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A YANG Data Model for In-Situ OAM
draft-zhou-ippm-ioam-yang-07

Abstract

In-situ Operations, Administration, and Maintenance (IOAM) records operational and telemetry information in user packets while the packets traverse a path between two points in the network. This document defines a YANG module for the IOAM function.

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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1. Introduction

In-situ Operations, Administration, and Maintenance (IOAM) [I-D.ietf-ippm-ioam-data] records OAM information within user packets while the packets traverse a network. The data types and data formats for IOAM data records have been defined in [I-D.ietf-ippm-ioam-data]. The IOAM data can be embedded in many protocol encapsulations such as Network Services Header (NSH) and IPv6.

This document defines a data model for IOAM capabilities using the YANG data modeling language [RFC7950]. This YANG model supports all the five IOAM options, which are Incremental Tracing Option, Pre-allocated Tracing Option, Direct Export Option[I-D.ietf-ippm-ioam-direct-export], Proof of Transit Option, and Edge-to-Edge Option.

2. Conventions used in this document

The keywords "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

BCP14, [RFC2119], [RFC8174] when, and only when, they appear in all capitals, as shown here.

The following terms are defined in [RFC7950] and are used in this specification:

- augment
- data model
- data node

The terminology for describing YANG data models is found in [RFC7950].

2.1. Tree Diagrams

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

3. Design of the IOAM YANG Data Model

3.1. Profiles

The IOAM model is organized as list of profiles as shown in the following figure. Each profile associates with one flow and the corresponding IOAM information.

```
module: ietf-ioam
   +--rw ioam
      +--rw ioam-profiles
         +--rw admin-config
         |  +--rw enabled?   boolean
         +--rw ioam-profile* [profile-name]
            +--rw profile-name                    string
            +--rw filter
            |  +--rw filter-type?   ioam-filter-type
            |  +--rw acl-name?      -> /acl:acls/acl/name
            +--rw protocol-type?                  ioam-protocol-type
            +--rw incremental-tracing-profile {incremental-trace}?
            |  ...
            +--rw preallocated-tracing-profile {preallocated-trace}?
            |  ...
            +--rw direct-export-profile {direct-export}?
            |  ...
            +--rw pot-profile {proof-of-transit}?
            |  ...
            +--rw e2e-profile {edge-to-edge}?
               ...
```

The "enabled" is an administrative configuration. When it is set to true, IOAM configuration is enabled for the system. Meanwhile, the IOAM data-plane functionality is enabled.

The "filter" is used to identify a flow, where the IOAM profile can apply. There may be multiple filter types. ACL is the default one.

The IOAM data can be encapsulated into multiple protocols, e.g., IPv6 [I-D.ietf-ippm-ioam-ipv6-options] and NSH [I-D.ietf-sfc-ioam-nsh]. The "protocol-type" is used to indicate where the IOAM is applied. For example, if the "protocol-type" is IPv6, the IOAM ingress node will encapsulate the associated flow with the IPv6-IOAM [I-D.ietf-ippm-ioam-ipv6-options] format.

IOAM data includes five encapsulation types, i.e., incremental tracing data, preallocated tracing data, direct export data, prove of transit data and end to end data. In practice, multiple IOAM data types can be encapsulated into the same IOAM header. The "ioam-profile" contains a set of sub-profiles, each of which relates to one encapsulation type. The configured object may not support all the sub-profiles. The supported sub-profiles are indicated by 5 defined features, i.e., "incremental-trace", "preallocated-trace", "direct export", "proof-of-transit", "edge-to-edge".

3.2. Preallocated Tracing Profile

The IOAM tracing data is expected to be collected at every node that a packet traverses to ensure visibility into the entire path a packet takes within an IOAM domain. The preallocated tracing option will create pre-allocated space for each node to populate its information . The "preallocated-tracing-profile" contains the detailed information for the preallocated tracing data. The information includes:

- enabled: indicates whether the preallocated tracing profile is enabled.
- node-action: indicates the operation (e.g., encapsulate IOAM header, transit the IOAM data, or decapsulate IOAM header) applied to the dedicated flow.
- use-namespace: indicate the namespace used for the trace types.
- trace-type: indicates the per-hop data to be captured by the IOAM enabled nodes and included in the node data list.
- Loopback mode is used to send a copy of a packet back towards the source.
- Active mode indicates that a packet is used for active measurement.

```
+--rw preallocated-tracing-profile {preallocated-trace}?
   +--rw enabled?                boolean
   +--rw node-action?            ioam-node-action
   +--rw trace-types
   |  +--rw use-namespace?   ioam-namespace
   |  +--rw trace-type*      ioam-trace-type
   +--rw enable-loopback-mode?   boolean
   +--rw enable-active-mode?   boolean
```

3.3. Incremental Tracing Profile

The incremental tracing option contains a variable node data fields where each node allocates and pushes its node data immediately following the option header. The "incremental-tracing-profile" contains the detailed information for the incremental tracing data. The detailed information is the same as the Preallocated Tracing Profile, but with one more variable, "max-length", which restricts the length of the IOAM header.

```
+--rw incremental-tracing-profile {incremental-trace}?
   +--rw enabled?                boolean
   +--rw node-action?            ioam-node-action
   +--rw trace-types
   |  +--rw use-namespace?   ioam-namespace
   |  +--rw trace-type*   ioam-trace-type
   +--rw enable-loopback-mode?   boolean
   +--rw enable-active-mode?   boolean
   +--rw max-length?             uint32
```

3.4. Direct Export Profile

The direct export option is used as a trigger for IOAM nodes to export IOAM data to a receiving entity (or entities). The "direct-export-profile" contains the detailed information for the direct export data. The detailed information is the same as the Preallocated Tracing Profile, but with one more optional variable, "flow-id", which is used to correlate the exported data of the same flow from multiple nodes and from multiple packets.

```
+--rw direct-export-profile {direct-export}?
   +--rw enabled?                boolean
   +--rw node-action?            ioam-node-action
   +--rw trace-types
   |  +--rw use-namespace?   ioam-namespace
   |  +--rw trace-type*      ioam-trace-type
   +--rw enable-loopback-mode?   boolean
   +--rw enable-active-mode?   boolean
   +--rw flow-id?              uint32
```

3.5. Proof of Transit Profile

The IOAM Proof of Transit data is to support the path or service function chain verification use cases. The "pot-profile" contains the detailed information for the prove of transit data. The detailed information are described in [I-D.brockners-proof-of-transit].

```
   +--rw pot-profile {proof-of-transit}?
      +--rw enabled?                boolean
      +--rw active-profile-index?   pot:profile-index-range
      +--rw pot-profile-list* [pot-profile-index]
         +--rw pot-profile-index    profile-index-range
         +--rw prime-number         uint64
         +--rw secret-share         uint64
         +--rw public-polynomial    uint64
         +--rw lpc                  uint64
         +--rw validator?           boolean
         +--rw validator-key?       uint64
         +--rw bitmask?             uint64
```

3.6. Edge to Edge Profile

The IOAM edge to edge option is to carry data that is added by the IOAM encapsulating node and interpreted by IOAM decapsulating node. The "e2e-profile" contains the detailed information for the edge to edge data. The detailed information includes:

- enabled: indicates whether the edge to edge profile is enabled.
- node-action is the same semantic as in Section 2.2.
- use-namespace: indicate the namespace used for the edge to edge types.
- e2e-type indicates data to be carried from the ingress IOAM node to the egress IOAM node.

```
   +--rw e2e-profile {edge-to-edge}?
      +--rw enabled?       boolean
      +--rw node-action?   ioam-node-action
      +--rw e2e-types
         +--rw use-namespace?   ioam-namespace
         +--rw e2e-type*        ioam-e2e-type
```

4. IOAM YANG Module

```
<CODE BEGINS> file "ietf-ioam@2020-07-08.yang"
module ietf-ioam {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-ioam";
  prefix "ioam";
  import ietf-pot-profile {
    prefix "pot";
    reference "draft-brockners-proof-of-transit";
  }
```

```
   import ietf-access-control-list {
     prefix "acl";
     reference
       "RFC 8519: YANG Data Model for Network Access Control
        Lists (ACLs)";
   }

   organization
     "IETF IPPM (IP Performance Metrics) Working Group";

   contact
     "WG Web: <http://tools.ietf.org/wg/ippm>
      WG List: <ippm@ietf.org>
      Editor: zhoutianran@huawei.com
      Editor: srihari@cisco.com";

   description
     "This YANG module specifies a vendor-independent data
      model for the In Situ OAM (IOAM).

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     authors of the code.  All rights reserved.

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

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

   revision 2020-07-08 {
     description "Initial revision.";
     reference "draft-zhou-ippm-ioam-yang";
   }

  /*
   * FEATURES
   */

   feature incremental-trace
   {
     description
       "This feature indicated that the incremental tracing option is
        supported";
   }
```

```
   feature preallocated-trace
   {
     description
       "This feature indicated that the preallocated tracing option is
        supported";
   }

   feature direct-export
   {
     description
       "This feature indicated that the direct export option is
        supported";
   }

   feature proof-of-transit
   {
     description
       "This feature indicated that the proof of transit option is
        supported";
   }

   feature edge-to-edge
   {
     description
       "This feature indicated that the edge to edge option is
        supported";
   }

  /*
   * IDENTITIES
   */
   identity base-filter {
     description
       "Base identity to represent a filter. A filter is used to
       specify the flow to apply the IOAM profile. ";
   }

   identity acl-filter {
     base base-filter;
     description
       "Apply ACL rule to specify the flow.";
   }

   identity base-protocol {
     description
       "Base identity to represent the carrier protocol. It's used to
        indicate what layer and protocol the IOAM data is embedded.";
   }
```

```
   identity ipv6-protocol {
     base base-protocol;
     description
       "The described IOAM data is embedded in IPv6 protocol.";
     reference "ietf-ippm-ioam-ipv6-options";
   }

   identity NSH {
     base base-protocol;
     description
       "The described IOAM data is embedded in NSH.";
     reference "ietf-sfc-ioam-nsh";
   }

   identity base-node-action {
     description
       "Base identity to represent the node actions. It's used to
        indicate what action the node will take.";
   }

   identity encapsulate {
     base base-node-action;
     description
       "indicate the node is to encapsulate the IOAM packet";
   }

   identity transit {
     base base-node-action;
     description
       "indicate the node is to transit the IOAM packet";
   }

   identity decapsulate {
     base base-node-action;
     description
       "indicate the node is to decapsulate the IOAM packet";
   }

   identity base-trace-type {
     description
       "Base identity to represent trace types";
   }

   identity trace-hop-lim-node-id {
     base base-trace-type;
     description
       "indicates presence of Hop_Lim and node_id in the
        node data.";
```

```
   }

   identity trace-if-id {
     base base-trace-type;
     description
       "indicates presence of ingress_if_id and egress_if_id in the
        node data.";
   }

   identity trace-timestamp-seconds {
     base base-trace-type;
     description
       "indicates presence of time stamp seconds in the node data.";
   }

   identity trace-timestamp-nanoseconds {
     base base-trace-type;
     description
       "indicates presence of time stamp nanoseconds in the node data.";
   }

   identity trace-transit-delay {
     base base-trace-type;
     description
       "indicates presence of transit delay in the node data.";
   }

   identity trace-namespace-data {
     base base-trace-type;
     description
       "indicates presence of namespace specific data (short format)
        in the node data.";
   }

   identity trace-queue-depth {
     base base-trace-type;
     description
       "indicates presence of queue depth in the node data.";
   }

   identity trace-opaque-state-snapshot {
     base base-trace-type;
     description
       "indicates presence of variable length Opaque State Snapshot
        field.";
   }

   identity trace-hop-lim-node-id-wide {
```

```
    base base-trace-type;
    description
      "indicates presence of Hop_Lim and node_id wide in the
       node data.";
  }

  identity trace-if-id-wide {
    base base-trace-type;
    description
      "indicates presence of ingress_if_id and egress_if_id wide in
       the node data.";
  }

  identity trace-namespace-data-wide {
    base base-trace-type;
    description
      "indicates presence of namespace specific data in wide format
       in the node data.";
  }

  identity trace-buffer-occupancy {
    base base-trace-type;
    description
      "indicates presence of buffer occupancy in the node data.";
  }

  identity trace-checksum-complement {
    base base-trace-type;
    description
      "indicates presence of the Checksum Complement node data.";
  }

  identity base-pot-type {
    description
      "Base identity to represent pot types";
  }

  identity pot-bytes-16 {
    base base-pot-type;
    description
      "POT data is a 16 Octet field.";
  }

  identity base-e2e-type {
    description
      "Base identity to represent e2e types";
  }
```

```
  identity e2e-seq-num-64 {
    base base-e2e-type;
    description
      "indicates presence of a 64-bit sequence number";
  }

  identity e2e-seq-num-32 {
    base base-e2e-type;
    description
      "indicates presence of a 32-bit sequence number";
  }

  identity e2e-timestamp-seconds {
    base base-e2e-type;
    description
      "indicates presence of timestamp seconds for the
       transmission of the frame";
  }

  identity e2e-timestamp-subseconds {
    base base-e2e-type;
    description
      "indicates presence of timestamp subseconds for the
       transmission of the frame";
  }

  identity base-namespace {
    description
      "Base identity to represent the namespace";
  }

  identity namespace-ietf {
    base base-namespace;
    description
      "namespace that specified in IETF.";
  }

 /*
  * TYPE DEFINITIONS
  */

  typedef ioam-filter-type {
    type identityref {
      base base-filter;
    }
    description
      "Specifies a known type of filter.";
  }
```

```
   typedef ioam-protocol-type {
     type identityref {
       base base-protocol;
     }
     description
       "Specifies a known type of carrier protocol for the IOAM data.";
   }

   typedef ioam-node-action {
     type identityref {
       base base-node-action;
     }
     description
       "Specifies a known type of node action.";
   }

   typedef ioam-trace-type {
     type identityref {
       base base-trace-type;
     }
     description
       "Specifies a known trace type.";
   }

   typedef ioam-pot-type {
     type identityref {
       base base-pot-type;
     }
     description
       "Specifies a known pot type.";
   }

   typedef ioam-e2e-type {
     type identityref {
       base base-e2e-type;
     }
     description
       "Specifies a known e2e type.";
   }

   typedef ioam-namespace {
     type identityref {
       base base-namespace;
     }
     description
       "Specifies the supported namespace.";
   }
```

```
  /*
   * GROUP DEFINITIONS
   */

   grouping ioam-filter {
     description "A grouping for IOAM filter definition";

     leaf filter-type {
       type ioam-filter-type;
       description "filter type";
     }

     leaf acl-name {
       when "../filter-type = 'ioam:acl-filter'";
       type leafref {
         path "/acl:acls/acl:acl/acl:name";
       }
       description "Access Control List name.";
     }
   }

   grouping encap-tracing {
     description
       "A grouping for the generic configuration for
        tracing profile.";

     container trace-types {
       description
         "the list of trace types for encapsulate";

       leaf use-namespace {
         type ioam-namespace;
         description
           "the namespace used for the encapsulation";
       }

       leaf-list trace-type {
         type ioam-trace-type;
         description
           "The trace type is only defined at the encapsulation node.";
       }
     }

     leaf enable-loopback-mode {
       type boolean;
       default false;
       description
         "Loopback mode is used to send a copy of a packet back towards
```

```
        the source. The loopback mode is only defined at the
        encapsulation node.";
    }

    leaf enable-active-mode {
      type boolean;
      default false;
      description
        "Active mode indicates that a packet is used for active
         measurement. An IOAM decapsulating node that receives a
         packet with the Active flag set in one of its Trace options
         must terminate the packet.";
    }
  }

  grouping ioam-incremental-tracing-profile {
    description
      "A grouping for incremental tracing profile.";
    reference "draft-ietf-ippm-ioam-data";

    leaf node-action {
      type ioam-node-action;
      description "node action";
    }

    uses encap-tracing {
          when "../node-action = 'ioam:encapsulate'";
        }

    leaf max-length {
      when "../node-action = 'ioam:encapsulate'";
      type uint32;
      description
        "This field specifies the maximum length of the node data list
        in octets. The max-length is only defined at the
        encapsulation node. And it's only used for the incremental
        tracing mode.";
    }
  }

  grouping ioam-preallocated-tracing-profile {
    description
      "A grouping for incremental tracing profile.";
    reference "draft-ietf-ippm-ioam-data";

    leaf node-action {
      type ioam-node-action;
      description "node action";
```

```
    }

    uses encap-tracing {
          when "../node-action = 'encapsulate'";
        }
  }

  grouping ioam-direct-export-profile {
    description
      "A grouping for direct export profile.";
    reference "ietf-ippm-ioam-direct-export";

    leaf node-action {
      type ioam-node-action;
      description "node action";
    }

    uses encap-tracing {
          when "../node-action = 'encapsulate'";
        }

    leaf flow-id {
      when "../node-action = 'encapsulate'";
      type uint32;
      description
        "flow-id is used to correlate the exported data of the same
         flow from multiple nodes and from multiple packets.";
    }
  }

  grouping ioam-e2e-profile {
    description
      "A grouping for tracing profile.";
    reference "draft-ietf-ippm-ioam-data";

    leaf node-action {
      type ioam-node-action;
      description
        "indicate how the node act for this profile";
    }

    container e2e-types {
      when "../node-action = 'encapsulate'";
      description
        "the list of e2e types for encapsulate";

      leaf use-namespace {
        type ioam-namespace;
```

```
        description
          "the namespace used for the encapsulation";
      }

      leaf-list e2e-type {
        type ioam-e2e-type;
        description
          "The e2e type is only defined at the encapsulation node.";
      }
    }
  }

  grouping ioam-admin-config {
    description
      "IOAM top-level administrative configuration.";

    leaf enabled {
      type boolean;
      default false;
      description
        "When true, IOAM configuration is enabled for the system.
         Meanwhile, the IOAM data-plane functionality is enabled.";
    }
  }

 /*
  * DATA NODES
  */

  container ioam {
    description "IOAM top level container";

    container ioam-profiles {
      description
        "Contains a list of IOAM profiles.";

      container admin-config {
        description
          "Contains all the administrative configurations related to
           the IOAM functionalities and all the IOAM profiles.";

        uses ioam-admin-config;
      }

      list ioam-profile {
        key "profile-name";
        ordered-by user;
        description
```

```
          "A list of IOAM profiles that configured on the node.";

        leaf profile-name {
          type string;
          mandatory true;
          description
            "Unique identifier for each IOAM profile";
        }

        container filter {
          uses ioam-filter;
          description
            "The filter which is used to indicate the flow to apply
            IOAM.";
        }

        leaf protocol-type {
          type ioam-protocol-type;
          description
            "This item is used to indicate the carrier protocol where
            the IOAM is applied.";
        }

        container incremental-tracing-profile {
          if-feature incremental-trace;
          description
            "describe the profile for incremental tracing option";

          leaf enabled {
            type boolean;
            default false;
            description
              "When true, apply incremental tracing option to the
               specified flow identified by the filter.";
          }

          uses ioam-incremental-tracing-profile;
        }

        container preallocated-tracing-profile {
          if-feature preallocated-trace;
          description
            "describe the profile for preallocated tracing option";

          leaf enabled {
            type boolean;
            default false;
            description
```

```
            "When true, apply preallocated tracing option to the
             specified flow identified by the following filter.";
          }

          uses ioam-preallocated-tracing-profile;
        }

        container direct-export-profile {
          if-feature direct-export;
          description
            "describe the profile for direct-export option";

          leaf enabled {
            type boolean;
            default false;
            description
              "When true, apply direct-export option to the
               specified flow identified by the following filter.";
          }

          uses ioam-direct-export-profile;
        }

        container pot-profile {
          if-feature proof-of-transit;
          description
            "describe the profile for pot option";

          leaf enabled {
            type boolean;
            default false;
            description
              "When true, apply Proof of Transit option to the
               specified flow identified by the following filter.";
          }

          leaf active-profile-index {
            type pot:profile-index-range;
            description
              "Proof of transit profile index that is currently
               active. Will be set in the first hop of the path
               or chain. Other nodes will not use this field.";
          }

          uses pot:pot-profile;
        }

        container e2e-profile {
```

```
          if-feature edge-to-edge;
          description
            "describe the profile for e2e option";

          leaf enabled {
            type boolean;
            default false;
            description
              "When true, apply End to end option to the
               specified flow identified by the following filter.";
          }

          uses ioam-e2e-profile;
        }
      }
    }
  }
}
<CODE ENDS>
```

5. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC5246].

The NETCONF access control model [RFC6536] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

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

o /ioam/ioam-profiles/admin-config

The items in the container above include the top level administrative configurations related to the IOAM functionalities and all the IOAM

profiles. Unexpected changes to these items could lead to the IOAM function disruption and/ or misbehavior of all the IOAM profiles.

o /ioam/ioam-profiles/ioam-profile

The entries in the list above include the whole IOAM profile configurations which indirectly create or modify the device configurations. Unexpected changes to these entries could lead to the mistake of the IOAM behavior for the corresponding flows.

6. IANA Considerations

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

IANA is requested to assign a new URI from the IETF XML Registry [RFC3688]. The following URI is suggested:

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

This document also requests a new YANG module name in the YANG Module Names registry [RFC7950] with the following suggestion:

```
name: ietf-ioam
namespace: urn:ietf:params:xml:ns:yang:ietf-ioam
prefix: ioam
reference: RFC XXXX
```

7. Acknowledgements

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