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A YANG Data Model for Layer 3 Topologies
draft-ietf-i2rs-yang-l3-topology-06.txt

Abstract

This document defines a YANG data model for layer 3 network topologies.

Status of This Memo

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

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This Internet-Draft will expire on June 3, 2017.

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1. Introduction

This document introduces a YANG [RFC7950] [RFC6991] data model for Layer 3 network topologies, specifically Layer 3 Unicast. The model allows an application to have a holistic view of the topology of a Layer 3 network, all contained in a single conceptual YANG datastore.

The data model builds on top of, and augments, the data model for network topologies defined in

[I-D.draft-ietf-i2rs-yang-network-topo]. An earlier revision of that Internet Draft contained not just the general model for network topologies, but also the model for layer 3 network topologies that is being specified here. However, we decided to "split" the earlier draft to separate the truly general aspects of a topology data model, which apply to any type of topology, from the application of this model to a particular domain, here: a Layer 3 network.

The document also shows how the model can be further refined to cover different Layer 3 Unicast topology types. For this purpose, example models are introduced that cover IS-IS [RFC1195] and OSPF [RFC2328]. Those examples are intended purely for illustrative purposes; we expect that full-blown IS-IS and OSPF models will be more comprehensive and refined than the examples shown here.

There are multiple applications for a topology data model. A number of use cases have been defined in section 6 of [I-D.draft-ietf-i2rs-usecase-reqs-summary]. For example, nodes within the network can use the data model to capture their understanding of the overall network topology and expose it to a network controller. A network controller can then use the instantiated topology data to compare and reconcile its own view of the network topology with that of the network elements that it controls. Alternatively, nodes within the network could propagate this understanding to compare and reconcile this understanding either amongst themselves or with help of a controller. Beyond the network element itself, a network controller might even use the data model to represent its view of the topology that it controls and expose it to applications north of itself.

There are several reasons to choose YANG to define the data model. Data defined using YANG can be exposed by a server to client applications and controllers via Netconf [RFC6241]. The fact that YANG can potentially be used with different protocols and interfaces provides for a degree of "future-proofing" of model implementations. Also, YANG can serve as the basis for model-driven toolchains, such as used in the Open Daylight project [OpenDaylight].

The data model for Layer 3 Unicast topologies defined in this document is specified in a YANG module "ietf-l3-unicast-topology". To do so, it augments general network topology model defined in [I-D.draft-ietf-i2rs-yang-network-topo] with information specific to Layer 3 Unicast. This way, the general topology model is extended to be able to meet the needs of Layer 3 Unicast topologies.

Information that is kept in the Traffic Engineering Database (TED) is specified in a separate model and outside the scope of this specification.

2. Definitions and Acronyms

Datastore: A conceptual store of instantiated management information, with individual data items represented by data nodes which are arranged in hierarchical manner.

Data subtree: An instantiated data node and the data nodes that are hierarchically contained within it.

HTTP: Hyper-Text Transfer Protocol

IGP: Interior Gateway Protocol

IS-IS: Intermediate System to Intermediate System protocol

LSP: Label Switched Path

NETCONF: Network Configuration Protocol

OSPF: Open Shortest Path First, a link state routing protocol

URI: Uniform Resource Identifier

ReST: Representational State Transfer, a style of stateless interface and protocol that is generally carried over HTTP

SRLG: Shared Risk Link Group

TED: Traffic Engineering Database

YANG: A data definition language for NETCONF

3. Model Structure

The Layer 3 Unicast topology model is defined by YANG module "l3-unicast-topology". The relationship of this module with other YANG modules is roughly depicted in the figure below.

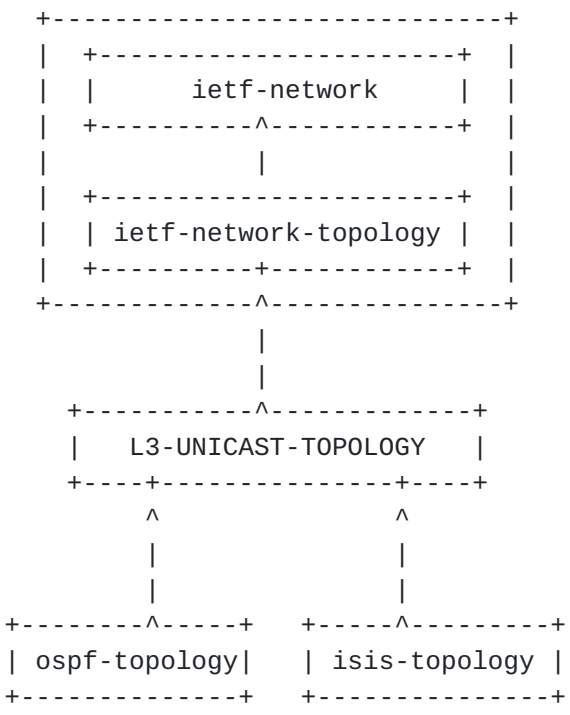

Figure 1: Overall model structure

YANG modules "ietf-network" and "ietf-network-topology" collectively define the basic network topology model. YANG module "ietf-l3-unicast-topology" augments those models with additional definitions needed to represent Layer 3 Unicast topologies. This module in turn can be augmented by YANG modules with additional definitions for specific types of Layer 3 Unicast topologies, such as OSPF and for IS-IS topologies.

4. Layer 3 Unicast Topology Model Overview

The Layer 3 Unicast topology model is defined by YANG module "ietf-l3-unicast-topology" and depicted in the following diagram. Brackets enclose list keys, "rw" means configuration, "ro" operational state data, "?" designates optional nodes, "*" designates nodes that can have multiple instances. Parantheses enclose choice and case nodes. The prefix "nd:" refers to the YANG module for networks; the prefix "lnk:" refers to the YANG module for network topology. In the interest of brevity, notifications are not depicted.

```
module: ietf-l3-unicast-topology
augment /nd:networks/nd:network/nd:network-types:
   +--rw l3-unicast-topology!
augment /nd:networks/nd:network:
   +--rw l3-topology-attributes
      +--rw name?   string
      +--rw flag*   l3-flag-type
augment /nd:networks/nd:network/nd:node:
   +--rw l3-node-attributes
      +--rw name?        inet:domain-name
      +--rw flag*        node-flag-type
      +--rw router-id*   inet:ip-address
      +--rw prefix* [prefix]
         +--rw prefix    inet:ip-prefix
         +--rw metric?   uint32
         +--rw flag*     prefix-flag-type
augment /nd:networks/nd:network/lnk:link:
   +--rw l3-link-attributes
      +--rw name?     string
      +--rw flag*     link-flag-type
      +--rw metric?   uint32
augment /nd:networks/nd:network/nd:node/lnk:termination-point:
   +--rw l3-termination-point-attributes
      +--rw (termination-point-type)?
         +--:(ip)
         |  +--rw ip-address*      inet:ip-address
         +--:(unnumbered)
            +--rw unnumbered-id?   uint32
```

The module augments the original ietf-network and ietf-network-topology modules as follows:

- A new network topology type is introduced, l3-unicast-topology. The corresponding container augments the network-types of the ietf-network module.

- Additional topology attributes are introduced, defined in a grouping, which augments the "network" list of the network module. The attributes include a name for the topology, as well as a set of flags (represented through a leaf-list). Each type of flag is represented by a separate identity. This allows to introduce additional flags in augmenting modules using additional identities without needing to revise this module.

- Additional data objects for nodes are introduced by augmenting the "node" list of the network module. New objects include again a set of flags, as well as a list of prefixes. Each prefix in turn

includes an ip prefix, a metric, and a prefix-specific set of flags.

- Links (in the ietf-network-topology module) are augmented with a set of parameters as well, allowing to associate a link with a link name, another set of flags, and a link metric.

- Termination points (in the ietf-network-topology module as well) are augmented with a choice of IP address or identifier.

In addition, the module defines a set of notifications to alert clients of any events concerning links, nodes, prefixes, and termination points. Each notification includes an indication of the type of event, the topology from which it originated, and the affected node, or link, or prefix, or termination point. In addition, as a convenience to applications, additional data of the affected node, or link, or termination point (respectively) is included. While this makes notifications larger in volume than they would need to be, it avoids the need for subsequent retrieval of context information, which also might have changed in the meantime.

5. Layer 3 Unicast Topology YANG Module

```
<CODE BEGINS> file "ietf-l3-unicast-topology@2016-11-30.yang"
module ietf-l3-unicast-topology {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-l3-unicast-topology";
  prefix "l3t";
  import ietf-network {
    prefix "nd";
  }
  import ietf-network-topology {
    prefix "lnk";
  }
  import ietf-inet-types {
    prefix "inet";
  }
  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>
     WG Chair:  Susan Hares
                <mailto:shares@ndzh.com>
     WG Chair:  Russ White
                <mailto:russ@riw.us>
     Editor:    Alexander Clemm
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```
                <mailto:alex@sympotech.com>
      Editor:   Jan Medved
                <mailto:jmedved@cisco.com>
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      Editor:   Igor Bryskin
                <mailto:Igor.Bryskin@huawei.com>
      Editor:   Aihua Guo
                <mailto:aguo@advaoptical.com>
      Editor:   Nitin Bahadur
                <mailto:nitin_bahadur@yahoo.com>
      Editor:   Hariharan Ananthakrishnan
                <mailto:hari@packetdesign.com>
      Editor:   Vishnu Pavan Beeram
                <mailto:vbeeram@juniper.net>";
    description
      "This module defines a model for Layer 3 Unicast
       topologies.
       Copyright (c) 2016 IETF Trust and the persons identified as
       authors of the code.  All rights reserved.
       Redistribution and use in source and binary forms, with or
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       Relating to IETF Documents
       (http://trustee.ietf.org/license-info).
       This version of this YANG module is part of
       draft-ietf-i2rs-yang-l3-topology-06;
       see the RFC itself for full legal notices.
       NOTE TO RFC EDITOR: Please replace above reference to
       draft-ietf-i2rs-yang-l3-topology-06 with RFC
       number when published (i.e. RFC xxxx).";
    revision "2016-11-30" {
      description
        "Initial revision.
         NOTE TO RFC EDITOR: Please replace the following reference
         to draft-ietf-i2rs-yang-l3-topology-06 with
         RFC number when published (i.e. RFC xxxx).";
      reference
        "draft-ietf-i2rs-yang-l3-topology-06";
    }

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

```
    typedef l3-event-type {
      type enumeration {
        enum "add" {
          description
            "An Layer 3 node or link or prefix or termination-point has
            been added";
        }
        enum "remove" {
          description
            "An Layer 3 node or link or prefix or termination-point has
            been removed";
        }
        enum "update" {
          description
            "An Layer 3 node or link or prefix or termination-point has
            been updated";
        }
      }
      description "Layer 3 Event type for notifications";
    }

    typedef prefix-flag-type {
      type identityref {
        base "flag-identity";
      }
      description "Prefix flag attributes";
    }

    typedef node-flag-type {
      type identityref {
        base "flag-identity";
      }
      description "Node flag attributes";
    }

    typedef link-flag-type {
      type identityref {
        base "flag-identity";
      }
      description "Prefix flag attributes";
    }

    typedef l3-flag-type {
      type identityref {
        base "flag-identity";
      }
      description "L3 flag attributes";
    }
```

```
    grouping l3-prefix-attributes {
      description
        "L3 prefix attributes";
      leaf prefix {
        type inet:ip-prefix;
        description
          "IP prefix value";
      }
      leaf metric {
        type uint32;
        description
          "Prefix metric";
      }
      leaf-list flag {
        type prefix-flag-type;
        description
          "Prefix flags";
      }
    }
    grouping l3-unicast-topology-type {
      description "Identify the topology type to be L3 unicast.";
      container l3-unicast-topology {
        presence "indicates L3 Unicast Topology";
        description
          "The presence of the container node indicates L3 Unicast
          Topology";
      }
    }
    grouping l3-topology-attributes {
      description "Topology scope attributes";
      container l3-topology-attributes {
        description "Containing topology attributes";
        leaf name {
          type string;
          description
            "Name of the topology";
        }
        leaf-list flag {
          type l3-flag-type;
          description
            "Topology flags";
        }
      }
    }
    grouping l3-node-attributes {
      description "L3 node scope attributes";
      container l3-node-attributes {
        description
```

```
          "Containing node attributes";
        leaf name {
          type inet:domain-name;
          description
            "Node name";
        }
        leaf-list flag {
          type node-flag-type;
          description
            "Node flags";
        }
        leaf-list router-id {
          type inet:ip-address;
          description
            "Router-id for the node";
        }
        list prefix {
          key "prefix";
          description
            "A list of prefixes along with their attributes";
          uses l3-prefix-attributes;
        }
      }
    }
    grouping l3-link-attributes {
      description
        "L3 link scope attributes";
      container l3-link-attributes {
        description
          "Containing link attributes";
        leaf name {
          type string;
          description
            "Link Name";
        }
        leaf-list flag {
          type link-flag-type;
          description
            "Link flags";
        }
        leaf metric {
          type uint32;
          description
              "Link Metric";
        }
      }
    }
    grouping l3-termination-point-attributes {
```

```
      description "L3 termination point scope attributes";
      container l3-termination-point-attributes {
        description
          "Containing termination point attributes";
        choice termination-point-type {
          description
            "Indicates the termination point type";
          case ip {
            leaf-list ip-address {
              type inet:ip-address;
              description
                "IPv4 or IPv6 address";
            }
          }
          case unnumbered {
            leaf unnumbered-id {
              type uint32;
              description
                "Unnumbered interface identifier";
            }
          }
        }
      }
    }
    augment "/nd:networks/nd:network/nd:network-types" {
      description
        "Introduce new network type for L3 unicast topology";
      uses l3-unicast-topology-type;
    }
    augment "/nd:networks/nd:network" {
      when "nd:network-types/l3-unicast-topology" {
        description
          "Augmentation parameters apply only for networks with
          L3 unicast topology";
      }
      description
          "L3 unicast for the network as a whole";
      uses l3-topology-attributes;
    }
    augment "/nd:networks/nd:network/nd:node" {
      when "../nd:network-types/l3-unicast-topology" {
        description
          "Augmentation parameters apply only for networks with
          L3 unicast topology";
      }
      description
          "L3 unicast node level attributes ";
      uses l3-node-attributes;
```

```
    }
    augment "/nd:networks/nd:network/lnk:link" {
      when "../nd:network-types/l3-unicast-topology" {
        description
          "Augmentation parameters apply only for networks with
          L3 unicast topology";
      }
      description
        "Augment topology link attributes";
      uses l3-link-attributes;
    }
    augment "/nd:networks/nd:network/nd:node/"
           +"lnk:termination-point" {
      when "../../nd:network-types/l3-unicast-topology" {
        description
          "Augmentation parameters apply only for networks with
          L3 unicast topology";
      }
      description "Augment topology termination point configuration";
      uses l3-termination-point-attributes;
    }
    notification l3-node-event {
      description
        "Notification event for L3 node";
      leaf l3-event-type {
        type l3-event-type;
        description
          "Event type";
      }
      uses nd:node-ref;
      uses l3-unicast-topology-type;
      uses l3-node-attributes;
    }
    notification l3-link-event {
      description
        "Notification event for L3 link";
      leaf l3-event-type {
        type l3-event-type;
        description
          "Event type";
      }
      uses lnk:link-ref;
      uses l3-unicast-topology-type;
      uses l3-link-attributes;
    }
    notification l3-prefix-event {
      description
        "Notification event for L3 prefix";
```

```
      leaf l3-event-type {
        type l3-event-type;
        description
          "Event type";
      }
      uses nd:node-ref;
      uses l3-unicast-topology-type;
      container prefix {
        description
          "Containing L3 prefix attributes";
        uses l3-prefix-attributes;
      }
    }
    notification termination-point-event {
      description
        "Notification event for L3 termination point";
      leaf l3-event-type {
        type l3-event-type;
        description
          "Event type";
      }
      uses lnk:tp-ref;
      uses l3-unicast-topology-type;
      uses l3-termination-point-attributes;
    }
  }

  <CODE ENDS>
```

6. Extending the Model

The model can be extended for specific Layer 3 Unicast types. Examples include OSPF and IS-IS topologies. In the following, two additional YANG modules are introduced that define simple topology models for OSPF and IS-IS, respectively. These modules intended to serve as examples that illustrate how the general topology model can be refined across multiple levels; they do not constitute full-fledged OSPF and IS-IS topology models which may be more comprehensive and refined than the models that are described here.

6.1. Example 1: OSPF Topology

6.1.1. Model Overview

The following model shows how the Layer 3 Unicast topology model can be extended to cover OSFP topologies. For this purpose, a set of augmentations are introduced in a separate YANG module, "example-ietf-ospf-topology", whose structure is depicted in the following

diagram. Like before, brackets enclose list keys, "rw" means configuration, "ro" operational state data, "?" designates optional nodes, "*" designates nodes that can have multiple instances. Parantheses enclose choice and case nodes. A "+" at the end of a line indicates a line break.

```
module: example-ietf-ospf-topology
augment /nd:networks/nd:network/nd:network-types/+
   l3t:l3-unicast-topology:
   +--rw ospf!
augment /nd:networks/nd:network/l3t:l3-topology-attributes:
   +--rw ospf-topology-attributes
      +--rw area-id?   area-id-type
augment /nd:networks/nd:network/nd:node/l3t:l3-node-attributes:
   +--rw ospf-node-attributes
      +--rw (router-type)?
      |  +--:(abr)
      |  |  +--rw abr?                empty
      |  +--:(asbr)
      |  |  +--rw asbr?               empty
      |  +--:(internal)
      |  |  +--rw internal?           empty
      |  +--:(pseudonode)
      |     +--rw pseudonode?         empty
      +--rw dr-interface-id?     uint32
      +--rw multi-topology-id*   uint8
augment /nd:networks/nd:network/lnk:link/l3t:l3-link-attributes:
   +--rw ospf-link-attributes
      +--rw multi-topology-id?   uint8
augment /l3t:l3-node-event:
   +---- ospf!
   +---- ospf-node-attributes
      +---- (router-type)?
      |  +--:(abr)
      |  |  +---- abr?                empty
      |  +--:(asbr)
      |  |  +---- asbr?               empty
      |  +--:(internal)
      |  |  +---- internal?           empty
      |  +--:(pseudonode)
      |     +---- pseudonode?         empty
      +---- dr-interface-id?     uint32
      +---- multi-topology-id*   uint8
augment /l3t:l3-link-event:
   +---- ospf!
   +---- ospf-link-attributes
      +---- multi-topology-id?   uint8
```

The module augments "ietf-l3-unicast-topology" as follows:

- A new topology type for an OSPF topology is introduced.
- Additional topology attributes are defined in a new grouping which augments l3-topology-attributes of the ietf-l3-unicast-topology module. The attributes include an OSPF area-id identifying the OSPF area.
- Additional data objects for nodes are introduced by augmenting the l3-node-attributes of the l3-unicast-topology module. New objects include router-type, dr-interface-id for pseudonodes, list of multi-topology-ids, ospf node capabilities, and traffic engineering attributes.
- Links are augmented with a multi-topology-id and traffic engineering link attributes.
- Prefixes are augmented with OSPF specific forwarding address.

In addition, the module extends notifications for events concerning Layer 3 nodes, links, termination points, and prefixes with OSPF attributes.

It should be noted that the model defined here represents topology and is intended as an example. It does not define how to configure OSPF routers or interfaces.

6.1.2. OSPF Topology YANG Module

The OSPF Topology YANG Module is specified below. As mentioned, the module is intended as an example for how the Layer 3 Unicast topology model can be extended to cover OSFP topologies, but it is not normative. Accordingly, the module is not delimited with <CODE BEGINS> and <CODE ENDS> tags.

```
file "example-ietf-ospf-topology@2016-11-30.yang"
module example-ietf-ospf-topology {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:example-ietf-ospf-topology";
  prefix "ospft";
  import ietf-yang-types {
    prefix "yang";
  }
  import ietf-network {
    prefix "nd";
  }
  import ietf-network-topology {
```

```
      prefix "lnk";
    }
    import ietf-l3-unicast-topology {
      prefix "l3t";
    }
     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>
       WG Chair:  Susan Hares
                  <mailto:shares@ndzh.com>
       WG Chair:  Russ White
                  <mailto:russ@riw.us>
       Editor:    Alexander Clemm
                  <mailto:alex@sympotech.com>
       Editor:    Jan Medved
                  <mailto:jmedved@cisco.com>
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                  <mailto:robert.varga@pantheon.sk>
       Editor:    Xufeng Liu
                  <mailto:xliu@kuatrotech.com>
       Editor:    Igor Bryskin
                  <mailto:Igor.Bryskin@huawei.com>
       Editor:    Aihua Guo
                  <mailto:aguo@advaoptical.com>
       Editor:    Nitin Bahadur
                  <mailto:nitin_bahadur@yahoo.com>
       Editor:    Hariharan Ananthakrishnan
                  <mailto:hari@packetdesign.com>
       Editor:    Vishnu Pavan Beeram
                  <mailto:vbeeram@juniper.net>";
    description
      "This module defines a model for OSPF network topologies.
       Copyright (c) 2016 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
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       Relating to IETF Documents
       (http://trustee.ietf.org/license-info).
       This version of this YANG module is part of
       draft-ietf-i2rs-yang-l3-topology-06;
       see the RFC itself for full legal notices.
       NOTE TO RFC EDITOR: Please replace above reference to
       draft-ietf-i2rs-yang-l3-topology-06 with RFC
       number when published (i.e. RFC xxxx).";
```

```
      revision "2016-11-30" {
        description
          "Initial revision.
           NOTE TO RFC EDITOR: Please replace the following reference
           to draft-ietf-i2rs-yang-l3-topology-06 with
           RFC number when published (i.e. RFC xxxx).";
        reference
          "draft-ietf-i2rs-yang-l3-topology-06";
      }
      typedef area-id-type {
        type yang:dotted-quad;
        description
          "Area ID type.";
      }
      grouping ospf-topology-type {
        description
          "Identifies the OSPF topology type.";
        container ospf {
          presence "indiates OSPF Topology";
          description
            "Its presence identifies the OSPF topology type.";
        }
      }
      augment "/nd:networks/nd:network/nd:network-types/"
        + "l3t:l3-unicast-topology" {
        description
          "Defines the OSPF topology type.";
        uses ospf-topology-type;
      }
      augment "/nd:networks/nd:network/l3t:l3-topology-attributes" {
        when "../nd:network-types/l3t:l3-unicast-topology/ospf" {
          description
            "Augment only for OSPF topology";
        }
        description
          "Augment topology configuration";
        container ospf-topology-attributes {
          description
            "Containing topology attributes";
          leaf area-id {
            type area-id-type;
            description
              "OSPF area ID";
          }
        }
      }
      augment "/nd:networks/nd:network/nd:node/l3t:l3-node-attributes" {
        when "../../nd:network-types/l3t:l3-unicast-topology/ospf" {
```

```
        description
          "Augment only for OSPF topology";
      }
      description
        "Augment node configuration";
      uses ospf-node-attributes;
    }
    augment "/nd:networks/nd:network/lnk:link/l3t:l3-link-attributes" {
      when "../../nd:network-types/l3t:l3-unicast-topology/ospf" {
        description
          "Augment only for OSPF topology";
      }
      description
        "Augment link configuration";
      uses ospf-link-attributes;
    }
    grouping ospf-node-attributes {
      description
        "OSPF node scope attributes";
      container ospf-node-attributes {
        description
          "Containing node attributes";
        choice router-type {
          description
            "Indicates router type";
          case abr {
            leaf abr {
              type empty;
              description
                "The node is ABR";
            }
          }
          case asbr {
            leaf asbr {
              type empty;
              description
                "The node is ASBR";
            }
          }
          case internal {
            leaf internal {
              type empty;
              description
                "The node is internal";
            }
          }
          case pseudonode {
            leaf pseudonode {
```

```
              type empty;
              description
                "The node is pseudonode";
            }
          }
        }
        leaf dr-interface-id {
          when "../pseudonode" {
            description
              "Valid only for pseudonode";
          }
          type uint32;
          default "0";
          description
            "For pseudonodes, DR interface-id";
        }
        leaf-list multi-topology-id {
          type uint8 {
            range "0..127";
          }
          max-elements "128";
          description
            "List of Multi-Topology Identifier up-to 128 (0-127).
             See RFC 4915";
        }
      }
    }
    grouping ospf-link-attributes {
      description
        "OSPF link scope attributes";
      container ospf-link-attributes {
        description
          "Containing OSPF link attributes";
        leaf multi-topology-id {
          type uint8 {
            range "0..127";
          }
          description "Multi topology ID";
        }
      }
    } // ospf-link-attributes
    augment "/l3t:l3-node-event" {
      description
        "OSPF node event";
      uses ospf-topology-type;
      uses ospft:ospf-node-attributes;
    }
    augment "/l3t:l3-link-event" {
```

```
      description
        "OSPF link event";
      uses ospf-topology-type;
      uses ospft:ospf-link-attributes;
    }
  }
```

6.2. Example 2: IS-IS Topology

6.2.1. Model Overview

IS-IS topologies are another type of Layer 3 Unicast topology. Like in the case of OSPF topology, a model for IS-IS topology can be defined in a separate module which augments "ietf-l3-unicast-igp-topology". The structure of a corresponding model, "ietf-isis-topology", is depicted in the following diagram. Like before, brackets enclose list keys, "rw" means configuration, "ro" operational state data, "?" designates optional nodes, "*" designates nodes that can have multiple instances. Parantheses enclose choice and case nodes. A "+" at the end of a line indicates a line break.

```
module: example-ietf-isis-topology
augment /nd:networks/nd:network/nd:network-types/+
   l3t:l3-unicast-topology:
   +--rw isis!
augment /nd:networks/nd:network/l3t:l3-topology-attributes:
   +--rw isis-topology-attributes
      +--rw net?   area-address
augment /nd:networks/nd:network/nd:node/l3t:l3-node-attributes:
   +--rw isis-node-attributes
      +--rw iso
      |  +--rw iso-system-id?       system-id
      |  +--rw iso-pseudonode-id?   iso-pseudonode-id
      +--rw net*                 area-address
      +--rw multi-topology-id*   uint16
      +--rw level?               level
augment /nd:networks/nd:network/lnk:link/l3t:l3-link-attributes:
   +--rw isis-link-attributes
      +--rw multi-topology-id?   uint16
augment /l3t:l3-node-event:
   +---- isis!
   +---- isis-node-attributes
      +---- iso
      |  +---- iso-system-id?       system-id
      |  +---- iso-pseudonode-id?   iso-pseudonode-id
      +---- net*                 area-address
      +---- multi-topology-id*   uint16
      +---- level?               level
augment /l3t:l3-link-event:
   +---- isis!
   +---- isis-link-attributes
      +---- multi-topology-id?   uint16
```

The module augments the ietf-l3-unicast-topology as follows:

- A new topology type is introduced for isis.

- Additional topology attributes are introduced in a new grouping which augments "topology-attributes" of the ietf-l3-unicast-topology module. The attributes include an ISIS NET-id identifying the area.

- Additional data objects for nodes are introduced by augmenting "node-attributes" of the ietf-l3-unicast-topology module. New objects include router-type, iso-system-id to identify the router, a list of multi-topology-id, a list of NET ids, and traffic engineering attributes.

o Links are augmented with multi-topology-id and traffic engineering link attributes.

In addition, the module augments nodes and links with IS-IS attributes.

Again, it should be noted that the model defined here represents a topology and is intended as an example. It does not define how to configure IS-IS routers or interfaces.

6.2.2. IS-IS Topology YANG Module

The IS-IS Topology YANG Module is specified as follows. As mentioned, the module is intended as an example for how the Layer 3 Unicast topology model can be extended to cover IS-IS topologies, but it is not normative. Accordingly, the module is not delimited with <CODE BEGINS> and <CODE ENDS> tags.

```
file "example-ietf-isis-topology@2016-11-30.yang"
module example-ietf-isis-topology {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:example-ietf-isis-topology";
  prefix "isist";
  import ietf-network {
    prefix "nd";
  }
  import ietf-network-topology {
    prefix "lnk";
  }
  import ietf-l3-unicast-topology {
    prefix "l3t";
  }
   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>
     WG Chair:  Susan Hares
                <mailto:shares@ndzh.com>
     WG Chair:  Russ White
                <mailto:russ@riw.us>
     Editor:    Alexander Clemm
                <mailto:sympotech.com>
     Editor:    Jan Medved
                <mailto:jmedved@cisco.com>
     Editor:    Robert Varga
                <mailto:robert.varga@pantheon.sk>
     Editor:    Xufeng Liu
```

```
                <mailto:xliu@kuatrotech.com>
      Editor:   Igor Bryskin
                <mailto:Igor.Bryskin@huawei.com>
      Editor:   Aihua Guo
                <mailto:aguo@advaoptical.com>
      Editor:   Nitin Bahadur
                <mailto:nitin_bahadur@yahoo.com>
      Editor:   Hariharan Ananthakrishnan
                <mailto:hari@packetdesign.com>
      Editor:   Vishnu Pavan Beeram
                <mailto:vbeeram@juniper.net>";
    description
      "This module defines a model for IS-IS network topologies.
       Copyright (c) 2016 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
       draft-ietf-i2rs-yang-l3-topology-06;
       see the RFC itself for full legal notices.
       NOTE TO RFC EDITOR: Please replace above reference to
       draft-ietf-i2rs-yang-l3-topology-06 with RFC
       number when published (i.e. RFC xxxx).";
     revision "2016-11-30" {
      description
        "Initial revision.
         NOTE TO RFC EDITOR: Please replace the following reference
         to draft-ietf-i2rs-yang-l3-topology-06 with
         RFC number when published (i.e. RFC xxxx).";
      reference
        draft-ietf-i2rs-yang-l3-topology-06;
    }
    typedef iso-pseudonode-id {
      type string {
        pattern '[0-9a-fA-F]{2}';
      }
      description
           "ISO pseudonode id for broadcast network.";
    }
    typedef area-address{
      type string {
        pattern '[0-9A-Fa-f]{2}\.([0-9A-Fa-f]{4}\.){0,3}';
      }
      description
```

```
        "This type defines the area address.";
    }
    typedef system-id {
      type string {
        pattern
         '[0-9A-Fa-f]{4}\.[0-9A-Fa-f]{4}\.[0-9A-Fa-f]{4}';
      }
      description
       "This type defines ISIS system id using a pattern;
        an example of a system id looks like: 0143.0438.AeF0.";
    }
    typedef level {
      type enumeration {
        enum "level-1" {
          description
           "This enum describes L1 only capability.";
        }
        enum "level-2" {
          description
           "This enum describes L2 only capability.";
        }
        enum "level-all" {
          description
           "This enum describes both levels (L1 and L2) capability.";
        }
      }
      default "level-all";
      description
       "This type defines the ISIS level of an object.";
    }
    grouping isis-topology-type {
      description
        "Identifies the ISIS topology type.";
      container isis {
        presence "Indicates ISIS Topology";
        description
          "Its presence identifies the ISIS topology type.";
      }
    }
    augment "/nd:networks/nd:network/nd:network-types/"
      +"l3t:l3-unicast-topology" {
      description
        "Defines the ISIS topology type.";
      uses isis-topology-type;
    }
    augment "/nd:networks/nd:network/l3t:l3-topology-attributes" {
      when "../nd:network-types/l3t:l3-unicast-topology/isis" {
        description
```

```
          "Augment only for ISIS topology";
      }
      description
        "Augment topology configuration";
      container isis-topology-attributes {
        description
          "Containing topology attributes";
        leaf net {
          type area-address;
          description
            "ISO NET ID value";
        }
      }
    }
    augment "/nd:networks/nd:network/nd:node/"+
      "l3t:l3-node-attributes" {
      when "../../nd:network-types/l3t:l3-unicast-topology/isis" {
        description
          "Augment only for ISIS topology";
      }
      description
        "Augment node configuration";
      uses isis-node-attributes;
    }
    augment "/nd:networks/nd:network/lnk:link/l3t:l3-link-attributes" {
      when "../../nd:network-types/l3t:l3-unicast-topology/isis" {
        description
          "Augment only for ISIS topology";
      }
      description
        "Augment link configuration";
      uses isis-link-attributes;
    }
    grouping isis-node-attributes {
      description
        "ISIS node scope attributes";
      container isis-node-attributes {
        description
          "Containing node attributes";
        container iso {
          description
            "Containing ISO atrributes";
          leaf iso-system-id {
            type system-id;
            description
              "ISO system ID";
          }
          leaf iso-pseudonode-id {
```

```
            type iso-pseudonode-id;
            default "00";
            description
              "Pseudonode ID";
          }
        }
        leaf-list net {
          type area-address;
          max-elements 3;
          description
            "List of ISO NET IDs";
        }
        leaf-list multi-topology-id {
          type uint16 {
            range "0..4095";
          }
          max-elements "128";
          description
            "List of Multi Topology Identifier up to 128 (0-127).
            RFC 4915";
        }
        leaf level {
          type level;
          description "Level 1, Level 2 or Level 1 and 2";
        }
      }
    }
    grouping isis-link-attributes {
      description
        "ISIS link scope attributes";
      container isis-link-attributes {
        description
          "Containing link attributes";
        leaf multi-topology-id {
          type uint16 {
            range "0..4095";
          }
          description
            "Multi topology ID";
        }
      }
    }
    augment "/l3t:l3-node-event" {
      description
        "ISIS node event";
      uses isis-topology-type;
      uses isis-node-attributes;
    }
```

```
    augment "/l3t:l3-link-event" {
      description
        "ISIS link event";
      uses isis-topology-type;
      uses isis-link-attributes;
    }
  }
```

7. Interactions with Other YANG Modules

As described in section Section 3, the model builds on top of, and augments, the YANG modules defined in [I-D.draft-ietf-i2rs-yang-network-topo]. Specifically, module ietf-l3-unicast-topology augments modules "ietf-network" and "ietf-network-topology". In addition, the model makes use of data types that have been defined in [RFC6991].

The moodel defines a protocol independent YANG data model with layer 3 topology information. It is separate from and not linked with data models that are used to configure routing protocols or routing information. This includes e.g. model "ietf-routing" [RFC8022] and model "ietf-fb-rib" [I-D.draft-acee-rtgwg-yang-rib-extend].

The model obeys the requirements for the ephemeral state found in the document [I-D.draft-ietf-i2rs-ephemeral-state]. For ephemeral topology data that is server provided, the process tasked with maintaining topology information will load information from the routing process (such as OSPF) into the data model without relying on a configuration datastore.

8. IANA Considerations

This document registers the following namespace URI in the "IETF XML Registry" [RFC3688]:

URI: urn:ietf:params:xml:ns:yang:ietf-l3-unicast-topology
Registrant Contact: The IESG.
XML: N/A; the requested URI is an XML namespace.

This document registers the following YANG module in the "YANG Module Names" registry [RFC6020]:

Name: ietf-l3-unicast-topology
Namespace: urn:ietf:params:xml:ns:yang:ietf-l3-unicast-topology
Prefix: l3t
Reference: draft-ietf-i2rs-yang-l3-topology-06.txt (RFC form)

9. Security Considerations

The YANG module defined in this memo is designed to be accessed via the NETCONF protocol [RFC6241]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF users to a pre-configured subset of all available NETCONF protocol operations and content.

In general, Layer 3 Unicast topologies are server-provided and provide ephemeral topology information. As they provide read-only access to clients, they are less vulnerable. That said, the YANG module does in principle allow information to be configurable in certain instances (when the server-provided flag for the topology is set to false). In such cases, a malicious client could introduce topologies that are undesired. For example, a client could remove or add topological links between nodes, which could lead to an undesired and suboptimal topology, which might impact service levels and network utilization. It is therefore important that the NETCONF access control model is vigorously applied to prevent topology configuration by unauthorized clients.

10. Contributors

The model presented in this paper was contributed to by more people than can be listed on the author list. Additional contributors include:

- Ken Gray, Juniper Networks
- Tom Nadeau, Brocade
- Tony Tkacik
- Aleksandr Zhdankin, Cisco

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