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A YANG Data Model for MPLS Static LSPs
draft-ietf-mpls-static-yang-10

Abstract

This document contains the specification for the MPLS Static Label Switched Paths (LSPs) YANG model. The model allows for the provisioning of static LSP(s) on Label Edge Router(s) LER(s) and Label Switched Router(s) LSR(s) devices along a LSP path without the dependency on any signaling protocol. The MPLS Static LSP model augments the MPLS base YANG model with specific data to configure and manage MPLS Static LSP(s).

Status of This Memo

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1. Introduction

This document describes a YANG [RFC7950] data model for configuring and managing the Multiprotocol Label Switching (MPLS) [RFC3031] Static LSPs. The model allows the configuration of LER and LSR devices with the necessary MPLS cross-connects or bindings to realize an end-to-end LSP service.

A static LSP is established by manually specifying incoming and outgoing MPLS label(s) and necessary forwarding information on each of the traversed LER and LSR devices (ingress, transit, or egress nodes) of the forwarding path.

For example, on an ingress LER device, the model is used to associate a specific Forwarding Equivalence Class (FEC) of packets- e.g. matching a specific IP prefix in a Virtual Routing or Forwarding (VRF) instance- to an MPLS outgoing label imposition, next-hop(s) and respective outgoing interface(s) to forward the packet. On an LSR device, the model is used to create a binding that swaps the incoming label with an outgoing label and forwards the packet on one or

multiple egress path(s). On an egress LER, it is used to create a binding that decapsulates the incoming MPLS label and performs forwarding based on the inner MPLS label (if present) or IP forwarding in the packet.

The MPLS Static LSP YANG model is broken into two modules "ietf-mpls-static" and "ietf-mpls-static-extended". The "ietf-mpls-static" module covers basic features for the configuration and management of unidirectional Static LSP(s), while "ietf-mpls-static-extended" covers extended features like the configuration and management of bidirectional Static LSP(s) and LSP admission control.

The module "ietf-mpls-static" augments the MPLS Base YANG model defined in module "ietf-mpls" in [I-D.ietf-mpls-base-yang].

1.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The terminology for describing YANG data models is found in [RFC7950].

1.2. Acronyms and Abbreviations

MPLS: Multiprotocol Label Switching

LSP: Label Switched Path

LSR: Label Switching Router

LER: Label Edge Router

FEC: Forwarding Equivalence Class

NHLFE: Next Hop Label Forwarding Entry

ILM: Incoming Label Map

2. MPLS Static LSP Model

2.1. Model Organization

The base MPLS Static LSP model covers the core features with the minimal set of configuration parameters needed to manage and operate MPLS Static LSPs.

Additional MPLS Static LSP parameters as well as optional feature(s) are grouped in a separate MPLS Static LSP extended model. The relationship between the MPLS base and other MPLS modules are shown in Figure 1.

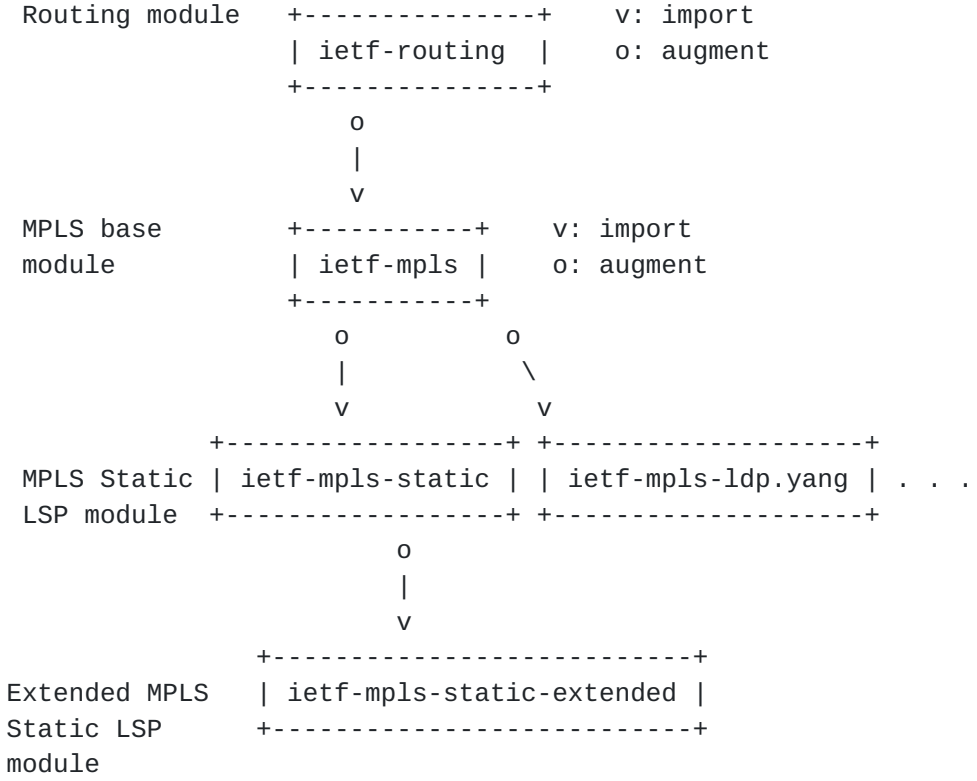


Figure 1: Relationship between MPLS modules

2.2. Model Tree Diagram

The MPLS Static and extended LSP tree diagram as per [RFC8340] is shown in Figure 2.

```
module: ietf-mpls-static
  augment /rt:routing/mpls:mpls:
    +--rw static-lsps
       +--rw static-lsp* [name]
       |  +--rw name           string
       |  +--rw operation?     mpls:mpls-operations-type
```

```
         |  +--rw in-segment
         |  |  +--rw fec
         |  |     +--rw (type)?
         |  |     |  +--:(ip-prefix)
         |  |     |  |  +--rw ip-prefix?        inet:ip-prefix
         |  |     |  +--:(mpls-label)
         |  |     |     +--rw incoming-label?   rt-types:mpls-label
         |  |     +--rw incoming-interface?     if:interface-ref
         |  +--rw out-segment
         |     +--rw (out-segment)?
         |        +--:(nhlfe-single)
         |        |  +--rw nhlfe-single
         |        |     +--rw mpls-label-stack
         |        |     |  +--rw entry* [id]
         |        |     |     +--rw id               uint8
         |        |     |     +--rw label?           rt-types:mpls-label
         |        |     |     +--rw ttl?             uint8
         |        |     |     +--rw traffic-class?   uint8
         |        |     +--rw outgoing-interface?   if:interface-ref
         |        +--:(nhlfe-multiple)
         |           +--rw nhlfe-multiple
         |              +--rw nhlfe* [index]
         |                 +--rw index                 string
         |                 +--rw backup-index?         string
         |                 +--rw loadshare?            uint16
         |                 +--rw role?                 nhlfe-role
         |                 +--rw mpls-label-stack
         |                 |  +--rw entry* [id]
         |                 |     +--rw id               uint8
         |                 |     +--rw label?
         |                 |     |       rt-types:mpls-label
         |                 |     +--rw ttl?             uint8
         |                 |     +--rw traffic-class?   uint8
         |                 +--rw outgoing-interface?   if:interface-ref
         +--rw mpls-static-ext:bandwidth?            uint32
         +--rw mpls-static-ext:lsp-priority-setup?   uint8
         +--rw mpls-static-ext:lsp-priority-hold?    uint8

  module: ietf-mpls-static-extended
    augment /rt:routing/mpls:mpls:
      +--rw bidir-static-lsps
         +--rw bidir-static-lsp* [name]
            +--rw name           string
            +--rw forward-lsp?   mpls-static:static-lsp-ref
            +--rw reverse-lsp?   mpls-static:static-lsp-ref
```

Figure 2: MPLS Static LSP tree diagram

2.3. Model Overview

This document defines two YANG modules for MPLS Static LSP(s) configuration and management: ietf-mpls-static.yang and ietf-mpls-static-extended.yang.

The ietf-mpls-static module contains the following high-level types and groupings:

static-lsp-ref:

A YANG reference type for a static LSP that can be used by data models to reference a configured static LSP.

in-segment:

A YANG grouping that describes parameters of an incoming class of FEC associated with a specific LSP as described in the MPLS architecture document [RFC3031]. The model allows the following types of traffic to be mapped onto the static LSP on an ingress LER:

- Unlabeled traffic destined to a specific prefix
- Labeled traffic arriving with a specific label

out-segment:

A YANG grouping that describes parameters for the forwarding path(s) and their associated attributes for an LSP. The model allows for the following cases:

- single forwarding path or NHLFE
- multiple forwarding path(s) or NHLFE(s), each of which can serve a primary, backup or both role(s).

The ietf-mpls-static-extended module contains the following high-level types and groupings:

bidir-static-lsp:

A YANG grouping that describes list of static bidirectional LSPs

The ietf-mpls-static-extended augments the ietf-mpls-static model with additional parameters to configure and manage:

- Bidirectional Static LSP(s)
- Defining Static LSP bandwidth allocation

- Defining Static LSP preemption priorities

2.4. Model YANG Module(s)

Configuring LSPs through an LSR/LER involves the following steps:

- Enabling MPLS on MPLS capable interfaces.
- Configuring in-segments and out-segments on LER(s) and LSR(s) traversed by the LSP.
- Setting up the cross-connect per LSP to associate segments and/or to indicate connection origination and termination.
- Optionally specifying label stack actions.
- Optionally specifying segment traffic parameters.

The objects covered by this model are derived from the Incoming Label Map (ILM) and Next Hop Label Forwarding Entry (NHLFE) as specified in the MPLS architecture document [RFC3031].

The ietf-mpls-static module imports the followinig modules:

- ietf-inet-types defined in [RFC6991]
- ietf-routing defined in [RFC8349]
- ietf-routing-types defined in [RFC8294]
- ietf-interfaces defined in [RFC8343]
- ietf-mpls defined in [I-D.ietf-mpls-base-yang]
- ietf-te defined in [I-D.ietf-teas-yang-te]

The ietf-mpls-static module is shown below:

```
<CODE BEGINS> file "ietf-mpls-static@2019-09-12.yang"
module ietf-mpls-static {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-mpls-static";
  prefix "mpls-static";

  import ietf-mpls {
    prefix "mpls";
    reference "draft-ietf-mpls-base-yang: MPLS Base YANG Data Model";
  }
```

```
   import ietf-routing {
     prefix "rt";
     reference "RFC8349: A YANG Data Model for Routing Management";
   }

   import ietf-routing-types {
     prefix "rt-types";
     reference "RFC8294: Common YANG Data Types for the Routing Area";
   }

   import ietf-inet-types {
     prefix inet;
     reference "RFC6991: Common YANG Data Types";
   }

   import ietf-interfaces {
     prefix "if";
     reference "RFC7223: A YANG Data Model for Interface Management";
   }

   organization "IETF MPLS Working Group";

   contact
     "WG Web:   <http://tools.ietf.org/wg/mpls/>

      WG List:  <mailto:mpls@ietf.org>

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                <mailto: xufeng.liu.ietf@gmail.com>

      Editor:   Vishnu Pavan Beeram
                <mailto:vbeeram@juniper.net>

      Editor:   Igor Bryskin
                <mailto: Igor.Bryskin@huawei.com>";

   description
      "This YANG module augments the 'ietf-routing' module with basic
       configuration and operational state data for MPLS static
       The model fully conforms to the Network Management Datastore
       Architecture (NMDA).
```

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

```
  // RFC Ed.: replace XXXX with actual RFC number and remove this
  // note.

  // RFC Ed.: update the date below with the date of RFC publication
  // and remove this note.

  revision "2019-09-12" {
    description
      "Latest revision of MPLS Static LSP YANG module";
    reference "RFC XXXX: A YANG Data Model for MPLS Static LSPs";
  }

  typedef static-lsp-ref {
    type leafref {
      path "/rt:routing/mpls:mpls/mpls-static:static-lsps/" +
           "mpls-static:static-lsp/mpls-static:name";
    }
    description
      "This type is used by data models that need to reference
       configured static LSP.";
  }

  grouping in-segment {
    description "In-segment grouping";
    container in-segment {
      description "MPLS incoming segment";
      container fec {
        description "Forwarding Equivalence Class grouping";
        choice type {
          description "FEC type choices";
          case ip-prefix {
            leaf ip-prefix {
              type inet:ip-prefix;
              description "An IP prefix";
            }
          }
```

```
          case mpls-label {
            leaf incoming-label {
              type rt-types:mpls-label;
              description "label value on the incoming packet";
            }
          }
        }
        leaf incoming-interface {
          type if:interface-ref;
          description
            "Optional incoming interface if FEC is restricted
             to traffic incoming on a specific interface";
        }
      }
    }
  }

  grouping out-segment {
    description "Out-segment grouping";
    container out-segment {
      description "MPLS outgoing segment";
      choice out-segment {
        description "The MPLS out-segment type choice";
        case nhlfe-single {
          container nhlfe-single {
            description "Container for single NHLFE entry";
            uses mpls:nhlfe-single-contents;
            leaf outgoing-interface {
              type if:interface-ref;
              description
                "The outgoing interface";
            }
          }
        }
        case nhlfe-multiple {
          container nhlfe-multiple {
            description "Container for multiple NHLFE entries";
            list nhlfe {
              key index;
              description "MPLS NHLFE entry";
              uses mpls:nhlfe-multiple-contents;
              leaf outgoing-interface {
                type if:interface-ref;
                description
                  "The outgoing interface";
              }
            }
          }
```

```
        }
      }
    }
  }

  augment "/rt:routing/mpls:mpls" {
    description "Augmentations for MPLS Static LSPs";
    container static-lsps {
      description
        "Statically configured LSPs, without dynamic signaling";
      list static-lsp {
        key name;
        description "list of defined static LSPs";
        leaf name {
          type string;
          description "name to identify the LSP";
        }
        leaf operation {
          type mpls:mpls-operations-type;
          description
            "The MPLS operation to be executed on the incoming packet";
        }
        uses in-segment;
        uses out-segment;
      }
    }
  }
}
<CODE ENDS>
```

The ietf-mpls-static-extended module imports the followinig modules:

- ietf-mpls defined in [I-D.ietf-mpls-base-yang]
- ietf-mpls-static defined in this document
- ietf-routing defined in [RFC8349]

The ietf-mpls-static-extended module is shown below:

```
<CODE BEGINS> file "ietf-mpls-static-extended@2019-09-12.yang"
module ietf-mpls-static-extended {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-mpls-static-extended";
  prefix "mpls-static-ext";

  import ietf-mpls {
    prefix "mpls";
```

```
      reference "draft-ietf-mpls-base-yang: MPLS Base YANG Data Model";
    }

    import ietf-routing {
      prefix "rt";
      reference "RFC8349: A YANG Data Model for Routing Management";
    }

    import ietf-routing-types {
      prefix "rt-types";
      reference "RFC8294: Common YANG Data Types for the Routing Area";
    }

    import ietf-mpls-static {
      prefix "mpls-static";
      reference "RFC XXXX: A YANG Data Model for MPLS Static LSPs";
    }

    organization "IETF MPLS Working Group";

    contact
      "WG Web:   <http://tools.ietf.org/wg/mpls/>

       WG List:  <mailto:mpls@ietf.org>

       Editor:   Tarek Saad
                 <mailto:tsaad@juniper.net>

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       Editor:   Vishnu Pavan Beeram
                 <mailto:vbeeram@juniper.net>

       Editor:   Igor Bryskin
                 <mailto: Igor.Bryskin@huawei.com>";

    description
      "This YANG module contains the Extended MPLS Static LSP YANG
       data model. The model fully conforms to the Network Management
       Datastore Architecture (NMDA).

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```

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        (https://trustee.ietf.org/license-info).
        This version of this YANG module is part of RFC XXXX; see
        the RFC itself for full legal notices.";

    // RFC Ed.: replace XXXX with actual RFC number and remove this
    // note.

    // RFC Ed.: update the date below with the date of RFC publication
    // and remove this note.

    revision "2019-09-12" {
      description
        "Latest revision of MPLS Static LSP Extended YANG module";
      reference "RFC XXXX: A YANG Data Model for MPLS Static LSPs";
    }

    grouping bidir-static-lsp {
      description
        "grouping for top level list of static bidirectional LSPs";
      leaf forward-lsp {
        type mpls-static:static-lsp-ref;
        description
          "Reference to a configured static forward LSP";
      }
      leaf reverse-lsp {
        type mpls-static:static-lsp-ref;
        description
          "Reference to a configured static reverse LSP";
      }
    }

    augment "/rt:routing/mpls:mpls/mpls-static:static-lsps" {
      description
        "Augmentation for static MPLS LSPs";

      leaf bandwidth {
        type rt-types:bandwidth-ieee-float32;
        units "Bytes per second";
        description
          "Bandwidth using offline calculation";
      }
      leaf lsp-priority-setup {
        type uint8 {
```

```
          range "0..7";
        }
        description "LSP setup priority";
      }
      leaf lsp-priority-hold {
        type uint8 {
          range "0..7";
        }
        description "LSP hold priority";
      }
    }

    augment "/rt:routing/mpls:mpls" {
      description "Augmentations for MPLS Static LSPs";
      container bidir-static-lsps {
        description
          "Statically configured bidirectional LSPs";
        list bidir-static-lsp {
          key name;
          description "List of static bidirectional LSPs";

          leaf name {
            type string;
            description "Name that identifies the bidirectional LSP";
          }
          uses bidir-static-lsp;
        }
      }
    }
  }
  <CODE ENDS>
```

3. IANA Considerations

This document registers the following URIs in the IETF XML registry [RFC3688]. Following the format in [RFC3688], the following registration is requested to be made.

```
   URI: urn:ietf:params:xml:ns:yang:ietf-mpls-static
   Registrant Contact: The MPLS WG of the IETF.
   XML: N/A, the requested URI is an XML namespace.

   URI: urn:ietf:params:xml:ns:yang:ietf-mpls-static-extended
   Registrant Contact: The MPLS WG of the IETF.
   XML: N/A, the requested URI is an XML namespace.
```

This document registers two YANG modules in the YANG Module Names registry [RFC6020].

```
name:       ietf-mpls-static
namespace:  urn:ietf:params:xml:ns:yang:ietf-mpls-static
prefix:     ietf-mpls-static
// RFC Ed.: replace XXXX with RFC number and remove this note
reference:  RFCXXXX

name:       ietf-mpls-static-extended
namespace:  urn:ietf:params:xml:ns:yang:ietf-mpls-static-extended
prefix:     ietf-mpls-static-extended
// RFC Ed.: replace XXXX with RFC number and remove this note
reference:  RFCXXXX
```

4. Security Considerations

The YANG modules specified in this document define schemas for data that is designed to be accessed via network management protocols 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 or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

All nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default) may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

o /ietf-routing:routing/ietf-mpls:mpls:/ietf-mpls:static-lsps: This entire subtree is related to security.

An administrator needs to restrict write access to all configurable objects within this data model.

5. Contributors

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6. References

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6.2. Informative References

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