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MPLS-TP Identifiers
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Abstract

This document specifies an initial set of identifiers to be used in the Transport Profile of Multiprotocol Label Switching (MPLS-TP). The MPLS-TP requirements (RFC 5654) require that the elements and objects in an MPLS-TP environment are able to be configured and managed without a control plane. In such an environment many conventions for defining identifiers are possible. This document defines identifiers for MPLS-TP management and OAM functions compatible with IP/MPLS conventions.

This document is a product of a joint Internet Engineering Task Force (IETF) / International Telecommunication Union Telecommunication Standardization Sector (ITU-T) effort to include an MPLS Transport Profile within the IETF MPLS and Pseudowire Emulation Edge-to-Edge (PWE3) architectures to support the capabilities and functionalities of a packet transport network as defined by the ITU-T.

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1. Introduction

This document specifies an initial set of identifiers to be used in the Transport Profile of Multiprotocol Label Switching (MPLS-TP). The MPLS-TP requirements (RFC 5654) [7] require that the elements and objects in an MPLS-TP environment are able to be configured and managed without a control plane. In such an environment many conventions for defining identifiers are possible. This document defines identifiers for MPLS-TP management and OAM functions compatible with IP/MPLS conventions. That is, the identifiers have been chosen to be compatible with existing IP, MPLS, GMPLS, and Pseudowire definitions.

This document is a product of a joint Internet Engineering Task Force (IETF) / International Telecommunication Union Telecommunication Standardization Sector (ITU-T) effort to include an MPLS Transport Profile within the IETF MPLS and Pseudowire Emulation Edge-to-Edge (PWE3) architectures to support the capabilities and functionalities of a packet transport network as defined by the ITU-T.

1.1. Terminology

AII: Attachment Interface Identifier

ASN: Autonomous System Number

EGP: Exterior Gateway Protocol

FEC: Forwarding Equivalence Class

GMPLS: Generalized Multi-Protocol Label Switching

IGP: Interior Gateway Protocol

LSP: Label Switched Path

LSR: Label Switching Router

MEG: Maintenance Entity Group

MEP: Maintenance Entity Group End Point

MIP: Maintenance Entity Group Intermediate Point

MPLS: Multi-Protocol Label Switching

NNI: Network-to-Network Interface

OAM: Operations, Administration and Maintenance

P2P: Point to Point

PW: Pseudowire

RSVP: Resource Reservation Protocol

RSVP-TE: RSVP Traffic Engineering

SPME: Sub Path Maintenance Entities

S-PE: Switching Provider Edge

T-PE: Terminating Provider Edge

1.2. 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 [1].

1.3. Notational Conventions

All multiple-word atomic identifiers use underscores (_) between the words to join the words. Many of the identifiers are composed of a set of other identifiers. These are expressed by listing the latter identifiers joined with double-colon, "::", notation.

Where the same identifier type is used multiple times in a concatenation, they are qualified by a prefix joined to the identifier by a dash (-). For example A1-Node_ID is the Node_ID of a node referred to as A1.

The notation defines a preferred ordering of the fields. Specifically the designation A1 is used to indicate the lower sort order of a field or set of fields and Z9 is used to indicate the higher sort order of the same. The sort is either alphanumeric or numeric depending on the field's definition. Where the sort applies to a group of fields, those fields are grouped with {...}.

Note, however, that the uniqueness of an identifier does not depend on the ordering, but rather, upon the uniqueness and scoping of the fields that compose the identifier. Further the preferred ordering is not intended to constrain protocol designs by dictating a particular field sequence (for example see Section 5.2.1) or even what fields appear in which objects (for example see Section 5.3).

2. Named Entities

In order to configure, operate and manage a transport network based on the MPLS Transport Profile, a number of entities require identification. Identifiers for the following entities are defined in this document:

* Global_ID

* Node

* Interface

* Tunnel

* LSP

* PW

* MEG

* MEP

* MIP

Note that we have borrowed the term tunnel from RSVP-TE (RFC 3209) [2] where it is used to describe an entity that provides a logical association between a source and destination LSR. The tunnel in turn is instantiated by one or more LSPs, where the additional LSPs are used for protection or re-grooming of the tunnel.

3. Uniquely Identifying an Operator - the Global_ID

The Global_ID is defined to uniquely identify an operator. RFC 5003 [3] defines a globally unique Attachment Interface Identifier (AII). That AII is composed of three parts, a Global_ID which uniquely identifies an operator, a prefix, and finally, an attachment circuit identifier. We have chosen to use that Global ID for MPLS-TP. Quoting from RFC 5003, section 3.2, "The global ID can contain the 2-octet or 4-octet value of the operator's Autonomous System Number (ASN). It is expected that the global ID will be derived from the globally unique ASN of the autonomous system hosting the PEs containing the actual AIIs. The presence of a global ID based on the operator's ASN ensures that the AII will be globally unique."

A Global_ID is an unsigned 32-bit value and MUST be derived from a 4-octet AS number assigned to the operator. Note that 2-octet AS

numbers have been incorporated in the 4-octet by placing the 2-octet AS number, in the low-order octets and setting the two high-order octets to zero.

ASN 0 is reserved and cannot be assigned to an operator. An identifier containing a Global_ID of zero means that no Global_ID is specified. Note that a Global_ID of zero is limited to entities contained within a single operator and MUST NOT be used across an NNI.

The Global_ID is used solely to provide a globally unique context for other MPLS-TP identifiers. While the AS Number used in the Global_ID MUST be one which the operator is entitled to use, the use of the Global_ID is not related to the use of the ASN in protocols such as BGP.

4. Node and Interface Identifiers

An LSR requires identification of the node itself and of its interfaces. An interface is the attachment point to a server (sub-)layer, e.g., MPLS-TP section or MPLS-TP tunnel.

We call the identifier associated with a node a Node Identifier (Node_ID). The Node_ID is a unique 32-bit value assigned by the operator within the scope of a Global_ID. The structure of the Node_ID is operator specific and is outside the scope of this document. However, the value zero is reserved and MUST NOT be used. Where IPv4 addresses are used, it may be convenient to use the Node's IPv4 loopback address as the Node_ID, however the Node_ID does not need to have any association with the IPv4 address space used in the operator's IGP or EGP. Where IPv6 addresses are used exclusively, a 32-bit value unique within the scope of a Global_ID is assigned.

An LSR can support multiple layers (e.g. hierarchical LSPs) and the Node_ID belongs to the multiple layer context i.e. it is applicable to all LSPs or PWs that originate on, have a intermediate point on, or terminate on the node.

In situations where a Node_ID needs to be globally unique, this is accomplished by prefixing the identifier with the operator's Global_ID.

The term interface is used for the attachment point to an MPLS-TP section. Within the context of a particular node, we call the identifier associated with an interface an Interface Number (IF_Num). The IF_Num is a 32-bit unsigned integer assigned by the operator and MUST be unique within the scope of a Node_ID. The IF_Num value 0 has

special meaning (see Section 7.3, MIP Identifiers) and MUST NOT be used to identify an MPLS-TP interface.

Note that IF_Num has no relation with the ifNum object defined in RFC 2863 [8]. Further, no mapping is mandated between IF_Num and ifIndex in RFC 2863.

An Interface Identifier (IF_ID) identifies an interface uniquely within the context of a Global_ID. It is formed by concatenating the Node_ID with the IF_Num. That is, an IF_ID is a 64-bit identifier formed as Node_ID::IF_Num.

This convention was chosen to allow compatibility with GMPLS. The GMPLS signaling functional description [4] requires interface identification. GMPLS allows three formats for the Interface_ID. The third format consists of an IPv4 Address plus a 32-bit unsigned integer for the specific interface. The format defined for MPLS-TP is consistent with this format, but uses the Node_ID instead of an IPv4 Address.

If an IF_ID needs to be globally unique, this is accomplished by prefixing the identifier with the operator's Global_ID.

Note that MPLS-TP supports hierarchical sections. The attachment point to a MPLS-TP Section at any (sub-)layer requires a node-unique IF_Num.

5. MPLS-TP Tunnel and LSP Identifiers

In MPLS the actual transport of packets is provided by label switched paths (LSPs). A transport service may be composed of multiple LSPs. Further the LSPs providing a service may change over time due to protection and restoration events. In order to clearly identify the service we use the term "MPLS-TP Tunnel" or simply "tunnel" for a service provided by (for example) a working LSP and protected by a protection LSP. The Tunnel Identifier (Tunnel_ID) identifies the transport service and provides a stable binding to the client in the face of changes in the data plane LSPs used to provide the service due to protection or restoration events. This section defines an MPLS-TP Tunnel_ID to uniquely identify a tunnel, and an MPLS-TP LSP Identifier (LSP_ID) to uniquely identify an LSP associated with a tunnel.

For the case where multiple LSPs (for example) are used to support a single service with a common set of end-points, using the Tunnel_ID allows for a trivial mapping between the server and client layers, providing a common service identifier which may be either defined by,

or used by, the client.

Note that this usage is not intended to constrain protection schemes, and may be used to identify any service (protected or unprotected) that may appear to the client as a single service attachment point. Keeping the Tunnel_ID consistent across working and protection LSPs is a useful construct currently employed within GMPLS. However, the Tunnel_ID for a protection LSP MAY differ from that used by its corresponding working LSP.

5.1. MPLS-TP Point to Point Tunnel Identifiers

At each endpoint a tunnel is uniquely identified by the endpoint's Node_ID and a locally assigned tunnel number. Specifically a Tunnel Number (Tunnel_Num) is a 16-bit unsigned integer unique within the context of the Node_ID. The motivation for each endpoint having its own tunnel number is to allow a compact form for the MEP_ID. See Section 7.2.2.

Having two tunnel numbers also serves to simplify other signaling (e.g., setup of associated bidirectional tunnels as described in Section 5.3).

The concatenation of the two endpoint identifiers serves as the full identifier. Using the A1/Z9 convention the format of a Tunnel_ID is:

```
A1-{Node_ID::Tunnel_Num}::Z9-{Node_ID::Tunnel_Num}
```

Where the Tunnel_ID needs to be globally unique, this is accomplished by using globally unique Node_IDs as defined above. Thus a globally unique Tunnel_ID becomes:

```
A1-{Global_ID::Node_ID::Tunnel_Num}::Z9-{Global_ID::Node_ID::
Tunnel_Num}
```

When an MPLS-TP Tunnel is configured, it MUST be assigned a unique IF_ID at each endpoint. As usual, the IF_ID is composed of the local Node_ID concatenated with a 32-bit IF_Num.

5.2. MPLS-TP LSP Identifiers

This section defines identifiers for MPLS-TP co-routed bidirectional and associated bidirectional LSPs. Note that MPLS-TP Sub Path Maintenance Entities (SPMEs) as defined in RFC 5921 [9] are also LSPs and use these same forms of identifiers.

5.2.1. MPLS-TP Co-Routed Bidirectional LSP Identifiers

A co-routed bidirectional LSP can be uniquely identified by a single LSP number within the scope of an MPLS-TP Tunnel_ID. Specifically an LSP Number (LSP_Num) is a 16-bit unsigned integer unique within the Tunnel_ID. Thus the format of an MPLS-TP co-routed bidirectional LSP_ID is:

```
A1-{Node_ID::Tunnel_Num}::Z9-{Node_ID::Tunnel_Num}::LSP_Num
```

Note that the uniqueness of identifiers does not depend on the A1/Z9 sort ordering. Thus the identifier

```
Z9-{Node_ID::Tunnel_Num}::A1-{Node_ID::Tunnel_Num}::LSP_Num
```

is synonymous with the one above.

At the dataplane level, a co-routed bidirectional LSP is composed of two unidirectional LSPs traversing the same links in opposite directions. Since a co-routed bidirectional LSP is provisioned or signaled as a single entity, a single LSP_Num is used for both unidirectional LSPs. The unidirectional LSPs can be referenced by the identifiers:

```
A1-Node_ID::A1-Tunnel_Num::LSP_Num::Z9-Node_ID and

Z9-Node_ID::Z9-Tunnel_Num::LSP_Num::A1-Node_ID respectively.
```

Where the LSP_ID needs to be globally unique, this is accomplished by using globally unique Node_IDs as defined above. Thus a globally unique LSP_ID becomes:

```
A1-{Global_ID::Node_ID::Tunnel_Num}::Z9-{Global_ID::
Node_ID::Tunnel_Num}::LSP_Num
```

5.2.2. MPLS-TP Associated Bidirectional LSP Identifiers

For an associated bidirectional LSP each of the unidirectional LSPs from A1 to Z9 and Z9 to A1 require LSP_Nums. Each unidirectional LSP is uniquely identified by a single LSP number within the scope of the ingress's Tunnel_Num. Specifically an LSP Number (LSP_Num) is a 16-bit unsigned integer unique within the scope of the ingress's Tunnel_Num. Thus the format of an MPLS-TP associated bidirectional LSP_ID is:

```
A1-{Node_ID::Tunnel_Num::LSP_Num}::
```

Z9-{Node_ID::Tunnel_Num::LSP_Num}

At the dataplane level, an associated bidirectional LSP is composed of two unidirectional LSPs between two nodes in opposite directions. The unidirectional LSPs may be referenced by the identifiers:

A1-Node_ID::A1-Tunnel_Num::A1-LSP_Num::Z9-Node_ID and

Z9-Node_ID::Z9-Tunnel_Num::Z9-LSP_Num::A1-Node_ID respectively.

Where the LSP_ID needs to be globally unique, this is accomplished by using globally unique Node_IDs as defined above. Thus a globally unique LSP_ID becomes:

A1-{Global_ID::Node_ID::Tunnel_Num::LSP_Num}::
Z9-{Global_ID::Node_ID::Tunnel_Num::LSP_Num}

5.3. Mapping to RSVP Signaling

This section is informative and exists to help understand the structure of the LSP IDs.

GMPLS [5] is based on RSVP-TE [2]. This section defines the mapping from an MPLS-TP LSP_ID to RSVP-TE. At this time, RSVP-TE has yet to be extended to accommodate Global_IDs. Thus a mapping is only made for the network unique form of the LSP_ID and assumes that the operator has chosen to derive its Node_IDs from valid IPv4 addresses.

GMPLS and RSVP-TE signaling use a 5-tuple to uniquely identify an LSP within a operator's network. This tuple is composed of a Tunnel Endpoint Address, Tunnel_ID, Extended Tunnel ID, and Tunnel Sender Address and (RSVP) LSP_ID. RFC 3209 allows some flexibility in how the Extended Tunnel ID is chosen and a direct mapping is not mandated. One convention that is often used, however, is to populate this field with the same value as the Tunnel Sender Address. The examples below follow that convention. Note that these are only examples.

For a co-routed bidirectional LSP signaled from A1 to Z9, the mapping to the GMPLS 5-tuple is as follows:

* Tunnel Endpoint Address = Z9-Node_ID

* Tunnel_ID = A1-Tunnel_Num

* Extended Tunnel_ID = A1-Node_ID

* Tunnel Sender Address = A1-Node_ID

* (RSVP) LSP_ID = LSP_Num

An associated bidirectional LSP between two nodes A1 and Z9 consists of two unidirectional LSPs, one from A1 to Z9 and one from Z9 to A1.

In situations where a mapping to the RSVP-TE 5-tuples is required, the following mappings are used. For the A1 to Z9 LSP the mapping would be:

* Tunnel Endpoint Address = Z9-Node_ID

* Tunnel_ID = A1-Tunnel_Num

* Extended Tunnel_ID = A1-Node_ID

* Tunnel Sender Address = A1-Node_ID

* (RSVP) LSP_ID = A1-LSP_Num

Likewise, the Z9 to A1 LSP, the mapping would be:

* Tunnel Endpoint Address = A1-Node_ID

* Tunnel_ID = Z9-Tunnel_Num

* Extended Tunnel_ID = Z9-Node_ID

* Tunnel Sender Address = Z9-Node_ID

* (RSVP) LSP_ID = Z9-LSP_Num

6. Pseudowire Path Identifiers

Pseudowire signaling (RFC 4447 [6]) defines two FECs used to signal pseudowires. Of these, FEC Type 129 along with AII Type 2 as defined in RFC 5003 [3] fits the identification requirements of MPLS-TP.

In an MPLS-TP environment, a PW is identified by a set of identifiers which can be mapped directly to the elements required by FEC 129 and AII Type 2. To distinguish this identifier from other Pseudowire Identifiers, we call this a Pseudowire Path Identifier (PW_Path_ID).

The AII Type 2 is composed of three fields. These are the Global_ID,

the Prefix, and the AC_ID. The Global_ID used in this document is identical to the Global_ID defined in RFC 5003. The Node_ID is used as the Prefix. The AC_ID is as defined in RFC 5003.

To complete the FEC 129, all that is required is an Attachment Group Identifier (AGI). That field is exactly as specified in RFC 4447. A (bidirectional) pseudowire consists of a pair of unidirectional LSPs, one in each direction. Thus for signaling, FEC 129 has a notion of Source AII (SAII) and Target AII (TAII). These terms are used relative to the direction of the LSP.

In a purely configured environment when referring to the entire PW, this distinction is not critical. That is a FEC 129 of AGIa::AIIb:: AIIc is equivalent to AGIa::AIIc::AIIb.

We note that in a signaled environment, the required convention in RFC 4447 is that at a particular endpoint, the AII associated with that endpoint comes first. The complete PW_Path_ID is:

```
AGI::A1-{Global_ID::Node_ID::AC_ID}::
Z9-{Global_ID::Node_ID::AC_ID}.
```

In a signaled environment the LSP from A1 to Z9 would be initiated with a label request from A1 to Z9 with the fields of the FEC 129 completed as follows:

```
AGI = AGI
SAII = A1-{Global_ID::Node_ID::AC_ID}
TAII = Z9-{Global_ID::Node_ID::AC_ID}
```

The LSP from Z9 to A1 would signaled with:

```
AGI = AGI
SAII = Z9-{Global_ID::Node_ID::AC_ID}
TAII = A1-{Global_ID::Node_ID::AC_ID}
```

7. Maintenance Identifiers

In MPLS-TP a Maintenance Entity Group (MEG) represents an Entity that requires management and defines a relationship between a set of maintenance points. A maintenance point is either a Maintenance Entity Group End-point (MEP), a Maintenance Entity Group Intermediate Point (MIP), or a Pseudowire Segment Endpoint. Within the context of a MEG, MEPs and MIPs must be uniquely identified. This section defines a means of uniquely identifying Maintenance Entity Groups, Maintenance Entities and uniquely defining MEPs and MIPs within the context of a Maintenance Entity Group.

7.1. Maintenance Entity Group Identifiers

Maintenance Entity Group Identifiers (MEG_IDs) are required for MPLS-TP sections, LSPs and Pseudowires. The formats were chosen to follow the IP compatible identifiers defined above.

7.1.1. MPLS-TP Section MEG_IDs

MPLS-TP allows a hierarchy of sections. See "MPLS-TP Data Plane Architecture" (RFC 5960)[10]. Sections above layer 0 are MPLS-TP LSPs. These use their MPLS-TP LSP MEG IDs defined in Section 7.1.2.

IP compatible MEG_IDs for MPLS-TP sections at layer 0 are formed by concatenating the two IF_IDs of the corresponding section using the A1/Z9 ordering. For example:

```
A1-IF_ID::Z9-IF_ID
```

Where the Section_MEG_ID needs to be globally unique, this is accomplished by using globally unique Node_IDs as defined above. Thus a globally unique Section_MEG_ID becomes:

```
A1-{Global_ID::IF_ID}::Z9-{Global_ID::IF_ID}
```

7.1.2. MPLS-TP LSP MEG_IDs

A MEG pertains to a unique MPLS-TP LSP. IP compatible MEG_IDs for MPLS-TP LSPs are simply the corresponding LSP_IDs, however, the A1/Z9 ordering MUST be used. For bidirectional co-routed LSPs the format of the LSP_ID is found in Section 5.2.1. For associated bidirectional LSPs the format is in Section 5.2.2.

We note that while the two identifiers are syntactically identical, they have different semantics. This semantic difference needs to be made clear. For instance if both a MPLS-TP LSP_ID and MPLS-TP LSP MEG_IDs are to be encoded in TLVs, different types need to be assigned for these two identifiers.

7.1.3. Pseudowire MEG_IDs

For Pseudowires a MEG pertains to a single PW. The IP compatible MEG_ID for a PW is simply the corresponding PW_Path_ID, however, the A1/Z9 ordering MUST be used. The PW_Path_ID is described in Section 6. We note that while the two identifiers are syntactically identical, they have different semantics. This semantic difference needs to be made clear. For instance if both a PW_Path_ID and a PW_MEG_ID are to be encoded in TLVs, different types need to be assigned for these two identifiers.

7.2. Maintenance Entity Group End Point Identifiers

7.2.1. MPLS-TP Section MEP_IDs

IP compatible MEP_IDs for MPLS-TP sections above layer 0 are their MPLS-TP LSP_MEP_IDs. See Section 7.2.2.

IP compatible MEP_IDs for MPLS-TP sections at layer 0 are simply the IF_IDs of each end of the section. For example, for a section whose MEG_ID is

    A1-IF_ID::Z9-IF_ID

the Section MEP_ID at A1 would be

    A1-IF_ID

and the Section MEP_ID at Z9 would be

    Z9-IF_ID.

Where the Section MEP_ID needs to be globally unique, this is accomplished by using globally unique Node_IDs as defined above. Thus a globally unique Section MEP_ID becomes

    Global_ID::IF_ID.

7.2.2. MPLS-TP LSP_MEP_ID

In order to automatically generate MEP_IDs for MPLS-TP LSPs, we use the elements of identification that are unique to an endpoint. This ensures that MEP_IDs are unique for all LSPs within a operator. When Tunnels or LSPs cross operator boundaries, these are made unique by pre-pending them with the operator's Global_ID.

The MPLS-TP LSP_MEP_ID is

    Node_ID::Tunnel_Num::LSP_Num

where the Node_ID is the node in which the MEP is located and Tunnel_Num is the tunnel number unique to that node. In the case of co-routed bidirectional LSPs, the single LSP_Num is used at both ends. In the case of associated bidirectional LSPs, the LSP_Num is the one unique to where the MEP resides.

In situations where global uniqueness is required this becomes:

Global_ID::Node_ID::Tunnel_Num::LSP_Num

7.2.3. MEP_IDs for Pseudowires

Like MPLS-TP LSPs, Pseudowire endpoints (T-PEs) require MEP_IDs. In order to automatically generate MEP_IDs for PWs, we simply use the AGI plus the AII associated with that end of the PW. Thus a MEP_ID for a Pseudowire T-PE takes the form

AGI::Global_ID::Node_ID::AC_ID

where the Node_ID is the node in which the MEP is located and the AC_ID is the AC_ID of the Pseudowire at that node.

7.3. Maintenance Entity Group Intermediate Point Identifiers

For a MIP which is associated with particular interface, we simply use the IF_ID (see Section 4) of the interfaces which are cross-connected. This allows, MIPs to be independently identified in one node where a per-interface MIP model is used. If only a per node MIP model is used then one MIP is configured. In this case the MIP_ID is formed using the Node_ID and an IF_Num of 0.

8. IANA Considerations

There are no IANA actions resulting from this document.

9. Security Considerations

This document describes an information model and, as such, does not introduce security concerns. Protocol specifications that describe use of this information model, however, may introduce security risks and concerns about authentication of participants. For this reason, the writers of protocol specifications for the purpose of describing implementation of this information model need to describe security and authentication concerns that may be raised by the particular mechanisms defined and how those concerns may be addressed.

Uniqueness of the identifiers from this document is guaranteed by the assigner (e.g., a Global_ID is unique based on the assignment of ASNs from IANA and both a Node_ID and a IF_Num are unique based on the assignment by an operator). Failure by an assigner to use unique values within the specified scoping for any of the identifiers defined herein could result in operational problems. For example and non-unique MEP value could result in failure to detect a mis-merged LSP.

Protocol specifications that utilize the identifiers defined herein need to consider the implications of guessable identifiers and, where there is a security implication, SHOULD give advice on how to make identifiers less guessable.

10. References

10.1. Normative References

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