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Multicast YANG Data Model
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Abstract

This document intents to provide a general and all-round multicast YANG data model, which tries to stand at a high level to take full advantages of existed multicast protocol models to control the multicast network, and guides the deployment of multicast service. And also, there will define several possible RPCs about how to interact between multicast YANG data model and multicast protocol models. This multicast YANG data model is mainly used by the management tools run by the network operators in order to manage, monitor and debug the network resources used to deliver multicast service, as well as gathering some data from the network.

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1. Introduction

Currently, there are many multicast protocol YANG models, such as PIM, MLD, and BIER and so on. But all these models are distributed in different working groups as separate files and focus on the protocol itself. Furthermore, they cannot describe a high-level multicast service required by network operators.

This document intents to provide a general and all-round multicast model, which tries to stand at a high level to take full advantages of these aforementioned models to control the multicast network, and guides the deployment of multicast service.

This multicast YANG data model is mainly used by the management tools run by the network operators in order to manage, monitor and debug the network resources used to deliver multicast service, as well as gathering some data from the network.

```
                  +------------------------+
                  |    Multicast Model   |
                  +------------------------+
                    |        |          |
                    |        |          |
                    |  +---------+  +-----------+
                    |  | EMS/NMS |  |Controller|
                    |  +---------+  +-----------+
                    |        |          |
                    |        |          |
           +-------------------------------------------------+
           |               Network Element1.....N           |
           +-------------------------------------------------+
```

Figure 1: Example usage of Multicast Model

Detailly, in figure 1, there is an example of usage of this multicast model. Network operators can use this model in a controller who is responsible to implement some multicast flows with specific protocols and invoke the corresponding protocols' model to configure the network elements through NETCONF/RESTCONF/CLI. Or network operators can use this model to the EMS/NMS to manage the network elements or configure the network elements directly. For example, a multicast service need to be delopy in a network, supposed that the multicast flow is 239.0.0.0/8, the flow should be transport by BIER technology. Then we use this multicast YANG data model and set the correspond key (239.0.0.0) and associated transport technology with BIER, send the model from controller to every egde node in the network. Then there is an interaction among all the nodes to exchange the multicast flow information. The ingress node will encapsulate the multicast flow with BIER header and send it into the network. Intermediate nodes will forward the flows to all the egress nodes by BIER forwarding.

On the other hand, when the network elements detect failure or some other changes, the network devices can send the affected multicast flows and the associated overlay/ transport/ underlay information to the controller. Then the controller/ EMS/NMS can response immediately due to the failure and distribute new model for the flows to the network nodes quickly. Such as the changing of the failure overlay protocol to another one, as well as transport and underlay protocol.

Specifically, in section 3, it provides a human readability of the whole multicast network through UML like class diagram, which frames different multicast components and correlates them in a readable fashion. Then, based on this UML like class diagram, there is instantiated and detailed YANG model in Section 5.

In other words, this document does not define any specific protocol model, instead, it depends on many existed multicast protocol models and relates several multicast information together to fulfill multicast service.

2. Design of the multicast model

This model includes multicast service keys and three layers: the multicast overlay, the transport layer and the multicast underlay information. Multicast keys include the features of multicast flow, such as(vpnid, multicast source and multicast group) information. In data center network, for fine-grained to gather the nodes belonging to the same virtual network, there may need VNI-related information to assist.

Multicast overlay defines (ingress-node, egress-nodes) nodes information. If the transport layer is BIER, there may define BIER information including (Subdomain, ingress-node BFR-id, egress-nodes BFR-id). If no (ingress-node, egress-nodes) information are defined directly, there may need overlay multicast signaling technology, such as MLD or MVPN, to collect these nodes information.

Multicast transport layer defines the type of transport technologies that can be used to forward multicast flow, including BIER forwarding type, MPLS forwarding type, or PIM forwarding type and so on. One or several transport technologies could be defined at the same time. As for the detailed parameters for each transport technology, this multicast YANG data model can invoke the corresponding protocol model to define them.

Multicast underlay defines the type of underlay technologies, such as OSPF, ISIS, BGP, PIM or BABEL and so on. One or several underlay technologies could be defined at the same time if there is protective requirement. As for the specific parameters for each underlay technology, this multicast YANG data model can depend the corresponding protocol model to configure them as well.

3. UML Class like Diagram for Multicast YANG data Model

The following is a UML like diagram for Multicast YANG data Model.

```
                                             +-------------------+
                                             |  Multicast  Model |
                                             +-------------------+
                                               |   |   |   |Contain
     +-----------------------------------------+   |   |   |
     |                         +---------------- -+    |
+---------------------------+
     |                         |
|                               |
+-----------+         +-------------------+           +----------------------
+         +--------------------+
|Multi-keys |         | Multicast Overlay |           | Multicast Transport
|         | Multicast Underlay |
+-----------+         +-------------------+           +----------------------
+         +--------------------+
|Group Addr |                |   |Contain                    | | | | |
invoke               | | | | | invoke
+-----------+       +---------+  +--------+             +----+ | | | +----
+            +----+ | | | +----+
|Source Addr|       |                    |              |      | | |
|            |      | | |      |
+-----------+ +------------+     +--------------+    +-----+   | | |   +------
+     +------+  | | |   +------+
|VPN Info   | |Overlay Tech|     | Ing/Eg Nodes |    | PIM |   | | |   | MPLS
|     | OSPF |  | | |   | PIM  |
+-----------+ +------------+     +--------------+    +-----+   | | |   +------
+     +------+  | | |   +------+
|VNI Info   | |     MLD    |     |Ingress Nodes |         +----+ | +-----
+               +----+ | +-----+
+-----------+ +------------+     +--------------+         |      |
|               |      |       |
              |     MVPN   |     |Egress Nodes  |   +----------+ |  +--------
+        +-----+   |    +------+
              +------------+     +--------------+   |Cisco Mode| |  |BIER-TE
|        |BABEL|   |    | BGP  |
              |     BGP    |             | relate   +----------+ |  +--------
+        +-----+   |    +------+
              +------------+            \|/                      +----
+                    +-----+
              |MLD-Snooping|    +----------------+
|                    |
              +------------+    | BIER Nodes Info|                 +------
+            +------+
                                +----------------+                 | BIER
|            | ISIS |
                                | BFR-ID         |                 +------
+            +------+
                                +----------------+
```

Figure 2: UML like Class Diagram for Multicast YANG data Model

4. Model Structure

```
module: ietf-multicast-model
    +--rw multicast-model
       +--rw multicast-keys* [vpn-rd source-address group-address vni-type vni-
value]
          +--rw vpn-rd                 rt-types:route-distinguisher
          +--rw source-address         ip-multicast-source-address
          +--rw group-address          rt-types:ip-multicast-group-address
          +--rw vni-type               virtual-type
          +--rw vni-value              uint32
          +--rw multicast-overlay
          |  +--rw ingress-egress
          |  |  +--rw ingress-node?   inet:ip-address
          |  |  +--rw egress-nodes* [egress-node]
          |  |     +--rw egress-node    inet:ip-address
          |  +--rw bier-ids
          |  |  +--rw sub-domain?     uint16
          |  |  +--rw ingress-node?   uint16
          |  |  +--rw egress-nodes* [egress-node]
          |  |     +--rw egress-node    uint16
          |  +--rw overlay-tech-type?   enumeration
          +--rw multicast-transport
          |  +--rw bier
          |  |  +--rw sub-domain?        uint16
          |  |  +--rw (encap-type)?
          |  |  |  +--:(mpls)
          |  |  |  +--:(eth)
          |  |  |  +--:(ipv6)
          |  |  +--rw bitstringlength?   uint16
          |  |  +--rw set-identifier?    uint16
          |  |  +--rw ecmp?              boolean
          |  |  +--rw frr?               boolean
          |  +--rw bier-te
          |  |  +--rw sub-domain?        uint16
          |  |  +--rw (encap-type)?
          |  |  |  +--:(mpls)
          |  |  |  +--:(non-mpls)
          |  |  +--rw bitstringlength?   uint16
          |  |  +--rw set-identifier?    uint16
          |  |  +--rw ecmp?              boolean
          |  |  +--rw frr?               boolean
          |  +--rw cisco-mode
          |  |  +--rw p-group?            rt-types:ip-multicast-group-address
          |  |  +--rw graceful-restart?   boolean
          |  |  +--rw bfd?                boolean
          |  +--rw mpls
          |  |  +--rw (mpls-tunnel-type)?
          |  |     +--:(mldp)
          |  |     |  +--rw mldp-tunnel-id?       uint32
          |  |     |  +--rw mldp-frr?             boolean
          |  |     |  +--rw mldp-backup-tunnel?   boolean
          |  |     +--:(p2mp-te)
          |  |        +--rw te-tunnel-id?         uint32
          |  |        +--rw te-frr?               boolean
          |  |        +--rw te-backup-tunnel?     boolean
          |  +--rw pim
          |     +--rw graceful-restart?   boolean
          |     +--rw bfd?                boolean
          +--rw multicast-underlay
             +--rw underlay-requirement?   boolean
             +--rw bgp
             +--rw ospf
             |  +--rw topology-id?   uint8
             +--rw isis
             |  +--rw topology-id?   uint16
             +--rw babel
```

```
  notifications:
    +---n head-end-event
       +--ro event-type?           enumeration
       +--ro multicast-key
       |  +--ro vpn-rd?            rt-types:route-distinguisher
       |  +--ro source-address?    ip-multicast-source-address
       |  +--ro group-address?     rt-types:ip-multicast-group-address
       |  +--ro vni-type?          virtual-type
       |  +--ro vni-value?         uint32
       +--ro overlay-tech-type?    enumeration
       +--ro transport-tech?       enumeration
       +--ro underlay-tech?        enumeration
```

5. Multicast YANG data Model

```
<CODE BEGINS> file "ietf-multicast-model.yang"
   module ietf-multicast-model {

    yang-version 1.1;

    namespace "urn:ietf:params:xml:ns:yang:ietf-multicast-model";
    prefix multicast-model;

    import ietf-inet-types {
        prefix "inet";
        reference "RFC6991";
    }

    import ietf-routing-types {
        prefix rt-types;
        reference "RFC8294";
    }

    organization " IETF MBONED( MBONE Deployment ) Working Group";
    contact
        "WG List:  <mailto:mboned@ietf.org>

         Editor:   Zheng Zhang
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        ";
```

```
    description
         "The module defines the YANG definitions for multicast service
          management.

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          identified as authors of the code.  All rights reserved.

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          set forth in Section 4.c of the IETF Trust's Legal Provisions
          Relating to IETF Documents
          (http://trustee.ietf.org/license-info).

          This version of this YANG module has relationship with
          overall multicast technologies, such as PIM(RFC7761),
          BIER(RFC8279), MVPN(RFC6513), and so on; see the RFC itself
          for full legal notices.";

    revision 2018-07-30 {
        description
         "Initial revision.";
       reference
         "RFC XXXX: A YANG Data Model for multicast YANG.
          RFC 7761: Protocol Independent Multicast - Sparse Mode (PIM-SM):
                    Protocol Specification (Revised).
          RFC 8279: Multicast Using Bit Index Explicit Replication (BIER);
          RFC 6513: Multicast in MPLS/BGP IP VPNs";
    }

/*key*/

    typedef ip-multicast-source-address {
        type union {
            type rt-types:ipv4-multicast-source-address;
            type rt-types:ipv6-multicast-source-address;
        }
        description
            "This type represents a version-neutral IP multicast
             source address.  The format of the textual
             representation implies the IP version.";
        reference
            "RFC8294: Common YANG Data Types for the Routing Area.";
    }

    typedef virtual-type {
        type enumeration {
            enum "vxlan" {
```

```
                description "The vxlan type. See more detail in RFC7348.";
            }
            enum "virtual subnet" {
                description "The nvgre type. See more detail in RFC7637.";
            }
            enum "vni" {
                description
                  "The geneve type. See more detail in [ietf-nvo3-geneve].";
            }
        }
        description "The collection of virtual network type.";
    }

    grouping general-multicast-key {
        description "The general multicast keys. They are used to
                     distinguish different multicast service.";
        leaf vpn-rd {
            type rt-types:route-distinguisher;
            description "A Route Distinguisher used to distinguish
                         routes from different MVPNs (RFC 6513).";
            reference
                "RFC8294: Common YANG Data Types for the Routing Area.";
        }
        leaf source-address {
            type ip-multicast-source-address;
            description
                "The IPv4/IPv6 source address of multicast flow. The
                 value set to zero means that the receiver interests
                 in all source that relevant to one given group.";
        }
        leaf group-address {
            type rt-types:ip-multicast-group-address;
            description
                "The IPv4/IPv6 group address of multicast flow. This
                 type represents a version-neutral IP multicast group
                 address. The format of the textual representation
                 implies the IP version.";
            reference
                "RFC8294: Common YANG Data Types for the Routing Area.";
        }
        leaf vni-type {
            type virtual-type;
            description
                "The type of virtual network identifier. Includes the
                 Vxlan, NVGRE and Geneve. This value and vni-value is
                 used to indicate a specific virtual multicast service.";
        }
        leaf vni-value {
```

```
            type uint32;
            description
                "The value of Vxlan network identifier, virtual subnet
                 ID or virtual net identifier. This value and vni-type
                 is used to indicate a specific virtual multicast service.";
        }
    }

/*overlay*/

    grouping overlay-technology {
        leaf overlay-tech-type {
            type enumeration {
                enum mld {
                    description "MLD technology is used for multicast
                        overlay. See more detail in [draft-ietf-bier-mld]";
                }
                enum mvpn {
                    description "MVPN technology is used for multicast
                        overlay. See more detail in RFC6513.";
                }
                enum bgp {
                    description "BGP technology is used for multicast
                                 overlay. See more detail in RFC7716.";
                }
                enum mld-snooping {
                    description "MLD snooping technology is used for
                                 multicast overlay. See more detail in
RFC4541.";
                }
            }
            description "The possible overlay technologies for multicast
service.";
        }
        description "The possible overlay technologies for multicast service.";
    }

    grouping multicast-overlay {
        description
          "The multicast overlay information, includes ingress node
           and egress nodes' information.";

        container ingress-egress {
            description "The ingress and egress nodes address collection.";
            leaf ingress-node {
                type inet:ip-address;
                description
                  "The ip address of ingress node for one or more
```

multicast flow. Or the ingress node of MVPN and
BIER. In MVPN, this is the address of ingress

```
                   PE; in BIER, this is the BFR-prefix of ingress
                   nodes.";
            }

            list egress-nodes {
                key "egress-node";
                description
                  "The egress multicast nodes of multicast flow. Or
                   the egress node of MVPN and BIER. In MVPN, this
                   is the address of egress PE; in BIER, this is the
                   BFR-prefix of ingress nodes.";

                leaf egress-node {
                    type inet:ip-address;
                    description
                      "The ip-address of egress multicast nodes.
                       See more details in RFC6513.";
                }
            }
        }

        container bier-ids {
            description
              "The BFR-ids of ingress and egress BIER nodes for
               one or more multicast flows.";
            leaf sub-domain {
                type uint16;
                description
                  "The sub-domain that this multicast flow belongs
                   to. See more details in RFC8279.";
            }
            leaf ingress-node {
                type uint16;
                description
                  "The ingress node of multicast flow. This is the
                   BFR-id of ingress nodes. See more details in RFC8279.";
            }
            list egress-nodes {
                key "egress-node";
                description
                  "This ID information of one adjacency. See more
                   details in RFC8279.";

                leaf egress-node {
                    type uint16;
                    description
                      "The BFR-ids of egress multicast BIER nodes.
                       See more details in RFC8279.";
```

```
                }
            }
        }

        uses overlay-technology;
    }


/*transport*/

    grouping transport-pim {
        description
          "The requirement information of pim transportion.
           PIM protocol is defined in RFC7761.";
        leaf graceful-restart {
            type boolean;
            description
              "If the graceful restart function should be supported.";
        }
        leaf bfd {
            type boolean;
            description "If the bfd function should be supported.";
        }
    }

    grouping multicast-transport {
        description "The transport information of multicast service.";
        container bier {
            description
              "The transport technology is BIER. The BIER technology
               is introduced in RFC8279. The parameter is consistent
               with the definition in [ietf-bier-bier-yang].";
            leaf sub-domain {
                type uint16;
                description
                  "The subdomain id that the multicast flow belongs
                   to. See more details in RFC8279.";
            }
            choice encap-type {
                case mpls {
                    description "The BIER forwarding depends on mpls.
                                 See more details in RFC8296.";
                }
                case eth {
                    description "The BIER forwarding depends on ethernet.
                                 See more details in RFC8296.";
                }
                case ipv6 {
```

```
                    description "The BIER forwarding depends on IPv6.";
                }
                description "The encapsulation type in BIER.";
            }
            leaf bitstringlength {
                type uint16;
                description "The bitstringlength used by BIER forwarding.
                             See more details in RFC8279.";
            }
            leaf set-identifier {
                type uint16;
                description "The set identifier used by the multicast flow.
                             See more details in RFC8279.";
            }
            leaf ecmp {
                type boolean;
                description
                  "The capability of ECMP. If this value is set to true,
                   ecmp mechanism should be enabled. See more details in
RFC8279.";
            }
            leaf frr {
                type boolean;
                description
                  "The capability of fast re-route. If this value is
                   set to true, fast re-route mechanism should be
                   enabled. See more details in RFC8279.";
            }
        }
        container bier-te {
            description
              "The transport technology is BIER-TE. BIER-TE technology
               is introduced in [ietf-bier-te-arch].";
            leaf sub-domain {
                type uint16;
                description
                  "The subdomain id that the multicast flow belongs to.
                   See more details in [ietf-bier-te-arch].";
            }
            choice encap-type {
                case mpls {
                    description
                      "The BIER-TE forwarding depends on mpls. See more
                       details in [ietf-bier-te-arch].";
                }
                case non-mpls {
                    description
                      "The BIER-TE forwarding depends on non-mpls. See
```

```
                         more details in [ietf-bier-te-arch].";
```

```
                }
                description "The encapsulation type in BIER-TE.";
            }
            leaf bitstringlength {
                type uint16;
                description "The bitstringlength used by BIER-TE forwarding.
                             See more details in [ietf-bier-te-arch].";
            }
            leaf set-identifier {
                type uint16;
                description
                  "The set identifier used by the multicast flow,
                   especially in BIER TE. See more details in
                   [ietf-bier-te-arch].";
            }
            leaf ecmp {
                type boolean;
                description
                  "The capability of ECMP. If this value is set to
                   true, ecmp mechanism should be enabled.
                   See more details in [ietf-bier-te-arch].";
            }
            leaf frr {
                type boolean;
                description
                  "The capability of fast re-route. If this value
                   is set to true, fast re-route mechanism should
                   be enabled. See more details in
                   [ietf-eckert-bier-te-frr].";
            }
        }
        container cisco-mode {
            description
              "The transport technology is cisco-mode. The Cisco MDT
               multicast mechanism is defined in RFC6037.";
            leaf p-group {
                type rt-types:ip-multicast-group-address;
                description
                  "The address of p-group. It is used to encapsulate
                   and forward flow according to multicast tree from
                   ingress node to egress nodes.";
            }
            uses transport-pim;
        }
        container mpls {
            description
              "The transport technology is mpls. MVPN overlay can use
               mpls tunnel technologies to build transport layer. The
```

```
                 usage is introduced in RFC6513.";
              choice mpls-tunnel-type {
                  case mldp {
                      description "The mldp tunnel. The protocol detail
                                   is defined in RFC6388.";
                      leaf mldp-tunnel-id {
                          type uint32;
                          description "The tunnel id that correspond this
                                       flow. The detail is defined in RFC6388.";
                      }
                      leaf mldp-frr {
                          type boolean;
                          description
                            "If the fast re-route function should be
                             supported. The detail is defined in RFC6388.";
                      }
                      leaf mldp-backup-tunnel {
                          type boolean;
                          description
                            "If the backup tunnel function should be
                             supported. The detail is defined in RFC6388.";
                      }
                  }
                  case p2mp-te {
                      description
                        "The p2mp te tunnel. The protocol detail is
                         defined in RFC4875.";
                      leaf te-tunnel-id {
                          type uint32;
                          description
                            "The tunnel id that correspond this flow.
                             The detail is defined in RFC4875.";
                      }
                      leaf te-frr {
                          type boolean;
                          description
                            "If the fast re-route function should be
                             supported. The detail is defined in RFC4875.";
                      }
                      leaf te-backup-tunnel {
                          type boolean;
                          description
                            "If the backup tunnel function should be
                             supported. The detail is defined in RFC4875.";
                      }
                  }
                  description "The collection types of mpls tunnels";
              }
```

```
        }
        container pim {
            uses transport-pim;
            description
              "The transport technology is PIM. PIM [RFC7761] is used
               commonly in traditional network.";
        }
    }

/*underlay*/

    grouping multicast-underlay {
        description
          "The underlay information relevant multicast service.
           Underlay protocols are used to build transport layer.
           It is unnecessary in traditional network that use
           PIM [RFC7761] to build multicast tree. Diversity underlay
           protocols can be choosed to build BIER transport layer.";
        leaf underlay-requirement {
            type boolean;
            description "If the underlay technology is required.";
        }
        container bgp {
            description
              "The underlay technology is BGP. BGP protocol RFC4271
               should be triggered to run if BGP is used as
               underlay protocol.";
        }
        container ospf {
            description
              "The underlay technology is OSPF. OSPF protocol RFC2328
               should be triggered to run if OSPF is used as underlay
               protocol.";
            leaf topology-id {
                type uint8;
                description
                  "The topology id of ospf instance. The topology id
                   can be assigned In some situations. More details
                   is defined in RFC2328.";
            }
        }
        container isis {
            description
              "The underlay technology is ISIS. ISIS protocol should
               be triggered to run if ISIS is used as underlay protocol.
               Details is defined in RFC1195.";
            leaf topology-id {
                type uint16;
```

```
                description
                  "The topology id of isis instance. The topology id
                   can be assigned In some situations.";
            }
        }
        container babel {
            description
              "The underlay technology is Babel. Babel protocol should
               be triggered to run if Babel is used as underlay protocol.";
        }
    }

    container multicast-model {
        description
          "The model of multicast YANG data. Include keys, overlay,
           transport and underlay.";

        list multicast-keys{
            key "vpn-rd source-address group-address vni-type vni-value";
            uses general-multicast-key;

            container multicast-overlay {
                description
                  "The overlay information of multicast service.
                   Overlay technology is used to exchange multicast
                   flows information. Overlay technology may not be
                   used in SDN controlled completely situation, but
                   it can be used in partial SDN controlled situation
                   or non-SDN controlled situation. Different overlay
                   technology can be choosed according to different
                   deploy consideration.";
                uses multicast-overlay;
            }
            container multicast-transport {
                description
                  "The transportion of multicast service. Transport
                   protocol is responsible for delivering multicast
                   flows from ingress nodes to egress nodes with or
                   without specific encapsulation. Different transport
                   technology can be choosed according to different
                   deploy consideration. Once a transport technology
                   is choosed, associated protocol should be triggered
                   to run.";
                uses multicast-transport;
            }
            container multicast-underlay {
                description
                  "The underlay of multicast service. Underlay protocol
```

```
                   is used to build transport layer. Underlay protocol
                   need not be assigned in ordinary network since
                   existed underlay protocol fits well, but it can be
                   assigned in particular networks for better
                   controll. Once a underlay technology is choosed,
                   associated protocol should be triggered to run.";
                uses multicast-underlay;
            }
            description
              "The model of multicast YANG data. Include keys,
               overlay, transport and underlay.";
        }
    }

/*Notifications*/

    notification head-end-event {
        leaf event-type {
            type enumeration {
                enum down {
                    description
                      "There is something wrong with head end node,
                       and head end node can't work properlay.";
                }
                enum module-loaded {
                    description
                      "Some new modules that can be used by multicast
                       flows finish loading.";
                }
                enum module-unloaded {
                    description
                      "Some new modules that can be used by multicast
                       flows have been unloaded.";
                }
            }
            description "Event type.";
        }
        container multicast-key {
            uses general-multicast-key;
            description
              "The associated multicast keys that are influenced by
               head end node failer.";
        }
        uses overlay-technology;

        leaf transport-tech {
            type enumeration {
                enum bier {
```

```
                    description
                      "BIER(RFC8279) technology can be used to
                       forward multicast flows.";
                }
                enum bier-te {
                    description
                      "BIER-TE(draft-ietf-bier-te-arch) technology
                       can be used to forward multicast flows.";
                }
                enum cisco-mode {
                    description
                      "Cisco mode(RFC6037) technology can be used
                       to forward multicast flows.";
                }
                enum mldp {
                    description
                      "MLDP(RFC6388) technology can be used to
                       forward multicast flows.";
                }
                enum p2mp-te {
                    description
                      "P2MP TE(RFC4875) technology can be used to
                       forward multicast flows.";
                }
                enum pim {
                    description
                      "PIM(RFC7761) technology can be used to
                       forward multicast flows.";
                }
            }
            description "The modules can be used to forward multicast flows.";
        }
        leaf underlay-tech {
            type enumeration {
                enum bgp {
                    description "BGP protocol can be used to build
                                 multicast transport layer.";
                }
                enum ospf {
                    description "OSPF protocol can be used to build
                                 multicast transport layer.";
                }
                enum isis {
                    description "ISIS protocol can be used to build
                                 multicast transport layer.";
                }
                enum babel {
                    description "Babel protocol can be used to build
```

```
                                 multicast transport layer.";
                }
            }
            description "The modules can be used to build multicast
                         transport layer.";
        }
        description
          "Notification events for the head end nodes. Like head
           node failer, overlay/ transport/ underlay module
           loading/ unloading. And the potential failer about some
           multicast flows and associated
           overlay/ transport/ underlay technologies.";
    }
}
<CODE ENDS>
```

6. Notifications

The defined Notifications include the events of head end nodes. Like head node failer, overlay/ transport/ underlay module loading/ unloading. And the potential failer about some multicast flows and associated overlay/ transport/ underlay technologies.

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