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YANG Data Model for MPLS LDP and mLDP
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Abstract

This document describes a YANG data model for Multi-Protocol Label Switching (MPLS) Label Distribution Protocol (LDP) and Multipoint LDP (mLDP).

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1. Introduction

The Network Configuration Protocol (NETCONF) [RFC6241] is one of the network management protocols that defines mechanisms to manage network devices. YANG [RFC6020] is a modular language that represents data structures in an XML tree format, and is used as a data modelling language for the NETCONF.

This document introduces a YANG data model for MPLS Label Distribution Protocol (LDP) [RFC5036] and Multipoint LDP (mLDP) [RFC6388]. For LDP, it also covers LDP IPv6 [RFC7552] and LDP capabilities [RFC5561].

The data model is defined for following constructs that are used for managing the protocol:

- o Configuration
- o Operational State
- o Executables (Actions)
- o Notifications

This document is organized to define the data model for each of the above constructs (configuration, state, action, and notifications) in the sequence as listed earlier. Given that mLDP is tightly coupled with LDP, mLDP data model is defined under LDP tree and in the sequence as listed above as well.

2. Specification of Requirements

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 this document, the word "IP" is used to refer to both IPv4 and IPv6, unless otherwise explicitly stated. For example, "IP address family" means and be read as "IPv4 and/or IPv6 address family"

3. LDP YANG Model

3.1. Overview

This document defines a new module named "ietf-mpls-ldp" for LDP/mLDP data models such that this module augments "mpls" list in "ietf-mpls" module that is defined in [I-D.saad-mpls-static-yang].

There are four main containers in "ietf-mpls-ldp" module as follows:

- o Read-Write parameters for configuration (Discussed in Section 3.2)

- o Read-only parameters for operational state (Discussed in Section 3.3)

- o Notifications for events (Discussed in Section 3.4)

- o RPCs for executing commands to perform some action (Discussed in Section 3.5)

For the configuration and state data, this model follows the approach described in [I-D.openconfig-netmod-opstate] to represent the configuration (intended state) and operational (applied and derived) state. This means that for every configuration (rw) item, there is an associated (ro) item under "state" container to represent the applied state. Furthermore, protocol derived state is also kept under "state" tree corresponding to the protocol area (discovery, peer etc.).

Following diagram depicts high level LDP yang tree organization and hierarchy:

```
module: ietf-mpls-ldp
   +-- rw routing
    +-- rw routing-instance [name]
     +-- rw mpls
          +-- rw mpls-ldp
              +-- rw global
              |   +-- rw config
              |       +-- rw ...
              |   +-- ro state
              |       +-- ro ...
              |       .
              +-- rw ...
              |
              |
              +-- rw ...
              ...

rpcs:
   +-- x mpls-ldp-xxx
   +-- x . . . . .

notifications:
   +--- n mpls-ldp-yyy
   +--- n ...
```

Figure 1

Before going into data model details, it is important to take note of the following points:

- o This module aims to address only the core LDP/mLDP parameters as per RFC specification, as well as some widely used and deployed non-RFC features. Any vendor specific feature should be defined in a vendor-specific augmentation of this model.

- o Multi-topology LDP [RFC7307] and Multi-topology mLDP [I-D.iwijnand-mpls-mldp-multi-topology] are beyond the scope of this document.

- o This module does not cover any applications running on top of LDP and mLDP, nor does it cover any OAM procedures for LDP and mLDP.

- o This model is a VPN Forwarding and Routing (VRF)-centric model and hence falls under an MPLS routing-instance. It is important to note that [RFC4364] defines VRF tables and default forwarding tables as different, however from a yang modelling perspective

this introduces unnecessary complications, hence we are treating the default forwarding table as just another VRF.

- o A "routing-instance" refers to a VRF instance (both default and non-default) within the scope of this model.

- o This model supports two address-families, namely "ipv4" and "ipv6".

- o This model assumes platform-wide label space (i.e. label space Id of zero).

- o The label and peer policies (including filters) are defined using a prefix-list. When used for a peer policy, the prefix refers to the LSR Id of the peer. The prefix-list is referenced from routing-policy model as defined in [I-D.ietf-rtgwg-policy-model].

- o The use of grouping (templates) for bundling and grouping the configuration items is not employed in current revision, and is a subject for consideration in future.

- o This model uses the terms LDP neighbor/adjacency, session, and peer more strictly than RFC 5036 does. In this model, these terms are meant as follows:

  * Neighbor/Adjacency: An LDP enabled LSR that is discovered by LDP discovery mechanisms.

  * Session: An LDP neighbor with whom a TCP connection has been established

  * Peer: An LDP session which has successfully progressed beyond its initialization phase and is ready for binding exchange.

  When used in this document, the above terms will refer strictly to the semantics and definitions defined for them.

A graphical representation of LDP YANG data model is presented in Figure 3, Figure 5, Figure 11, and Figure 12. Whereas, the actual model definition in YANG is captured in Section 5.

3.2. Configuration

This specification defines the configuration parameters for base LDP as defined in [RFC5036] and LDP IPv6 [RFC7552]. Moreover, it incorporates provisions to enable LDP Capabilities [RFC5561], and defines some of the most significant and commonly used capabilities

such as Typed Wildcard FEC [RFC5918], End-of-LIB [RFC5919], and LDP Upstream Label Assignment [RFC6389].

This specification supports VRF-centric configuration. For implementations that support protocol-centric configuration, with provision for inheritance and items that apply to all vrfs, we recommend an augmentation of this model such that any protocol-centric or all-vrf configuration is defined under their designated containers within the standard routing-instance (please see section Section 3.2.2)

This model augments MPLS configuration as defined in MPLS base specification [I-D.saad-mpls-static-yang]. For LDP interfaces, this model still uses its own container and leaf, and is subject to alignment in future once MPLS interface model is solidified in MPLS base specification. Furthermore, as mentioned earlier, the configuration tree presents read-write intended configuration leave/items as well as read-only state of the applied configuration. The former is listed under "config" container and latter under "state" container.

Following is high-level configuration organization for LDP/mLDP:

```
module: ietf-mpls-ldp
   +-- routing
    +-- routing-instance [name]
     +-- mpls
          +-- mpls-ldp
              +-- global
              |    +-- ...
              |    +-- ...
              |    +-- address-family* [afi]
              |        +-- . . .
              |        +-- . . .
              |    +-- discovery
              |        +-- . . .
              +-- peers
                   +-- ...
                   +-- ...
```

Figure 2

Given the configuration hierarchy, the model allows inheritance such that an item in a child tree is able to derive value from a similar or related item in one of the parent. For instance, hello holdtime can be configured per-VRF or per-VRF-interface, thus allowing

inheritance as well flexibility to override with a different value on any child level.

Following is a simplified graphical representation of the data model for LDP configuration

```
module: ietf-mpls-ldp
augment /rt:routing/rt:routing-instance/mpls:mpls:
   +--rw mpls-ldp!
      +--rw global
      |  +--rw config
      |  |  +--rw capability
      |  |  |  +--rw end-of-lib {capability-end-of-lib}?
      |  |  |  |  +--rw enable?   boolean
      |  |  |  +--rw typed-wildcard-fec {capability-typed-wildcard-fec}?
      |  |  |  |  +--rw enable?   boolean
      |  |  |  +--rw upstream-label-assignment {capability-upstream-label-
assignment}?
      |  |  |     +--rw enable?   boolean
      |  |  +--rw graceful-restart
      |  |  |  +--rw enable?                boolean
      |  |  |  +--rw helper-enable?         boolean {graceful-restart-helper-
mode}?
      |  |  |  +--rw reconnect-time?        uint16
      |  |  |  +--rw recovery-time?         uint16
      |  |  |  +--rw forwarding-holdtime?   uint16
      |  |  +--rw igp-synchronization-delay?   uint16
      |  |  +--rw lsr-id?                      yang:dotted-quad
      |  +--rw address-family* [afi]
      |  |  +--rw afi       address-family
      |  |  +--rw config
      |  |  |  +--rw enable?         boolean
      |  |  |  +--rw label-policy
      |  |  |  |  +--rw independent-mode
      |  |  |  |  |  +--rw assign {policy-label-assignment-config}?
      |  |  |  |  |  |  +--rw (prefix-option)?
      |  |  |  |  |  |     +--:(prefix-list)
      |  |  |  |  |  |     |  +--rw prefix-list?        prefix-list-ref
      |  |  |  |  |  |     +--:(host-routes-only)
      |  |  |  |  |  |        +--rw host-routes-only?   boolean
      |  |  |  |  |  +--rw advertise
      |  |  |  |  |  |  +--rw explicit-null!
      |  |  |  |  |  |  |  +--rw prefix-list?   prefix-list-ref
      |  |  |  |  |  |  +--rw prefix-list?     prefix-list-ref
      |  |  |  |  |  +--rw accept
      |  |  |  |  |     +--rw prefix-list?   prefix-list-ref
      |  |  |  |  +--rw ordered-mode {policy-ordered-label-config}?
```

```
      |  |  |  |     +--rw egress-lsr
      |  |  |  |     |  +--rw prefix-list?   prefix-list-ref
```

```
      |  |  |  |     +--rw advertise
      |  |  |  |     |  +--rw prefix-list?   prefix-list-ref
      |  |  |  |     +--rw accept
      |  |  |  |        +--rw prefix-list?   prefix-list-ref
      |  |  |  +--rw ipv4
      |  |  |  |  +--rw transport-address?   inet:ipv4-address
      |  |  |  +--rw ipv6
      |  |  |     +--rw transport-address?   inet:ipv6-address
      |  +--rw discovery
      |  |  +--rw interfaces
      |  |  |  +--rw config
      |  |  |  |  +--rw hello-holdtime?   uint16
      |  |  |  |  +--rw hello-interval?   uint16
      |  |  |  +--rw interface* [interface]
      |  |  |     +--rw interface         if:interface-ref
      |  |  |     +--rw config
      |  |  |     |  +--rw hello-holdtime?              uint16
      |  |  |     |  +--rw hello-interval?              uint16
      |  |  |     |  +--rw igp-synchronization-delay?   uint16 {per-interface-
timer-config}?
      |  |  |     +--rw address-family* [afi]
      |  |  |        +--rw afi       address-family
      |  |  |        +--rw config
      |  |  |           +--rw enable?   boolean
      |  |  |           +--rw ipv4
      |  |  |           |  +--rw transport-address?   union
      |  |  |           +--rw ipv6
      |  |  |            +--rw transport-address?   union
      |  |  +--rw targeted
      |  |     +--rw config
      |  |     |  +--rw hello-holdtime?   uint16
      |  |     |  +--rw hello-interval?   uint16
      |  |     |  +--rw hello-accept {policy-extended-discovery-config}?
      |  |     |     +--rw enable?          boolean
      |  |     |     +--rw neighbor-list?   neighbor-list-ref
      |  |     +--rw address-family* [afi]
      |  |        +--rw afi      address-family
      |  |        +--rw ipv4
      |  |        |  +--rw target* [adjacent-address]
      |  |        |     +--rw adjacent-address    inet:ipv4-address
      |  |        |     +--rw config
      |  |        |        +--rw enable?          boolean
      |  |        |        +--rw local-address?   inet:ipv4-address
      |  |        +--rw ipv6
      |  |           +--rw target* [adjacent-address]
      |  |              +--rw adjacent-address    inet:ipv6-address
      |  |              +--rw config
      |  |                 +--rw enable?          boolean
```

```
      |  |                 +--rw local-address?   inet:ipv6-address
```

```
      |  +--rw forwarding-nexthop {forwarding-nexthop-config}?
      |  |  +--rw interfaces
      |  |     +--rw interface* [interface]
      |  |        +--rw interface         if:interface-ref
      |  |        +--rw address-family* [afi]
      |  |           +--rw afi       address-family
      |  |           +--rw config
      |  |              +--rw ldp-disable?    boolean
      |  +--rw label-policy
      |     +--rw independent-mode
      |     |  +--rw assign {policy-label-assignment-config}?
      |     |  |  +--rw (prefix-option)?
      |     |  |     +--:(prefix-list)
      |     |  |     |  +--rw prefix-list?        prefix-list-ref
      |     |  |     +--:(host-routes-only)
      |     |  |        +--rw host-routes-only?   boolean
      |     |  +--rw advertise
      |     |  |  +--rw explicit-null!
      |     |  |  |  +--rw prefix-list?   prefix-list-ref
      |     |  |  +--rw prefix-list?     prefix-list-ref
      |     |  +--rw accept
      |     |     +--rw prefix-list?   prefix-list-ref
      |     +--rw ordered-mode {policy-ordered-label-config}?
      |        +--rw egress-lsr
      |        |  +--rw prefix-list?   prefix-list-ref
      |        +--rw advertise
      |        |  +--rw prefix-list?   prefix-list-ref
      |        +--rw accept
      |           +--rw prefix-list?   prefix-list-ref
      +--rw peers
         +--rw config
         |  +--rw session-authentication-md5-password?   string
         |  +--rw session-ka-holdtime?                   uint16
         |  +--rw session-ka-interval?                   uint16
         |  +--rw session-downstream-on-demand {session-downstream-on-demand-
config}?
         |     +--rw enable?      boolean
         |     +--rw peer-list?   peer-list-ref
         +--rw peer* [lsr-id]
            +--rw lsr-id    yang:dotted-quad
            +--rw config
               +--rw admin-down?                            boolean
               +--rw capability
               +--rw label-policy
               |  +--rw advertise
               |  |  +--rw prefix-list?   prefix-list-ref
               |  +--rw accept
               |     +--rw prefix-list?   prefix-list-ref
```

```
+--rw session-authentication-md5-password?   string
```

```
               +--rw graceful-restart
               |  +--rw enable?           boolean
               |  +--rw reconnect-time?   uint16
               |  +--rw recovery-time?    uint16
               +--rw session-ka-holdtime?                   uint16
               +--rw session-ka-interval?                   uint16
               +--rw address-family
                  +--rw ipv4
                  |  +--rw label-policy
                  |     +--rw advertise
                  |     |  +--rw prefix-list?   prefix-list-ref
                  |     +--rw accept
                  |        +--rw prefix-list?   prefix-list-ref
                  +--rw ipv6
                     +--rw label-policy
                        +--rw advertise
                        |  +--rw prefix-list?   prefix-list-ref
                        +--rw accept
                           +--rw prefix-list?   prefix-list-ref
```

Figure 3

3.2.1. Configuration Hierarchy

The LDP configuration container is logically divided into following high-level config areas:

```
      Per-VRF parameters
          o Global parameters
          o Per-address-family parameters
          o LDP Capabilities parameters
          o Hello Discovery parameters
              - interfaces
                 - Per-interface:
                    Global
                    Per-address-family
              - targeted
                 - Per-target
         o Peer parameters
              - Global
              - Per-peer
                 Per-address-family
                 Capabilities parameters
         o Forwarding parameters
```

Figure 4

Following subsections briefly explain these configuration areas.

3.2.1.1. Per-VRF parameters

LDP module resides under an MPLS routing-instance and the scope of any LDP configuration defined under this tree is per routing-instance (per-VRF). This configuration is further divided into sub categories as follows.

3.2.1.1.1. Per-VRF global parameters

There are configuration items that are available directly under a VRF instance and do not fall under any other sub tree. Example of such a parameter is LDP LSR id that is typically configured per VRF. To keep legacy LDP features and applications working in an LDP IPv4 networks with this model, this document recommends an operator to pick a routable IPv4 unicast address as an LSR Id.

3.2.1.1.2. Per-VRF Capabilities parameters

This container falls under global tree and holds the LDP capabilities that are to be enabled for certain features. By default, an LDP capability is disabled unless explicitly enabled. These capabilities are typically used to negotiate with LDP peer(s) the support/non-support related to a feature and its parameters. The scope of a capability enabled under this container applies to all LDP peers in the given VRF instance. There is also a per-peer level capability

container that is provided to override a capability that is enabled/ specified at VRF level.

3.2.1.1.3. Per-VRF Per-Address-Family parameters

Any LDP configuration parameter related to IP address family (AF) whose scope is VRF wide is configured under this tree. The examples of per-AF parameters include enabling an address family, prefix-list based label policies, and LDP transport address.

3.2.1.1.4. Per-VRF Hello Discovery parameters

This container is used to hold LDP configuration related to Hello and discovery process for both basic (link) and extended (targeted) discovery.

The "interfaces" is a container to configure parameters related to VRF interfaces. There are parameters that apply to all interfaces (such as hello timers), as well as parameters that can be configured per-interface. Hence, an interface list is defined under "interfaces" container. The model defines parameters to configure per-interface non AF related items, as well as per-interface per-AF items. The example of former is interface hello timers, and example of latter is enabling hellos for a given AF under an interface. [Ed note: TODO: Align with IETF MPLS base interface model once IETF MPLS base model gets matured]

The "targeted" container under a VRF instance allows to configure LDP targeted discovery related parameters. Within this container, the "target" list provides a mean to configure multiple target addresses to perform extended discovery to a specific destination target, as well as to fine-tune the per-target parameters.

3.2.1.1.5. Per-VRF Peer parameters

This container is used to hold LDP configuration related to LDP sessions and peers under a VRF instance. This container allows to configure parameters that either apply on VRF's all peers or a subset (peer-list) of VRF peers. The example of such parameters include authentication password, session KA timers etc. Moreover, the model also allows per-peer parameter tuning by specifying a "peer" list under the "peers" container. A peer is uniquely identified using its LSR Id and hence LSR Id is the key for peer list

Like per-interface parameters, some per-peer parameters are AF-agnostic (i.e. either non AF related or apply to both IP address families), and some that belong to an AF. The example of former is per-peer session password configuration, whereas the example of

latter is prefix-list based label policies (inbound and outbound) that apply to a given peer.

3.2.1.1.6. Per-VRF Forwarding parameters

This container is used to hold configuration used to control LDP forwarding behavior under a VRF instance. One example of a configuration under this container is when a user wishes to enable neighbor discovery on an interface but wishes to disable use of the same interface as forwarding nexthop. This example configuration makes sense only when there are more than one LDP enabled interfaces towards the neighbor.

3.2.2. All-VRFs Configuration

[Ed note: TODO]

3.3. Operational State

Operational state of LDP can be queried and obtained from this read-only container "mpls-ldp" which is augmented from "routing" of MPLS tree (/rt:routing/rt:routing-instance/mpls:mpls).

Please note this state tree refers both the configuration "applied" state as well as the "derived" state related to the protocol.

Following is a simplified graphical representation of the data model for LDP operational state.

```
module: ietf-mpls-ldp
augment /rt:routing/rt:routing-instance/mpls:mpls:
   +--rw mpls-ldp!
      +--rw global
      |  +--ro state
      |  |  +--ro capability
      |  |  |  +--ro end-of-lib {capability-end-of-lib}?
      |  |  |  |  +--ro enable?   boolean
      |  |  |  +--ro typed-wildcard-fec {capability-typed-wildcard-fec}?
      |  |  |  |  +--ro enable?   boolean
      |  |  |  +--ro upstream-label-assignment {capability-upstream-label-
assignment}?
      |  |  |  |  +--ro enable?   boolean
      |  |  +--ro graceful-restart
      |  |  |  +--ro enable?                boolean
      |  |  |  +--ro helper-enable?         boolean {graceful-restart-helper-
mode}?
      |  |  |  +--ro reconnect-time?        uint16
      |  |  |  +--ro recovery-time?         uint16
```

```
      |  |  |  +--ro forwarding-holdtime?   uint16
```

```
      |  |  +--ro igp-synchronization-delay?   uint16
      |  |  +--ro lsr-id?                      yang:dotted-quad
      |  +--rw address-family* [afi]
      |  |  +--rw afi       address-family
      |  |  +--ro state
      |  |     +--ro enable?         boolean
      |  |     +--ro label-policy
      |  |     |  +--ro independent-mode
      |  |     |  |  +--ro assign {policy-label-assignment-config}?
      |  |     |  |  |  +--ro (prefix-option)?
      |  |     |  |  |     +--:(prefix-list)
      |  |     |  |  |     |  +--ro prefix-list?        prefix-list-ref
      |  |     |  |  |     +--:(host-routes-only)
      |  |     |  |  |        +--ro host-routes-only?   boolean
      |  |     |  |  +--ro advertise
      |  |     |  |  |  +--ro explicit-null!
      |  |     |  |  |  |  +--ro prefix-list?   prefix-list-ref
      |  |     |  |  |  +--ro prefix-list?     prefix-list-ref
      |  |     |  |  +--ro accept
      |  |     |  |     +--ro prefix-list?   prefix-list-ref
      |  |     |  +--ro ordered-mode {policy-ordered-label-config}?
      |  |     |     +--ro egress-lsr
      |  |     |     |  +--ro prefix-list?   prefix-list-ref
      |  |     |     +--ro advertise
      |  |     |     |  +--ro prefix-list?   prefix-list-ref
      |  |     |     +--ro accept
      |  |     |        +--ro prefix-list?   prefix-list-ref
      |  |     +--ro ipv4
      |  |     |  +--ro transport-address?   inet:ipv4-address
      |  |     |  +--ro bindings
      |  |     |     +--ro address* [address]
      |  |     |     |  +--ro address      inet:ipv4-address
      |  |     |     |  +--ro direction?   advertised-received
      |  |     |     |  +--ro peer?        leafref
      |  |     |     +--ro fec-label* [fec]
      |  |     |        +--ro fec     inet:ipv4-prefix
      |  |     |        +--ro peer* [direction peer]
      |  |     |           +--ro direction             advertised-received
      |  |     |           +--ro peer                  leafref
      |  |     |           +--ro label?                uint32
      |  |     |           +--ro used-in-forwarding?   boolean
      |  |     +--ro ipv6
      |  |        +--ro transport-address?   inet:ipv6-address
      |  |        +--ro binding
      |  |           +--ro address* [address]
      |  |           |  +--ro address      inet:ipv6-address
      |  |           |  +--ro direction?   advertised-received
      |  |           |  +--ro peer?        leafref
```

```
      |  |          +--ro fec-label* [fec]
      |  |             +--ro fec     inet:ipv6-prefix
      |  |             +--ro peer* [direction peer]
      |  |                +--ro direction             advertised-received
      |  |                +--ro peer                  leafref
      |  |                +--ro label?                uint32
      |  |                +--ro used-in-forwarding?   boolean
      |  +--rw discovery
      |  |  +--rw interfaces
      |  |  |  +--ro state
      |  |  |  |  +--ro hello-holdtime?   uint16
      |  |  |  |  +--ro hello-interval?   uint16
      |  |  |  +--rw interface* [interface]
      |  |  |     +--rw interface         if:interface-ref
      |  |  |     +--ro state
      |  |  |     |  +--ro hello-holdtime?              uint16
      |  |  |     |  +--ro hello-interval?              uint16
      |  |  |     |  +--ro igp-synchronization-delay?   uint16 {per-interface-
timer-config}?
      |  |  |     |  +--ro next-hello?                  uint16
      |  |  |     +--rw address-family* [afi]
      |  |  |        +--rw afi       address-family
      |  |  |        +--ro state
      |  |  |           +--ro enable?   boolean
      |  |  |           +--ro ipv4
      |  |  |           |  +--ro transport-address?   union
      |  |  |           |  +--ro hello-adjacencies* [adjacent-address]
      |  |  |           |     +--ro adjacent-address    inet:ipv4-address
      |  |  |           |     +--ro flag*               identityref
      |  |  |           |     +--ro hello-holdtime
      |  |  |           |     |  +--ro adjacent?     uint16
      |  |  |           |     |  +--ro negotiated?   uint16
      |  |  |           |     |  +--ro remaining?    uint16
      |  |  |           |     +--ro next-hello?         uint16
      |  |  |           |     +--ro statistics
      |  |  |           |     |  +--ro discontinuity-time    yang:date-and-time
      |  |  |           |     |  +--ro hello-received?       yang:counter64
      |  |  |           |     |  +--ro hello-dropped?        yang:counter64
      |  |  |           |     +--ro peer?               leafref
      |  |  |           +--ro ipv6
      |  |  |              +--ro transport-address?   union
      |  |  |              +--ro hello-adjacencies* [adjacent-address]
      |  |  |                 +--ro adjacent-address    inet:ipv6-address
      |  |  |                 +--ro flag*               identityref
      |  |  |                 +--ro hello-holdtime
      |  |  |                 |  +--ro adjacent?     uint16
      |  |  |                 |  +--ro negotiated?   uint16
      |  |  |                 |  +--ro remaining?    uint16
```

```
      |  |  |                 +--ro next-hello?         uint16
```

```
      |  |  |                +--ro statistics
      |  |  |                |  +--ro discontinuity-time    yang:date-and-time
      |  |  |                |  +--ro hello-received?       yang:counter64
      |  |  |                |  +--ro hello-dropped?        yang:counter64
      |  |  |                +--ro peer?               leafref
      |  |  +--rw targeted
      |  |     +--ro state
      |  |     |  +--ro hello-holdtime?   uint16
      |  |     |  +--ro hello-interval?   uint16
      |  |     |  +--ro hello-accept {policy-extended-discovery-config}?
      |  |     |     +--ro enable?          boolean
      |  |     |     +--ro neighbor-list?   neighbor-list-ref
      |  |     +--rw address-family* [afi]
      |  |        +--rw afi      address-family
      |  |        +--ro state
      |  |        |  +--ro ipv4
      |  |        |  |  +--ro hello-adjacencies* [local-address adjacent-
address]
      |  |        |  |     +--ro local-address       inet:ipv4-address
      |  |        |  |     +--ro adjacent-address    inet:ipv4-address
      |  |        |  |     +--ro flag*               identityref
      |  |        |  |     +--ro hello-holdtime
      |  |        |  |     |  +--ro adjacent?     uint16
      |  |        |  |     |  +--ro negotiated?   uint16
      |  |        |  |     |  +--ro remaining?    uint16
      |  |        |  |     +--ro next-hello?         uint16
      |  |        |  |     +--ro statistics
      |  |        |  |     |  +--ro discontinuity-time    yang:date-and-time
      |  |        |  |     |  +--ro hello-received?       yang:counter64
      |  |        |  |     |  +--ro hello-dropped?        yang:counter64
      |  |        |  |     +--ro peer?               leafref
      |  |        |  +--ro ipv6
      |  |        |     +--ro hello-adjacencies* [local-address adjacent-
address]
      |  |        |        +--ro local-address       inet:ipv6-address
      |  |        |        +--ro adjacent-address    inet:ipv6-address
      |  |        |        +--ro flag*                identityref
      |  |        |        +--ro hello-holdtime
      |  |        |        |  +--ro adjacent?     uint16
      |  |        |        |  +--ro negotiated?   uint16
      |  |        |        |  +--ro remaining?    uint16
      |  |        |        +--ro next-hello?         uint16
      |  |        |        +--ro statistics
      |  |        |        |  +--ro discontinuity-time    yang:date-and-time
      |  |        |        |  +--ro hello-received?       yang:counter64
      |  |        |        |  +--ro hello-dropped?        yang:counter64
      |  |        |        +--ro peer?               leafref
      |  |        +--rw ipv4
```

```
      |  |        |  +--rw target* [adjacent-address]
      |  |        |     +--rw adjacent-address    inet:ipv4-address
```

```
      |  |        |     +--ro state
      |  |        |        +--ro enable?          boolean
      |  |        |        +--ro local-address?   inet:ipv4-address
      |  |        +--rw ipv6
      |  |           +--rw target* [adjacent-address]
      |  |              +--rw adjacent-address    inet:ipv6-address
      |  |              +--ro state
      |  |                 +--ro enable?          boolean
      |  |                 +--ro local-address?   inet:ipv6-address
      |  +--rw forwarding-nexthop {forwarding-nexthop-config}?
      |  |  +--rw interfaces
      |  |     +--rw interface* [interface]
      |  |        +--rw interface         if:interface-ref
      |  |        +--rw address-family* [afi]
      |  |           +--rw afi       address-family
      |  |           +--ro state
      |  |              +--ro ldp-disable?    boolean
      +--rw peers
         +--ro state
         |  +--ro session-authentication-md5-password?   string
         |  +--ro session-ka-holdtime?                   uint16
         |  +--ro session-ka-interval?                   uint16
         |  +--ro session-downstream-on-demand {session-downstream-on-demand-
config}?
         |     +--ro enable?      boolean
         |     +--ro peer-list?   peer-list-ref
         +--rw peer* [lsr-id]
            +--rw lsr-id    yang:dotted-quad
            +--ro state
               +--ro admin-down?                           boolean
               +--ro capability
               +--ro label-policy
               |  +--ro advertise
               |  |  +--ro prefix-list?   prefix-list-ref
               |  +--ro accept
               |     +--ro prefix-list?   prefix-list-ref
               +--ro session-authentication-md5-password?   string
               +--ro graceful-restart
               |  +--ro enable?           boolean
               |  +--ro reconnect-time?   uint16
               |  +--ro recovery-time?    uint16
               +--ro session-ka-holdtime?                   uint16
               +--ro session-ka-interval?                   uint16
               +--ro address-family
               |  +--ro ipv4
               |  |  +--ro label-policy
               |  |  |  +--ro advertise
               |  |  |  |  +--ro prefix-list?   prefix-list-ref
```

```
                |  |  |  +--ro accept
```

```
                |  |  |     +--ro prefix-list?   prefix-list-ref
                |  |  +--ro hello-adjacencies* [local-address adjacent-address]
                |  |     +--ro local-address       inet:ipv4-address
                |  |     +--ro adjacent-address    inet:ipv4-address
                |  |     +--ro flag*               identityref
                |  |     +--ro hello-holdtime
                |  |     |  +--ro adjacent?     uint16
                |  |     |  +--ro negotiated?   uint16
                |  |     |  +--ro remaining?    uint16
                |  |     +--ro next-hello?         uint16
                |  |     +--ro statistics
                |  |     |  +--ro discontinuity-time    yang:date-and-time
                |  |     |  +--ro hello-received?       yang:counter64
                |  |     |  +--ro hello-dropped?        yang:counter64
                |  |     +--ro interface?          if:interface-ref
                |  +--ro ipv6
                |     +--ro label-policy
                |     |  +--ro advertise
                |     |  |  +--ro prefix-list?   prefix-list-ref
                |     |  +--ro accept
                |     |     +--ro prefix-list?   prefix-list-ref
                |     +--ro hello-adjacencies* [local-address adjacent-address]
                |        +--ro local-address       inet:ipv6-address
                |        +--ro adjacent-address    inet:ipv6-address
                |        +--ro flag*               identityref
                |        +--ro hello-holdtime
                |        |  +--ro adjacent?     uint16
                |        |  +--ro negotiated?   uint16
                |        |  +--ro remaining?    uint16
                |        +--ro next-hello?         uint16
                |        +--ro statistics
                |        |  +--ro discontinuity-time    yang:date-and-time
                |        |  +--ro hello-received?       yang:counter64
                |        |  +--ro hello-dropped?        yang:counter64
                |        +--ro interface?          if:interface-ref
                +--ro label-advertisement-mode
                |  +--ro local?        label-adv-mode
                |  +--ro peer?         label-adv-mode
                |  +--ro negotiated?   label-adv-mode
                +--ro next-keep-alive?                       uint16
                +--ro peer-ldp-id?                           yang:dotted-quad
                +--ro received-peer-state
                |  +--ro graceful-restart
                |  |  +--ro enable?           boolean
                |  |  +--ro reconnect-time?   uint16
                |  |  +--ro recovery-time?    uint16
                |  +--ro capability
                |     +--ro end-of-lib
```

```
               |     |  +--ro enable?   boolean
               |     +--ro typed-wildcard-fec
               |     |  +--ro enable?   boolean
               |     +--ro upstream-label-assignment
               |        +--ro enable?   boolean
               +--ro session-holdtime
               |  +--ro peer?         uint16
               |  +--ro negotiated?   uint16
               |  +--ro remaining?    uint16
               +--ro session-state?                        enumeration
               +--ro tcp-connection
               |  +--ro local-address?    inet:ip-address
               |  +--ro local-port?       uint16
               |  +--ro remote-address?   inet:ip-address
               |  +--ro remote-port?      uint16
               +--ro up-time?                              string
               +--ro statistics
                  +--ro discontinuity-time          yang:date-and-time
                  +--ro received
                  |  +--ro total-octets?          yang:counter64
                  |  +--ro total-messages?        yang:counter64
                  |  +--ro address?               yang:counter64
                  |  +--ro address-withdraw?      yang:counter64
                  |  +--ro initialization?        yang:counter64
                  |  +--ro keepalive?             yang:counter64
                  |  +--ro label-abort-request?   yang:counter64
                  |  +--ro label-mapping?         yang:counter64
                  |  +--ro label-release?         yang:counter64
                  |  +--ro label-request?         yang:counter64
                  |  +--ro label-withdraw?        yang:counter64
                  |  +--ro notification?          yang:counter64
                  +--ro sent
                  |  +--ro total-octets?          yang:counter64
                  |  +--ro total-messages?        yang:counter64
                  |  +--ro address?               yang:counter64
                  |  +--ro address-withdraw?      yang:counter64
                  |  +--ro initialization?        yang:counter64
                  |  +--ro keepalive?             yang:counter64
                  |  +--ro label-abort-request?   yang:counter64
                  |  +--ro label-mapping?         yang:counter64
                  |  +--ro label-release?         yang:counter64
                  |  +--ro label-request?         yang:counter64
                  |  +--ro label-withdraw?        yang:counter64
                  |  +--ro notification?          yang:counter64
                  +--ro total-addresses?            uint32
                  +--ro total-labels?               uint32
                  +--ro total-fec-label-bindings?   uint32
```

Figure 5

3.3.1. Derived States

Following are main areas for which LDP operational derived state is defined:

Neighbor Adjacencies

Peer

Bindings (FEC-label and address)

Capabilities

3.3.1.1. Adjacency state

Neighbor adjacencies are per address-family hello adjacencies that are formed with neighbors as result of LDP basic or extended discovery. In terms of organization, there is a source of discovery (e.g. interface or target address) along with its associated parameters and one or more discovered neighbors along with neighbor discovery related parameters. For the basic discovery, there could be more than one discovered neighbor for a given source (interface), whereas there is at most one discovered neighbor for an extended discovery source (local-address and target-address). This is also to be noted that the reason for a targeted neighbor adjacency could be either an active source (locally configured targeted) or passive source (to allow any incoming extended/targeted hellos). A neighbor/adjacency record also contains session-state that helps highlight whether a given adjacency has progressed to subsequent session level or to eventual peer level.

Following captures high level tree hierarchy for neighbor adjacency state.

```
   +--rw mpls-ldp!
      +--rw discovery
         +--rw interfaces
         |  +--rw interface* [interface]
         |     +--rw address-family* [af]
         |        +--ro state
         |           +--ro ipv4 (or ipv6)
         |              +--ro hello-adjacencies* [adjacent-address]
         |                 +--ro adjacent-address
         |                    . . . .
         |                    . . . .
         +--rw targeted
            +--rw address-family* [afi]
                +--rw afi      address-family
                   +--ro state
                      +--ro ipv4 (or ipv6)
                         +--ro hello-adjacencies* [local-address adjacent-
address]
                            +--ro local-address
                            +--ro adjacent-address
                               . . . .
                               . . . .
```

Figure 6

3.3.1.2. Peer state

Peer related derived state is presented under peers tree. This is one of the core state that provides info on the session related parameters (mode, authentication, KA timeout etc.), TCP connection info, hello adjacencies for the peer, statistics related to messages and bindings, and capabilities exchange info.

Following captures high level tree hierarchy for peer state.

```
  +--rw mpls-ldp!
      +--rw peers
         +--rw peer* [lsr-id]
            +--rw lsr-id
            +--ro state
               +--ro session-ka-holdtime?
               +-- . . . .
               +-- . . . .
               +--ro capability
               +  +ro -- . . .
               +--ro address-family
               |  +--ro ipv4 (or ipv6)
               |     +--ro hello-adjacencies* [local-address adjacent-address]
               |        . . . .
               |        . . . .
               +--ro received-peer-state
               |  +--ro . . . .
               |  +--ro capability
               |     +--ro . . . .
               +--ro statistics
                  +-- . . . .
                  +-- . . . .
```

Figure 7

3.3.1.3. Bindings state

Binding state provides information on LDP FEC-label bindings as well as address binding for both inbound (received) as well as outbound (advertised). FEC-label bindings are presented as a FEC-centric view, and address bindings are presented as an address-centric view:

```
        FEC-Label bindings:
            FEC 200.1.1.1/32:
              advertised: local-label 16000
                peer 192.168.0.2:0
                peer 192.168.0.3:0
                peer 192.168.0.4:0
              received:
                peer 192.168.0.2:0, label 16002, used-in-forwarding=Yes
                peer 192.168.0.3:0, label 17002, used-in-forwarding=No
            FEC 200.1.1.2/32:
               . . . .
            FEC 201.1.0.0/16:
               . . . .


        Address bindings:
            Addr 1.1.1.1:
              advertised
            Addr 1.1.1.2:
              advertised
            Addr 2.2.2.2:
              received, peer 192.168.0.2
            Addr 2.2.2.22:
              received, peer 192.168.0.2
            Addr 3.3.3.3:
              received, peer 192.168.0.3
            Addr 3.3.3.33:
              received, peer 192.168.0.3
```

Figure 8

Note that all local addresses are advertised to all peers and hence no need to provide per-peer information for local address advertisement.

Following captures high level tree hierarchy for bindings state.

```
+--rw mpls-ldp!
   +--rw global
      +--rw address-family* [afi]
         +--rw afi       address-family
         +--ro state
            +--ro ipv4 (or ipv6)
               +--ro bindings
                  +--ro address* [address]
                  |  +--ro address
                  |  +--ro direction?   advertised-received
                  |  +--ro peer?        leafref
                  +--ro fec-label* [fec]
                     +--ro fec     inet:ipv4-prefix
                     +--ro peer* [direction peer]
                        +--ro direction             advertised-received
                        +--ro peer                  leafref
                        +--ro label?                uint32
                        +--ro used-in-forwarding?   boolean
```

Figure 9

3.3.1.4. Capabilities state

LDP capabilities state comprise two types of information - a global information (such as timer etc.), and per-peer information.

Following captures high level tree hierarchy for LDP capabilities state.

```
   +--rw mpls-ldp!
      +--rw global
      |  +--ro state
      |     +--ro capability
      |        +--ro . . . .
      |        +--ro . . . .
      +--rw peers
         +--rw peer* [lsr-id]
            +--rw lsr-id    yang:dotted-quad
            +--ro state
               +--ro received-peer-state
                  +--ro capability
                     +--ro . . . .
                     +--ro . . . .
```

Figure 10

3.4. Notifications

This model defines a list of notifications to inform client of important events detected during the protocol operation. These events include events related to changes in the operational state of an LDP peer, hello adjacency, and FEC etc. It is to be noted that an LDP FEC is treated as operational (up) as long as it has at least 1 NHLFE with outgoing label.

Following is a simplified graphical representation of the data model for LDP notifications.

```
module: ietf-mpls-ldp
notifications:
   +---n mpls-ldp-peer-event
   |  +--ro event-type?             oper-status-event-type
   |  +--ro routing-instance-ref?   rt:routing-instance-ref
   |  +--ro peer-ref?               leafref
   +---n mpls-ldp-hello-adjacency-event
   |  +--ro event-type?             oper-status-event-type
   |  +--ro routing-instance-ref?   rt:routing-instance-ref
   |  +--ro (hello-adjacency-type)?
   |     +--:(targeted)
   |     |  +--ro targeted
   |     |     +--ro target-address?   inet:ip-address
   |     +--:(link)
   |        +--ro link
   |           +--ro next-hop-interface?   if:interface-ref
   |           +--ro next-hop-address?     inet:ip-address
   +---n mpls-ldp-fec-event
      +--ro event-type?             oper-status-event-type
      +--ro routing-instance-ref?   rt:routing-instance-ref
      +--ro prefix?                 inet:ip-prefix
```

Figure 11

3.5. Actions

This model defines a list of rpcs that allow performing an action or executing a command on the protocol. For example, it allows to clear (reset) LDP peers, hello-adjacencies, and statistics. The model makes an effort to provide different level of control so that a user is able to either clear all, or clear all of a given type, or clear a specific entity.

Following is a simplified graphical representation of the data model for LDP actions.

```
module: ietf-mpls-ldp
rpcs:
  +---x mpls-ldp-clear-peer
   |  +---w input
   |     +---w routing-instance-ref?   rt:routing-instance-ref
   |     +---w lsr-id?                 union
   +---x mpls-ldp-clear-hello-adjacency
   |  +---w input
   |     +---w routing-instance-ref?   rt:routing-instance-ref
   |     +---w hello-adjacency
   |        +---w (hello-adjacency-type)?
   |           +--:(targeted)
   |           |  +---w targeted!
   |           |     +---w target-address?   inet:ip-address
   |           +--:(link)
   |              +---w link!
   |                 +---w next-hop-interface?   if:interface-ref
   |                 +---w next-hop-address?     inet:ip-address
   +---x mpls-ldp-clear-peer-statistics
      +---w input
         +---w routing-instance-ref?   rt:routing-instance-ref
         +---w lsr-id?                 union
```

Figure 12

4. mLDP YANG Model

4.1. Overview

Due to tight dependency of mLDP on LDP, mLDP model builds on top of LDP model defined earlier in the document. Following are the main mLDP areas and documents that are within the scope of this model:

- o mLDP Base Specification [RFC6388]
- o mLDP Recursive FEC [RFC6512]
- o Targeted mLDP [RFC7060]
- o mLDP Fast-Reroute (FRR)
  - * Node Protection [RFC7715]

  * Multicast-only

- o Hub-and-Spoke Multipoint LSPs [RFC7140]

- o mLDP In-band Signaling [RFC6826] (future revision)

- o mLDP In-band Signaling with Wildcards [RFC7438] (future revision)

- o Configured Leaf LSPs (manually provisioned)

[Ed Note: Some of the topics in the above list are to be addressed/ added in later revision of this document].

4.2. Configuration

4.2.1. Configuration Hierarchy

In terms of overall configuration layout, following figure highlights extensions to LDP configuration model to incorporate mLDP:

```
      +-- mpls-ldp
         +-- ...
         +-- ...
         +-- mldp
         |  +-- ...
         |  +-- ...
         |  +-- address-family* [af]
         |     +-- af
         |        +-- ...
         |        +-- ...
         +-- global
         |  +-- ...
         |  +-- capability
         |     +-- ...
         |     +-- ...
         |     +-- mldp
         |        +-- ...
         |        +-- ...
         +-- discovery
         |  +-- ...
         |  +-- ...
         +-- forwarding-nexthop
         |  +-- interfaces
         |     +-- interface* [interface]
         |        +-- interface
         |        +-- address-family* [af]
         |           +-- af
         |           +-- ...
         |           +-- mldp-disable
         +-- peers
            +-- ...
            +-- ...
            +-- peer* [lsr-id]
                +-- ...
                +-- ...
                +-- capability
                    +-- ...
                    +-- ...
                    +-- mldp
                        +-- ...
                        +-- ...
```

Figure 13

From above hierarchy, we can categorize mLDP configuration parameters into two types:

- o Parameters that leverage/extend LDP containers and parameters

- o Parameters that are mLDP specific

Following subsections first describe mLDP specific configuration parameters, followed by those leveraging LDP.

4.2.2. mldp container

mldp container resides directly under "mpls-ldp" and holds the configuration related to items that are mLDP specific. The main items under this container are:

- o mLDP enabling: To enable mLDP under a (VRF) routing instance, mldp container is enabled under LDP. Given that mLDP requires LDP signalling, it is not sensible to allow disabling LDP control plane under a (VRF) routing-instance while requiring mLDP to be enabled for the same. However, if a user wishes only to allow signalling for multipoint FECs on an LDP/mLDP enabled VRF instance, he/she can use LDP label-policies to disable unicast FECs under the VRF.

- o mLDP per-AF features: mLDP manages its own list of IP address-families and the features enabled underneath. The per-AF mLDP configuration items include:

  - * Multicast-only FRR: This enables Multicast-only FRR functionality for a given AF under mLDP. The feature allows route-policy to be configured for finer control/applicability of the feature.

  - * Recursive FEC: The recursive-fec feature [RFC6512] can be enabled per AF with a route-policy.

  - * Configured Leaf LSPs: To provision multipoint leaf LSP manually, a container is provided per-AF under LDP. The configuration is flexible and allows a user to specify MP LSPs of type p2mp or mp2mp with IPv4 or IPv6 root address(es) by using either LSP-Id or (S,G).

Targeted mLDP feature specification [RFC7060] do not require any mLDP specific configuration. It, however, requires LDP upstream-label-assignment capability to be enabled.

4.2.3. Leveraging LDP containers

mLDP configuration model leverages following configuration areas and containers that are already defined for LDP:

- o Capabilities: A new container "mldp" is defined under Capabilities container. This new container specifies any mLDP specific capabilities and their parameters. Moreover, a new "mldp" container is also added under per-peer capability container to override/control mLDP specific capabilities on a peer level. In the scope of this document, the most important capabilities related to mLDP are p2mp, mp2mp, make-before-break, hub-and-spoke, and node-protection.

- o Discovery and Peer: mLDP requires LDP discovery and peer procedures to form mLDP peering. A peer is treated as mLDP peer only when either P2MP or MP2MP capabilities have been successfully exchanged with the peer. If a user wish to selectively enable or disable mLDP with a mLDP-enabled peer, he/she may use per-peer mLDP capabilities configuration. [Ed Note: The option to control mLDP enabling/disabling on a peer-list is being explored for future]. In most common deployments, it is desirable to disable mLDP (capabilities announcements) on a targeted-only LDP peering, where targeted-only peer is the one whose discovery sources are targeted only. In future revision, a configuration option for this support will also be provided.

- o Forwarding: By default, mLDP is allowed to select any of the LDP enabled interface as a downstream interface towards a nexthop (LDP/mLDP peer) for MP LSP programming. However, a configuration option is provided to allow mLDP to exclude a given interface from such a selection. Note that such a configuration option will be useful only when there are more than one interfaces available for the downstream selection.

This goes without saying that mLDP configuration tree follows the same approach as LDP, where the tree comprise leafs for intended configuration.

4.2.4. YANG tree

The following figure captures the YANG tree for mLDP configuration. To keep the focus, the figure has been simplified to display only mLDP items and not LDP items.

```
module: ietf-mpls-ldp
augment /rt:routing/rt:routing-instance/mpls:mpls:
```

```
   +--rw mpls-ldp!
      +--rw global
      |  +--rw config
      |  |  +--rw capability
      |  |     +--rw mldp {mldp}?
      |  |        +--rw p2mp
      |  |        |  +--rw enable?   boolean
      |  |        +--rw mp2mp
      |  |        |  +--rw enable?   boolean
      |  |        +--rw make-before-break
      |  |        |  +--rw enable?             boolean
      |  |        |  +--rw switchover-delay?   uint16
      |  |        |  +--rw timeout?            uint16
      |  |        +--rw hub-and-spoke {capability-mldp-hsmp}?
      |  |        |  +--rw enable?   boolean
      |  |        +--rw node-protection {capability-mldp-node-protection}?
      |  |          +--rw plr?           boolean
      |  |           +--rw merge-point
      |  |              +--rw enable?                           boolean
      |  |              +--rw targeted-session-teardown-delay?   uint16
      |  +--rw mldp {mldp}?
      |  |  +--rw config
      |  |  |  +--rw enable?   boolean
      |  |  +--rw address-family* [afi]
      |  |     +--rw afi                     address-family
      |  |     +--rw config
      |  |     |  +--rw multicast-only-frr {mldp-mofrr}?
      |  |     |  |  +--rw prefix-list?   prefix-list-ref
      |  |     |  +--rw recursive-fec
      |  |     |     +--rw prefix-list?   prefix-list-ref
      |  |     +--rw configured-leaf-lsps
      |  |        +--rw p2mp
      |  |        |  +--rw roots-ipv4
      |  |        |  |  +--rw root* [root-address]
      |  |        |  |     +--rw root-address    inet:ipv4-address
      |  |        |  |     +--rw lsp* [lsp-id source-address group-address]
      |  |        |  |        +--rw lsp-id            uint16
      |  |        |  |        +--rw source-address    inet:ipv4-address-no-zone
      |  |        |  |        +--rw group-address     inet:ipv4-address-no-zone
      |  |        |  +--rw roots-ipv6
      |  |        |     +--rw root* [root-address]
      |  |        |        +--rw root-address    inet:ipv6-address
      |  |        |        +--rw lsp* [lsp-id source-address group-address]
      |  |        |           +--rw lsp-id            uint16
      |  |        |           +--rw source-address    inet:ipv6-address-no-zone
      |  |        |           +--rw group-address     inet:ipv6-address-no-zone
      |  |        +--rw mp2mp
      |  |           +--rw roots-ipv4
```

```
      |  |           |  +--rw root* [root-address]
      |  |           |     +--rw root-address    inet:ipv4-address
      |  |           |     +--rw lsp* [lsp-id source-address group-address]
      |  |           |        +--rw lsp-id            uint16
      |  |           |        +--rw source-address    inet:ipv4-address-no-zone
      |  |           |        +--rw group-address     inet:ipv4-address-no-zone
      |  |           +--rw roots-ipv6
      |  |              +--rw root* [root-address]
      |  |                 +--rw root-address    inet:ipv6-address
      |  |                 +--rw lsp* [lsp-id source-address group-address]
      |  |                    +--rw lsp-id            uint16
      |  |                    +--rw source-address    inet:ipv6-address-no-zone
      |  |                    +--rw group-address     inet:ipv6-address-no-zone
      |  +--rw forwarding-nexthop {forwarding-nexthop-config}?
      |     +--rw interfaces
      |        +--rw interface* [interface]
      |           +--rw interface         if:interface-ref
      |           +--rw address-family* [afi]
      |              +--rw afi       address-family
      |              +--rw config
      |                 +--rw mldp-disable?   boolean {mldp}?
      +--rw peers
         +--rw peer* [lsr-id]
            +--rw lsr-id    yang:dotted-quad
            +--rw config
                  +--rw mldp {mldp}?
                     +--rw p2mp
                     |  +--rw enable?   boolean
                     +--rw mp2mp
                     |  +--rw enable?   boolean
                     +--rw make-before-break
                     |  +--rw enable?             boolean
                     |  +--rw switchover-delay?   uint16
                     |  +--rw timeout?            uint16
                     +--rw hub-and-spoke {capability-mldp-hsmp}?
                     |  +--rw enable?   boolean
                     +--rw node-protection {capability-mldp-node-protection}?
                        +--rw plr?           boolean
                        +--rw merge-point
                           +--rw enable?                           boolean
                           +--rw targeted-session-teardown-delay?   uint16
```

Figure 14

4.3. Operational State

Operational state of mLDP can be queried and obtained from this read-only container "mldp" which resides under mpls-ldp container. Please note that "applied" state of an mLDP configuration item is already captured under mldp configuration tree. This mldp state tree only refers to the "derived" state related to mLDP protocol.

Following is a simplified graphical representation of the data model for mLDP operational state for applied state. [Ed note: Derived state for mldp is TODO]

```
module: ietf-mpls-ldp
augment /rt:routing/rt:routing-instance/mpls:mpls:
   +--rw mpls-ldp!
      +--rw global
      |  +--ro state
      |  |  +--ro capability
      |  |     +--ro mldp {mldp}?
      |  |        +--ro p2mp
      |  |        |  +--ro enable?   boolean
      |  |        +--ro mp2mp
      |  |        |  +--ro enable?   boolean
      |  |        +--ro make-before-break
      |  |        |  +--ro enable?             boolean
      |  |        |  +--ro switchover-delay?   uint16
      |  |        |  +--ro timeout?            uint16
      |  |        +--ro hub-and-spoke {capability-mldp-hsmp}?
      |  |        |  +--ro enable?   boolean
      |  |        +--ro node-protection {capability-mldp-node-protection}?
      |  |           +--ro plr?           boolean
      |  |           +--ro merge-point
      |  |              +--ro enable?                            boolean
      |  |              +--ro targeted-session-teardown-delay?   uint16
      |  +--rw mldp {mldp}?
      |  |  +--ro state
      |  |  |  +--ro enable?   boolean
      |  |  +--rw address-family* [afi]
      |  |     +--rw afi                     address-family
      |  |     +--ro state
      |  |        +--ro multicast-only-frr {mldp-mofrr}?
      |  |        |  +--ro prefix-list?   prefix-list-ref
      |  |        +--ro recursive-fec
      |  |           +--ro prefix-list?   prefix-list-ref
      |  +--rw forwarding-nexthop {forwarding-nexthop-config}?
      |     +--rw interfaces
      |        +--rw interface* [interface]
```

```
      |           +--rw interface         if:interface-ref
      |           +--rw address-family* [afi]
      |              +--rw afi       address-family
      |              +--ro state
      |                 +--ro mldp-disable?   boolean {mldp}?
      +--rw peers
         +--rw peer* [lsr-id]
            +--rw lsr-id    yang:dotted-quad
            +--ro state
               +--ro capability
               |  +--ro mldp {mldp}?
               |     +--ro p2mp
               |     |  +--ro enable?   boolean
               |     +--ro mp2mp
               |     |  +--ro enable?   boolean
               |     +--ro make-before-break
               |     |  +--ro enable?             boolean
               |     |  +--ro switchover-delay?   uint16
               |     |  +--ro timeout?            uint16
               |     +--ro hub-and-spoke {capability-mldp-hsmp}?
               |     |  +--ro enable?   boolean
               |     +--ro node-protection {capability-mldp-node-protection}?
               |        +--ro plr?           boolean
               |        +--ro merge-point
               |           +--ro enable?                            boolean
               |           +--ro targeted-session-teardown-delay?   uint16
               +--ro received-peer-state
                  +--ro capability
                     +--ro mldp {mldp}?
                        +--ro p2mp
                        |  +--ro enable?   boolean
                        +--ro mp2mp
                        |  +--ro enable?   boolean
                        +--ro make-before-break
                        |  +--ro enable?   boolean
                        +--ro hub-and-spoke
                        |  +--ro enable?   boolean
                        +--ro node-protection
                           +--ro plr?           boolean
                           +--ro merge-point?   boolean
```

Figure 15

4.4. Notifications

mLDP notification module consists of notification related to changes in the operational state of an mLDP FEC. Following is a simplified graphical representation of the data model for mLDP notifications:

```
module: ietf-mpls-ldp
notifications:
   +---n mpls-mldp-fec-event
      +--ro event-type?             oper-status-event-type
      +--ro routing-instance-ref?   rt:routing-instance-ref
      +--ro tree-type?              multipoint-type
      +--ro root?                   inet:ip-address
      +--ro (lsp-key-type)?
         +--:(lsp-id-based)
         |  +--ro lsp-id?                 uint16
         +--:(source-group-based)
            +--ro source-address?         inet:ip-address
            +--ro group-address?          inet:ip-address
```

Figure 16

4.5. Actions

Currently, no RPCs/actions are defined for mLDP.

5. YANG Specification

Following are actual YANG definition for LDP and mLDP constructs defined earlier in the document.

```
<CODE BEGINS> file "ietf-mpls-ldp@2016-03-18.yang" -->

module ietf-mpls-ldp {
  namespace "urn:ietf:params:xml:ns:yang:ietf-mpls-ldp";
  // replace with IANA namespace when assigned
  prefix ldp;

  import ietf-inet-types {
    prefix "inet";
  }

  import ietf-yang-types {
    prefix "yang";
```

```
   }

   import ietf-interfaces {
     prefix "if";
   }

   import ietf-ip {
     prefix "ip";
   }

   import ietf-routing {
     prefix "rt";
   }

   import routing-policy {
     prefix "rpl";
   }

   organization "TBD";
   contact "TBD";
   description
     "";

   revision 2016-03-18 {
     description
       "Initial revision.";
     reference
       "";
   }

   /*
    * Features
    */

   feature admin-down-config {
     description
       "This feature indicates that the system allows to configure
        administrative down on a VRF instance and a peer.";
   }

   feature all-af-policy-config {
     description
       "This feature indicates that the system allows to configure
        policies that are applied to all address families.";
   }

   feature capability-end-of-lib {
     description
```

```
      "This feature indicates that the system allows to configure
       LDP end-of-lib capability.";
  }

  feature capability-mldp-hsmp {
    description
      "This feature indicates that the system allows to configure
       mLDP hub-and-spoke-multipoint capability.";
  }

  feature capability-mldp-node-protection {
    description
      "This feature indicates that the system allows to configure
       mLDP node-protection capability.";
  }

  feature capability-typed-wildcard-fec {
    description
      "This feature indicates that the system allows to configure
       LDP typed-wildcard-fec capability.";
  }

  feature capability-upstream-label-assignment {
    description
      "This feature indicates that the system allows to configure
       LDP upstream label assignment capability.";
  }

  feature forwarding-nexthop-config {
    description
      "This feature indicates that the system allows to configure
       forwarding nexthop on interfaces.";
  }

  feature global-session-authentication {
    description
      "This feature indicates that the system allows to configure
       authentication at global level.";
  }

  feature graceful-restart-helper-mode {
    description
      "This feature indicates that the system supports graceful
       restart helper mode.";
  }

  feature mldp {
    description
```

```
       "This feature indicates that the system supports Multicast
        LDP (mLDP).";
   }

   feature mldp-mofrr {
     description
       "This feature indicates that the system supports mLDP
        Multicast only FRR (MoFRR).";
   }

   feature per-interface-timer-config {
     description
       "This feature indicates that the system allows to configure
        interface hello timers at the per-interface level.";
   }

   feature per-peer-graceful-restart-config {
     description
       "This feature indicates that the system allows to configure
        graceful restart at the per-peer level.";
   }

   feature per-peer-session-attributes-config {
     description
       "This feature indicates that the system allows to configure
        session attributes at the per-peer level.";
   }

   feature policy-extended-discovery-config {
     description
       "This feature indicates that the system allows to configure
        policies to control the acceptance of extended neighbor
        discovery hello messages.";
   }

   feature policy-label-assignment-config {
     description
       "This feature indicates that the system allows to configure
        policies to assign labels according to certain prefixes.";
   }

   feature policy-ordered-label-config {
     description
       "This feature indicates that the system allows to configure
        ordered label policies.";
   }

   feature session-downstream-on-demand-config {
```

```
      description
        "This feature indicates that the system allows to configure
         session downstream-on-demand";
    }

    /*
     * Typedefs
     */
    typedef address-family {
      type enumeration {
        enum ipv4 {
          description "IPv4";
        }
        enum ipv6 {
          description "IPv6";
        }
      }
      description
        "Address family type.";
    }

    typedef duration32-inf {
      type union {
        type uint32;
        type enumeration {
          enum "infinite" {
            description "The duration is infinite.";
          }
        }
      }
      units seconds;
      description
        "Duration represented as 32 bit seconds with infinite.";
    }

    typedef advertised-received {
      type enumeration {
        enum advertised {
          description "Advertised information.";
        }
        enum received {
          description "Received information.";
        }
      }
      description
        "Received or advertised.";
    }
```

```
   typedef label-adv-mode {
     type enumeration {
       enum downstream-unsolicited {
         description "Downstream Unsolicited.";
       }
       enum downstream-on-demand {
         description "Downstream on Demand.";
       }
     }
     description
       "Label Advertisement Mode.";
   }

   typedef multipoint-type {
     type enumeration {
       enum p2mp {
         description "Point to multipoint.";
       }
       enum mp2mp {
         description "Multipoint to multipoint.";
       }
     }
     description
       "p2mp or mp2mp.";
   }

   typedef neighbor-list-ref {

     type leafref {
       path "/rpl:routing-policy/rpl:defined-sets/rpl:neighbor-sets/"
         + "rpl:neighbor-set/rpl:neighbor-set-name";
     }
     description
       "A type for a reference to a neighbor list.";
   }

   typedef peer-list-ref {

     type leafref {
       path "/rpl:routing-policy/rpl:defined-sets/rpl:neighbor-sets/"
         + "rpl:neighbor-set/rpl:neighbor-set-name";
     }
     description
       "A type for a reference to a peer list.";
   }

   typedef prefix-list-ref {
     type leafref {
```

```
      path "/rpl:routing-policy/rpl:defined-sets/rpl:prefix-sets/"
        + "rpl:prefix-set/rpl:prefix-set-name";
    }
    description
      "A type for a reference to a prefix list.";
  }

  typedef oper-status-event-type {
    type enumeration {
      enum up {
        value 1;
        description
          "Operational status changed to up.";
      }
      enum down {
        value 2;
        description
          "Operational status changed to down.";
      }
    }
    description "Operational status event type for notifications.";
  }

  /*
   * Identities
   */
  identity adjacency-flag-base {
    description "Base type for adjacency flags.";
  }

  identity adjacency-flag-active {
    base "adjacency-flag-base";
    description
      "This adjacency is configured and actively created.";
  }

  identity adjacency-flag-passive {
    base "adjacency-flag-base";
    description
      "This adjacency is not configured and passively accepted.";
  }

  /*
   * Groupings
   */

  grouping adjacency-state-attributes {
    description
```

```
        "Adjacency state attributes.";

      leaf-list flag {
        type identityref {
          base "adjacency-flag-base";
        }
        description "Adjacency flags.";
      }
      container hello-holdtime {
        description "Hello holdtime state.";
        leaf adjacent {
          type uint16;
          units seconds;
          description "Peer holdtime.";
        }
        leaf negotiated {
          type uint16;
          units seconds;
          description "Negotiated holdtime.";
        }
        leaf remaining {
          type uint16;
          units seconds;
          description "Remaining holdtime.";
        }
      }

      leaf next-hello {
        type uint16;
        units seconds;
        description "Time to send the next hello message.";
      }

      container statistics {
        description
          "Statistics objects.";

        leaf discontinuity-time {
          type yang:date-and-time;
          mandatory true;
          description
            "The time on the most recent occasion at which any one or
             more of this interface's counters suffered a
             discontinuity.  If no such discontinuities have occurred
             since the last re-initialization of the local management
             subsystem, then this node contains the time the local
             management subsystem re-initialized itself.";
        }
```

```
      leaf hello-received {
        type yang:counter64;
        description
          "The number of hello messages received.";
      }
      leaf hello-dropped {
        type yang:counter64;
        description
          "The number of hello messages received.";
      }
    } // statistics
  } // adjacency-state-attributes

  grouping basic-discovery-timers {
    description
      "Basic discovery timer attributes.";
    leaf hello-holdtime {
      type uint16 {
        range 15..3600;
      }
      units seconds;
      default 15;
      description
        "The time interval for which a LDP link Hello adjacency
         is maintained in the absence of link Hello messages from
         the LDP neighbor";
    }
    leaf hello-interval {
      type uint16 {
        range 5..1200;
      }
      units seconds;
      default 5;
      description
        "The interval between consecutive LDP link Hello messages
         used in basic LDP discovery";
    }
  } // basic-discovery-timers

  grouping binding-address-state-attributes {
    description
      "Address binding attributes";
    leaf direction {
      type advertised-received;
      description
        "Received or advertised.";
    }
    leaf peer {
```

```
      type leafref {
        path "../../../../../../../peers/peer/lsr-id";
      }
      must "../advertised-received = 'received'" {
        description
          "Applicable for received address.";
      }
      description
        "LDP peer from which this address is received.";
    } // peer
  } // binding-address-state-attributes

  grouping binding-label-state-attributes {
    description
      "Label binding attributes";
    list peer {
      key "direction peer";
      description
        "List of advertised and received peers.";
      leaf direction {
        type advertised-received;
        description
          "Received or advertised.";
      }
      leaf peer {
        type leafref {
          path "../../../../../../../../peers/peer/lsr-id";
        }
        description
          "LDP peer from which this binding is received,
           or to which this binding is advertised.";
      }
      leaf label {
        type uint32;
        description
          "Advertised (outbound) or received (inbound)
           label.";
      }
      leaf used-in-forwarding {
        type boolean;
        description
          "'true' if the lable is used in forwarding.";
      }
    } // peer
  } // binding-label-state-attributes

  grouping extended-discovery-policy-attributes {
    description
```

```
       "LDP policy to control the acceptance of extended neighbor
        discovery hello messages.";
     container hello-accept {
       if-feature policy-extended-discovery-config;
       description
         "Extended discovery acceptance policies.";

       leaf enable {
         type boolean;
         description
           "'true' to accept; 'false' to deny.";
       }
       leaf neighbor-list {
         type neighbor-list-ref;
         description

           "The name of a peer ACL.";
       }
     } // hello-accept
   } // extended-discovery-policy-attributes

   grouping extended-discovery-timers {
     description
       "Extended discovery timer attributes.";
     leaf hello-holdtime {
       type uint16 {
         range 15..3600;
       }
       units seconds;
       default 45;
       description
         "The time interval for which LDP targeted Hello adjacency

          is maintained in the absence of targeted Hello messages
          from an LDP neighbor.";
     }
     leaf hello-interval {
       type uint16 {
         range 5..3600;
       }
       units seconds;
       default 15;
       description
         "The interval between consecutive LDP targeted Hello
          messages used in extended LDP discovery.";
     }
   } // extended-discovery-timers
```

```
   grouping global-attributes {
     description "Configuration attributes at global level.";

     uses instance-attributes;
   } // global-attributes

   grouping graceful-restart-attributes {
     description
       "Graceful restart configuration attributes.";
     container graceful-restart {
       description
         "Attributes for graceful restart.";
       leaf enable {
         type boolean;
         description
           "Enable or disable graceful restart.";
       }
       leaf helper-enable {
         if-feature graceful-restart-helper-mode;
         type boolean;
         description
           "Enable or disable graceful restart helper mode.";
       }
       leaf reconnect-time {
         type uint16 {
           range 10..1800;
         }
         units seconds;
         description
           "Specifies the time interval that the remote LDP peer
            must wait for the local LDP peer to reconnect after the
            remote peer detects the LDP communication failure.";
       }
       leaf recovery-time {
         type uint16 {
           range 30..3600;
         }
         units seconds;
         description
           "";
       }
       leaf forwarding-holdtime {
         type uint16 {
           range 30..3600;
         }
         units seconds;
         description
           "";
```

```
      }
    } // graceful-restart
  } // graceful-restart-attributes

  grouping graceful-restart-attributes-per-peer {
    description
      "Per peer graceful restart configuration attributes.";
    container graceful-restart {
      description
        "Attributes for graceful restart.";
      leaf enable {
        type boolean;
        description
          "Enable or disable graceful restart.";
      }
      leaf reconnect-time {
        type uint16 {
          range 10..1800;
        }
        units seconds;
        description
          "Specifies the time interval that the remote LDP peer
           must wait for the local LDP peer to reconnect after the
           remote peer detects the LDP communication failure.";
      }
      leaf recovery-time {
        type uint16 {
          range 30..3600;
        }
        units seconds;
        description
          "";
      }
    } // graceful-restart
  } // graceful-restart-attributes-per-peer

  grouping instance-attributes {
    description "Configuration attributes at instance level.";

    container capability {
      description "Configure capability.";
      container end-of-lib {
        if-feature capability-end-of-lib;
        description
          "Configure end-of-lib capability.";
        leaf enable {
          type boolean;
          description
```

```
              "Enable end-of-lib capability.";
          }
        }
        container typed-wildcard-fec {
          if-feature capability-typed-wildcard-fec;
          description
            "Configure typed-wildcard-fec capability.";
          leaf enable {
            type boolean;
            description
              "Enable typed-wildcard-fec capability.";
          }
        }
        container upstream-label-assignment {
          if-feature capability-upstream-label-assignment;
          description
            "Configure upstream label assignment capability.";
          leaf enable {
            type boolean;
            description
              "Enable upstream label assignment.";
          }
        }
        container mldp {
          if-feature mldp;

          description
            "Multipoint capabilities.";
          uses mldp-capabilities;
        }
      } // capability

      uses graceful-restart-attributes;

      leaf igp-synchronization-delay {
        type uint16 {
          range 3..60;
        }
        units seconds;
        description
          "Sets the interval that the LDP waits before notifying the
           Interior Gateway Protocol (IGP) that label exchange is
           completed so that IGP can start advertising the normal
           metric for the link.";
      }
      leaf lsr-id {
        type yang:dotted-quad;
        description "Router ID.";
```

```
      }
    } // instance-attributes

    grouping ldp-adjacency-ref {
      description
        "An absolute reference to an LDP adjacency.";
      choice hello-adjacency-type {
        description
          "Interface or targeted adjacency.";
        case targeted {
          container targeted {
            description "Targeted adjacency.";
            leaf target-address {
              type inet:ip-address;
              description
                "The target address.";
            }
          } // targeted
        }
        case link {
          container link {
            description "Link adjacency.";
            leaf next-hop-interface {
              type if:interface-ref;
              description
                "Interface connecting to next-hop.";
            }
            leaf next-hop-address {
              type inet:ip-address;
              must "../next-hop-interface" {
                description
                  "Applicable when interface is specified.";

              }
              description
                "IP address of next-hop.";
            }
          } // link
        }
      }
    } // ldp-adjacency-ref

    grouping ldp-fec-event {
      description
        "A LDP FEC event.";
      leaf prefix {
        type inet:ip-prefix;
        description
```

```
        "FEC.";
      }
    } // ldp-fec-event

    grouping ldp-peer-ref {
      description
        "An absolute reference to an LDP peer.";
      leaf peer-ref {
        type leafref {
          path "/rt:routing/rt:routing-protocols/mpls-ldp/"
            + "peers/peer/lsr-id";
        }
        description
          "Reference to an LDP peer.";
      }
    } // ldp-peer-ref

    grouping mldp-capabilities {
      description
        "mLDP capabilities.";
      container p2mp {
        description
          "Configure point-to-multipoint capability.";
        leaf enable {
          type boolean;
          description
            "Enable point-to-multipoint.";
        }
      }
      container mp2mp {
        description
          "Configure multipoint-to-multipoint capability.";
        leaf enable {
          type boolean;
          description
            "Enable multipoint-to-multipoint.";
        }
      }
      container make-before-break {
        description
          "Configure make-before-break capability.";
        leaf enable {
          type boolean;
          description
            "Enable make-before-break.";
        }
        leaf switchover-delay {
          type uint16;
```

```
          units seconds;
          description
            "Switchover delay in seconds.";
        }
        leaf timeout {
          type uint16;
          units seconds;
          description
            "Timeout in seconds.";
        }
      }
      container hub-and-spoke {
        if-feature capability-mldp-hsmp;
        description
          "Configure hub-and-spoke-multipoint capability.";
        reference
          "RFC7140: LDP Extensions for Hub and Spoke Multipoint
           Label Switched Path";
        leaf enable {
          type boolean;
          description
            "Enable hub-and-spoke-multipoint.";
        }
      }
      container node-protection {
        if-feature capability-mldp-node-protection;
        description
          "Configure node-protection capability.";
        reference
          "RFC7715: mLDP Node Protection.";
        leaf plr {
          type boolean;
          description
            "Point of Local Repair capable for MP LSP node
             protection.";
        }
        container merge-point {
          description
            "Merge Point capable for MP LSP node protection.";
          leaf enable {
            type boolean;
            description
              "Enable merge point capability.";
          }
          leaf targeted-session-teardown-delay {
            type uint16;
            units seconds;
            description
```

```
             "Targeted session teardown delay.";
         }
       } // merge-point
     }
   } // mldp-capabilities

   grouping  mldp-configured-lsp-roots {
     description
       "mLDP roots containers.";

     container roots-ipv4 {

       when "../../../af = 'ipv4'" {
         description
           "Only for IPv4.";
       }
       description
         "Configured IPv4 multicast LSPs.";
       list root {
         key "root-address";
         description
           "List of roots for configured multicast LSPs.";

         leaf root-address {
           type inet:ipv4-address;
           description
             "Root address.";
         }

         list lsp {
           must "(lsp-id = 0 and source-address != '0.0.0.0' and "
             + "group-address != '0.0.0.0') or "
             + "(lsp-id != 0 and source-address = '0.0.0.0' and "
             + "group-address = '0.0.0.0')" {
             description
               "A LSP can be identified by either <lsp-id> or
                <source-address, group-address>.";
           }
           key "lsp-id source-address group-address";
           description
             "List of LSPs.";
           leaf lsp-id {
             type uint16;
             description "ID to identify the LSP.";
           }
           leaf source-address {
             type inet:ipv4-address-no-zone;
             description
```

```
               "Source address.";
           }
           leaf group-address {
             type inet:ipv4-address-no-zone;
             description
               "Group address.";
           }
         } // list lsp
       } // list root
     } // roots-ipv4

     container roots-ipv6 {

       when "../../../af = 'ipv6'" {
         description
           "Only for IPv6.";
       }
       description
         "Configured IPv6 multicast LSPs.";

       list root {
         key "root-address";
         description
           "List of roots for configured multicast LSPs.";

         leaf root-address {
           type inet:ipv6-address;
           description
             "Root address.";
         }

         list lsp {
           must "(lsp-id = 0 and source-address != '::' and "
             + "group-address != '::') or "
             + "(lsp-id != 0 and source-address = '::' and "
             + "group-address = '::')" {
             description
               "A LSP can be identified by either <lsp-id> or
                <source-address, group-address>.";
           }
           key "lsp-id source-address group-address";
           description
             "List of LSPs.";
           leaf lsp-id {
             type uint16;
             description "ID to identify the LSP.";
           }
           leaf source-address {
```

```
            type inet:ipv6-address-no-zone;
            description
              "Source address.";
          }
          leaf group-address {
            type inet:ipv6-address-no-zone;
            description
              "Group address.";
          }
        } // list lsp
      } // list root
    } // roots-ipv6
  } // mldp-configured-lsp-roots

  grouping mldp-fec-event {
    description
      "A mLDP FEC event.";
    leaf tree-type {
      type multipoint-type;
      description
        "p2mp or mp2mp.";
    }
    leaf root {
      type inet:ip-address;
      description
        "Root address.";
    }
    choice lsp-key-type {
      description
        "LSP ID based or source-group based .";
      case lsp-id-based {
        leaf lsp-id {
          type uint16;
          description
            "ID to identify the LSP.";
        }
      }
      case source-group-based {
        leaf source-address {
          type inet:ip-address;
          description

            "LSP source address.";
        }
        leaf group-address {
          type inet:ip-address;
          description
            "Multicast group address.";
```

```
        }
      } // case source-group-based
    }
  } // mldp-fec-event

  grouping peer-af-policy-container {
    description
      "LDP policy attribute container under peer address-family.";
    container label-policy {
      description
        "Label policy attributes.";
      container advertise {
        description
          "Label advertising policies.";
        leaf prefix-list {
          type prefix-list-ref;
            description
              "Applies the prefix list to outgoing label
               advertisements.";
        }
      }
      container accept {
        description
          "Label advertisement acceptance policies.";
        leaf prefix-list {
          type prefix-list-ref;
          description
            "Applies the prefix list to incoming label
             advertisements.";
        }
      } // accept
    } // label-policy
  } // peer-af-policy-container

  grouping peer-attributes {
    description "Peer configuration attributes.";

    leaf session-ka-holdtime {
      type uint16 {
        range 45..3600;
      }
      units seconds;
      description
        "The time interval after which an inactive LDP session
         terminates and the corresponding TCP session closes.
         Inactivity is defined as not receiving LDP packets from the
         peer.";
    }
```

```
      leaf session-ka-interval {
        type uint16 {
          range 15..1200;
        }
        units seconds;
        description
          "The interval between successive transmissions of keepalive
           packets. Keepalive packets are only sent in the absence of
           other LDP packets transmitted over the LDP session.";
      }
    } // peer-attributes

    grouping peer-authentication {
      description
        "Peer authentication attributes.";
      leaf session-authentication-md5-password {
        type string {
          length "1..80";
        }
        description
          "Assigns an encrypted MD5 password to an LDP
           peer";
      } // md5-password
    } // peer-authentication

    grouping peer-state-derived {
      description "Peer derived state attributes.";

      container label-advertisement-mode {
        description "Label advertisement mode state.";
        leaf local {
          type label-adv-mode;
          description
            "Local Label Advertisement Mode.";
        }
        leaf peer {
          type label-adv-mode;
          description
            "Peer Label Advertisement Mode.";
        }
        leaf negotiated {
          type label-adv-mode;
          description
            "Negotiated Label Advertisement Mode.";
        }
      }
      leaf next-keep-alive {
        type uint16;
```

```
        units seconds;
        description "Time to send the next KeepAlive message.";
      }

      leaf peer-ldp-id {
        type yang:dotted-quad;
        description "Peer LDP ID.";
      }

      container received-peer-state {
        description "Peer features.";

        uses graceful-restart-attributes-per-peer;

        container capability {
          description "Configure capability.";
          container end-of-lib {
            description
              "Configure end-of-lib capability.";
            leaf enable {
              type boolean;
              description
                "Enable end-of-lib capability.";
            }
          }
          container typed-wildcard-fec {
            description
              "Configure typed-wildcard-fec capability.";
            leaf enable {
              type boolean;
              description
                "Enable typed-wildcard-fec capability.";
            }
          }
          container upstream-label-assignment {
            description
              "Configure upstream label assignment capability.";
            leaf enable {
              type boolean;
              description
                "Enable upstream label assignment.";
            }
          }
          container mldp {
            if-feature mldp;
            description
              "Multipoint capabilities.";
```

```
            container p2mp {
              description
                "Configure point-to-multipoint capability.";
              leaf enable {
                type boolean;
                description
                  "Enable point-to-multipoint.";
              }
            }
            container mp2mp {
              description
                "Configure multipoint-to-multipoint capability.";
              leaf enable {
                type boolean;
                description
                  "Enable multipoint-to-multipoint.";
              }
            }
            container make-before-break {
              description
                "Configure make-before-break capability.";
              leaf enable {
                type boolean;
                description
                  "Enable make-before-break.";
              }
            }
            container hub-and-spoke {
              description
                "Configure hub-and-spoke-multipoint capability.";
              reference
                "RFC7140: LDP Extensions for Hub and Spoke Multipoint
                 Label Switched Path";
              leaf enable {
                type boolean;
                description
                  "Enable hub-and-spoke-multipoint.";
              }
            }
            container node-protection {
              description
                "Configure node-protection capability.";
              reference
                "RFC7715: mLDP Node Protection.";
              leaf plr {
                type boolean;
                description
                  "Point of Local Repair capable for MP LSP node
```

```
                  protection.";
            }
            leaf merge-point {
              type boolean;
              description
                "Merge Point capable for MP LSP node protection.";
            } // merge-point
          } // node-protection
        } // mldp
      } // capability
    } // received-peer-state

    container session-holdtime {
      description "Session holdtime state.";
      leaf peer {
        type uint16;
        units seconds;
        description "Peer holdtime.";
      }
      leaf negotiated {
        type uint16;
        units seconds;
        description "Negotiated holdtime.";
      }
      leaf remaining {
        type uint16;
        units seconds;
        description "Remaining holdtime.";
      }
    } // session-holdtime

    leaf session-state {
      type enumeration {
        enum non-existent {
          description "NON EXISTENT state. Transport disconnected.";
        }
        enum initialized {
          description "INITIALIZED state.";
        }
        enum openrec {
          description "OPENREC state.";
        }
        enum opensent {
          description "OPENSENT state.";
        }
        enum operational {
          description "OPERATIONAL state.";
        }
```

```
        }
        description
          "Representing the operational status.";
      }

      container tcp-connection {
        description "TCP connection state.";
        leaf local-address {
          type inet:ip-address;
          description "Local address.";
        }
        leaf local-port {
          type uint16;
          description "Local port.";
        }
        leaf remote-address {
          type inet:ip-address;
          description "Remote address.";
        }
        leaf remote-port {
          type uint16;
          description "Remote port.";
        }
      } // tcp-connection

      leaf up-time {
        type string;
        description "Up time. The interval format in ISO 8601.";
      }

      container statistics {
        description
          "Statistics objects.";

        leaf discontinuity-time {
          type yang:date-and-time;
          mandatory true;
          description
            "The time on the most recent occasion at which any one or
             more of this interface's counters suffered a
             discontinuity.  If no such discontinuities have occurred
             since the last re-initialization of the local management
             subsystem, then this node contains the time the local
             management subsystem re-initialized itself.";
        }

        container received {
          description "Inbound statistics.";
```

```
        uses statistics-peer-received-sent;
      }
      container sent {
        description "Outbound statistics.";
        uses statistics-peer-received-sent;
      }

      leaf total-addresses {
        type uint32;
        description
          "The number of learned addresses.";
      }
      leaf total-labels {
        type uint32;
        description
          "The number of learned labels.";
      }
      leaf total-fec-label-bindings {
        type uint32;
        description
          "The number of learned label-address bindings.";
      }
    } // statistics
  } // peer-state-derived

  grouping policy-container {
    description
      "LDP policy attributes.";
    container label-policy {
      description
        "Label policy attributes.";
      container independent-mode {
        description
          "Independent label policy attributes.";
        container assign {

          if-feature policy-label-assignment-config;
          description
            "Label assignment policies";
          choice prefix-option {
            description
              "Use either prefix-list or host-routes-only.";
            case prefix-list {
              leaf prefix-list {
                type prefix-list-ref;
                description
                  "Assign labels according to certain prefixes.";
              }
```

```
            }
            case host-routes-only {
              leaf host-routes-only {
                type boolean;
                description
                  "'true' to apply host routes only.";
              }
            }
          } // prefix-option
        }
        container advertise {
          description
            "Label advertising policies.";
          container explicit-null {
            presence "Present to enable explicit null.";
            description
              "Enables an egress router to advertise an
               explicit null label (value 0) in place of an
               implicit null label (value 3) to the
               penultimate hop router.";
            leaf prefix-list {
              type prefix-list-ref;
              description
                "Prefix list name. Applies the filters in the
                 specified prefix list to label
                 advertisements.
                 If the prefix list is not specified, explicit
                 null label advertisement is enabled for all
                 directly connected prefixes.";
            }
          }
          leaf prefix-list {
            type prefix-list-ref;
            description
              "Applies the prefix list to outgoing label
               advertisements.";

          }
        }
        container accept {
          description
            "Label advertisement acceptance policies.";
          leaf prefix-list {
            type prefix-list-ref;
            description
              "Applies the prefix list to incoming label
               advertisements.";
          }
```

```
        }
      } // independent-mode
      container ordered-mode {
        if-feature policy-ordered-label-config;
        description
          "Ordered label policy attributes.";
        container egress-lsr {
          description
            "Egress LSR label assignment policies";
          leaf prefix-list {
            type prefix-list-ref;
            description
              "Assign labels according to certain prefixes.";
          }
        }
        container advertise {
          description
            "Label advertising policies.";
          leaf prefix-list {
            type prefix-list-ref;
            description
              "Applies the prefix list to outgoing label
               advertisements.";
          }
        }
        container accept {
          description
            "Label advertisement acceptance policies.";
          leaf prefix-list {
            type prefix-list-ref;
            description
              "Applies the prefix list to incoming label
               advertisements.";
          }
        }
      } // ordered-mode
    } // label-policy
  } // policy-container

  grouping statistics-peer-received-sent {
    description
      "Inboud and outbound statistic counters.";
    leaf total-octets {
      type yang:counter64;
      description
        "The total number of octets sent or received.";
    }
    leaf total-messages {
```

```
        type yang:counter64;
        description
          "The number of messages sent or received.";
      }
      leaf address {
        type yang:counter64;
        description
          "The number of address messages sent or received.";
      }
      leaf address-withdraw {
        type yang:counter64;
        description
          "The number of address-withdraw messages sent or received.";
      }
      leaf initialization {
        type yang:counter64;
        description
          "The number of initialization messages sent or received.";
      }
      leaf keepalive {
        type yang:counter64;
        description
          "The number of keepalive messages sent or received.";
      }
      leaf label-abort-request {
        type yang:counter64;
        description
          "The number of label-abort-request messages sent or
           received.";
      }
      leaf label-mapping {
        type yang:counter64;
        description
          "The number of label-mapping messages sent or received.";
      }
      leaf label-release {
        type yang:counter64;
        description
          "The number of label-release messages sent or received.";
      }
      leaf label-request {
        type yang:counter64;
        description
          "The number of label-request messages sent or received.";
      }
      leaf label-withdraw {
        type yang:counter64;
        description
```

```
         "The number of label-withdraw messages sent or received.";
     }
     leaf notification {
       type yang:counter64;
       description
         "The number of messages sent or received.";
     }
   } // statistics-peer-received-sent

   /*
    * Configuration data nodes
    */

   augment "/rt:routing/rt:routing-protocols" {
     description "LDP augmentation.";

     container mpls-ldp {
       presence "Container for LDP protocol.";
       description
         "Container for LDP protocol.";

       container global {
         description
           "Global attributes for LDP.";
         container config {
           description
             "Configuration data.";
           uses global-attributes;
         }
         container state {
           config false;
           description
             "Operational state data.";
           uses global-attributes;
         }

         container mldp {
           if-feature mldp;
           description
             "mLDP attributes at per instance level. Defining
              attributes here does not enable any MP capabilities.
              MP capabilities need to be explicitly enabled under
              container capability.";

           container config {
             description
               "Configuration data.";
             leaf enable {
```

```
                type boolean;
                description
                  "Enable mLDP.";
              }
            }
            container state {
              config false;
              description

                "Operational state data.";
              leaf enable {
                type boolean;
                description
                  "Enable mLDP.";
              }
            }

            list address-family {
              key "afi";
              description
                "Per-af params.";
              leaf afi {
                type address-family;
                description
                  "Address family type value.";
              }

              container config {
                description
                  "Configuration data.";
                container multicast-only-frr {
                  if-feature mldp-mofrr;
                  description
                    "Multicast only FRR (MoFRR) policy.";
                  leaf prefix-list {
                    type prefix-list-ref;
                    description
                      "Enables MoFRR for the specified access list.";
                  }
                } // multicast-only-frr
                container recursive-fec {
                  description
                    "Recursive FEC policy.";
                  leaf prefix-list {
                    type prefix-list-ref;
                    description
                      "Enables recursive FEC for the specified access
                       list.";
```

```
                }
              } // recursive-for
            }
            container state {
              config false;
              description
                "Operational state data.";
              container multicast-only-frr {
                if-feature mldp-mofrr;

                description
                  "Multicast only FRR (MoFRR) policy.";
                leaf prefix-list {
                  type prefix-list-ref;
                  description
                    "Enables MoFRR for the specified access list.";
                }
              } // multicast-only-frr
              container recursive-fec {
                description
                  "Recursive FEC policy.";
                leaf prefix-list {
                  type prefix-list-ref;
                  description
                    "Enables recursive FEC for the specified access
                     list.";
                }
              } // recursive-fec
            }

            container configured-leaf-lsps {
              description
                "Configured multicast LSPs.";

              container p2mp {
                description
                  "Configured point-to-multipoint LSPs.";
                uses mldp-configured-lsp-roots;
              }
              container mp2mp {
                description
                  "Configured multipoint-to-multipoint LSPs.";
                uses mldp-configured-lsp-roots;
              }
            } // configured-leaf-lsps
          } // list address-family
        } // mldp
```

```
          list address-family {
            key "afi";
            description
              "Per-vrf per-af params.";
            leaf afi {
              type address-family;
              description
                "Address family type value.";
            }

            container config {
              description
                "Configuration data.";
              leaf enable {
                type boolean;
                description
                  "'true' to enable the address family.";
              }
              uses policy-container;

              container ipv4 {
                when "../../af = 'ipv4'" {
                  description
                    "Only for IPv4.";
                }
                description
                  "IPv4 address family.";
                leaf transport-address {
                  type inet:ipv4-address;
                  description
                    "The transport address advertised in LDP Hello
                     messages.";
                }
              } // ipv4
              container ipv6 {
                when "../../af = 'ipv6'" {
                  description
                    "Only for IPv6.";
                }
                description
                  "IPv6 address family.";
                leaf transport-address {
                  type inet:ipv6-address;
                  description
                    "The transport address advertised in LDP Hello
                     messages.";
                }
              } // ipv6
```

```
            }
            container state {
              config false;
              description
                "Operational state data.";
              leaf enable {
                type boolean;
                description
                  "'true' to enable the address family.";
              }

              uses policy-container;

              container ipv4 {
                when "../../af = 'ipv4'" {
                  description
                    "Only for IPv4.";
                }
                description
                  "IPv4 address family.";
                leaf transport-address {
                  type inet:ipv4-address;
                  description
                    "The transport address advertised in LDP Hello
                     messages.";
                }

                container bindings {
                  description
                    "LDP address and label binding information.";
                  list address {
                    key "address";
                    description
                      "List of address bindings.";
                    leaf address {
                      type inet:ipv4-address;
                      description
                        "Binding address.";
                    }
                    uses binding-address-state-attributes;
                  } // binding-address

                  list fec-label {
                    key "fec";
                    description
                      "List of label bindings.";
                    leaf fec {
                      type inet:ipv4-prefix;
```

```
                    description
                      "Prefix FEC.";
                  }
                  uses binding-label-state-attributes;
                } // fec-label
              } // binding
            } // ipv4
            container ipv6 {
              when "../../af = 'ipv6'" {
                description
                  "Only for IPv6.";
              }
              description
                "IPv6 address family.";
              leaf transport-address {
                type inet:ipv6-address;
                description
                  "The transport address advertised in LDP Hello
                   messages.";
              }

              container binding {
                description
                  "LDP address and label binding information.";
                list address {
                  key "address";
                  description
                    "List of address bindings.";
                  leaf address {
                    type inet:ipv6-address;
                    description
                      "Binding address.";
                  }
                  uses binding-address-state-attributes;
                } // binding-address

                list fec-label {
                  key "fec";
                  description
                    "List of label bindings.";
                  leaf fec {
                    type inet:ipv6-prefix;
                    description
                      "Prefix FEC.";
                  }
                  uses binding-label-state-attributes;
                } // fec-label
              } // binding
```

```
            } // ipv6
          } // state
        } // address-family

        container discovery {
          description
            "Neibgbor discovery configuration.";

          container interfaces {
            description
              "A list of interfaces for basic descovery.";
            container config {
              description
                "Configuration data.";
              uses basic-discovery-timers;
            }
            container state {
              config false;
              description

                "Operational state data.";
              uses basic-discovery-timers;
            }

            list interface {
              key "interface";
              description
                "List of LDP interfaces.";
              leaf interface {
                type if:interface-ref;
                description
                  "Interface.";
              }
              container config {
                description
                  "Configuration data.";
                uses basic-discovery-timers {
                  if-feature per-interface-timer-config;
                }
                leaf igp-synchronization-delay {
                  if-feature per-interface-timer-config;
                  type uint16 {
                    range 3..60;
                  }
                  units seconds;
                  description
                    "Sets the interval that the LDP waits before
                     notifying the Interior Gateway Protocol (IGP)
```

```
                 that label exchange is completed so that IGP
                 can start advertising the normal metric for
                 the link.";
            }
          }
          container state {
            config false;
            description
              "Operational state data.";
            uses basic-discovery-timers {
              if-feature per-interface-timer-config;
            }
            leaf igp-synchronization-delay {
              if-feature per-interface-timer-config;
              type uint16 {
                range 3..60;
              }
              units seconds;
              description
                "Sets the interval that the LDP waits before
                 notifying the Interior Gateway Protocol (IGP)
                 that label exchange is completed so that IGP
                 can start advertising the normal metric for
                 the link.";
            }
            leaf next-hello {
              type uint16;
              units seconds;
              description "Time to send the next hello message.";
            }
          } // state

          list address-family {
            key "afi";
            description
              "Per-vrf per-af params.";
            leaf afi {
              type address-family;
              description
                "Address family type value.";
            }
            container config {
              description
                "Configuration data.";
              leaf enable {
                type boolean;
                description
                  "Enable the address family on the interface.";
```

```
                    }

                    container ipv4 {
                      must "/if:interfaces/if:interface"
                        + "[name = current()/../../../interface]/"
                        + "ip:ipv4" {
                        description
                          "Only if IPv4 is enabled on the interface.";
                      }
                      description
                        "IPv4 address family.";
                      leaf transport-address {
                        type union {
                          type enumeration {
                            enum "use-interface-address" {
                              description
                              "Use interface address as the transport
                               address.";
                            }
                          }
                          type inet:ipv4-address;
                        }
                        description
                          "IP address to be advertised as the LDP
                           transport address.";
                      }
                    }

                    container ipv6 {
                      must "/if:interfaces/if:interface"
                        + "[name = current()/../../../interface]/"
                        + "ip:ipv6" {
                        description
                          "Only if IPv6 is enabled on the interface.";
                      }
                      description
                        "IPv6 address family.";
                      leaf transport-address {
                        type union {
                          type enumeration {
                            enum "use-interface-address" {
                              description
                                "Use interface address as the transport
                                 address.";
                            }
                          }
                          type inet:ipv4-address;
                        }
```

```
                    description
                      "IP address to be advertised as the LDP
                       transport address.";
                  }
                } // ipv6
              }
              container state {
                config false;
                description
                  "Operational state data.";
                leaf enable {
                  type boolean;
                  description
                    "Enable the address family on the interface.";
                }

                container ipv4 {
                  must "/if:interfaces/if:interface"
                    + "[name = current()/../../../interface]/"
                    + "ip:ipv4" {
                    description
                      "Only if IPv4 is enabled on the interface.";
                  }
                  description
                    "IPv4 address family.";
                  leaf transport-address {
                    type union {
                      type enumeration {

                        enum "use-interface-address" {
                          description
                            "Use interface address as the transport
                             address.";
                        }
                      }
                      type inet:ipv4-address;
                    }
                    description
                      "IP address to be advertised as the LDP
                       transport address.";
                  }

                  list hello-adjacencies {
                    key "adjacent-address";
                    description "List of hello adjacencies.";

                    leaf adjacent-address {
                      type inet:ipv4-address;
```

```
                    description "";
                  }

                  uses adjacency-state-attributes;

                  leaf peer {
                    type leafref {
                      path "../../../../../../../../../peers/peer/"
                        + "lsr-id";
                    }
                    description
                      "LDP peer from this adjacency.";
                  }
                } // hello-adjacencies
              }
              container ipv6 {
                must "/if:interfaces/if:interface"
                  + "[name = current()/../../../interface]/"
                  + "ip:ipv6" {
                  description
                    "Only if IPv6 is enabled on the interface.";
                }
                description
                  "IPv6 address family.";
                leaf transport-address {
                  type union {
                    type enumeration {
                      enum "use-interface-address" {
                        description
                        "Use interface address as the transport
                         address.";
                      }
                    }
                    type inet:ipv4-address;
                  }
                  description
                    "IP address to be advertised as the LDP
                     transport address.";
                }

                list hello-adjacencies {
                  key "adjacent-address";
                  description "List of hello adjacencies.";

                  leaf adjacent-address {
                    type inet:ipv6-address;
                    description "";
                  }
```

```
                      uses adjacency-state-attributes;

                      leaf peer {
                        type leafref {
                          path "../../../../../../../../../peers/peer/"
                            + "lsr-id";
                        }
                        description
                          "LDP peer from this adjacency.";
                      }
                    } // hello-adjacencies
                  } // ipv6
                }
              } // address-family
            } // list interface
          } // interfaces

          container targeted
          {
            description
              "A list of targeted neighbors for extended discovery.";
            container config {

              description
                "Configuration data.";
              uses extended-discovery-timers;
              uses extended-discovery-policy-attributes;
            }
            container state {
              config false;
              description
                "Operational state data.";
              uses extended-discovery-timers;
              uses extended-discovery-policy-attributes;
            }

            list address-family {
              key "afi";
              description
                "Per-af params.";
              leaf afi {
                type address-family;
                description
                  "Address family type value.";
              }

              container state {
                config false;
```

```
                  description
                    "Operational state data.";

                  container ipv4 {
                    when "../../af = 'ipv4'" {
                      description
                        "For IPv4.";
                    }
                    description
                      "IPv4 address family.";
                    list hello-adjacencies {
                      key "local-address adjacent-address";
                      description "List of hello adjacencies.";

                      leaf local-address {
                        type inet:ipv4-address;
                        description "";
                      }
                      leaf adjacent-address {
                        type inet:ipv4-address;
                        description "";
                      }

                      uses adjacency-state-attributes;

                      leaf peer {
                        type leafref {
                          path "../../../../../../../../peers/peer/"
                            + "lsr-id";
                        }
                        description
                          "LDP peer from this adjacency.";
                      }
                    } // hello-adjacencies
                  } // ipv4

                  container ipv6 {
                    when "../../af = 'ipv6'" {
                      description
                        "For IPv6.";
                    }
                    description
                      "IPv6 address family.";
                    list hello-adjacencies {
                      key "local-address adjacent-address";
                      description "List of hello adjacencies.";

                      leaf local-address {
```

```
                    type inet:ipv6-address;
                    description "";
                  }
                  leaf adjacent-address {
                    type inet:ipv6-address;
                    description "";
                  }

                  uses adjacency-state-attributes;

                  leaf peer {
                    type leafref {
                      path "../../../../../../../../peers/peer/"
                        + "lsr-id";
                    }
                    description
                      "LDP peer from this adjacency.";
                  }
                } // hello-adjacencies
              } // ipv6
            } // state

            container ipv4 {
              when "../af = 'ipv4'" {
                description
                  "For IPv4.";
              }
              description
                "IPv4 address family.";
              list target {
                key "adjacent-address";
                description
                  "Targeted discovery params.";

                leaf adjacent-address {
                  type inet:ipv4-address;
                  description
                    "Configures a remote LDP neighbor and enables
                     extended LDP discovery of the specified
                     neighbor.";
                }
                container config {
                  description
                    "Configuration data.";
                  leaf enable {
                    type boolean;
                    description
                      "Enable the target.";
```

```
                    }
                    leaf local-address {
                      type inet:ipv4-address;
                      description
                        "The local address.";
                    }
                  }
                  container state {
                    config false;
                    description
                      "Operational state data.";
                    leaf enable {
                      type boolean;
                      description
                        "Enable the target.";
                    }
                    leaf local-address {
                      type inet:ipv4-address;
                      description
                        "The local address.";
                    }
                  } // state
                }
              } // ipv4
              container ipv6 {
                when "../af = 'ipv6'" {
                  description
                    "For IPv6.";
                }
                description
                  "IPv6 address family.";
                list target {
                  key "adjacent-address";
                  description
                    "Targeted discovery params.";

                  leaf adjacent-address {
                    type inet:ipv6-address;
                    description
                      "Configures a remote LDP neighbor and enables
                       extended LDP discovery of the specified
                       neighbor.";
                  }
                  container config {
                    description
                      "Configuration data.";
                    leaf enable {
                      type boolean;
```

```
                      description
                        "Enable the target.";
                    }
                    leaf local-address {
                      type inet:ipv6-address;
                      description
                        "The local address.";
                    }
                  }
                  container state {
                    config false;
                    description
                      "Operational state data.";
                    leaf enable {
                      type boolean;
                      description
                        "Enable the target.";
                    }
                    leaf local-address {
                      type inet:ipv6-address;
                      description
                        "The local address.";
                    }
                  } // state
                }
              } // ipv6
            } // address-family
          } // targeted
        } // discovery

        container forwarding-nexthop {
          if-feature forwarding-nexthop-config;
          description
            "Configuration for forwarding nexthop.";

          container interfaces {
            description
              "A list of interfaces on which forwarding is
               disabled.";

            list interface {
              key "interface";
              description
                "List of LDP interfaces.";
              leaf interface {
                type if:interface-ref;
                description
                  "Interface.";
```

```
                }
                list address-family {
                  key "afi";
                  description
                    "Per-vrf per-af params.";
                  leaf afi {
                    type address-family;
                    description
                      "Address family type value.";
                  }
                  container config {
                    description
                      "Configuration data.";
                    leaf ldp-disable {
                      type boolean;
                      description
                        "Disable LDP forwarding on the interface.";
                    }
                    leaf mldp-disable {
                      if-feature mldp;
                      type boolean;
                      description
                        "Disable mLDP forwarding on the interface.";
                    }
                  }
                  container state {
                    config false;
                    description
                      "Operational state data.";
                    leaf ldp-disable {
                      type boolean;
                      description
                        "Disable LDP forwarding on the interface.";
                    }
                    leaf mldp-disable {
                      if-feature mldp;

                      type boolean;
                      description
                        "Disable mLDP forwarding on the interface.";
                    }
                  }
                } // address-family
              } // list interface
            } // interfaces
          } // forwarding-nexthop
          uses policy-container {
            if-feature all-af-policy-config;
```

```
        }
      } // global

      container peers {
        description
          "Peers configuration attributes.";

        container config {
          description
            "Configuration data.";
          uses peer-authentication {
            if-feature global-session-authentication;
          }
          uses peer-attributes;

          container session-downstream-on-demand {
            if-feature session-downstream-on-demand-config;
            description
              "Session downstream-on-demand attributes.";
            leaf enable {
              type boolean;
              description
                "'true' if session downstream-on-demand is enabled.";
            }
            leaf peer-list {
              type peer-list-ref;
              description
                "The name of a peer ACL.";
            }
          }
        }
        container state {
          config false;
          description
            "Operational state data.";
          uses peer-authentication {
            if-feature global-session-authentication;
          }
          uses peer-attributes;

          container session-downstream-on-demand {
            if-feature session-downstream-on-demand-config;
            description
              "Session downstream-on-demand attributes.";
            leaf enable {
              type boolean;
              description
                "'true' if session downstream-on-demand is enabled.";
```

```
            }
            leaf peer-list {
              type peer-list-ref;
              description
                "The name of a peer ACL.";
            }
          }
        }

        list peer {
          key "lsr-id";
          description
            "List of peers.";

          leaf lsr-id {
            type yang:dotted-quad;
            description "LSR ID.";
          }

          container config {
            description
              "Configuration data.";
            leaf admin-down {
              type boolean;
              default false;
              description
                "'true' to disable the peer.";
            }

            container capability {
              description
                "Per peer capability";
              container mldp {
                if-feature mldp;
                description
                  "mLDP capabilities.";
                uses mldp-capabilities;
              }
            }

            uses peer-af-policy-container {
              if-feature all-af-policy-config;
            }

            uses peer-authentication;

            uses graceful-restart-attributes-per-peer {
              if-feature per-peer-graceful-restart-config;
```

```
              }

              uses peer-attributes {
                if-feature per-peer-session-attributes-config;
              }

              container address-family {
                description
                  "Per-vrf per-af params.";
                container ipv4 {
                  description
                    "IPv4 address family.";
                  uses peer-af-policy-container;
                }
                container ipv6 {
                  description
                    "IPv6 address family.";
                  uses peer-af-policy-container;
                } // ipv6
              } // address-family
            }
            container state {
              config false;
              description
                "Operational state data.";
              leaf admin-down {
                type boolean;
                default false;
                description
                  "'true' to disable the peer.";
              }

              container capability {
                description
                  "Per peer capability";
                container mldp {
                  if-feature mldp;
                  description
                    "mLDP capabilities.";
                  uses mldp-capabilities;
                }
              }

              uses peer-af-policy-container {
                if-feature all-af-policy-config;
              }

              uses peer-authentication;
```

```
              uses graceful-restart-attributes-per-peer {
                if-feature per-peer-graceful-restart-config;
              }

              uses peer-attributes {
                if-feature per-peer-session-attributes-config;
              }

              container address-family {
                description
                  "Per-vrf per-af params.";
                container ipv4 {
                  description
                    "IPv4 address family.";
                  uses peer-af-policy-container;

                  list hello-adjacencies {
                    key "local-address adjacent-address";
                    description "List of hello adjacencies.";

                    leaf local-address {
                      type inet:ipv4-address;
                      description "";
                    }
                    leaf adjacent-address {
                      type inet:ipv4-address;
                      description "";
                    }

                    uses adjacency-state-attributes;

                    leaf interface {
                      type if:interface-ref;
                      description "Interface for this adjacency.";
                    }
                  } // hello-adjacencies
                } // ipv4
                container ipv6 {
                  description
                    "IPv6 address family.";
                  uses peer-af-policy-container;

                  list hello-adjacencies {
                    key "local-address adjacent-address";
                    description "List of hello adjacencies.";

                    leaf local-address {
                      type inet:ipv6-address;
```

```
                    description "";
                  }
                  leaf adjacent-address {
                    type inet:ipv6-address;
                    description "";
                  }

                  uses adjacency-state-attributes;

                  leaf interface {
                    type if:interface-ref;
                    description "Interface for this adjacency.";
                  }
                } // hello-adjacencies
              } // ipv6
            } // address-family

            uses peer-state-derived;
          } // state
        } // list peer
      } // peers
    } // container mpls-ldp
  }

  /*
   * RPCs
   */
  rpc mpls-ldp-clear-peer {
    description
      "Clears the session to the peer.";
    input {
      leaf lsr-id {
        type union {
          type yang:dotted-quad;
          type uint32;
        }
        description
          "LSR ID of peer to be cleared. If this is not provided
           then all peers are cleared";
      }
    }
  }

  rpc mpls-ldp-clear-hello-adjacency {
    description
      "Clears the hello adjacency";
    input {
      container hello-adjacency {
```

```
         description
           "Link adjacency or targettted adjacency. If this is not
            provided then all hello adjacencies are cleared";
         choice hello-adjacency-type {
           description "Adjacency type.";
           case targeted {
             container targeted {
               presence "Present to clear targeted adjacencies.";
               description
                 "Clear targeted adjacencies.";
               leaf target-address {
                 type inet:ip-address;
                 description
                   "The target address. If this is not provided then
                    all targeted adjacencies are cleared";
               }
             } // targeted
           }
           case link {
             container link {
               presence "Present to clear link adjacencies.";
               description
                 "Clear link adjacencies.";
               leaf next-hop-interface {
                 type if:interface-ref;
                 description

                   "Interface connecting to next-hop. If this is not
                    provided then all link adjacencies are cleared.";
               }
               leaf next-hop-address {
                 type inet:ip-address;
                 must "../next-hop-interface" {
                   description
                     "Applicable when interface is specified.";
                 }
                 description
                   "IP address of next-hop. If this is not provided
                    then adjacencies to all next-hops on the given
                    interface are cleared.";
               } // next-hop-address
             } // link
           }
         }
       }
     }
   }
```

```
   rpc mpls-ldp-clear-peer-statistics {
     description
       "Clears protocol statistics (e.g. sent and received
        counters).";
     input {
       leaf lsr-id {
         type union {
           type yang:dotted-quad;
           type uint32;
         }
         description
           "LSR ID of peer whose statistic are to be cleared.
            If this is not provided then all peers statistics are
            cleared";
       }
     }
   }

   /*
    * Notifications
    */
   notification mpls-ldp-peer-event {

     description
       "Notification event for a change of LDP peer operational
        status.";
     leaf event-type {
       type oper-status-event-type;
       description "Event type.";
     }
     uses ldp-peer-ref;
   }

   notification mpls-ldp-hello-adjacency-event {
     description
       "Notification event for a change of LDP adjacency operational
        status.";
     leaf event-type {
       type oper-status-event-type;
       description "Event type.";
     }
     uses ldp-adjacency-ref;
   }

   notification mpls-ldp-fec-event {
     description
       "Notification event for a change of FEC status.";
     leaf event-type {
```

```
      type oper-status-event-type;
      description "Event type.";
    }
    uses ldp-fec-event;
  }

  notification mpls-mldp-fec-event {
    description
      "Notification event for a change of FEC status.";
    leaf event-type {
      type oper-status-event-type;
      description "Event type.";
    }
    uses mldp-fec-event;
  }
}

<CODE ENDS>
```

Figure 17

6. Security Considerations

The configuration, state, action and notification data defined using YANG data models in this document are likely to be accessed via the protocols such as NETCONF [RFC6241] etc.

Hence, YANG implementations MUST comply with the security requirements specified in section 15 of [RFC6020]. Additionally, NETCONF implementations MUST comply with the security requirements specified in sections 2.2, 2.3 and 9 of [RFC6241] as well as section 3.7 of [RFC6536].

7. IANA Considerations

This document does not extend LDP or mLDP base protocol specifiction and hence there are no IANA considerations.

Note to the RFC Editor: Please remove IANA section before the publication.

8. Acknowledgments

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