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A YANG Data Model for Segment Routing (SR) Policy and SR in IPv6 (SRv6) support in Path Computation Element Communications Protocol (PCEP)

Abstract

This document augments a YANG data model for the management of Path Computation Element Communications Protocol (PCEP) for communications between a Path Computation Client (PCC) and a Path Computation Element (PCE), or between two PCEs in support for Segment Routing in IPv6 (SRv6) and SR Policy. The data model includes configuration data and state data (status information and counters for the collection of statistics).

Status of This Memo

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1. Introduction

The Path Computation Element (PCE) defined in [\[RFC4655\]](#) is an entity that is capable of computing a network path or route based on a network graph, and applying computational constraints. A Path Computation Client (PCC) may make requests to a PCE for paths to be computed.

PCEP is the communication protocol between a PCC and PCE and is defined in [\[RFC5440\]](#). PCEP interactions include path computation requests and path computation replies as well as notifications of specific states related to the use of a PCE in the context of Multiprotocol Label Switching (MPLS) and Generalized MPLS (GMPLS) Traffic Engineering (TE). [\[RFC8231\]](#) specifies extensions to PCEP to enable stateful control of MPLS TE LSPs.

[\[I-D.ietf-pce-segment-routing-ipv6\]](#) extends [\[RFC8664\]](#) to support SR for IPv6 data plane.

[\[I-D.ietf-pce-pcep-yang\]](#) defines a YANG [\[RFC7950\]](#) data model for the management of PCEP speakers. This document contains a specification of the PCEP-SRV6 YANG module, "ietf-pcep-srv6" which provides the PCEP-SRV6 [\[I-D.ietf-pce-segment-routing-ipv6\]](#) data model. This document also contains the PCEP SR Policy YANG module, "ietf-pcep-srpolicy" which provides a reference to SR Policies [\[I-D.ietf-spring-segment-routing-policy\]](#).

The PCEP operational state is included in the same tree as the PCEP configuration consistent with Network Management Datastore Architecture (NMDA) [[RFC8342](#)]. The origin of the data is indicated as per the origin metadata annotation.

2. Requirements Language

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

3. Terminology and Notation

This document also uses the following terms defined in [[RFC7420](#)]:

- *PCEP entity: a local PCEP speaker.
- *PCEP peer: a remote PCEP speaker.
- *PCEP speaker: where it is not necessary to distinguish between local and remote.

Further, this document also uses the following terms defined in [[RFC8231](#)] :

- *Stateful PCE, Passive Stateful PCE, Active Stateful PCE.
- *Delegation, Revocation, Redefinition.
- *LSP State Report, Path Computation Report message (PCRpt).
- *LSP State Update, Path Computation Update message (PCUpd).

[[RFC8281](#)] :

- *PCE-initiated LSP, Path Computation LSP Initiate Message (PCInitiate).

[[RFC8408](#)] :

- *Path Setup Type (PST).

[[RFC8664](#)] :

- *Segment Routing (SR).

[[I-D.ietf-pce-segment-routing-ipv6](#)] :

- *Segment Routing in IPv6 (SRv6).

[[I-D.ietf-spring-segment-routing-policy](#)] :

- *SR Policy.

3.1. Tree Diagrams

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in these diagrams is defined in [[RFC8340](#)].

3.2. Prefixes in Data Node Names

In this document, names of data nodes 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
inet	ietf-inet-types	[RFC6991]
te-types	ietf-te-types	[RFC8776]
pcep	ietf-pcep	[I-D.ietf-pce-pcep-yang]
srv6-types	ietf-srv6-types	[I-D.ietf-spring-srv6-yang]
sr-policy-types	ietf-sr-policy-types	[I-D.ietf-spring-sr-policy-yang]

Table 1: Prefixes and corresponding YANG modules

3.3. References in the Model

Following additional documents are referenced in the model defined in this document -

Title	Reference
PCEP Extensions for Segment Routing leveraging the IPV6 data plane	[I-D.ietf-pce-segment-routing-ipv6]
Carrying Binding Label/Segment Identifier (SID) in PCE-based Networks	[I-D.ietf-pce-binding-label-sid]
Segment Routing Policy Architecture	[I-D.ietf-spring-segment-routing-policy]
PCEP Extensions for Signaling Multipath Information	[I-D.ietf-pce-multipath]

Table 2: References in the YANG modules

3.4. Further Discussion

[[I-D.ietf-pce-multipath](#)] defines a mechanism to encode multiple paths for a single set of objectives and constraints. This is a generic PCEP mechanism, not specific to any path setup type or dataplane but the key usecase is SR.

Further discussion is needed on how to model it in PCEP YANG.

4. The Design of YANG Data Model

4.1. The Overview of PCEP SRV6 Data Model

The PCEP-SRV6 YANG module defined in this document has all the common building blocks for the PCEP-SRV6 extension. The model augments PCEP capabilities at the Entity and peer level with SRV6 capability in PCEP, support for NAI, MSD and the SID structure. The model also extends the LSP in the LSP-DB to maintain SRV6 paths.

module: ietf-pcep-srv6

```
augment /pcep:pcep/pcep:entity/pcep:capabilities:
  +--rw srv6 {srv6}?
  | +--rw enabled?      boolean
  | +--rw nai?         boolean
  | +--rw msd-limit?   boolean
  | +--rw srv6-msd* [msd-type]
  |   +--rw msd-type    uint8
  |   +--rw msd-value?  uint8
  +--rw sid-str {sid-str}?
    +--rw lb?    uint8
    +--rw ln?    uint8
    +--rw fn?    uint8
    +--rw an?    uint8
augment /pcep:pcep/pcep:entity/pcep:peers/pcep:peer
  /pcep:capabilities:
  +--rw srv6 {srv6}?
  +--rw enabled?      boolean
  +--rw nai?         boolean
  +--rw msd-limit?   boolean
  +--rw srv6-msd* [msd-type]
  +--rw msd-type    uint8
  +--rw msd-value?  uint8
augment /pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp:
  +--ro srv6 {srv6}?
  +--ro segment-list
  +--ro segment* [index]
  +--ro index                uint32
  +--ro sid-value?          srv6-types:srv6-sid
  +--ro sid-str {sid-str}?
  | +--ro lb?    uint8
  | +--ro ln?    uint8
  | +--ro fn?    uint8
  | +--ro an?    uint8
  +--ro endpoint-behavior?  identityref
```

4.2. The Overview of PCEP SR Policy Data Model

The PCEP-SRPolicy YANG module defined in this document has all the common building blocks for the PCEP-SR Policy extension. The model augments the LSP in the LSPDB to have information referring to the SR Policy and the candidate path.

```
module: ietf-pcep-srpolicy
```

```
augment /pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp:
  +--ro sr-policy
    +--ro headend?          inet:ip-address-no-zone
    +--ro color?           uint32
    +--ro endpoint?       inet:ip-address-no-zone
    +--ro protocol-origin? sr-policy-types:protocol-origin-type
    +--ro originator?     string
    +--ro discriminator?  uint32
```

The sr-policy container is applicable for both SR-MPLS and SRv6.

5. The YANG Modules

5.1. ietf-pcep-srv6 module

RFC Ed.: In this section, replace all occurrences of 'XXXX' with the actual RFC number and all occurrences of the revision date below with the date of RFC publication (and remove this note).

```

<CODE BEGINS> file "ietf-pcep-srv6@2022-07-11.yang"

module ietf-pcep-srv6 {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-pcep-srv6";
  prefix pcep-srv6;

  import ietf-srv6-types {
    prefix srv6-types;
    reference
      "I-D.ietf-spring-srv6-yang: YANG Data Model for SRv6
      Base and Static";
  }
  import ietf-te-types {
    prefix te-types;
    reference
      "RFC 8776: Common YANG Data Types for Traffic Engineering";
  }
  import ietf-pcep {
    prefix pcep;
    reference
      "I-D.ietf-pce-pcep-yang: A YANG Data Model for Path
      Computation Element Communications Protocol (PCEP)";
  }

  organization
    "IETF PCE (Path Computation Element) Working Group";
  contact
    "WG Web: <https://datatracker.ietf.org/wg/pce/>
    WG List: <mailto:pcep@ietf.org>
    Editor: Cheng Li
           <mailto:c.l@huawei.com>
           Shuping Peng
           <mailto:pengshuping@huawei.com>";
  description
    "The YANG module augments the Path Computation Element
    Communications Protocol (PCEP) YANG operational model
    with Segment Routing in IPv6 (SRv6).

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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.";

  revision 2022-07-11 {
    description
      "Initial revision.";
    reference
      "RFC XXXX: A YANG Data Model for Segment Routing (SR) Policy
      and SRv6 support in Path Computation Element Communications

```

```

        Protocol (PCEP)";
    }

/* Features */

feature srv6 {
    description
        "Support Segment Routing in IPv6 (SRv6) for PCE.";
    reference
        "I-D.ietf-pce-segment-routing-ipv6: PCEP Extensions
        for Segment Routing leveraging the IPv6 data plane";
}

feature bsid {
    description
        "Support Binding SID for PCE.";
    reference
        "I-D.ietf-pce-binding-label-sid: Carrying Binding
        Label/Segment Identifier (SID) in PCE-based Networks.";
}

feature sid-str {
    description
        "Support for SID Structure";
    reference
        "I-D.ietf-pce-segment-routing-ipv6: PCEP Extensions
        for Segment Routing leveraging the IPv6 data plane";
}

/* Identity */

identity path-setup-srv6 {
    if-feature "srv6";
    base te-types:path-signaling-type;
    description
        "SRv6 path setup type";
}

/* Groupings */

grouping srv6-msd {
    description
        "SRv6 MSD";
    leaf msd-type {
        type uint8;
        description
            "SRv6 Maximum Segment Depth (MSD) Type";
    }
    leaf msd-value {
        type uint8;
        description
            "SRv6 MSD value for the type";
    }
    reference
        "I-D.ietf-pce-segment-routing-ipv6: PCEP Extensions
        for Segment Routing leveraging the IPv6 data plane";
}

```



```

grouping srv6 {
  description
    "SRV6";
  container srv6 {
    if-feature "srv6";
    description
      "If SRV6 is supported";
    leaf enabled {
      type boolean;
      description
        "Enabled or Disabled; set to true when
        Enabled";
    }
    leaf nai {
      type boolean;
      default "false";
      description
        "True indicates capability to resolve Node or
        Adjacency Identifier (NAI) to SRV6 Segment
        Identifier (SID)";
    }
    leaf msd-limit {
      type boolean;
      default "false";
      description
        "True indicates no limit on MSD, the
        list srv6-msd is ignored";
    }
    list srv6-msd {
      key "msd-type";
      description
        "list of SRv6 MSD";
      uses srv6-msd;
    }
  }
}

```

```

grouping segment-list {
  description
    "Segment list grouping";
  container segment-list {
    description
      "Segments for given segment list";
    list segment {
      key "index";
      description
        "Configure Segment/hop at the index";
      uses segment-properties;
    }
  }
}

```

```

grouping segment-properties {
  description
    "Segment properties grouping";
  leaf index {
    type uint32;
    description

```

```

        "Segment index";
    }
    leaf sid-value {
        type srv6-types:srv6-sid;
        description
            "SRv6 SID value";
    }
    uses sid-str;
    leaf endpoint-behavior {
        type identityref {
            base srv6-types:srv6-endpoint-type;
        }
        description
            "The behavior associated with the SRv6 SIDs.";
    }
}
/*Query: Add NAI?*/
}

grouping sid-str {
    description
        "The default SID Structure";
    container sid-str {
        if-feature "sid-str";
        description
            "The default SID Structure";
        leaf lb {
            type uint8;
            description
                "SRv6 SID Locator Block length in bits";
        }
        leaf ln {
            type uint8;
            description
                "SRv6 SID Locator Node length in bits";
        }
        leaf fn {
            type uint8;
            description
                "SRv6 SID Function length in bits";
        }
        leaf an {
            type uint8;
            description
                "SRv6 SID Arguments length in bits";
        }
    }
}

}

/*
 * Augment modules to add SRv6
 */

augment "/pcep:pcep/pcep:entity/pcep:capabilities" {
    description
        "Augmenting SRv6";
    uses srv6;
    uses sid-str;
}

```

```

augment "/pcep:pcep/pcep:entity/pcep:peers/pcep:peer"
  + "/pcep:capabilities" {
  description
    "Augmenting SRv6";
  uses srv6;
}

augment "/pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp" {
  description
    "Augmenting SRv6";
  container srv6 {
    when
      "derived-from-or-self
        (/pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp/pcep:pst,
          'path-setup-srv6')" {
      description
        "For SRv6 path";
    }
    if-feature "srv6";
    uses segment-list;
    description
      "SRv6";
  }
}
}
}

```

<CODE ENDS>

5.2. ietf-pcep-srpolicy module

RFC Ed.: In this section, replace all occurrences of 'XXXX' with the actual RFC number and all occurrences of the revision date below with the date of RFC publication (and remove this note).

```

<CODE BEGINS> file "ietf-pcep-srpolicy@2022-07-11.yang"

module ietf-pcep-srpolicy {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-pcep-srpolicy";
  prefix pcep-srp;

  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Data Types";
  }
  import ietf-pcep {
    prefix pcep;
    reference
      "I-D.ietf-pce-pcep-yang: A YANG Data Model for Path
      Computation Element Communications Protocol (PCEP)";
  }
  import ietf-sr-policy-types {
    prefix sr-policy-types;
    reference
      "I-D.ietf-spring-sr-policy-yang: YANG Data Model for
      Segment Routing Policy";
  }

  organization
    "IETF PCE (Path Computation Element) Working Group";
  contact
    "WG Web: <https://datatracker.ietf.org/wg/pce/>
    WG List: <mailto:pce@ietf.org>
    Editor: Cheng Li
           <mailto:c.l@huawei.com>
           Shuping Peng
           <mailto:pengshuping@huawei.com>";
  description
    "The YANG module augments the Path Computation Element
    Communications Protocol (PCEP) YANG model with Segment
    Routing (SR) Policy.

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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.";

  revision 2022-07-11 {
    description
      "Initial revision.";
    reference
      "RFC XXXX: A YANG Data Model for Segment Routing (SR) Policy
      and SRv6 support in Path Computation Element Communications

```

```

        Protocol (PCEP)";
    }

/* Features */

feature multipath {
    description
        "Support for multipath ERO.";
    reference
        "I-D.ietf-pce-multipath: PCEP Extensions for Signaling
        Multipath Information";
}

/* Groupings */

grouping sr-policy {
    description
        "Segment Routing Policy grouping";
    leaf headend {
        type inet:ip-address-no-zone;
        description
            "SR Policy headend";
        reference
            "I-D.ietf-spring-segment-routing-policy: Segment
            Routing Policy Architecture";
    }
    leaf color {
        type uint32 {
            range "1..max";
        }
        description
            "SR Policy Color";
        reference
            "I-D.ietf-spring-segment-routing-policy: Segment
            Routing Policy Architecture";
    }
    leaf endpoint {
        type inet:ip-address-no-zone;
        description
            "SR Policy Endpoint";
        reference
            "I-D.ietf-spring-segment-routing-policy: Segment
            Routing Policy Architecture";
    }
}

grouping sr-policy-cp {
    description
        "Segment Routing Policy Candidate Path grouping";
    leaf protocol-origin {
        type sr-policy-types:protocol-origin-type;
        description
            "SR Policy Candidate Path Protocol";
        reference
            "I-D.ietf-spring-segment-routing-policy: Segment
            Routing Policy Architecture";
    }
    leaf originator {

```

```

    type string;
    description
      "SR Policy Candidate Path Originator";
    reference
      "I-D.ietf-spring-segment-routing-policy: Segment
      Routing Policy Architecture";
  }
  leaf discriminator {
    type uint32 {
      range "1..max";
    }
    description
      "SR Policy Candidate Path Discriminator";
    reference
      "I-D.ietf-spring-segment-routing-policy: Segment
      Routing Policy Architecture";
  }
}
}

augment "/pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp" {
  description
    "Augmenting SR Policy";
  container sr-policy {
    when
      "derived-from-or-self
      (/pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp/pcep:pst,
      'path-setup-sr') or
      derived-from-or-self
      (/pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp/pcep:pst,
      'path-setup-srv6')" {
      description
        "Applicable for SR or SRv6";
    }
    uses sr-policy;
    uses sr-policy-cp;
    description
      "SR Policy Candidate Path";
  }
}
}
}

```

<CODE ENDS>

6. Security Considerations

The YANG module defined in this document is designed to be accessed via network management protocol such as NETCONF [[RFC6241](#)] or RESTCONF [[RFC8040](#)]. The lowest NETCONF layer is the secure transport layer and the mandatory-to-implement secure transport is SSH [[RFC6242](#)]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [[RFC8446](#)].

The NETCONF access control model [[RFC8341](#)] 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 YANG module which are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., <edit-config>) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

`*/pcep:pcep/pcep:entity/pcep:capabilities/pcep-srv6:srv6` - configure local SRv6 capability and parameters.

`*/pcep:pcep/pcep:entity/pcep:peers/pcep:peer/pcep:capabilities/pcep-srv6:srv6` - configure peer's SRv6 capability and parameters.

Unauthorized access to above list can adversely affect the PCEP session between the local entity and the peers. This may lead to inability to compute new paths, stateful operations on the delegated as well as PCE-initiated LSPs.

Some of the readable data nodes in this YANG module 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. These are the subtrees and data nodes and their sensitivity/vulnerability:

`*/pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp/pcep-srv6:srv6` - The SRv6 SID in the network. Unauthorized access to this could provide entire path and network usage information.

`*/pcep:pcep/pcep:entity/pcep:lsp-db/pcep:lsp/pcep-srpolicy:sr-policy` - The reference to SR Policy. Unauthorized access to this could provide SR Policy usage information.

7. IANA Considerations

This document registers a URI in the "IETF XML Registry" [[RFC3688](#)]. Following the format in RFC 3688, the following registration has been made.

URI: urn:ietf:params:xml:ns:yang:ietf-pcep-srv6

Registrant Contact: The PCE WG of the IETF.

XML: N/A; the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-pcep-srpolicy

Registrant Contact: The PCE WG of the IETF.

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-pcep-srv6
Namespace: urn:ietf:params:xml:ns:yang:ietf-pcep-srv6
Prefix: pcep-srv6
Reference: This I-D

Name: ietf-pcep-srpolicy
Namespace: urn:ietf:params:xml:ns:yang:ietf-pcep-srpolicy
Prefix: pcep-srp
Reference: This I-D

8. Acknowledgements

The authors would like to thank Dhruv Dhody for the initial YANG model.

9. References

9.1. Normative References

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