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YANG Data Model for Segment Routing
draft-ietf-spring-sr-yang-28

Abstract

This document defines a YANG data model for segment routing configuration and operation, which is to be augmented by different segment routing data planes. The document also defines a YANG model that is intended to be used on network elements to configure or operate segment routing MPLS data plane, as well as some generic containers to be reused by IGP protocol modules to support segment routing.

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 1, 2021.

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1. Introduction

This document defines a YANG data model [RFC7950] for segment routing [RFC8402] configuration and operation. The document also defines a YANG model that is intended to be used on network elements to configure or operate segment routing MPLS data plane [RFC8660]. This document does not define the IGP extensions to support segment routing but defines generic groupings that SHOULD be reused by IGP

extension modules. The reason of this design choice is to not require implementations to support all IGP extensions. For example, an implementation may support IS-IS extension but not OSPF.

The YANG modules in this document conform to the Network Management Datastore Architecture (NMDA) [RFC8342].

2. Terminology and Notation

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.

2.1. Tree diagram

Tree diagrams used in this document follow the notation defined in [RFC8340].

2.2. Prefixes in Data Node Names

In this document, names of data nodes, actions, and other data model objects are often used without a prefix, as long as it is clear from the context in which YANG module each name is defined. Otherwise, names are prefixed using the standard prefix associated with the corresponding YANG module, as shown in Table 1.

Prefix	YANG module	Reference
if	ietf-interfaces	[RFC8343]
rt	ietf-routing	[RFC8349]
rt-types	ietf-routing-types	[RFC8294]
yang	ietf-yang-types	[RFC6991]
inet	ietf-inet-types	[RFC6991]

Table 1: Prefixes and Corresponding YANG Modules

3. Design of the Data Model

Module ietf-segment-routing augments the routing container in the ietf-routing model [RFC8349], and defines generic segment routing configuration and operational state. This module is augmented by modules supporting different data planes.

Module ietf-segment-routing-mpls augments ietf-segment-routing, and supports SR MPLS data plane configuration and operational state.

```
module: ietf-segment-routing
  augment /rt:routing:
    +--rw segment-routing

module: ietf-segment-routing-mpls
  augment /rt:routing/sr:segment-routing:
    +--rw sr-mpls
       +--ro node-capabilities
       |  +--ro entropy-readable-label-depth?   uint8
       +--ro msd {max-sid-depth}?
       |  +--ro node-msd?   uint8
       |  +--ro link-msds
       |     +--ro link-msds* [interface]
       |        +--ro interface    if:interface-ref
       |        +--ro msd?         uint8
       +--rw bindings
       |  +--rw mapping-server {mapping-server}?
       |  |  +--rw policy* [name]
       |  |     +--rw name       string
       |  |     +--rw entries
       |  |        +--rw mapping-entry* [prefix algorithm]
       |  |           +--rw prefix        inet:ip-prefix
       |  |           +--rw value-type?   enumeration
       |  |           +--rw start-sid     uint32
       |  |           +--rw range?        uint32
       |  |           +--rw algorithm     identityref
       |  +--rw connected-prefix-sid-map
       |  |  +--rw connected-prefix-sid* [prefix algorithm]
       |  |     +--rw prefix               inet:ip-prefix
       |  |     +--rw value-type?          enumeration
       |  |     +--rw start-sid            uint32
       |  |     +--rw range?               uint32
       |  |     +--rw algorithm            identityref
       |  |     +--rw last-hop-behavior?   enumeration
       |  +--rw local-prefix-sid
       |     +--rw local-prefix-sid* [prefix algorithm]
       |        +--rw prefix        inet:ip-prefix
       |        +--rw value-type?   enumeration
       |        +--rw start-sid     uint32
       |        +--rw range?        uint32
       |        +--rw algorithm     identityref
       +--rw global-srgb
       |  +--rw srgb* [lower-bound upper-bound]
       |     +--rw lower-bound    uint32
       |     +--rw upper-bound    uint32
```

```
        +--rw srlb
        |  +--rw srlb* [lower-bound upper-bound]
        |     +--rw lower-bound    uint32
        |     +--rw upper-bound    uint32
        +--ro label-blocks* []
        |  +--ro lower-bound?   uint32
        |  +--ro upper-bound?   uint32
        |  +--ro size?          uint32
        |  +--ro free?          uint32
        |  +--ro used?          uint32
        |  +--ro scope?         enumeration
        +--ro sid-db
           +--ro sid* [target sid source source-protocol binding-type]
              +--ro target             string
              +--ro sid                uint32
              +--ro algorithm?         uint8
              +--ro source             inet:ip-address
              +--ro used?              boolean
              +--ro source-protocol    -> /rt:routing
                                          /control-plane-protocols
                                          /control-plane-protocol/name
              +--ro binding-type       enumeration
              +--ro scope?             enumeration

notifications:
  +---n segment-routing-global-srgb-collision
  |  +--ro srgb-collisions* []
  |     +--ro lower-bound?          uint32
  |     +--ro upper-bound?          uint32
  |     +--ro routing-protocol?     -> /rt:routing
  |                                    /control-plane-protocols
  |                                    /control-plane-protocol/name
  |     +--ro originating-rtr-id?   router-or-system-id
  +---n segment-routing-global-sid-collision
  |  +--ro received-target?       string
  |  +--ro new-sid-rtr-id?        router-or-system-id
  |  +--ro original-target?       string
  |  +--ro original-sid-rtr-id?   router-or-system-id
  |  +--ro index?                 uint32
  |  +--ro routing-protocol?      -> /rt:routing
  |                                  /control-plane-protocols
  |                                  /control-plane-protocol/name
  +---n segment-routing-index-out-of-range
     +--ro received-target?    string
     +--ro received-index?     uint32
     +--ro routing-protocol?   -> /rt:routing
                                  /control-plane-protocols
                                  /control-plane-protocol/name
```

4. Configuration

The module ietf-segment-routing-mpls augments the "/rt:routing/ sr:segment-routing:" with a sr-mpls container. This container defines all the configuration parameters related to segment-routing MPLS data plane.

The sr-mpls configuration is split in global configuration and interface configuration.

The global configuration includes :

- bindings : Defines prefix to SID mappings. The operator can control advertisement of Prefix-SID independently for IPv4 and IPv6. Two types of mappings are available:
  - Mapping-server : maps non local prefixes to a segment ID. Configuration of bindings does not automatically allow advertisement of those bindings. Advertisement must be controlled by each routing-protocol instance (see Section 5). Multiple mapping policies may be defined.
  - Connected prefixes : maps connected prefixes to a segment ID. Advertisement of the mapping will be done by IGP when enabled for segment routing (see Section 5). The SID value can be expressed as an index (default), or an absolute value. The "last-hop-behavior" configuration dictates the PHP behavior: "explicit-null", "php", or "non-php".
- SRGB (Segment Routing Global Block): Defines a list of label blocks represented by a pair of lower-bound/upper-bound labels. The SRGB is also agnostic to the control plane used. So all routing-protocol instance will have to advertise the same SRGB.
- SRLB (Segment Routing Local Block): Defines a list of label blocks represented by a pair of lower-bound/upper-bound labels, reserved for local SIDs.

5. IGP Control plane configuration

Support of segment-routing extensions for a particular IGP control plane is done by augmenting routing-protocol configuration with segment-routing extensions. This augmentation SHOULD be part of separate YANG modules in order to not create any dependency for implementations to support all protocol extensions.

This module defines groupings that SHOULD be used by IGP segment routing modules.

The "sr-control-plane" grouping defines the generic global configuration for the IGP.

The "enabled" leaf enables segment-routing extensions for the routing-protocol instance.

The "bindings" container controls the routing-protocol instance's advertisement of local bindings and the processing of received bindings.

5.1. IGP interface configuration

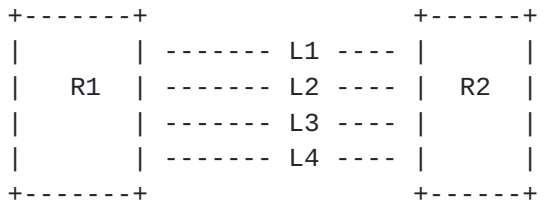
The interface configuration is part of the "igp-interface" grouping and includes Adjacency SID properties.

5.1.1. Adjacency SID properties

5.1.1.1. Bundling

In case of parallel IP links between routers, an additional Adjacency SID [RFC8402] may be advertised representing more than one adjacency (i.e., a bundle of adjacencies). The "advertise-adj-group-sid" configuration controls whether or not an additional adjacency SID is advertised.

The "advertise-adj-group-sid" is a list of "group-id". The "group-id" will identify interfaces that are bundled together.



In the figure above, R1 and R2 are interconnected by four links. A routing protocol adjacency is established on each link. Operator would like to create segment-routing Adj-SID that represent some bundles of links. We can imagine two different bundles : L1/L2 and L3/L4. To achieve this behavior, the service provider will configure a "group-id" X for both interfaces L1 and L2 and a "group-id" Y for both interfaces L3 and L4. This will result in R1 advertising an additional Adj-SID for each adjacency, for example a Adj-SID with S flag set and value of 400 will be added to L1 and L2. A Adj-SID with S flag set and value of 500 will be added to L3 and L4. As L1/L2 and L3/L4 does not share the same "group-id", a different SID value will be allocated.

5.1.1.2. Protection

The "advertise-protection" defines how protection for an interface is advertised. It does not control the activation or deactivation of protection. If the "single" option is used, a single Adj-SID will be advertised for the interface. If the interface is protected, the B-Flag for the Adj-SID advertisement will be set. If the "dual" option is used and if the interface is protected, two Adj-SIDs will be advertised for the interface adjacencies. One Adj-SID will always have the B-Flag set and the other will have the B-Flag clear. This option is intended to be used in the case of traffic engineering where a path must use either protected segments or non-protected segments.

6. State Data

The operational states contain information reflecting the usage of allocated SRGB labels.

It also includes a list of all global SIDs, their associated bindings, and other information such as the source protocol and algorithm.

7. Notifications

The model defines the following notifications for segment-routing.

- segment-routing-global-srgb-collision: Raised when a control plane advertised SRGB blocks have conflicts.

- segment-routing-global-sid-collision: Raised when a control plane advertised index is already associated with another target (in this version, the only defined targets are IPv4 and IPv6 prefixes).

- segment-routing-index-out-of-range: Raised when a control plane advertised index falls outside the range of SRGBs configured for the network device.

8. YANG Modules

There are three YANG modules included in this document.

The following RFCs and drafts are not referenced in the document text but are referenced in the ietf-segment-routing.yang, ietf-segment-routing-common.yang, and/or ietf-segment-routing-mpls.yang modules: [RFC6991], [RFC8294], [RFC8476], [RFC8491], [RFC8665], [RFC8667], [RFC8669], and [RFC8814].

8.1. YANG Module for Segment Routing

ietf-segment-routing.yang: This module defines a generic framework for Segment Routing, and it is to be augmented by models for different SR data planes.

```
<CODE BEGINS> file "ietf-segment-routing@2020-11-27.yang"
module ietf-segment-routing {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-segment-routing";
  prefix sr;

  import ietf-routing {
    prefix rt;
    reference "RFC 8349: A YANG Data Model for Routing
               Management (NMDA Version)";
  }

  organization
    "IETF SPRING - SPRING Working Group";
  contact
    "WG Web:   <https://tools.ietf.org/wg/spring/>
     WG List:  <mailto:spring@ietf.org>

     Author:    Stephane Litkowski
                <mailto:slitkows.ietf@gmail.com>
     Author:    Yingzhen Qu
                <mailto:yingzhen.qu@futurewei.com>
     Author:    Acee Lindem
                <mailto:acee@cisco.com>
     Author:    Pushpasis Sarkar
                <mailto:pushpasis.ietf@gmail.com>
     Author:    Jeff Tantsura
                <jefftant.ietf@gmail.com>

    ";
  description
    "The YANG module defines a generic framework for Segment
     Routing. It is to be augmented by models for different
     SR data planes.

     This YANG model conforms to the Network Management
     Datastore Architecture (NMDA) as described in RFC 8242.

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     authors of the code.  All rights reserved.

     Redistribution and use in source and binary forms, with or
```

```
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        (https://trustee.ietf.org/license-info).

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

        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 (RFC 2119) (RFC 8174) when, and only when,
        they appear in all capitals, as shown here.";


    reference "RFC XXXX: YANG Data Model for Segment Routing.";

    revision 2020-11-27 {
      description
        "Initial Version";
      reference "RFC XXXX: YANG Data Model for Segment Routing.";
    }

    augment "/rt:routing" {
      description
        "This module augments routing data model (RFC 8349)
         with Segment Routing (SR).";
      container segment-routing {
        description
          "Segment Routing configuration. This container
           is to be augmented by models for different SR
           data planes.";
        reference "RFC 8402: Segment Routing Architecture.";
      }
    }
  }
  <CODE ENDS>
```

8.2. YANG Module for Segment Routing Common Types

ietf-segment-routing-common.yang: This module defines a collection of generic types and groupings for SR as defined in [RFC8402].

```
  <CODE BEGINS> file "ietf-segment-routing-common@2020-11-27.yang"
  module ietf-segment-routing-common {
    yang-version 1.1;
    namespace
```

```
      "urn:ietf:params:xml:ns:yang:ietf-segment-routing-common";
    prefix sr-cmn;

    import ietf-inet-types {
      prefix inet;
      reference "RFC 6991: Common YANG Data Types";
    }

    organization
      "IETF SPRING - SPRING Working Group";

    contact
      "WG Web:   <https://tools.ietf.org/wg/spring/>
       WG List:  <mailto:spring@ietf.org>

       Author:    Stephane Litkowski
                  <mailto:slitkows.ietf@gmail.com>
       Author:    Yingzhen Qu
                  <mailto:yingzhen.qu@futurewei.com>
       Author:    Acee Lindem
                  <mailto:acee@cisco.com>
       Author:    Pushpasis Sarkar
                  <mailto:pushpasis.ietf@gmail.com>
       Author:    Jeff Tantsura
                  <jefftant.ietf@gmail.com>

      ";
    description
      "The YANG module defines a collection of generic types and
       groupings for Segment Routing (SR) as described in RFC 8402.

       This YANG model conforms to the Network Management
       Datastore Architecture (NMDA) as described in RFC 8242.

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

       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 (RFC 2119) (RFC 8174) when, and only when,
       they appear in all capitals, as shown here.";

   reference "RFC XXXX: YANG Data Model for Segment Routing.";

   revision 2020-11-27 {
     description
       "Initial version";
     reference "RFC XXXX: YANG Data Model for Segment Routing.";
   }

   feature sid-last-hop-behavior {
     description
       "Configurable last hop behavior.";
     reference "RFC 8660: Segment Routing with the MPLS Data Plane";
   }

   identity prefix-sid-algorithm {
     description
       "Base identity for prefix-sid algorithm.";
     reference "RFC 8402: Segment Routing Architecture";
   }

   identity prefix-sid-algorithm-shortest-path {
     base prefix-sid-algorithm;
     description
       "Shortest Path First (SPF) prefix-sid algorithm. This
        is the default algorithm.";
   }

   identity prefix-sid-algorithm-strict-spf {
     base prefix-sid-algorithm;
     description
       "This algorithm mandates that the packet is forwarded
        according to ECMP-aware SPF algorithm.";
   }

   grouping srlr {
     description
       "Grouping for SR Label Range configuration.";
     leaf lower-bound {
         type uint32;
         description
           "Lower value in the label range.";
     }
     leaf upper-bound {
```

```
          type uint32;
          must "../lower-bound < ../upper-bound" {
            error-message
              "The upper-bound must be greater than the lower-bound.";
            description
              "The value must be greater than 'lower-bound'.";
          }
          description
            "Upper value in the label range.";
        }
      }

      grouping srgb {
        description
          "Grouping for SR Global Label range.";
        list srgb {
          key "lower-bound upper-bound";
          ordered-by user;
          description
            "List of global blocks to be advertised.";
          uses srlr;
        }
      }

      grouping srlb {
        description
          "Grouping for SR Local Block range.";
        list srlb {
          key "lower-bound upper-bound";
          ordered-by user;
          description
            "List of SRLBs.";
          uses srlr;
        }
      }

      grouping sid-value-type {
        description
          "Defines how the SID value is expressed.";
        leaf value-type {
          type enumeration {
            enum "index" {
              description
                "The value will be interpreted as an index.";
            }
            enum "absolute" {
              description
                "The value will become interpreted as an absolute
```

```
              value.";
          }
        }
        default "index";
        description
          "This leaf defines how value must be interpreted.";
      }
    }

    grouping prefix-sid {
      description
        "This grouping defines cfg of prefix SID.";
      leaf prefix {
        type inet:ip-prefix;
        description
          "connected prefix sid.";
      }
      uses prefix-sid-attributes;
    }

    grouping ipv4-sid {
      description
        "Grouping for an IPv4 prefix SID.";
      leaf prefix {
        type inet:ipv4-prefix;
        description
          "Connected IPv4 prefix sid.";
      }
      uses prefix-sid-attributes;
    }
    grouping ipv6-sid {
      description
        "Grouping for an IPv6 prefix SID.";
      leaf prefix {
        type inet:ipv6-prefix;
        description
          "Connected ipv6 prefix sid.";
      }
      uses prefix-sid-attributes;
    }

    grouping last-hop-behavior {
      description
        "Defines last hop behavior";
      leaf last-hop-behavior {
        if-feature "sid-last-hop-behavior";
        type enumeration {
          enum "explicit-null" {
```

```
            description
              "Use explicit-null for the SID.";
          }
          enum "no-php" {
            description
              "Do not use Penultimate Hop Popping (PHP)
               for the SID.";
          }
          enum "php" {
            description
              "Use PHP for the SID.";
          }
        }
        description
          "Configure last hop behavior.";
      }
    }

    grouping node-capabilities {
      description
        "Containing SR node capabilities.";
      container node-capabilities {
        config false;
        description
          "Shows the SR capability of the node.";
        leaf entropy-readable-label-depth {
          type uint8;
          description
            "Maximum label stack depth that a router can read.";
        }
      }
    }

    grouping prefix-sid-attributes {
      description
        "Grouping for Segment Routing (SR) prefix attributes.";
      uses sid-value-type;
      leaf start-sid {
        type uint32;
        mandatory true;
        description
          "Value associated with prefix. The value must be
           interpreted in the context of value-type.";
      }
      leaf range {
        type uint32;
        description
          "Indicates how many SIDs can be allocated.";
```

```
      }
      leaf algorithm {
        type identityref {
          base prefix-sid-algorithm;
        }
        description
          "Prefix-sid algorithm.";
      }
    }
  }
  <CODE ENDS>
```

8.3. YANG Module for Segment Routing MPLS

ietf-segment-routing-mpls.yang: This module defines the configuration and operational states for Segment Routing MPLS data plane.

```
  <CODE BEGINS> file "ietf-segment-routing-mpls@2020-11-28
  module ietf-segment-routing-mpls {
    yang-version 1.1;
    namespace "urn:ietf:params:xml:ns:yang:ietf-segment-routing-mpls";
    prefix sr-mpls;

    import ietf-inet-types {
      prefix inet;
      reference "RFC 6991: Common YANG Data Types";
    }
    import ietf-routing {
      prefix rt;
      reference "RFC 8349: A YANG Data Model for Routing
                           Management (NMDA Version)";
    }
    import ietf-interfaces {
      prefix if;
      reference "RFC 8343: A YANG Data Model for Interface
                           Management (NMDA Version)";
    }
    import ietf-routing-types {
      prefix rt-types;
      reference "RFC 8294: Common YANG Data Types for the
                           Routing Area";
    }
    import ietf-segment-routing {
      prefix sr;
      reference "RFC XXXX: YANG Data Model for Segment Routing.";
    }
    import ietf-segment-routing-common {
      prefix sr-cmn;
```

```
      reference "RFC XXXX: YANG Data Model for Segment Routing.";
    }

    organization
      "IETF SPRING - SPRING Working Group";
    contact
      "WG Web:   <https://tools.ietf.org/wg/spring/>
       WG List:  <mailto:spring@ietf.org>

       Author:    Stephane Litkowski
                  <mailto:slitkows.ietf@gmail.com>
       Author:    Yingzhen Qu
                  <mailto:yingzhen.qu@futurewei.com>
       Author:    Acee Lindem
                  <mailto:acee@cisco.com>
       Author:    Pushpasis Sarkar
                  <mailto:pushpasis.ietf@gmail.com>
       Author:    Jeff Tantsura
                  <jefftant.ietf@gmail.com>

      ";
    description
      "The YANG module defines a generic configuration model for
       Segment Routing MPLS data plane.

       This YANG model conforms to the Network Management
       Datastore Architecture (NMDA) as described in RFC 8242.

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       This version of this YANG module is part of RFC XXXX;
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       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 (RFC 2119) (RFC 8174) when, and only when,
       they appear in all capitals, as shown here.";

    reference "RFC XXXX: YANG Data Model for Segment Routing.";
```

```
    revision 2020-11-28 {
      description
        "Initial Version";
      reference "RFC XXXX: YANG Data Model for Segment Routing.";
    }

    feature mapping-server {
      description
        "Support for Segment Routing Mapping Server (SRMS).";
      reference "RFC 8661: Segment Routing MPLS Interworking
                           with LDP";
    }

    feature protocol-srgb {
      description
        "Support for per-protocol Segment Routing Global Block
         (SRGB) configuration.";
         reference "RFC 8660: Segment Routing with the MPLS
                              Data Plane";
    }

    feature max-sid-depth {
      description
        "Support for signaling MSD (Maximum SID Depth) in IGP.";
        reference "RFC 8476: Signaling Maximum SID Depth (MSD)
                             Using OSPF
                   RFC 8491: Signaling Maximum SID Depth (MSD)
                             Using IS-IS
                   RFC 8814: Singaling Maximum SID Deppt (MSD)
                             Using the Border Gateway Protocol
                             (BGP) - Link State";
    }

    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 IS-IS system-id using pattern,
         An example system-id is 0143.0438.AEF0";
    }

    typedef router-or-system-id {
      type union {
        type rt-types:router-id;
        type system-id;
      }
```

```
      description
        "OSPF/BGP router-id or ISIS system ID.";
    }

    grouping sr-control-plane {
      description
        "Defines protocol configuration.";
      container segment-routing {
        description
          "Segment Routing global configuration.";
        leaf enabled {
          type boolean;
          default "false";
          description
            "Enables segment-routing control-plane protocol
            extensions.";
        }
        container bindings {
          if-feature mapping-server;
          description
            "Control of binding advertisement and reception.";
          container advertise {
            description
              "Control advertisement of local mappings
               in binding TLVs.";
            leaf-list policies {
              type leafref {
                path "/rt:routing/sr:segment-routing/sr-mpls:sr-mpls"
                   + "/sr-mpls:bindings/sr-mpls:mapping-server"
                   + "/sr-mpls:policy/sr-mpls:name";
              }
              description
                "List of binding advertisement policies.";
            }
          }
          leaf receive {
            type boolean;
            default "true";
            description
              "Allow the reception and usage of binding TLVs.";
          }
        }
      }
    }

    grouping igp-interface {
      description
        "Grouping for IGP interface configuration.";
```

```
       container segment-routing {
         description
           "Container for SR interface configuration.";
         container adjacency-sid {
           description
             "Adjacency SID configuration.";
             reference "RFC 8660: Segment Routing with the MPLS
                        Data Plane";
           list adj-sids {
             key "value";
             uses sr-cmn:sid-value-type;
             leaf value {
               type uint32;
               description
                 "Value of the Adj-SID.";
             }
             leaf protected {
               type boolean;
               default false;
               description
                 "It is used to protect the manual adj-SID, e.g. using
                  IPFRR or MPLS-FRR.";
             }
             leaf weight {
               type uint8;
               description
                 "The load-balancing factor over parallel adjacencies.";
               reference "RFC 8402: Segment Routing Architecture
                          RFC 8665: OSPF Extensions for Segment Routing
                          RFC 8667: IS-IS Extensions for Segment
                                    Routing";
             }
             description
               "List of adj-sid configuration.";
           }
           list advertise-adj-group-sid {
             key "group-id";
             description
               "Control advertisement of S or G flag. Enable
                advertisement of a common Adj-SID for parallel
                links.";
             reference "RFC 8665: OSPF Extensions for Segment Routing
                        Section 6.1
                        RFC 8667: IS-IS Extensions for Segment
                                  Routing Section 2.2.1";
             leaf group-id {
               type uint32;
               description
```

```
                "The value is an internal value to identify a
                 group-ID. Interfaces with the same group-ID
                 will be bundled together.";
            }
          }
          leaf advertise-protection {
            type enumeration {
              enum "single" {
                description
                  "A single Adj-SID is associated with the adjacency
                   and reflects the protection configuration.";
              }
              enum "dual" {
                description
                  "Two Adj-SIDs will be associated with the adjacency
                   if the interface is protected. In this case, will
                   be advertised with backup flag set, the other will
                   be advertised with the backup flag clear. In case
                   protection is not configured, single Adj-SID will
                   be advertised with the backup flag clear.";
              }
            }
            description
              "If set, the Adj-SID refers to a protected adjacency.";
            reference "RFC 8665: OSPF Extensions for Segment Routing
                               Section 6.1
                       RFC 8667: IS-IS Extensions for Segment
                               Routing Section 2.2.1";
          }
        }
      }
    }

    grouping max-sid-depth {
      description
        "Maximum SID Depth (MSD) operational state grouping.";
      leaf node-msd {
        type uint8;
        description
          "Node MSD is the lowest MSD supported by the node.";
      }
      container link-msds {
        description
          "MSD supported by an individual interface.";
        list link-msds {
          key "interface";
          description
            "List of link MSDs.";
```

```
          leaf interface {
            type if:interface-ref;
            description
              "Reference to device interface.";
          }
          leaf msd {
            type uint8;
            description
              "MSD supported by the interface.";
          }
        }
      }
    }

    augment "/rt:routing/sr:segment-routing" {
      description
        "This augments routing data model (RFC 8349)
         with Segment Routing (SR).";
      container sr-mpls {
        description
          "Segment Routing global configuration and
           operational state.";
        uses sr-cmn:node-capabilities;
        container msd {
          if-feature "max-sid-depth";
          config false;
          description
            "Maximum Segment Depth (MSD) Operational State.";
          uses max-sid-depth;
        }
        container bindings {
          description
            "List of bindings.";
          container mapping-server {
            if-feature "mapping-server";
            description
              "Configuration of mapping-server local entries.";
            list policy {
              key "name";
              description
                "List mapping-server policies.";
              leaf name {
                type string;
                description
                  "Name of the mapping policy.";
              }
              container entries {
                description
```

```
              "IPv4/IPv6 mapping entries.";
            list mapping-entry {
              key "prefix algorithm";
              description
                "Mapping entries.";
              uses sr-cmn:prefix-sid;
            }
          }
        }
      }
      container connected-prefix-sid-map {
        description
          "Prefix SID configuration.";
        list connected-prefix-sid {
          key "prefix algorithm";
          description
            "List of prefix SID mapped to IPv4/IPv6
             local prefixes.";
          uses sr-cmn:prefix-sid;
          uses sr-cmn:last-hop-behavior;
        }
      }
      container local-prefix-sid {
        description
          "Local sid configuration.";
        list local-prefix-sid {
          key "prefix algorithm";
          description
            "List of local IPv4/IPv6 prefix-sids.";
          uses sr-cmn:prefix-sid;
        }
      }
    }
    container global-srgb {
      description
        "Global SRGB configuration.";
      uses sr-cmn:srgb;
    }
    container srlb {
      description
        "Segment Routing Local Block (SRLB) configuration.";
      uses sr-cmn:srlb;
    }

    list label-blocks {
      config false;
      description
        "List of label blocks currently in use.";
```

```
          leaf lower-bound {
            type uint32;
            description
              "Lower bound of the label block.";
          }
          leaf upper-bound {
            type uint32;
            description
              "Upper bound of the label block.";
          }
          leaf size {
            type uint32;
            description
              "Number of indexes in the block.";
          }
          leaf free {
            type uint32;
            description
              "Number of free indexes in the block.";
          }
          leaf used {
            type uint32;
            description
              "Number of indexes in use in the block.";
          }
          leaf scope {
            type enumeration {
              enum "global" {
                description
                  "Global SID.";
              }
              enum "local" {
                description
                  "Local SID.";
              }
            }
            description
              "Scope of this label block.";
          }
        }
        container sid-db {
          config false;
          description
            "List of prefix and SID associations.";
          list sid {
            key "target sid source source-protocol binding-type";
            ordered-by system;
            description
```

```
            "SID Binding.";
          leaf target {
            type string;
            description
              "Defines the target of the binding. It can be a
               prefix or something else.";
          }
          leaf sid {
            type uint32;
            description
              "Index associated with the prefix.";
          }
          leaf algorithm {
            type uint8;
            description
              "Algorithm to be used for the prefix SID.";
            reference "RFC 8665: OSPF Extensions for Segment Routing
                       RFC 8667: IS-IS Extensions for Segment
                                 Routing
                       RFC 8669: Segment Routing Prefix Segment
                                 Identifier Extensions to BGP";
          }
          leaf source {
            type inet:ip-address;
            description
              "IP address of the router that owns the binding.";
          }
          leaf used {
            type boolean;
            description
              "Indicates if the binding is installed in the
               forwarding plane.";
          }
          leaf source-protocol {
            type leafref {
              path "/rt:routing/rt:control-plane-protocols/"
                 + "rt:control-plane-protocol/rt:name";
            }
            description
              "Routing protocol that owns the binding";
          }
          leaf binding-type {
            type enumeration {
              enum "prefix-sid" {
                description
                  "Binding is learned from a prefix SID.";
              }
              enum "binding-tlv" {
```

```
                  description
                    "Binding is learned from a binding TLV.";
                }
              }
              description
                "Type of binding.";
            }
            leaf scope {
              type enumeration {
                enum "global" {
                  description
                    "Global SID.";
                }
                enum "local" {
                  description
                    "Local SID.";
                }
              }
              description
                "SID scoping.";
            }
          }
        }
      }
    }

    notification segment-routing-global-srgb-collision {
      description
        "This notification is sent when SRGB blocks received from
         routers collide.";
      list srgb-collisions {
        description
          "List of SRGB blocks that collide.";
        leaf lower-bound {
          type uint32;
          description
            "Lower value in the block.";
        }
        leaf upper-bound {
          type uint32;
          description
            "Upper value in the block.";
        }
        leaf routing-protocol {
          type leafref {
            path "/rt:routing/rt:control-plane-protocols/"
               + "rt:control-plane-protocol/rt:name";
          }
```

```
          description
            "Routing protocol reference for SRGB collision.";
        }
        leaf originating-rtr-id {
          type router-or-system-id;
          description
            "Originating Router ID of this SRGB block.";
        }
      }
    }
    notification segment-routing-global-sid-collision {
      description
        "This notification is sent when a new mapping is learned
         containing a mapping where the SID is already used.
         The notification generation must be throttled with at least
         a 5 second gap between notifications.";
      leaf received-target {
        type string;
        description
          "Target received in the router advertisement that caused
           the SID collision.";
      }
      leaf new-sid-rtr-id {
        type router-or-system-id;
        description
          "Router ID that advertised the colliding SID.";
      }
      leaf original-target {
        type string;
        description
          "Target already available in the database with the same SID
           as the received target.";
      }
      leaf original-sid-rtr-id {
        type router-or-system-id;
        description
          "Router-ID for the router that originally advertised the
           conlliding SID, i.e., the instance in the database.";
      }
      leaf index {
        type uint32;
        description
          "Value of the index used by two different prefixes.";
      }
      leaf routing-protocol {
        type leafref {
          path "/rt:routing/rt:control-plane-protocols/"
             + "rt:control-plane-protocol/rt:name";
```

```
        }
        description
          "Routing protocol reference for colliding SID.";
      }
    }
    notification segment-routing-index-out-of-range {
      description
        "This notification is sent when a binding is received
         containing a segment index  which is out of the local
         configured ranges. The notification generation must be
         throttled with at least a 5 second gap between
         notifications.";
      leaf received-target {
        type string;
        description
          "Target received in the router advertisement with
           the out-of-range index.";
      }
      leaf received-index {
        type uint32;
        description
          "Value of the index received.";
      }
      leaf routing-protocol {
        type leafref {
          path "/rt:routing/rt:control-plane-protocols/"
             + "rt:control-plane-protocol/rt:name";
        }
        description
          "Routing protocol reference for out-of-range indexd.";
      }
    }
  }
  <CODE ENDS>
```

9. Security Considerations

The YANG modules specified in this document define 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 [RFC5246].

The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF or RESTCONF users to a pre-

configured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in the modules 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. Writable data nodes represent configuration of the router's bindings and the global and local label blocks. These correspond to the following schema nodes:

/segment-routing

/segment-routing/mpls

/segment-routing/mpls/bindings - Modification to the local bindings could result in a Denial of Service (DoS) attack. Additionally, the addition of bindings could result in traffic being redirected to the router.

/segment-routing/mpls/global-srgb - Modification of the Segment Routing Global Block (SRGB) could be used to mount a DoS attack.

/segment-routing/mpls/srlb - Modification of the Segment Routing Local Block (SRLB) could be used to mount a DoS attack.

/segment-routing/mpls/label-blocks - Modification of the Segment Routing label blocks could be used to mount a DoS attack.

Some of the readable data nodes in the modules may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or notification) to these data nodes. The exposure of both local bindings and SID database will exposure segment routing paths that may be attacked. These correspond to the following schema nodes:

/segment-routing/mpls/bindings - Knowledge of these data nodes can be used to attack the local router with either a a Denial of Service (DoS) attack or rediection of traffic destined to the local router.

/segment-routing/mpls/sid-db - Knowledge of these data nodes can be used to attack the other routers in the segment routing domain with either a a Denial of Service (DoS) attack or rediection traffic destined for those routers.

Furthermore exposure the node's capabilities and maximum segment depth may be useful in mounting a Denial-of-Service (DOS) attack by sending the node SR packets that the router can't process. These correspond to the following schema nodes:

/segment-routing/mpls/node-capabilities

/segment-routing/mpls/msd

10. Acknowledgements

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11. IANA Considerations

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

URI: urn:ietf:params:xml:ns:yang:ietf-segment-routing-commmon
Registrant Contact: The IESG.
XML: N/A, the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-segment-routing
Registrant Contact: The IESG.
XML: N/A, the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-segment-routing-mpls
Registrant Contact: The IESG.
XML: N/A, the requested URI is an XML namespace.

This document registers a YANG module in the YANG Module Names registry [RFC6020].

name: ietf-segment-routing-common
namespace: urn:ietf:params:xml:ns:yang:ietf-segment-routing-common
prefix: sr-cmn
reference: RFC XXXX

name: ietf-segment-routing
namespace: urn:ietf:params:xml:ns:yang:ietf-segment-routing
prefix: sr
reference: RFC XXXX

```
name: ietf-segment-routing-mpls
namespace: urn:ietf:params:xml:ns:yang:ietf-segment-routing-mpls
prefix: sr-mpls
reference: RFC XXXX
```

12. References

12.1. Normative References

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Appendix A. Configuration examples

Note: '\' line wrapping per [RFC8792].

A.1. SR MPLS with IPv4

The following is an XML example using the SR MPLS YANG modules with IPv4 addresses.

```
<routing xmlns="urn:ietf:params:xml:ns:yang:ietf-routing">
  <segment-routing
    xmlns="urn:ietf:params:xml:ns:yang:ietf-segment-routing">
    <sr-mpls
      xmlns="urn:ietf:params:xml:ns:yang:ietf-segment-routing-mpls">
      <bindings>
        <mapping-server>
          <policy>
            <name>mapping 1</name>
            <entries>
              <mapping-entry>
                <prefix>198.51.100.0/24</prefix>
                <algorithm xmlns:sr-cmn="urn:ietf:params:xml:ns:yang\
                  :ietf-segment-routing-common">\
                  sr-cmn:prefix-sid-algorithm-shortest-path\
                </algorithm>
                <start-sid>200</start-sid>
                <range>100</range>
              </mapping-entry>
            </entries>
          </policy>
        </mapping-server>
        <connected-prefix-sid-map>
          <connected-prefix-sid>
            <prefix>192.0.2.0/24</prefix>
            <algorithm xmlns:sr-cmn="urn:ietf:params:xml:ns:yang:\
              ietf-segment-routing-common">\
              sr-cmn:prefix-sid-algorithm-strict-spf</algorithm>
            <start-sid>100</start-sid>
            <range>1</range>
            <last-hop-behavior>php</last-hop-behavior>
          </connected-prefix-sid>
        </connected-prefix-sid-map>
      </bindings>
      <global-srgb>
        <srgb>
          <lower-bound>45000</lower-bound>
          <upper-bound>55000</upper-bound>
        </srgb>
      </global-srgb>
    </sr-mpls>
  </segment-routing>
</routing>
```

The following is the same example using JSON format.

```
{
```

```
    "ietf-routing:routing": {
      "ietf-segment-routing:segment-routing": {
        "ietf-segment-routing-mpls:sr-mpls": {
          "bindings": {
            "mapping-server": {
              "policy": [
                {
                  "name": "mapping 1",
                  "entries": {
                    "mapping-entry": [
                      {
                        "prefix": "198.51.100.0/24",
                        "algorithm": "ietf-segment-routing-common:\
                        prefix-sid-algorithm-shortest-path",
                        "start-sid": 200,
                        "range": 100
                      }
                    ]
                  }
                }
              ]
            },
            "connected-prefix-sid-map": {
              "connected-prefix-sid": [
                {
                  "prefix": "192.0.2.0/24",
                  "algorithm": "ietf-segment-routing-common:\
                  prefix-sid-algorithm-strict-spf",
                  "start-sid": 100,
                  "range": 1,
                  "last-hop-behavior": "php"
                }
              ]
            }
          },
          "global-srgb": {
            "srgb": [
              {
                "lower-bound": 45000,
                "upper-bound": 55000
              }
            ]
          }
        }
      }
    }
  }
```

A.2. SR MPLS with IPv6

The following is an XML example using the SR MPLS YANG modules with IPv6 addresses.

```
<routing xmlns="urn:ietf:params:xml:ns:yang:ietf-routing">
  <segment-routing
    xmlns="urn:ietf:params:xml:ns:yang:ietf-segment-routing">
    <sr-mpls
      xmlns="urn:ietf:params:xml:ns:yang:ietf-segment-routing-mpls">
      <bindings>
        <mapping-server>
          <policy>
            <name>mapping 1</name>
            <entries>
              <mapping-entry>
                <prefix>2001:db8:aaaa:bbbb::/64</prefix>
                <algorithm xmlns:sr-cmn="urn:ietf:params:xml:ns:yang\
                  :ietf-segment-routing-common">\
                  sr-cmn:prefix-sid-algorithm-shortest-path\
                </algorithm>
                <start-sid>200</start-sid>
                <range>100</range>
              </mapping-entry>
            </entries>
          </policy>
        </mapping-server>
        <connected-prefix-sid-map>
          <connected-prefix-sid>
            <prefix>2001:db8:aaaa:cccc::/64</prefix>
            <algorithm xmlns:sr-cmn="urn:ietf:params:xml:ns:yang:\
              ietf-segment-routing-common">\
              sr-cmn:prefix-sid-algorithm-strict-spf</algorithm>
            <start-sid>100</start-sid>
            <range>1</range>
            <last-hop-behavior>php</last-hop-behavior>
          </connected-prefix-sid>
        </connected-prefix-sid-map>
      </bindings>
      <global-srgb>
        <srgb>
          <lower-bound>45000</lower-bound>
          <upper-bound>55000</upper-bound>
        </srgb>
      </global-srgb>
    </sr-mpls>
  </segment-routing>
</routing>
```

The following is the same example using JSON format.

```
{
```

```
    "ietf-routing:routing": {
      "ietf-segment-routing:segment-routing": {
        "ietf-segment-routing-mpls:sr-mpls": {
          "bindings": {
            "mapping-server": {
              "policy": [
                {
                  "name": "mapping 1",
                  "entries": {
                    "mapping-entry": [
                      {
                        "prefix": "2001:db8:aaaa:bbbb::/64",
                        "algorithm": "ietf-segment-routing-common:\
                        prefix-sid-algorithm-shortest-path",
                        "start-sid": 200,
                        "range": 100
                      }
                    ]
                  }
                }
              ]
            },
            "connected-prefix-sid-map": {
              "connected-prefix-sid": [
                {
                  "prefix": "2001:db8:aaaa:cccc::/64",
                  "algorithm": "ietf-segment-routing-common:\
                  prefix-sid-algorithm-strict-spf",
                  "start-sid": 100,
                  "range": 1,
                  "last-hop-behavior": "php"
                }
              ]
            }
          },
          "global-srgb": {
            "srgb": [
              {
                "lower-bound": 45000,
                "upper-bound": 55000
              }
            ]
          }
        }
      }
    }
  }
```

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