Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: February 29, 2020

J. Dong
X. Wei
Q. Wu
Huawei
M. Boucadair
Orange
A. Liu
Tecent

August 28, 2019

A YANG Data Model for Layer-2 Network Topologies
draft-ietf-i2rs-yang-l2-network-topology-10

Abstract

This document defines a YANG data model for Layer 2 network topologies.

Editorial Note (To be removed by RFC Editor)

Please update these statements within the document with the RFC number to be assigned to this document:

- "This version of this YANG module is part of RFC XXXX;"

- "RFC XXXX: A YANG Data Model for Layer-2 Network Topologies";

- reference: RFC XXXX

Please update the "revision" date of the YANG module.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at https://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on February 29, 2020.

Copyright Notice

Copyright (c) 2019 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (https://trustee.ietf.org/license-info) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1. Introduction 2
2. Terminology 3
3. Layer 2 Topology Model 3
4. Layer 2 Topology YANG Module 6
5. IANA Considerations 17
6. Security Considerations 18
7. Acknowledgements 19
8. References 19
  8.1. Normative References 19
  8.2. Informative References 21
Appendix A. Companion YANG Module for Non-NMDA Compliant Implementations 22
Appendix B. An Example 26
Authors' Addresses 31

1. Introduction

[RFC8345] defines the YANG [RFC6020] [RFC7950] data models of the abstract (generic) network and network topology. Such models can be augmented with technology-specific details to build more specific topology models.

This document defines the YANG data model for Layer 2 network topologies by augmenting the generic network and network topology data models with L2 specific topology attributes. A sample example is provided in Appendix B.

This document uses the common YANG types defined in [RFC6991] and adopts the Network Management Datastore Architecture (NMDA [RFC8342]).

The terminology for describing YANG modules is defined in [RFC7950]. The meanings of the symbols used in the tree diagram are defined in [RFC8340].

2. Terminology

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

3. Layer 2 Topology Model

The Layer 2 network topology YANG module is designed to be generic and applicable to Layer 2 networks built with different L2 technologies. It can be used to describe both the physical and the logical (virtual) L2 network topologies.

The relationship between the Layer 2 topology module and the generic network and network topology module is shown in Figure 1. In order to represent a Layer 2 network topology, the generic network and topology models are augmented with Layer-2 specific information, such as the identifiers, descriptions, attributes and states of the Layer-2 networks, nodes, links and termination points. Some of the information may be collected via Link Layer Discovery Protocol (LLDP) [IEEE802.1AB] or other Layer-2 protocols, and some of them may be locally configured.

```
+---------------------+
|    ietf-network     |
+----------^----------+
           |
           |
+---------------------+
|ietf-network-topology|
+----------^----------+
           |
           |
+----------^----------+
|   ietf-l2-topology  |
+---------------------+
```

Figure 1: L2-topology YANG Module Structure

The structure of "ietf-l2-topology" YANG module is depicted in the following tree diagram:

```
module: ietf-l2-topology
  augment /nw:networks/nw:network/nw:network-types:
    +--rw l2-network!
  augment /nw:networks/nw:network:
    +--rw l2-network-attributes
       +--rw name?   string
       +--rw flag*   l2-flag-type
  augment /nw:networks/nw:network/nw:node:
    +--rw l2-node-attributes
       +--rw name?                string
       +--rw description?         string
       +--rw management-address*  inet:ip-address
       +--rw sys-mac-address?     yang:mac-address
       +--rw management-vid?      vlan {VLAN}?
       +--rw flag*                node-flag-type
  augment /nw:networks/nw:network/nt:link:
    +--rw l2-link-attributes
       +--rw name?    string
       +--rw flag*    link-flag-type
       +--rw rate?    decimal64
       +--rw delay?   uint32
       +--rw srlg*    uint32
  augment /nw:networks/nw:network/nw:node/nt:termination-point:
    +--rw l2-termination-point-attributes
       +--rw description?         string
       +--rw maximum-frame-size?  uint32
       +--rw (l2-termination-point-type)?
       |  +--:(ethernet)
       |  |  +--rw mac-address?         yang:mac-address
       |  |  +--rw eth-encapsulation?   identityref
       |  |  +--rw port-vlan-id?        vlan {VLAN}?
       |  |  +--rw vlan-id-name* [vlan-id] {VLAN}?
       |  |     +--rw vlan-id      vlan
       |  |     +--rw vlan-name?   string
       |  +--:(legacy)
       |     +--rw layer-2-address?     yang:phys-address
       |     +--rw encapsulation?       identityref
       +--ro tp-state?            enumeration
  notifications:
    +---n l2-node-event
    |  +--ro event-type?
    |  +--ro node-ref?
    |  +--ro network-ref?
    |  +--ro l2-network!
    |  +--ro l2-node-attributes
    +---n l2-link-event
    |  +--ro event-type?
    |  +--ro link-ref?
```

```
       |  +--ro network-ref?
       |  +--ro l2-network!
       |  +--ro l2-link-attributes
       +---n l2-termination-point-event
          +--ro event-type?
          +--ro tp-ref?
          +--ro node-ref?
          +--ro network-ref?
          +--ro l2-network!
          +--ro l2-termination-point-attributes
```

The L2-topology module augments the generic 'ietf-network' and 'ietf-network-topology' modules as follows:

- o A new network type "l2-network-type" is introduced. This is represented by a container object, and is inserted under the "network-types" container of the generic 'ietf-network' module defined in [RFC8345].

- o Additional network attributes are introduced in a grouping "l2-network-attributes", which augments the "network" list of the 'ietf-network' module. The attributes include Layer-2 network name and a set of flags. Each type of flag is represented by a separate identity.

- o Additional data objects for Layer-2 nodes are introduced by augmenting the "node" list of the generic 'ietf-network' module. New objects include Layer-2 node identifier, description, management address, and a set of flags.

- o Additional data objects for Layer-2 termination points are introduced by augmenting the "termination-point" list of the 'ietf-network-topology' module defined in [RFC8345]. New objects include Layer-2 termination point descriptions, Layer-2 termination point type specific attributes and Layer-2 termination point states.

- o Links in the 'ietf-network-topology' module are augmented as well with a set of Layer-2 parameters, allowing to associate a link with a name, a set of Layer-2 link attributes and flags.

- o The optional L2 technology specific attributes are introduced in this module as Layer-2 features.

4. Layer 2 Topology YANG Module

This module uses the common YANG types defined in [RFC6991][RFC7224][IEEE802.1Qcp] and types defined in [RFC8345], and it references [RFC4761][RFC4762][RFC6325][RFC6326][RFC7348][RFC4202].

```
<CODE BEGINS> file "ietf-l2-topology@2019-06-04.yang"
module ietf-l2-topology {
    yang-version 1.1;
    namespace "urn:ietf:params:xml:ns:yang:ietf-l2-topology";
    prefix "l2t";

    import ietf-network {
      prefix "nw";
      reference
        "RFC 8345: A YANG Data Model for Network Topologies";
    }
    import ietf-network-topology {
      prefix "nt";
      reference
        "RFC 8345: A YANG Data Model for Network Topologies";
    }
    import ietf-inet-types {
      prefix "inet";
      reference "Section 4 of RFC 6991";
    }
    import ietf-yang-types {
      prefix "yang";
      reference "Section 3 of RFC 6991";
    }
     import iana-if-type  {
       prefix ift;
       reference
         "RFC 7224: IANA Interface Type YANG Module";
     }
     import ieee802-dot1q-types {
      prefix dot1q-type;
      reference
        "IEEE Std 802.1Q-2017: Virtual Bridged Local Area Networks.";
     }
    organization
      "IETF I2RS (Interface to the Routing System) Working Group";
    contact
      "WG Web:   <http://tools.ietf.org/wg/i2rs/>
       WG List:  <mailto:i2rs@ietf.org>
       Editor:    Jie Dong
                 <mailto:jie.dong@huawei.com>
```

```
       Editor:    Xiugang Wei
                 <mailto:weixiugang@huawei.com>

       Editor:    Qin Wu
                 <mailto:bill.wu@huawei.com>

       Editor:    Mohamed Boucadair
                 <mailto:mohamed.boucadair@orange.com>

       Editor:   Anders Liu
                 <andersliu@tencent.com>";

    description
      "This module defines a basic model for
       the layer-2 topology of a network.

       Copyright (c) 2019 IETF Trust and the persons identified as
       authors of the code.  All rights reserved.

       Redistribution and use in source and binary forms, with or
       without modification, is permitted pursuant to, and subject
       to the license terms contained in, the Simplified BSD License
       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 is part of
       RFC XXXX: A YANG Data Model for Layer-2 Network Topologies
       see the RFC itself for full legal notices.";

    revision "2019-06-04" {
      description "Initial revision";
      reference
        "RFC XXXX: A YANG Data Model for Layer-2 Network Topologies";
    }

   /*
    * Typedefs
    */

    typedef trill-nickname {
      type uint16;
      description "TRILL Nickname";
      reference
        "RFC 6326: Transparent Interconnection of Lots
         of Links (TRILL) Use of IS-IS";
    }
```

```
    typedef vni {
      type uint32 {
       range "1..16777215";
      }
      description "VxLAN Network Identifier";
      reference
        "RFC 7348: Virtual eXtensible Local Area
         Network (VXLAN): A Framework for Overlaying
         Virtualized Layer 2 Networks over Layer 3
         Networks";
    }

    typedef l2-flag-type {
      type identityref {
        base "flag-identity";
      }
      description "Base type for l2 flags";
    }
   typedef node-flag-type {
       type identityref {
         base "flag-identity";
       }
       description "Node flag attributes";
     }
   typedef link-flag-type {
       type identityref {
         base "flag-identity";
       }
       description "Link flag attributes";
     }

    typedef l2-network-event-type {
      type enumeration {
        enum "add" {
          value 0;
          description "An L2 node or link or termination-point
          has been added";
        }
        enum "remove" {
          value 1;
          description "An L2 node or link or termination-point
          has been removed";
        }
        enum "update" {
          value 2;
          description "An L2 node or link or termination-point
          has been updated";
        }
```

```
      }
      description "l2 network event type for notifications";
    } // l2-topology-event-type

    /*

    * Features
    */

    feature VLAN {
      description
        "Indicates that the system supports the
         vlan functions (also known as an IEEE 802.1Q tag).";
    }

    feature QinQ {
      description
        "Indicates that the system supports the
         qinq functions (also known as IEEE 802.1ad double tag)";
    }

    feature PBB {
      description
       "Indicates that the device supports the
        provider-backbone-bridging functions developed
        in IEEE 802.1ah.";
    }

    feature VPLS {
      description
        "Indicates that the device supports the
         VPLS functions.";
      reference
        "RFC 4761: Virtual Private LAN Service (VPLS) Using
         BGP for Auto-Discovery and Signaling
         RFC 4762: Virtual Private LAN Service (VPLS) Using
         Label Distribution Protocol (LDP) Signaling";
    }

    feature TRILL {
      description
        "Indicates that the device supports the
         TRILL functions.";
      reference
        "RFC 6325: Routing Bridges (RBridges): Base Protocol
         Specification";
    }
```

```
    feature VXLAN {
      description
        "Indicates that the device supports the
         VXLAN functions.";
      reference
        "RFC 7348: Virtual eXtensible Local Area Network (VXLAN):
         A Framework for Overlaying Virtualized Layer 2 Networks
         over Layer 3 Networks";
    }

   /*
    * Identities
    */

    identity flag-identity {
      description "Base type for flags.";
    }

    identity eth-encapsulation-type {
      base ift:iana-interface-type;
      description
        "Base identity from which specific Ethernet
         encapsulation types are derived.";
      reference
        "RFC 7224: IANA Interface Type YANG Module";
    }

    identity ethernet {
      base eth-encapsulation-type;
      description
        "Native Ethernet encapsulation.";
    }

    identity vlan {
      base eth-encapsulation-type;
      description
        "VLAN encapsulation.";
    }

    identity qinq {
      base eth-encapsulation-type;
      description
        "QinQ encapsulation.";
    }

    identity pbb {
      base eth-encapsulation-type;
      description
```

```
        "PBB encapsulation.";
    }

    identity trill {
      base eth-encapsulation-type;
      description
        "TRILL encapsulation.";
    }

    identity vpls {
      base eth-encapsulation-type;
      description
        "Ethernet VPLS interface encapsulation.";
    }

    identity vxlan {
      base eth-encapsulation-type;
      description
        "VXLAN MAC in UDP encapsulation.";
    }

   /*
    * Groupings
    */


    grouping l2-network-type {
      description "Identify the topology type to be L2.";
      container l2-network {
        presence "indicates L2 Network";
        description
        "The presence of the container node indicates
         L2 Topology.";
      }
    }

    grouping l2-network-attributes {
      description "L2 Topology scope attributes";
      container l2-network-attributes {
        description "Containing L2 network attributes";
        leaf name {
          type string;
          description "Name of the L2 network.";
        }

        leaf-list flag {
          type l2-flag-type;
          description "L2 network flags";
```

```
        }
      }
    }

    grouping l2-node-attributes {
      description "L2 node attributes";
      container l2-node-attributes {
        description "Containing L2 node attributes";
        leaf name {
          type string;
          description "Node name.";
        }
        leaf description {
          type string;
          description "Node description.";
        }
        leaf-list management-address {
          type inet:ip-address;
          description "System management address.";
        }
        leaf sys-mac-address {
          type yang:mac-address;
          description "System MAC-address.";
        }
        leaf management-vid {
          if-feature VLAN;
          type dot1q-type:vlanid;
          description "System management VID.";
        }
        leaf-list flag {
          type node-flag-type;
          description "Node operational flags.";
        }
      }
    }  // grouping l2-node-attributes

    grouping l2-link-attributes {
      description "L2 link attributes";
      container l2-link-attributes {
        description "Containing L2 link attributes.";
        leaf name {
          type string;
          description "Link name.";
        }
        leaf-list flag {
          type link-flag-type;
          description "Link flags.";
        }
```

```
        leaf rate {
          type decimal64 {
            fraction-digits 2;
          }
          units "Mbps";
          description "Link rate.";
        }
        leaf delay {
          type uint32;
          description "Link delay in microseconds.";
        }
        leaf-list srlg {
          type uint32;
          description
            "List of Shared Risk Link Groups
             this link belongs to.";
          reference
            "RFC 4202: Routing Extensions in Support of
            Generalized Multi-Protocol Label Switching
            (GMPLS)";
        }
      }
    } // grouping l2-link-attributes

    grouping l2-termination-point-attributes {
      description "L2 termination point attributes";
      container l2-termination-point-attributes {
        description "Containing L2 TP attributes";
        leaf description {
          type string;
          description "Port description.";
        }

        leaf maximum-frame-size {
          type uint32;
          description "Maximum L2 frame size. If L2 frame is an ethernet
          frame, the ethernet header should be included; if L2 frame is
          other type (e.g.,PPP), the L2 header should be
          included.";
        }

        choice l2-termination-point-type {
          description
            "Indicates termination-point type
             specific attributes.";
          case ethernet {
            leaf mac-address {
              type yang:mac-address;
```

```
              description "Interface MAC address.";
            }

            leaf eth-encapsulation {
              type identityref {
                base eth-encapsulation-type;
              }
              description
                "Encapsulation type of this
                 termination point.";
            }

            leaf port-vlan-id {
              if-feature VLAN;
              type dot1q-type:vlanid;
              description "Port VLAN ID is the VLAN id that
              will be assigned to any untagged frames entering
              the switch on the specific port.";
            }

            list vlan-id-name {
              if-feature VLAN;
              key "vlan-id";
              description "Interface configured VLANs.";
              leaf vlan-id {
                type dot1q-type:vlanid;
                description "VLAN ID.";
              }
              leaf vlan-name {
                type string {
                length "1..31";
                }
                description "VLAN name.";
              }
            }
          } //case ethernet

          case legacy {
            leaf layer-2-address {
              type yang:phys-address;
              description "Interface Layer 2 address.";
            }

            leaf encapsulation {
              type identityref {
                base ift:iana-interface-type;
              }
              description
```

```
                "Other legacy encapsulation type of this
                 termination point.";
            }
          } //case legacy such as atm, ppp, hdlc,etc.

        } //choice termination-point-type

        leaf tp-state {
          type enumeration {
            enum in-use {
              value 1;
              description
                "the termination point is in forwarding state.";
            }
            enum blocking {
              value 2;
              description
                "the termination point is in blocking state.";
            }
            enum down {
              value 3;
              description
                "the termination point is in down state.";
            }
            enum others {
              value 4;
              description
                "the termination point is in other state.";
            }
          }
          config false;
          description "State of the termination point.";
        }
      }
    } // grouping l2-termination-point-attributes

   /*
    * Data nodes
    */

    augment "/nw:networks/nw:network/nw:network-types" {
      description
        "Introduce new network type for L2 topology.";
      uses l2-network-type;
    }

    augment "/nw:networks/nw:network" {
      when "/nw:networks/nw:network/nw:network-types/l2t:l2-network" {
```

```
        description
          "Augmentation parameters apply only for networks
           with L2 topology.";
      }
      description
        "Configuration parameters for the L2 network
         as a whole";
      uses l2-network-attributes;
    }

    augment "/nw:networks/nw:network/nw:node" {
      when "/nw:networks/nw:network/nw:network-types/l2t:l2-network" {
        description
          "Augmentation parameters apply only for networks
           with L2 topology.";
      }
      description
        "Configuration parameters for L2 at the node
         level.";
      uses l2-node-attributes;
    }

    augment "/nw:networks/nw:network/nt:link" {
      when "/nw:networks/nw:network/nw:network-types/l2t:l2-network" {
        description
          "Augmentation parameters apply only for networks
           with L2 topology.";
      }
      description "Augment L2 topology link information";
      uses l2-link-attributes;
    }

    augment "/nw:networks/nw:network/nw:node/nt:termination-point" {
      when "/nw:networks/nw:network/nw:network-types/l2t:l2-network" {
        description
          "Augmentation parameters apply only for networks
           with L2 topology.";
      }
      description
        "Augment L2 topology termination point information.";
      uses l2-termination-point-attributes;
    }

    /*
     * Notifications
     */

    notification l2-node-event {
```

```
      description "Notification event for L2 node";
      leaf event-type {
        type l2-network-event-type;
        description "Event type.";
      }
      uses nw:node-ref;
      uses l2-network-type;
      uses l2-node-attributes;
    }

    notification l2-link-event {
      description "Notification event for L2 link.";
      leaf event-type {
        type l2-network-event-type;
        description "Event type";
      }
      uses nt:link-ref;
      uses l2-network-type;
      uses l2-link-attributes;
    }

    notification l2-termination-point-event {
      description "Notification event for L2 termination point.";
      leaf event-type {
        type l2-network-event-type;
        description "Event type";
      }
      uses nt:tp-ref;
      uses l2-network-type;
      uses l2-termination-point-attributes;
    }
}  // module l2-topology
<CODE ENDS>
```

5. IANA Considerations

This document requests IANA to register the following URIs in the "ns" subregistry within the "IETF XML Registry" [RFC3688]:

```
      URI: urn:ietf:params:xml:ns:yang:ietf-l2-topology
      Registrant Contact: The IESG.
      XML: N/A; the requested URI is an XML namespace.

      URI: urn:ietf:params:xml:ns:yang:ietf-l2-topology-state
      Registrant Contact: The IESG.
      XML: N/A; the requested URI is an XML namespace.
```

This document requests IANA to register the following YANG modules in the "YANG Module Names" subregistry [RFC6020] within the "YANG Parameters" registry.

```
name: ietf-l2-topology
namespace: urn:ietf:params:xml:ns:yang:ietf-l2-topology
prefix: l2t
reference: RFC XXXX

name: ietf-l2-topology-state
namespace: urn:ietf:params:xml:ns:yang:ietf-l2-topology-state
prefix: l2t-s
reference: RFC XXXX
```

These modules are not maintained by IANA.

6. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].

The Network Configuration Access Control Model (NACM) [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

In general, Layer 2 network topologies are system-controlled and provide ephemeral topology information. In an NMDA-complient server, they are only part of <operational> which provides read-only access to clients, they are less vulnerable. That said, the YANG module does in principle allow information to be configurable.

The Layer 2 topology module define information that can be configurable in certain instances, for example in the case of virtual topologies that can be created by client applications. In such cases, a malicious client could introduce topologies that are undesired. Specifically, a malicious client could attempt to remove or add a node, a link, a termination point, by creating or deleting corresponding elements in the node, link, and termination point lists, respectively. In the case of a topology that is learned, the server will automatically prohibit such misconfiguration attempts. In the case of a topology that is configured, i.e. whose origin is "intended", the undesired configuration could become effective and be

reflected in the operational state datastore, leading to disruption of services provided via this topology might be disrupted. For those reasons, it is important that the NETCONF access control model is vigorously applied to prevent topology misconfiguration by unauthorized clients.

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

- o l2-network-attributes: A malicious client could attempt to sabotage the configuration of any of the contained attributes, such as the name or the flag data nodes.

- o l2-node-attributes: A malicious client could attempt to sabotage the configuration of important node attributes, such as the name or the management-address.

- o l2-link-attributes: A malicious client could attempt to sabotage the configuration of important link attributes, such as the rate or the delay data nodes.

- o l2-termination-point-attributes: A malicious client could attempt to sabotage the configuration of important termination point attributes, such as the maximum-frame-size.

7. Acknowledgements

The authors would like to acknowledge the comments and suggestions received from Susan Hares, Alia Atlas, Juergen Schoenwaelder, Mach Chen, Alexander Clemm and Sriganesh Kini.

8. References

8.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <https://www.rfc-editor.org/info/rfc3688>.

[RFC4202] Kompella, K., Ed. and Y. Rekhter, Ed., "Routing Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", RFC 4202, DOI 10.17487/RFC4202, October 2005, <https://www.rfc-editor.org/info/rfc4202>.

[RFC4761] Kompella, K., Ed. and Y. Rekhter, Ed., "Virtual Private LAN Service (VPLS) Using BGP for Auto-Discovery and Signaling", RFC 4761, DOI 10.17487/RFC4761, January 2007, <https://www.rfc-editor.org/info/rfc4761>.

[RFC4762] Lasserre, M., Ed. and V. Kompella, Ed., "Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling", RFC 4762, DOI 10.17487/RFC4762, January 2007, <https://www.rfc-editor.org/info/rfc4762>.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <https://www.rfc-editor.org/info/rfc6020>.

[RFC6325] Perlman, R., Eastlake 3rd, D., Dutt, D., Gai, S., and A. Ghanwani, "Routing Bridges (RBridges): Base Protocol Specification", RFC 6325, DOI 10.17487/RFC6325, July 2011, <https://www.rfc-editor.org/info/rfc6325>.

[RFC6326] Eastlake, D., Banerjee, A., Dutt, D., Perlman, R., and A. Ghanwani, "Transparent Interconnection of Lots of Links (TRILL) Use of IS-IS", RFC 6326, DOI 10.17487/RFC6326, July 2011, <https://www.rfc-editor.org/info/rfc6326>.

[RFC6991] Schoenwaelder, J., Ed., "Common YANG Data Types", RFC 6991, DOI 10.17487/RFC6991, July 2013, <https://www.rfc-editor.org/info/rfc6991>.

[RFC7224] Bjorklund, M., "IANA Interface Type YANG Module", RFC 7224, DOI 10.17487/RFC7224, May 2014, <https://www.rfc-editor.org/info/rfc7224>.

[RFC7348] Mahalingam, M., Dutt, D., Duda, K., Agarwal, P., Kreeger, L., Sridhar, T., Bursell, M., and C. Wright, "Virtual eXtensible Local Area Network (VXLAN): A Framework for Overlaying Virtualized Layer 2 Networks over Layer 3 Networks", RFC 7348, DOI 10.17487/RFC7348, August 2014, <https://www.rfc-editor.org/info/rfc7348>.

[RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, DOI 10.17487/RFC7950, August 2016, <https://www.rfc-editor.org/info/rfc7950>.

[RFC7951] Lhotka, L., "JSON Encoding of Data Modeled with YANG", RFC 7951, DOI 10.17487/RFC7951, August 2016, <https://www.rfc-editor.org/info/rfc7951>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8341] Bierman, A. and M. Bjorklund, "Network Configuration Access Control Model", STD 91, RFC 8341, DOI 10.17487/RFC8341, March 2018, <https://www.rfc-editor.org/info/rfc8341>.

[RFC8345] Clemm, A., Medved, J., Varga, R., Bahadur, N., Ananthakrishnan, H., and X. Liu, "A YANG Data Model for Network Topologies", RFC 8345, DOI 10.17487/RFC8345, March 2018, <https://www.rfc-editor.org/info/rfc8345>.

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

8.2. Informative References

[IEEE802.1AB]
"Station and Media Access Control Connectivity Discovery", IEEE Std 802.1AB-2016, 2016.

[IEEE802.1ad]
"Virtual Bridged Local Area Networks Amendment 4: Provider Bridges", IEEE Std 802.1ad-2005, December 2005.

[IEEE802.1ah]
"Virtual Bridged Local Area Networks Amendment 4: Provider Bridges", IEEE Std 802.1ah-2008, June 2008.

[IEEE802.1Qcp]
"Bridges and Bridged Networks - Amendment: YANG Data Model", IEEE Std 802.1Qcp-2018, 2018.

[RFC5246] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", RFC 5246, DOI 10.17487/RFC5246, August 2008, <https://www.rfc-editor.org/info/rfc5246>.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <https://www.rfc-editor.org/info/rfc6241>.

[RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure Shell (SSH)", RFC 6242, DOI 10.17487/RFC6242, June 2011, <https://www.rfc-editor.org/info/rfc6242>.

[RFC6536] Bierman, A. and M. Bjorklund, "Network Configuration Protocol (NETCONF) Access Control Model", RFC 6536, DOI 10.17487/RFC6536, March 2012, <https://www.rfc-editor.org/info/rfc6536>.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <https://www.rfc-editor.org/info/rfc8040>.

[RFC8340] Bjorklund, M. and L. Berger, Ed., "YANG Tree Diagrams", BCP 215, RFC 8340, DOI 10.17487/RFC8340, March 2018, <https://www.rfc-editor.org/info/rfc8340>.

[RFC8342] Bjorklund, M., Schoenwaelder, J., Shafer, P., Watsen, K., and R. Wilton, "Network Management Datastore Architecture (NMDA)", RFC 8342, DOI 10.17487/RFC8342, March 2018, <https://www.rfc-editor.org/info/rfc8342>.

Appendix A. Companion YANG Module for Non-NMDA Compliant Implementations

The YANG module ietf-l2-topology defined in this document augments two modules, ietf-network and ietf-network-topology, that are designed to be used in conjunction with implementations that support the Network Management Datastore Architecture (NMDA) defined in [RFC8342]. In order to allow implementations to use the model even in cases when NMDA is not supported, a set of companion modules have been defined that represent a state model of networks and network topologies, ietf- network-state and ietf-network-topology-state, respectively.

In order to be able to use the model for layer 2 topologies defined in this document in conjunction with non-NMDA compliant implementations, a corresponding companion module is defined that represent the operational state of layer 2 network topologies. The module ietf-l2-topology-state mirrors the module ietf-l2-topology defined earlier in this document. However, it augments ietf-network-state and ietf-network-topology-state (instead of ietf-network and ietf-network-topology) and all its data nodes are non-configurable.

The companion module ietf-l2-topology SHOULD NOT be supported by implementations that support NMDA. It is for this reason that this module is defined in the informative Appendix.

As the structure of this modules mirrors that of its underlying modules, the YANG tree is not depicted separately.

```
<CODE BEGINS> file "ietf-l2-topology-state@2019-06-04.yang"
module ietf-l2-topology-state {
    yang-version 1.1;
    namespace "urn:ietf:params:xml:ns:yang:ietf-l2-topology-state";
    prefix "l2t-s";

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

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

    import ietf-l2-topology {
      prefix "l2t";
      reference
        "RFC XXXX: A YANG Data Model for Layer-2 Network Topologies";
    }

    organization
      "IETF I2RS (Interface to the Routing System) Working Group";
    contact
      "WG Web:   <http://tools.ietf.org/wg/i2rs/>
       WG List:  <mailto:i2rs@ietf.org>
       Editor:    Jie Dong
                 <mailto:jie.dong@huawei.com>
       Editor:    Xiugang Wei
                 <mailto:weixiugang@huawei.com>
       Editor:    Qin Wu
                 <mailto:bill.wu@huawei.com>
       Editor:    Mohamed Boucadair
                 <mailto:mohamed.boucadair@orange.com>
       Editor:   Anders Liu
                 <andersliu@tencent.com>";

    description
```

```
      " This module defines a model for Layer 2 Network Topology
        state, representing topology that either is learned or
        results from applying topology that has been configured per
        the 'ietf-l2-topology' model, mirroring the
        corresponding data nodes in this model.

        This model mirrors 'ietf-l2-topology' but contains only
        read-only state data.  The model is not needed when the
        underlying implementation infrastructure supports the Network
        Management Datastore Architecture (NMDA).

       Copyright (c) 2018 IETF Trust and the persons identified as
       authors of the code.  All rights reserved.

       Redistribution and use in source and binary forms, with or
       without modification, is permitted pursuant to, and subject
       to the license terms contained in, the Simplified BSD License
       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 is part of
       RFC XXXX: A YANG Data Model for Layer-2 Network Topologies
       see the RFC itself for full legal notices.";

    revision "2019-06-04" {
      description "Initial revision";
      reference "RFC XXXX: A YANG Data Model for Layer-2 Network Topologies";
    }

   /*
    * Data nodes
    */
    augment "/nw-s:networks/nw-s:network/nw-s:network-types" {
      description
        "Introduce new network type for L2 topology";
      uses l2t:l2-network-type;
    }

    augment "/nw-s:networks/nw-s:network" {
      when "/nw-s:networks/nw-s:network/nw-s:network-types/"+
        "l2t-s:l2-network" {
        description
          "Augmentation parameters apply only for networks
           with L2 topology";
      }
      description
        "Configuration parameters for the L2 network
```

```
         as a whole";
      uses l2t:l2-network-attributes;
    }

    augment "/nw-s:networks/nw-s:network/nw-s:node" {
      when "../nw-s:network-types/l2t-s:l2-network" {
        description
          "Augmentation parameters apply only for networks
           with L2 topology";
      }
      description
        "Configuration parameters for L2 at the node
         level";
      uses l2t:l2-node-attributes;
    }

    augment "/nw-s:networks/nw-s:network/nt-s:link" {
      when "../nw-s:network-types/l2t-s:l2-network" {
        description
          "Augmentation parameters apply only for networks
           with L2 topology";
      }
      description "Augment L2 topology link information";
      uses l2t:l2-link-attributes;
    }

    augment "/nw-s:networks/nw-s:network/nw-s:node/"+
      "nt-s:termination-point" {
      when "../../nw-s:network-types/l2t-s:l2-network" {
        description
          "Augmentation parameters apply only for networks
           with L2 topology";
      }
      description
        "Augment L2 topology termination point information";
      uses l2t:l2-termination-point-attributes;
    }

   /*
    * Notifications
    */

    notification l2-node-event {
      description "Notification event for L2 node";
      leaf event-type {
        type l2t:l2-network-event-type;
        description "Event type";
      }
```

```
      uses nw-s:node-ref;
      uses l2t:l2-network-type;
      uses l2t:l2-node-attributes;
    }

    notification l2-link-event {
      description "Notification event for L2 link";
      leaf event-type {
        type l2t:l2-network-event-type;
        description "Event type";
      }
      uses nt-s:link-ref;
      uses l2t:l2-network-type;
      uses l2t:l2-link-attributes;
    }

    notification l2-termination-point-event {
      description "Notification event for L2 termination point";
      leaf event-type {
        type l2t:l2-network-event-type;
        description "Event type";
      }
      uses nt-s:tp-ref;
      uses l2t:l2-network-type;
      uses l2t:l2-termination-point-attributes;
    }
}  // module l2-topology-state
<CODE ENDS>
```

Appendix B. An Example

This section contains an example of an instance data tree in JSON encoding [RFC7951]. The example instantiates "ietf-l2- topology" for the topology that is depicted in the following diagram. There are three nodes: D1, D2, and D3. D1 has three termination points: 1-0-1, 1-2-1, and 1-3-1. D2 has three termination points as well: 2-1-1, 2-0-1, and 2-3-1. D3 has two termination points: 3-1-1 and 3-2-1. In addition, there are six links, two between each pair of nodes, with one going in each direction.

```
                  +------------+                  +------------+
                  |     D1     |                  |     D2     |
                 /-\          /-\                /-\          /-\
                 | | 1-0-1    | |---------------->| | 2-1-1    | |
                 | |    1-2-1 | |<----------------| |    2-0-1 | |
                 \-/  1-3-1   \-/                \-/  2-3-1   \-/
                  |   /----\   |                  |   /----\   |
                  +---|    |---+                  +---|    |---+
                      \----/                          \----/
                       A  |                            A  |
                       |  |                            |  |
                       |  |                            |  |
                       |  |       +------------+       |  |
                       |  |       |     D3     |       |  |
                       |  |      /-\          /-\      |  |
                       |  +----->| | 3-1-1    | |------+  |
                       +---------| |    3-2-1 | |<---------+
                                 \-/          \-/
                                  |            |
                                  +------------+
```

Figure 2. A Network Topology Example

The corresponding instance data tree is depicted as below. Note that some lines have been wrapped to adhere to the 72-character line limitation of RFCs.

```
 {
     "ietf-network:networks": {
       "network": [
         {
           "network-types": {
             "ietf-l2-topology:l2-network": {}
           },
           "network-id": "l2-topo-example",
           "node": [
             {
               "node-id": "D1",
               "termination-point": [
                 {
                   "tp-id": "1-0-1",
                   "ietf-l2-topology:
                     l2-termination-point-attributes": {
                     "mac-address": "00-00-5E-00-53-D0"
                   }
                 },
                 {
                   "tp-id": "1-2-1",
```

```
                "ietf-l2-topology:
                  l2-termination-point-attributes": {
                  "mac-address": "00-00-5E-00-53-D1"
                }
              },
              {
                "tp-id": "1-3-1",
                "ietf-l2-topology:
                  l2-termination-point-attributes": {
                  "mac-address": "00-00-5E-00-53-D2"
                }
              }
            ],
            "ietf-l2-topology:l2-node-attributes": {
              "management-address": ["192.0.2.1"]
            }
          },
          {
            "node-id": "D2",
            "termination-point": [
              {
                "tp-id": "2-0-1",
                "ietf-l2-topology:
                  l2-termination-point-attributes": {
                  "mac-address": "00-00-5E-00-53-E0"
                }
              },
              {
                "tp-id": "2-1-1",
                "ietf-l2-topology:
                  l2-termination-point-attributes": {
                  "mac-address": "00-00-5E-00-53-E1"
                }
              },
              {
                "tp-id": "2-3-1",
                "ietf-l2-topology:
                  l2-termination-point-attributes": {
                  "mac-address": "00-00-5E-00-53-E2"
                }
              }
            ],
            "ietf-l2-topology:l2-node-attributes": {
              "management-address": ["192.0.2.2"]
            }
          },
          {
            "node-id": "D3",
```

```
                "termination-point": [
                  {
                    "tp-id": "3-1-1",
                    "ietf-l2-topology:
                      l2-termination-point-attributes": {
                      "mac-address": "00-00-5E-00-53-F0"
                    }
                  },
                  {
                    "tp-id": "3-2-1",
                    "ietf-l2-topology:
                      l2-termination-point-attributes": {
                      "mac-address": "00-00-5E-00-53-F1"
                    }
                  }
                ],
                "ietf-l2-topology:l2-node-attributes": {
                  "management-address": ["192.0.2.3"]
                }
              }
            ],
            "ietf-network-topology:link": [
              {
                "link-id": "D1,1-2-1,D2,2-1-1",
                "source": {
                  "source-node": "D1",
                  "source-tp": "1-2-1"
                }
                "destination": {
                  "dest-node": "D2",
                  "dest-tp": "2-1-1"
                },
                "ietf-l2-topology:l2-link-attributes": {
                  "rate": "1000"
                }
              },
              {
                "link-id": "D2,2-1-1,D1,1-2-1",
                "source": {
                  "source-node": "D2",
                  "source-tp": "2-1-1"
                }
                "destination": {
                  "dest-node": "D1",
                  "dest-tp": "1-2-1"
                },
                "ietf-l2-topology:l2-link-attributes": {
                  "rate": "1000"
```

```
                }
              },
              {
                "link-id": "D1,1-3-1,D3,3-1-1",
                "source": {
                  "source-node": "D1",
                  "source-tp": "1-3-1"
                }
                "destination": {
                  "dest-node": "D3",
                  "dest-tp": "3-1-1"
                },
                "ietf-l2-topology:l2-link-attributes": {
                  "rate": "1000"
                }
              },
              {
                "link-id": "D3,3-1-1,D1,1-3-1",
                "source": {
                  "source-node": "D3",
                  "source-tp": "3-1-1"
                }
                "destination": {
                  "dest-node": "D1",
                  "dest-tp": "1-3-1"
                },
                "ietf-l2-topology:l2-link-attributes": {
                  "rate": "1000"
                }
              },
              {
                "link-id": "D2,2-3-1,D3,3-2-1",
                "source": {
                  "source-node": "D2",
                  "source-tp": "2-3-1"
                }
                "destination": {
                  "dest-node": "D3",
                  "dest-tp": "3-2-1"
                },
                "ietf-l2-topology:l2-link-attributes": {
                  "rate": "1000"
                }
              },
              {
                "link-id": "D3,3-2-1,D2,2-3-1",
                "source": {
                  "source-node": "D3",
```

```
                    "source-tp": "3-2-1"
                  }
                  "destination": {
                    "dest-node": "D2",
                    "dest-tp": "2-3-1"
                  },
                  "ietf-l2-topology:l2-link-attributes": {
                    "rate": "1000"
                  }
                }
              ]
            }
          ]
        }
      }
```


Authors' Addresses

Jie Dong
Huawei
Huawei Campus, No. 156 Beiqing Rd.
Beijing 100095
China

Email: jie.dong@huawei.com

Xiugang Wei
Huawei
Huawei Campus, No. 156 Beiqing Rd.
Beijing 100095
China

Email: weixiugang@huawei.com

Qin Wu
Huawei
101 Software Avenue, Yuhua District
Nanjing 210012
China

Email: bill.wu@huawei.com

Mohamed Boucadair
Orange
Rennes 35000
France

Email: mohamed.boucadair@orange.com

Anders Liu
Tecent
Yinke Building 38 Haidian St, Haidian District
Beijing 100080
China

Email: andersliu@tencent.com