling "lambda" encoding. In the switching fabric, some interfaces can terminate Lambda LSPs and perform frame (or cell) switching whilst other interfaces can terminate Lambda LSPs and perform packet switching.

Therefore, within multi-region networks, the advertisement of the so-called adjustment capability to terminate LSPs (not the interface capability since the latter can be inferred from the bandwidth available for each switching capability) provides the information to take into account when performing multi-region path computation. This concept enables a node to discriminate the remote nodes (and thus allows their selection during path computation) with respect to their adjustment capability e.g. to terminate LSPs at the PSC or LSC level.

Hence, we introduce the capability of discriminating the (internal) adjustment capability from the (interface) switching capability by defining an Interface Adjustment Capability Descriptor (IACD).

A more detailed problem statement can be found in [RFC5339].

3.2. Interface Adjustment Capability Descriptor (IACD)

The interface adjustment capability descriptor (IACD) provides the information for the forwarding/switching capability.

Note that the addition of the IACD as a TE link attribute does not modify the format of the Interface Switching Capability Descriptor (ISCD) defined in [RFC4202], and does not change how the ISCD sub-TLV is carried in the routing protocols or how it is processed when it is received [RFC4201], [RFC4203].

The receiving LSR uses its Link State Database to determine the IACD(s) of the far-end of the link. Different Interface Adjustment Capabilities at two ends of a TE link are allowed.

3.2.1 OSPF

In OSPF, the IACD sub-TLV is defined as an optional sub-TLV of the TE Link TLV (Type 2, see [RFC3630]), with Type 24 (to be assigned by IANA) and variable length.

The IACD sub-TLV format is defined 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Lower SC      | Lower Encoding| Upper SC      | Upper Encoding|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  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              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Adjustment Capability-specific information         |
|                           (variable)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Lower Switching Capability (SC) field (byte 1) - 8 bits

Indicates the Lower Switching Capability associated to the Lower Encoding field (byte 2). The value of the Lower Switching Capability field MUST be set to the value of Switching Capability of the ISCD sub-TLV advertized for this TE Link. If multiple ISCD sub-TLVs are advertized for that TE link, the Lower Switching Capability (SC) value MUST be set to the value of SC to which the adjustment capacity is associated.

Lower Encoding (byte 2) - 8 bits

Contains one of the LSP Encoding Type values specified in Section 3.1.1 of [RFC3471] and updates.

Upper Switching Capability (SC) field (byte 3) - 8 bits

Indicates the Upper Switching capability. The Upper Switching Capability field MUST be set to one of the values defined in [RFC4202].

Upper Encoding (byte 4) - 8 bits

Set to the encoding of the available adjustment capacity and to 0xFF when the corresponding SC value has no access to the wire, i.e., there is no ISC sub-TLV for this upper switching capability. The adjustment capacity is the set of resources associated to the upper switching capability.

Max LSP Bandwidth

The 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 per second. Processing MUST follow the rules specified in [RFC4202].

The Adjustment Capability-specific information - variable

This field is defined so as to leave the possibility for future addition of technology-specific information associated to the adjustment capability.

Other fields MUST be processed as specified in [RFC4202] and [RFC4203].

The bandwidth values provide an indication of the resources still available to perform insertion/extraction for a given adjustment at a given priority (resource pool concept: set of shareable available resources that can be assigned dynamically).

Multiple IACD sub-TLVs MAY be present within a given TE Link TLV.

The presence of the IACD sub-TLV as part of the TE Link TLV does not modify the format/messaging and the processing associated to the ISCD sub-TLV defined in [RFC4203].

3.2.2 IS-IS

In IS-IS, the IACD sub-TLV is an optional sub-TLV of the Extended IS Reachability TLV (see [RFC5305]) with Type 24 (to be assigned by IANA).

The IACD sub-TLV format is identical to the OSPF sub-TLV format defined in Section 3.2.1. The fields of the IACD sub-TLV have the same processing and interpretation rules as defined in Section 3.2.1.

Multiple IACD sub-TLVs MAY be present within a given extended IS reachability TLV.

The presence of the IACD sub-TLV as part of the extended IS reachability TLV does not modify format/messaging and processing associated to the ISCD sub-TLV defined in [RFC5307].

4. Multi-Region Signaling

Section 6.2 of [RFC4206] specifies that when a region boundary node receives a Path message, the node determines whether or not it is at the edge of an LSP region with respect to the ERO carried in the message. If the node is at the edge of a region, it must then determine the other edge of the region with respect to the Explicit Route Object (ERO), using the IGP database. The node then extracts from the ERO the sub-sequence of hops from itself to the other end of the region.

The node then compares the sub-sequence of hops with all existing FA-LSPs originated by the node:

o If a match is found, that FA-LSP has enough unreserved bandwidth for the LSP being signaled, and the G-PID of the FA-LSP is compatible with the G-PID of the LSP being signaled, the node uses that FA-LSP as follows. The Path message for the original LSP is sent to the egress of the FA-LSP. The PHOP in the message is the address of the node at the head-end of the FA-LSP. Before sending the Path message, the ERO in that message is adjusted by removing the subsequence of the ERO that lies in the FA-LSP, and replacing it with just the end point of the FA-LSP.

o If no existing FA-LSP is found, the node sets up a new FA-LSP. That is, it initiates a new LSP setup just for the FA-LSP.

Note: compatible G-PID implies that traffic can be processed by both ends of the FA-LSP without dropping traffic after its establishment.

Applying the procedure of [RFC4206], in a MRN environment MAY lead to setup single-hop FA-LSPs between each pair of nodes. Therefore, considering that the path computation is able to take into account richness of information with regard to the SC available on given nodes belonging to the path, it is consistent to provide enough signaling information to indicate the SC to be used and over which link. Particularly, in case a TE link has multiple SCs advertised as part of its ISCD sub-TLVs, an ERO does not provide a mechanism to select a particular SC.

In order to limit the modifications to existing RSVP-TE procedures ([RFC3473] and referenced), this document defines a new sub-object of the eXclude Route Object (XRO), see [RFC4874], called the Switching Capability sub-object. This sub-object enables (when desired) the explicit identification of at least one switching capability to be excluded from the resource selection process described above.

Including this sub-object as part of the XRO that explicitly indicates which SCs have to be excluded (before initiating the procedure described here above) over a specified TE link, solves the ambiguous choice among SCs that are potentially used along a given path and give the possibility to optimize resource usage on a multi-region basis. Note that implicit SC inclusion is easily supported by explicitly excluding other SCs (e.g. to include LSC, it is required to exclude PSC, L2SC, TDM and FSC).

The approach followed here is to concentrate exclusions in XRO and inclusions in ERO. Indeed, the ERO specifies the topological characteristics of the path to be signaled. Usage of EXRS subobjects would also lead in the exclusion over certain portions of the LSP during the FA-LSP setup. Thus, it is more suited to extend generality of the elements excluded by the XRO but also prevent complex consistency checks as well as transpositions between EXRS and XRO at FA-LSP head-ends.

4.1. XRO Subobjects

The contents of an EXCLUDE_ROUTE object defined in [RFC4874] are a series of variable-length data items called subobjects.

This document defines the Switching Capability (SC) subobject of the XRO (Type 35), its encoding and processing. It also complements the subobjects defined in [RFC4874] with a Label subobject (Type 3).

4.1.1 SC Subobject

XRO subobject Type 35: Switching Capability

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|L|   Type=35   |    Length     |   Attribute   | Switching Cap |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

L (1 bit)

0 indicates that the attribute specified MUST be excluded

1 indicates that the attribute specified SHOULD be avoided

Type (7 bits)

The Type of the XRO SC subobject is 35.

Length (8 bits)

The total length of the subobject in bytes (including the Type and Length fields). The Length of the XRO SC subobject is 4.

Attribute (8 bits)

0 reserved value

1 indicates that the specified SC SHOULD be excluded or avoided with respect to the preceding numbered (Type 1 or Type 2) or unnumbered interface (Type) subobject.

Switching Cap (8 bits)

Switching Capability value to be excluded.

The Switching Capability subobject MUST follow the set of one or more numbered or unnumbered interface sub-objects to which this sub-object refers.

In case, of loose hop ERO subobject, the XRO sub-object MUST precede the loose-hop sub-object identifying the tail-end node/interface of the traversed region(s).

4.1.2 Label Subobject

The encoding of the XRO Label subobject is identical to the Label ERO subobject defined in [RFC3473] with the exception of the L bit. The XRO Label subobject is defined as follows:

XRO Subobject Type 3: Label Subobject

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|L|  Type=3     |    Length     |U|   Reserved  |   C-Type      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             Label                             |
|                              ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

L (1 bit)

0 indicates that the attribute specified MUST be excluded.

1 indicates that the attribute specified SHOULD be avoided

Type (7 bits)

The Type of the XRO Label subobject is 3.

Length (8 bits)

The total length of the subobject in bytes (including the Type and Length fields). The Length is always divisible by 4.

U (1 bit)

See [RFC3471].

C-Type (8 bits)

The C-Type of the included Label Object. Copied from the Label Object (see [RFC3471]).

Label

See [RFC3471].

XRO Label subobjects MUST follow the numbered or unnumbered interface sub-objects to which they refer, and, when present, MUST also follow the Switching Capability sub-object.

When XRO Label subobjects are following the Switching Capability sub-object, the corresponding label values MUST be compatible with the SC capability to be explicitly excluded.

5. Virtual TE link

A virtual TE link is defined as a TE link between two upper layer nodes that is not associated with a fully provisioned FA-LSP in a lower layer [RFC5212]. A virtual TE link is advertised as any TE link, following the rules in [RFC4206] defined for fully provisioned TE links. A virtual TE link represents thus the potentiality to setup an FA-LSP in the lower layer to support the TE link that has been advertised. In particular, the flooding scope of a virtual TE link is within an IGP area, as is the case for any TE link.

Two techniques can be used for the setup, operation, and maintenance of virtual TE links. The corresponding GMPLS protocols extensions are described in this section. The procedures described in this section complement those defined in [RFC4206] and [HIER-BIS].

5.1. Edge-to-edge Association

This approach, that does not require state maintenance on transit LSRs, relies on extensions to the GMPLS RSVP-TE Call procedure (see [RFC4974]). This technique consists of exchanging identification and TE attributes information directly between TE link end points through the establishment of a call between terminating LSRs. These TE link end-points correspond to the LSP head-end and tail-end points of the LSPs

that will be established. The end-points MUST belong to the same (LSP) region.

Once the call is established the resulting association populates the local Traffic Engineering DataBase (TEDB) and the resulting virtual TE link is advertised as any other TE link. The latter can then be used to attract traffic. When an upper layer/region LSP tries to make use of this virtual TE link, one or more FA LSPs MUST be established using the procedures defined in [RFC4206] to make the virtual TE link "real" and allow it to carry traffic by nesting the upper layer/region LSP.

In order to distinguish usage of such call from the call and associated procedures defined in [RFC4974], a CALL ATTRIBUTES object is introduced.

5.1.1 CALL_ATTRIBUTES Object

The CALL_ATTRIBUTES object is used to signal attributes required in support of a call, or to indicate the nature or use of a call. It is modeled on the LSP_ATTRIBUTES object defined in [RFC5420]. The CALL_ATTRIBUTES object MAY also be used to report call operational state on a Notify message.

The CALL_ATTRIBUTES object class is 201 (TBD by IANA) of the form 11bbbbbb. This C-Num value (see [RFC2205], Section 3.10) ensures that LSRs that do not recognize the object pass it on transparently.

One C-Type is defined, C-Type = 1 for Call Attributes. This object is OPTIONAL and MAY be placed on Notify messages to convey additional information about the desired attributes of the call.

CALL_ATTRIBUTES class = 201, C-Type = 1

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
//                      Call Attributes TLVs                   //
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Call Attributes TLVs are encoded as described in Section 5.1.3.

5.1.2 Processing

If an egress (or intermediate) LSR does not support the object, it forwards it unexamined and unchanged. This facilitates the exchange of attributes across legacy networks that do not support this new object.

5.1.3 Call Attributes TLVs

Attributes carried by the CALL_ATTRIBUTES object are encoded within TLVs names Call Attributes TLVs. One or more Call Attributes TLVs MAY be present in each object.

There are no ordering rules for Call Attributes TLVs, and no interpretation SHOULD be placed on the order in which these TLVs are received.

Each Call Attributes TLV carried by the CALL_ATTRIBUTES object is encoded 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Type              |           Length              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
//                            Value                            //
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type

The identifier of the TLV.

Length

Indicates the total length of the TLV in octets. That is, the combined length of the Type, Length, and Value fields, i.e., four plus the length of the Value field in octets.

The entire TLV MUST be padded with between zero and three trailing zeros to make it four-octet aligned. The Length

field does not count any padding.

Value

The data field for the TLV padded as described above.

Assignment of Call Attributes TLV types MUST follow the rules specified in Section 8 (IANA Considerations).

5.1.4 Call Attributes Flags TLV

The Call Attributes TLV of Type 1 defines the Call Attributes Flags TLV. The Call Attributes Flags TLV MAY be present in a CALL_ATTRIBUTES object.

The Call Attribute Flags TLV value field is an array of units of 32 flags numbered from the most significant bit as bit zero. The Length field for this TLV MUST therefore always be a multiple of 4 bytes, regardless of the number of bits carried and no padding is required.

Unassigned bits are considered as reserved and MUST be set to zero on transmission by the originator of the object. Bits not contained in the Call Attribute Flags TLV MUST be assumed to be set to zero. If the Call Attribute Flags TLV is absent either because it is not contained in the CALL_ATTRIBUTES object or because this object is itself absent, all processing MUST be performed as though the bits were present and set to zero. In other terms, assigned bits that are not present either because the Call Attribute Flags TLV is deliberately foreshortened or because the TLV is not included MUST be treated as though they are present and are set to zero.

5.1.5 Call Inheritance Flag

This document introduces a specific Call Inheritance Flag at position bit 0 (most significant bit) in the Attributes Flags TLV. This flag indicates that the association initiated between the end-points belonging to a call results into a (virtual) TE link advertisement.

The Call Inheritance Flag MUST be set to 1 in order to indicate that the established association is to be translated into a TE link advertisement. The value of this flag SHALL by default be set to 1. Setting this flag to 0 results in a hidden TE link or in deleting the corresponding TE link advertisement (by setting

the corresponding Opaque LSA Age to MaxAge) if the association had been established with this flag set to 1. In the latter case, the corresponding FA-LSP SHOULD also be torn down to prevent unused resources.

The Notify message used for establishing the association is defined as per [RFC4974]. Additionally, the Notify message MUST carry an LSP_TUNNEL_INTERFACE_ID Object, that allows identifying unnumbered FA-LSPs ([RFC3477], [RFC4206], [HIER-BIS]) and numbered FA-LSPs ([RFC4206], [HIER-BIS]).

5.2. Soft Forwarding Adjacency (Soft FA)

The Soft Forwarding Adjacency (Soft FA) approach consists of setting up the FA LSP at the control plane level without actually committing resources in the data plane. This means that the corresponding LSP exists only in the control plane domain. Once such FA is established the corresponding TE link can be advertised following the procedures described in [RFC4206].

There are two techniques to setup Soft FAs:

- The first one consists in setting up the FA LSP by precluding resource commitment during its establishment. These are known as pre-planned LSPs.

- The second technique consists in making use of path provisioned LSPs only. In this case, there is no associated resource demand during the LSP establishment. This can be considered as the RSVP-TE equivalent of the Null service type specified in [RFC2997].

5.2.1 Pre-Planned LSP Flag

The LSP ATTRIBUTES object and Attributes Flags TLV are defined in [RFC5420]. The present document defines a new flag, the Pre-Planned LSP flag, in the existing Attributes Flags TLV (numbered as Type 1).

The position of this flag is TBD in accordance with IANA assignment. This flag, part of the Attributes Flags TLV, follows general processing of [RFC5420] for LSP_REQUIRED_ATTRIBUTE object. That is, LSRs that do not recognize the object reject the LSP setup effectively saying that they do not support the attributes requested. Indeed, the

newly defined attribute requires examination at all transit LSRs along the LSP being established.

The Pre-Planned LSP flag can take one of the following values:

- o When set to 0 this means that the LSP MUST be fully provisioned. Absence of this flag (hence corresponding TLV) is therefore compliant with the signaling message processing per [RFC3473]).

- o When set to 1 this means that the LSP MUST be provisioned in the control plane only.

If an LSP is established with the Pre-Planned flag set to 1, no resources are committed at the data plane level.

The operation of committing data plane resources occurs by re-signaling the same LSP with the Pre-Planned flag set to 0. It is RECOMMENDED that no other modifications are made to other RSVP objects during this operation. That is each intermediate node, processing a flag transiting from 1 to 0 shall only be concerned with the commitment of data plane resources and no other modification of the LSP properties and/or attributes.

If an LSP is established with the Pre-Planned flag set to 0, it MAY be re-signaled by setting the flag to 1.

5.2.2 Path Provisioned LSPs

There is a difference in between an LSP that is established with 0 bandwidth (path provisioning) and an LSP that is established with a certain bandwidth value not committed at the data plane level (i.e. pre-planned LSP).

Mechanisms for provisioning (pre-planned or not) LSP with 0 bandwidth is straightforward for PSC LSP: in the SENDER_TSPEC/ FLOWSPEC object, the Peak Data Rate field of Int-Serv objects (see [RFC2210]) MUST be set to 0. For L2SC LSP: the CIR, EIR, CBS, and EBS values MUST be set to 0 in the Type 2 sub-TLV of the Ethernet Bandwidth Profile TLV. In both cases, upon LSP resource commitment, actual traffic parameter values are used to perform corresponding resource reservation.

However, mechanisms for provisioning (pre-planned or not) TDM or LSC LSP with 0 bandwidth is currently not possible because the exchanged label value is tightly coupled with resource

allocation during LSP signaling (see e.g. [RFC4606] for SDH/SONET LSP). For TDM and LSC LSP, a NULL Label value is used to prevent resource allocation at the data plane level. In these cases, upon LSP resource commitment, actual label value exchange is performed to commit allocation of timeslots/ wavelengths.

6. Backward Compatibility

New objects and procedures defined in this document are running within a given TE domain, defined as group of LSRs that enforces a common TE policy. Thus, the extensions defined in this document are expected to run in the context of a consistent TE policy. Specification of a consistent TE policy is outside the scope of this document.

In such TE domains, we distinguish between edge LSRs and intermediate LSRs. Edge LSRs MUST be able to process Call Attribute as defined in Section 5.1 if this is the method selected for creating edge-to-edge associations. In that domain, intermediate LSRs are by definition transparent to the Call processing.

In case the Soft FA method is used for the creation of virtual TE links, edge and intermediate LSRs MUST support processing of the LSP ATTRIBUTE object per Section 5.2.

7. Security Considerations

This document does not introduce any new security consideration from the ones already detailed in [MPLS-SEC] that describes the MPLS and GMPLS security threats, the related defensive techniques, and the mechanisms for detection and reporting. Indeed, the applicability of the proposed GMPLS extensions is limited to single TE domain. Such a domain is under the authority of a single administrative entity. In this context, multiple switching layers comprised within such TE domain are under the control of a single GMPLS control plane instance.

Nevertheless, Call initiation, as depicted in Section 5.1, MUST strictly remain under control of the TE domain administrator. To prevent any abuse of Call setup, edge nodes MUST ensure isolation of their call controller (i.e. the latter is not reachable via external TE domains). To further prevent man-in-the-middle attack, security associations MUST be established between edge nodes initiating and terminating calls. For this

purpose, IKE [RFC4306] MUST be used for performing mutual authentication and establishing and maintaining these security associations.

8. IANA Considerations

8.1 RSVP

IANA has made the following assignments in the "Class Names, Class Numbers, and Class Types" section of the "RSVP PARAMETERS" registry located at http://www.iana.org/assignments/rsvp-parameters.

This document introduces a new class named CALL_ATTRIBUTES has been created in the 11bbbbbb range (201) with the following definition:

```
Class Number  Class Name                        Reference
------------  -----------------------           ---------
201           CALL ATTRIBUTES                   [This I-D]

              Class Type (C-Type):

              1   Call Attributes               [This.I-D]
```

Upon approval of this document, IANA is requested to establish a "Call attributes TLV" registry. The following types should be defined:

TLV Value	Name	Reference
0	Reserved	[This I-D]
1	Call Attributes Flags TLV	[This I-D]

The values should be allocated based on the following allocation policy as defined in [RFC5226].

Range	Registration Procedures
0-32767	RFC
32768-65535	Private Use

Upon approval of this document, IANA is requested to establish a "Call attributes flags" registry. The following flags should be defined:

Bit Number	32-bit Value	Name	Reference
0	0x80000000	Call Inheritance Flag	[This I-D]

The values should be allocated based on the RFC allocation policy as defined in [RFC5226].

This document introduces a new Flag in the Attributes Flags TLV defined in [RFC5420]:

Bit Number	32-bit Value	Name	Reference
TBD	TBD	Pre-Planned LSP Flag	[This I-D]

This document introduces two new subobjects for the EXCLUDE_ROUTE object [RFC4874], C-Type 1.

Subobject Type	Subobject Description
3	Label
35	Switching Capability (SC)

8.2 OSPF

IANA maintains Open Shortest Path First (OSPF) Traffic Engineering TLVs Registries included below for Top level Types in TE LSAs and Types for sub-TLVs of TE Link TLV (Value 2).

This document defines the following sub-TLV of TE Link TLV (Value 2)

Value	Sub-TLV
25	Interface Adjustment Capability Descriptor (IACD)

8.3 IS-IS

This document defines the following new sub-TLV type of top-level TLV 22 that need to be reflected in the ISIS sub-TLV registry for TLV 22:

Type	Description	Length
25	Interface Adjustment Capability Descriptor (IACD)	Var.

9. References

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