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A YANG Data Model for MPLS-TE Topology

Abstract

This document defines a YANG data model for representing, retrieving, and manipulating MPLS-TE network topologies. It is based on and augments existing YANG models that describe network and traffic engineering packet network topologies.

This document also defines a collection of common YANG data types and groupings specific to MPLS-TE. These common types and groupings are intended to be imported by modules that model MPLS-TE technology-specific configuration and state capabilities.

The YANG models defined in this document can also be used for MPLS Transport Profile (MPLS-TP) network topologies.

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1. Introduction

This document defines a YANG data model for representing, retrieving, and manipulating MPLS-TE network topologies. It is based on and augments existing YANG models that describe network and traffic engineering packet network topologies.

This document also defines a collection of common YANG data types and groupings specific to MPLS-TE. These common types and groupings are intended to be imported by modules that model MPLS-TE technology-specific configuration and state capabilities, such as the MPLS-TE topology model, defined in this document, and the MPLS-TE tunnel model, defined in [I-D.ietf-teas-yang-te-mpls].

MPLS Transport Profile (MPLS-TP) is a profile of the MPLS protocol that is used in packet switched transport networks and operated in a

similar manner to other existing transport technologies (e.g., OTN), as described in [RFC5921].

The YANG models defined in this document can also be used for MPLS-TP network topologies.

The YANG models defined in this document conform to the Network Management Datastore Architecture defined in [RFC8342].

1.1. Tree Diagram

A simplified graphical representation of the data model is used in Section 5.1 of this this document. The meaning of the symbols in these diagrams is defined in [RFC8340].

1.2. Prefixes in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules, as shown in Table 1.

Prefix	YANG Module	Reference
rt-types	ietf-routing-types	[RFC8294]
mpls-te-types	ietf-mpls-te-types	RFC XXXX
nw	ietf-network	[RFC8345]
nt	ietf-network-topology	[RFC8345]
tet	ietf-te-topology	[RFC8795]
tet-pkt	ietf-te-topology-packet	[RFCYYYY]
tet-mpls	ietf-te-mpls-topology	RFC XXXX

Table 1: Prefixes and corresponding YANG modules

RFC Editor Note: Please replace XXXX with the RFC number assigned to the RFC once this draft becomes an RFC. Please replace YYYY with the RFC numbers assigned to [I-D.ietf-teas-yang-l3-te-topo]. Please remove this note.

2. MPLS-TE Types Overview

The module ietf-mpls-te-types contains the following YANG types and groupings which can be used by other MPLS-TE YANG models:

load-balancing-type:

> This identity defines the types of load-balancing algorithms used on a bundled MPLS-TE link.

te-mpls-label-hop:

   This grouping is used for augmentation of the TE label for MPLS-TE paths.

3. MPLS-TE Topology Model Overview

The MPLS-TE technology-specific topology model augments the ietf-te-topology-packet YANG module, defined in [I-D.ietf-teas-yang-l3-te-topo], which in turn augments the generic ietf-te-topology YANG module, defined in [RFC8795], as shown in Figure 1.

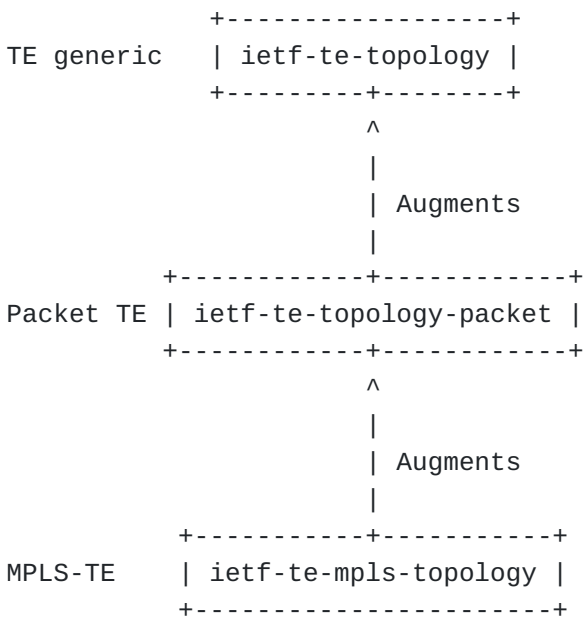

Figure 1: Relationship between MPLS-TE, Packet-TE and TE Topology Models

Given the guidance for augmentation in [RFC8795], the following technology-specific augmentations need are provided:

*A network-type to indicate that the TE topology is an MPLS-TE topology, as follow:

```
augment /nw:networks/nw:network/nw:network-types
        /tet:te-topology/tet-pkt:packet:
  +--rw mpls-topology!
```

*TE Label augmentations as described in Section 3.1.

Note: TE bandwidth augmentations for paths, LSPs, and links are provided by the ietf-te-topology-packet module, defined in [I-D.ietf-teas-yang-l3-te-topo].

3.1. TE Label Augmentations

In MPLS-TE, label allocation is done by the network element. Information about the availability of label values does not need to be provided to the controller. Moreover, MPLS-TE tunnels are currently mainly only established within a single domain.

Therefore this document does not define any MPLS-TE technology-specific augmentations, of the TE Topology model specific to the TE label because no TE label-related attributes are instantiated for MPLS-TE Topologies.

Furthermore, because the primary use cases are for single domain MPLS-TE tunnels, this document does not define objects that facilitate the setup of multi-domain MPLS-TE tunnels. It is an item for future study to understand how a management system would coordinate YANG configuration of a tunnel that crosses a domain boundary, and it is expected that that would be defined in a separate document.

3.2. MPLS-TP Topology

Multiprotocol Label Switching - Transport Profile (MPLS-TP) is a profile of the MPLS protocol that is used in packet switched transport networks and operated in a similar manner to other existing transport technologies (e.g., OTN), as described in [RFC5921].

Therefore, the YANG models defined in this document can also be applied to MPLS-TP network topologies.

However, as described in [RFC5921], MPLS-TP networks support bidirectional LSPs and require no equal cost multipath (ECMP) and no previous hop popping (PHP). When reporting the topology for an MPLS-TP network, additional information is required to indicate whether the network components (links and nodes) support these MPLS-TP characteristics.

It is worth noting that [RFC8795] is already capable of modeling TE topologies supporting either unidirectional or bidirectional LSPs: all bidirectional TE links can support bidirectional LSPs, and all links can support unidirectional LSPs. Further, it is always possible to associate two unidirectional LSPs to compose a bidirecitonal service as long as they belong to the same tunnel.

When setting up bidirectional LSPs (e.g., MPLS-TP LSPs) only bidirectional TE Links are selected by path computation.

In order to allow reporting that ECMP is not affecting forwarding the packets of a given LSP, the model defined in this documents

provides the load-balancing-type attribute which reports whether a link aggregation group (LAG) or TE Bundled Link performs load-balancing, and if so, whether it is on a per-flow or per-top-label basis:

```
 augment /nw:networks/nw:network/nt:link/tet:te:
   +--rw load-balancing-type?   mte-types:load-balancing-type
```

When setting up LSPs which require the non-use of ECMP (e.g., MPLS-TP LSPs) only links that are not part of a LAG or TE Bundle, or that perform per-top-label load balancing are selected by path computation.

It is assumed that almost all the MPLS-TE nodes are capable of supporting Ultimate Hop Popping (UHP) (i.e., they do not require the previous node on the path to perform PHP). However, if some interfaces are not able to support UHP, they can report it in the MPLS-TE topology:

```
 augment /nw:networks/nw:network/nw:node/nt:termination-point
         /tet:te:
   +--ro uhp-incapable?   empty
```

When setting up LSPs which require the non-use of PHP (e.g., MPLS-TP LSPs) only the destination node interfaces (link termination points - LTPs) that are capable of supporting UHP are selected by path computation.

4. YANG model for common MPLS-TE Types

```
<CODE BEGINS> file "ietf-mpls-te-types@2023-10-13.yang"

module ietf-mpls-te-types {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-mpls-te-types";
  prefix mpls-te-types;

  import ietf-routing-types {
    prefix rt-types;
    reference
      "RFC 8294: Common YANG Data Types for the Routing Area";
  }

  organization
    "Internet Engineering Task Force (IETF) TEAS WG";
  contact
    "WG Web:   <https://datatracker.ietf.org/wg/teas/>
     WG List:  <mailto:teas@ietf.org>

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     Editor:   Tarek Saad
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     Editor:   Rakesh Gandhi
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  description
    "This module defines a collection of common YANG data type
    and grouping definitions specific to MPLS-TE.

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    identified as authors of the code.  All rights reserved.

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     This version of this YANG module is part of RFC XXXX; see
     the RFC itself for full legal notices.";
```

```
revision 2023-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXXX: A YANG Data Model for MPLS-TE Topology";
}
// RFC Editor: replace XXXX with the actual RFC number assigned
// to the RFC once this draft
// becomes an RFC, update date information and remove this note.

/*
* Typedefs
*/

typedef load-balancing-type {
  type enumeration {
    enum per-flow {
      description
        "The load-balancing algorithm ensures that packets
         characterized as the same flow (e.g. based on IP 5-tuple)
         that egress on a LAG or a bundled TE link are forwarded
         on the same component link.

         Packets for different flows within the same LSP can be
         forwarded on different component links.";
    }
    enum per-top-label {
      description
        "The load-balancing algorithm ensures incoming MPLS
         packets with the same top MPLS label and that egress on
         on a LAG or bundled TE link are forwarded on the same
         component link.

         Packets for different flows within the same LSP are
         forwarded on the same component link.";
    }
  }
  description
    "The type of load balancing used on bundled links.";
}  // typedef load-balancing-type

/*
* Groupings
*/

grouping te-mpls-label-hop {
  description
    "MPLS-TE Label Hop.";
```

```
    leaf mpls-label {
      type rt-types:mpls-label;
      description
        "MPLS Label.";
    }
  }  // grouping te-mpls-label-hop
}

<CODE ENDS>
```

Figure 2: MPLS-TE Types YANG model

5. YANG Model for MPLS-TE Topology

5.1. YANG Tree

Figure 3 shows the tree diagram of the YANG model defined in module ietf-te-mpls-topology.yang.

```
module: ietf-te-mpls-topology

  augment /nw:networks/nw:network/nw:network-types/tet:te-topology
            /tet-pkt:packet:
    +--rw mpls-topology!
  augment /nw:networks/nw:network/nt:link/tet:te:
    +--rw load-balancing-type?   mpls-te-types:load-balancing-type
  augment /nw:networks/nw:network/nw:node/nt:termination-point
            /tet:te:
    +--ro uhp-incapable?   empty
```

Figure 3: MPLS-TE topology YANG tree

5.2. YANG Code

```
<CODE BEGINS> file "ietf-te-mpls-topology@2023-10-13.yang"

module ietf-te-mpls-topology {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-te-mpls-topology";
  prefix tet-mpls;

  import ietf-network {
    prefix nw;
    reference
      "RFC 8345: A YANG Data Model for Network Topologies";
  }

  import ietf-network-topology {
    prefix nt;
    reference
      "RFC 8345: A YANG Data Model for Network Topologies";
  }

  import ietf-te-topology {
    prefix tet;
    reference
      "RFC 8795: YANG Data Model for Traffic Engineering
       (TE) Topologies";
  }

  import ietf-te-topology-packet {
    prefix tet-pkt;
    reference
      "RFC YYYY: YANG Data Model for Layer 3 TE Topologies";
  }
  // RFC Editor: replace YYYY with the actual RFC number assigned
  // to the RFC once draft-ietf-teas-yang-l3-te-topo
  // becomes an RFC and remove this note.

  import ietf-mpls-te-types {
    prefix mpls-te-types;
    reference
      "RFC XXXX: A YANG Data Model for MPLS-TE Topology";
  }
  // RFC Editor: replace XXXX with the actual RFC number assigned
  // to the RFC once this draft
  // becomes an RFC and remove this note.

  organization
    "Internet Engineering Task Force (IETF) TEAS WG";
  contact
    "WG Web:   <https://datatracker.ietf.org/wg/teas/>
     WG List:  <mailto:teas@ietf.org>
```

```
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             <mailto:italo.busi@huawei.com>

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   Editor:   Xufeng Liu
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   Editor:   Tarek Saad
             <mailto:tsaad.net@gmail.com>

   Editor:   Rakesh Gandhi
             <mailto:rgandhi@cisco.com>";

  description
    "This module defines a YANG data model for representing,
    retrieving, and manipulating MPLS-TE network topologies.

    This module defines MPLS-TE technology-specific augmentations
    to the generic Packet TE topology module
    (ietf-te-topology-packet).

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    This version of this YANG module is part of RFC XXXX; see
    the RFC itself for full legal notices.";

  revision 2023-10-13 {
    description
      "Initial Version";
    reference
      "RFC XXXX: A YANG Data Model for MPLS-TE Topology";
  }
  // RFC Editor: replace XXXX with the actual RFC number assigned
  // to the RFC once this draft
  // becomes an RFC, update date information and remove this note.

  /*
   * Augmentations
   */
```

```
  augment "/nw:networks/nw:network/nw:network-types/"
        + "tet:te-topology/tet-pkt:packet" {
    description
      "Augment network types to include MPLS-TE Topology Type";
    container mpls-topology {
      presence
        "Indicates an MPLS-TE Topology Type.";
      description
        "Its presence indicates an MPLS-TE Topology";
    }
  }

  augment "/nw:networks/nw:network/nt:link/tet:te" {
    when "../../nw:network-types/tet:te-topology/"
       + "tet-pkt:packet/tet-mpls:mpls-topology"  {
      description
        "Augment MPLS-TE Topology.";
    }
    description
      "Augment TE Link.";

    leaf load-balancing-type {
      type mpls-te-types:load-balancing-type;
      default 'per-flow';
      description
        "Indicates the type of load-balancing (per-flow or per-LSP)
         performed by the bundled TE Link.

         This leaf is not present when the TE Link is not bundled.";
    }  // leaf load-balancing-type
  }

  augment "/nw:networks/nw:network/nw:node/nt:termination-point/"
        + "tet:te" {
    when "../../../nw:network-types/tet:te-topology/"
       + "tet-pkt:packet/tet-mpls:mpls-topology" {
      description "Augment MPLS-TE Topology.";
    }
    description "Augment LTP.";

    leaf uhp-incapable {
      type empty;
      config false;
      description
        "When present, indicates that the LTP is not capable to
         support Ultimate Hop Popping (UHP).";
    }   // leaf uhp-incapable
  }
}
```

<CODE ENDS>

Figure 4: MPLS-TE topology YANG module

6. Security Considerations

The configuration, state, and action data defined in this document are designed to be accessed via a management protocol with a secure transport layer, such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

The NETCONF access control model [RFC8341] provides the means to restrict access for particular NETCONF users to a preconfigured subset of all available NETCONF protocol operations and content.

The ietf-mpls-te-types model presented in this document defines common types intended to be used as imports by other YANG models. Those other models are responsible for considering the security of the objects they define using those imports. Writers of those other models should consider the vulnerabilities created by exposing information about link characteristics and behaviors (such as how packets may be steered onto parallel links), and should be aware of the risks of enabling configuration of which labels are used on hops within an LSP.

The ietf-te-mpls-topology model presented in this document defines technology-specific objects to describe an MPLS-TE topology. It is intended as an aumentation of the te-topology model [RFC8795] and so the core security considerations for that model also apply. In addition, this model defines objects that could expose information about the network behavior or which, if modified by an attacker could disrupt the delivery of services in the network.

The leaf objects defined in ietf-te-mpls-topology are read-only so the risk is from unauthorized access to the information, or from misrepresenting the information reported from the network elements. The objects are:

"tet:te-topology/tet-pkt:packet": Unauthorized read access to this simply indicates that the network topology is MPLS-TE packet-capable: that information is not very valuable to an attacker. Modification of this information might cause a path computation element to incorrectly presume that a network is capable or incapable of supporting MPLS-TE services.

"tet-pkt:packet/tet-mpls:mpls-topology/load-balancing-type": Unauthorized read access to this indicates the mechanism used by a nework node to share traffic across members of a LAG or bundled MPLS-TE link. Such knowledge might help an attacker predict which

component link is carrying specific traffic making a physical attack slightly easier. Modification of this information might cause a path computation element to incorrectly presume that a link is suitable or unsuitable for use to provide an MPLS-TP service.

"tet-pkt:packet/tet-mpls:mpls-topology/uhp-incapable": Unauthorized read access to this will give an attacker knowledge about whether PHP is being applied on the final hop of all LSPs to a particular node on the associated link: that information is of little use to an attacker except it may help them to parse an inflight packet. Modification of this information would cause a path computation element to incorrectly consider the associated link as suitable or unsuitable for inclusion in the path of an MPLS-TP service.

7. IANA Considerations

This document requests IANA to register the following URIs in the "ns" subregistry within the "IETF XML Registry" [RFC3688]. Following the format in [RFC3688], the following registrations are requested.

```
URI:  urn:ietf:params:xml:ns:yang:ietf-mpls-te-types
Registrant Contact:  The IESG.
XML: N/A; the requested URI is an XML namespace.

URI:  urn:ietf:params:xml:ns:yang:ietf-te-mpls-topology
Registrant Contact:  The IESG.
XML: N/A; the requested URI is an XML namespace.
```

This document requests IANA to register the following YANG modules in the "IANA Module Names" [RFC6020]. Following the format in [RFC6020], the following registrations are requested:

```
name:      ietf-mpls-te-types
namespace: urn:ietf:params:xml:ns:yang:ietf-mpls-te-types
prefix:    mpls-te-types
reference: RFC XXXX

name:      ietf-te-mpls-topology
namespace: urn:ietf:params:xml:ns:yang:ietf-te-mpls-topology
prefix:    tet-mpls
reference: RFC XXXX
```

RFC Editor: Please replace XXXX with the RFC number assigned to this document.

8. References

8.1. Normative References

[I-D.ietf-teas-yang-l3-te-topo]

Liu, X., Bryskin, I., Beeram, V. P., Saad, T., Shah, H. C., and O. G. de Dios, "YANG Data Model for Layer 3 TE Topologies", Work in Progress, Internet-Draft, draft-ietf-teas-yang-l3-te-topo-15, 21 October 2023, <https://datatracker.ietf.org/doc/html/draft-ietf-teas-yang-l3-te-topo-15>.

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Network Topologies", RFC 8345, DOI 10.17487/RFC8345, March 2018, <https://www.rfc-editor.org/info/rfc8345>.

[RFC8446] Rescorla, E., "The Transport Layer Security (TLS) Protocol Version 1.3", RFC 8446, DOI 10.17487/RFC8446, August 2018, <https://www.rfc-editor.org/info/rfc8446>.

[RFC8795] Liu, X., Bryskin, I., Beeram, V., Saad, T., Shah, H., and O. Gonzalez de Dios, "YANG Data Model for Traffic Engineering (TE) Topologies", RFC 8795, DOI 10.17487/RFC8795, August 2020, <https://www.rfc-editor.org/info/rfc8795>.

8.2. Informative References

[I-D.ietf-teas-yang-te-mpls] Saad, T., Gandhi, R., Liu, X., Beeram, V. P., and I. Bryskin, "A YANG Data Model for MPLS Traffic Engineering Tunnels", Work in Progress, Internet-Draft, draft-ietf-teas-yang-te-mpls-04, 26 May 2023, <https://datatracker.ietf.org/doc/html/draft-ietf-teas-yang-te-mpls-04>.

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