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On-~~path~~ Path Telemetry YANG Data Model

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Abstract

This document proposes a YANG data model for monitoring ~~on~~On-~~path~~Path ~~telemetry~~ network performance information to be published in YANG notifications. The Alternate-Marking Method and In-situ Operations, Administration, and Maintenance (IOAM) are ~~the on~~On-~~path~~Path hybrid measurement methods considered in this document.

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1. Introduction

Alternate-Marking Method [RFC9341] [RFC9342] (AltMark) is a technique used to perform packet loss, delay, and jitter measurements on in-flight packets. In-situ Operations, Administration, and Maintenance (IOAM) is a method to produce operational and telemetry information that may be exported using the in-band or out-of-band method. The data types and data formats for IOAM data records have been defined in [RFC9197] [RFC9326].

This document defines a YANG data model for monitoring ~~on~~On-~~path~~Path telemetry information of Alternate Marking Method and IOAM. It provides YANG data models with performance monitoring parameters that can be subscribed ~~to~~ for monitoring and telemetry via ~~the mechanism~~YANG-Push specified in [RFC8639] ~~,~~[RFC8640] and [RFC8641].

This document ~~does not introduce new telemetry metrics for network performance for measuring network performance, but it~~ uses the existing mechanisms of [RFC9341], [RFC9342], [RFC9197], [RFC9326] to monitor the performance of the network and ~~the~~ connectivity services.

1.1. 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.

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1.2. Conventions

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. Use Case

Some applications may use the subscription model specified in [RFC8641] to subscribe to the ~~on~~On-~~path~~ Path telemetry network performance data. For example, ~~network~~ Network ~~telemetry~~ Telemetry [RFC9232] updates may be ~~obtained~~ subscribed ~~through~~to YANG-Push on-change notifications [RFC8641] for state changes. ~~A~~ YANG-Push periodic notifications [RFC8641] can be ~~specified~~ subscribed to obtain real-time performance data.

There is a need for real-time traffic monitoring of the network to optimize the network performance. The next figure shows an example of a high-level workflow for dynamic network control based on traffic monitoring that could use the mechanism described in this document.

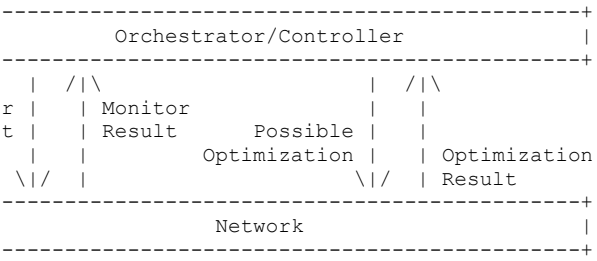

Figure 1: Workflow for dynamic network control based on traffic monitoring

The Controller sends a Monitor Request and receive Monitor Result. ~~As a consequence of~~Because of this Closed-Loop approach, the controller can take Optimization actions, that can be related to ~~network~~ forwarding path modification or performance measurements variation ([I-D.ydt-ippm-alt-mark-yang]), as also described in [RFC9342] with regard to the flexible and adaptive performance measurements.

3. On-~~path~~ Path Telemetry Tree Diagram

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

The On-~~path~~ Path Telemetry model is organized as shown in the following figure. This model ~~complement~~complements the AltMark model in [I-D.ydt-ippm-alt-mark-yang] and the IOAM model in [RFC9617].

```
module: on-path-telemetry
  +--ro on-path-telemetry-data
     +--ro timestamp?                        yang:date-and-time
     +--ro interface*                        [if-name]
        +--ro if-name                        if:interface-ref
        +--ro profile-name                   string
        +--ro filter
        |  +--ro filter-type?                telemetry-filter-type
        |  +--ro ace-name?                -> /acl:acls/acl/aces/ace/name
        +--ro protocol-type?                 telemetry-protocol-type
        +--ro node-action                    telemetry-node-action
        +--ro period?                        uint64
        +--ro period-number?                 uint64
        +--ro flow-mon-id?                   uint32
        +--rw method-type?                   altmark-method-type
        +--ro altmark-loss-measurement?
        |  +--ro in-traffic-pkts?            yang:counter64
        |  +--ro out-traffic-pkts?           yang:counter64
        |  +--ro in-traffic-bytes?           uint64
        |  +--ro out-traffic-bytes?          uint64
        +--ro altmark-delay-measurement?
        |  +--ro pkts-timestamps?            yang:date-and-time
        |     +--ro pkt-timestamp?           yang:date-and-time
        +--ro path-delay?
        |  +--ro path-delay-mean             uint32
        |  +--ro path-delay-min              uint32
        |  +--ro path-delay-max              uint32
        |  +--ro path-delay-sum              uint64
        +--ro ioam-incremental-tracing       ioam-trace-data
        +--ro ioam-preallocated-tracing      ioam-trace-data
        +--ro ioam-direct-export             ioam-trace-data
        +--ro ioam-proof-of-transit          ioam-pot-data
        +--ro ioam-edge-to-edge              ioam-e2e-data
```

4. On-~~path~~ Path Telemetry Data

The "on-path-telemetry-data" contains ~~the~~ detailed information for the AltMark telemetry data and IOAM telemetry data. The information includes:

* timestamp: ~~it~~ is the timestamp of the message.
* interface: indicates the list of interface where the On-~~path~~Path Telemetry is applied.

The "interface" contains the detailed information for the each interface. The information includes:

* if-name: ~~it~~ is the interface name as in ifName [RFC2863]
* profile-name: ~~it~~ is the unique identifier for each profile
* filter: ~~it~~ is used to identify the monitored flow
* protocol-type: ~~it~~ is used to indicate the protocol where the On-path telemetry is applied
* node-action: indicates the operation applied to the flow.
* period: ~~it~~ indicates the period.
* period-number: ~~it~~ indicates the period number (for AltMark see [I-D.ietf-ippm-alt-mark-deployment]).
* flow-mon-id: ~~it~~ is used to identify the monitored flow and to correlate the exported data of the same flow from multiple nodes and from multiple packets.
* altmark-loss-measurement: ~~it~~ indicates loss counters.
* altmark-delay-measurement: ~~it~~ indicates packet timestamps.
* ioam-incremental-tracing: ~~it~~ indicates IOAM incremental tracing data.
* ioam-preallocated-tracing: ~~it~~ indicates IOAM pre-allocated tracing data.
* ioam-direct-export: ~~it~~ indicates direct export data.
* ioam-proof-of-transit: ~~it~~ indicates proof of transit data.

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* ioam-edge-to-edge: ~~it~~ indicates edge-to-edge data.

The "altmark-loss-measurement" contains:

* in-traffic-pkts: ~~it~~ indicates the inbound packets of the period.
* out-traffic-pkts: ~~it~~ indicates the outbound packets of the period.
* in-traffic-bytes: ~~it~~ indicates the inbound bytes of the period.
* out-traffic-bytes: ~~it~~ indicates the outbound bytes of the period.

The "altmark-delay-measurement" contains:

* pkts-timestamps: ~~it~~ indicates the list of packet timestamps for delay measurement in the period (pkt-timestamp).

The "path-delay" in introduced in [I-D.ietf-opsawg-ipfix-on-path-telemetry] and contains:

* path-delay-mean: ~~it~~ indicates the mean path delay between the encapsulation/marking node and the local node.
* path-delay-min: ~~it~~ indicates the lowest path delay between the encapsulation/marking node and the local node.
* path-delay-max: ~~it~~ indicates the highest path delay between the encapsulation/marking node and the local node.
* path-delay-sum: ~~it~~ indicates the sum of the path delay between the encapsulation/marking node and the local node.

5. On-Path Telemetry YANG Data Model

<CODE BEGINS> file "ietf-on-path-telemetry@2024-12-20.yang"

```
module ietf-on-path-telemetry {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-on-path-telemetry";
  prefix "on-path-telemetry";
     import ietf-access-control-list {
       prefix acl;
       reference
         "RFC 8519: YANG Data Model for Network Access Control
          Lists (ACLs)";
     }
     import ietf-interfaces {
```

```
          prefix if;
          reference
            "RFC 8343: A YANG Data Model for Interface Management";
        }
        import ietf-yang-types {
          prefix yang;
          reference
            "Section 3 of RFC 6991";
        }
      organization
        "IETF IPPM (IP Performance Metrics) Working Group";
      contact
        "WG Web: <https://datatracker.ietf.org/wg/ippm>
         WG List: <ippm@ietf.org>
         Author: giuseppe.fioccola@huawei.com
         Author: zhoutianran@huawei.com";
      description
        "This YANG module specifies a vendor-independent data
         model for Alternate Marking Telemetry.
         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.
         Copyright (c) 2024 IETF Trust and the persons identified as
         authors of the code.  All rights reserved.
         Redistribution and use in source and binary forms, with or
         without modification, is permitted pursuant to, and subject to
         the license terms contained in, the Revised BSD License set
         forth in Section 4.c of the IETF Trust's Legal Provisions
         Relating to IETF Documents
         (https://trustee.ietf.org/license-info).
         This version of this YANG module is part of RFC XXXX
         (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
         for full legal notices.";
      revision 2024-12-20 {
        description "First revision.";
        reference "RFC XXXX: A YANG Data Model for On-path Telemetry";
      }
```

```
    /*
     * FEATURES
     */
     feature altmark
     {
       description
         "This feature indicated that the Alternate-Marking Method is
             supported.";
       reference
             "RFC 9341: Alternate-Marking Method;
              RFC 9342: Clustered Alternate-Marking Method";
     }
     feature pathdelay
     {
       description
         "This feature indicated that the Path Delay is
             supported.";
       reference
             "[I-D.ietf-opsawg-ipfix-on-path-telemetry]";
     }
     feature incremental-trace
     {
       description
         "This feature indicated that the incremental tracing option is
         supported.";
       reference "RFC 9197: Data Fields for In-situ OAM";
     }
     feature preallocated-trace
     {
       description
         "This feature indicated that the preallocated tracing option is
         supported.";
       reference "RFC 9197: Data Fields for In-situ OAM";
     }
     feature direct-export
     {
       description
         "This feature indicated that the direct export option is
         supported.";
       reference "RFC 9326: In-situ OAM Direct Exporting";
     }
     feature proof-of-transit
```


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```
     {
       description
         "This feature indicated that the proof of transit option is
         supported";
       reference "RFC 9197: Data Fields for In-situ OAM";
     }
     feature edge-to-edge
     {
       description
         "This feature indicated that the edge-to-edge option is
         supported.";
       reference "RFC 9197: Data Fields for In-situ OAM";
     }
    /*
     * IDENTITIES
     */
     identity filter {
       description
         "Base identity to represent a filter. A filter is used to
         specify the flow to which the On-Path Telemetry method is
applied.";
     }
     identity acl-filter {
       base filter;
       description
         "Apply ACL rules to specify the flow.";
     }
     identity protocol {
       description
         "Base identity to represent the protocol. It's used to
          indicate the protocol for the application of the On-Path
Telemetry
             method.";
     }
     identity ipv6 {
       base protocol;
       description
         "The On-Path Telemetry method is applied to IPv6 protocol.";
       reference
         "RFC 9343: IPv6 Application of the Alternate-Marking Method,
             RFC 9486: In-situ OAM IPv6 Options";
     }
     identity srh  {
```

```
       base protocol;
       description
         "The On-Path Telemetry method is applied to SRH.";
       reference
         "[I-D.fz-spring-srv6-alt-mark]: Application of the
             Alternate Marking Method to the Segment Routing Header";
     }
     identity mpls  {
       base protocol;
       description
         "The On-Path Telemetry method is applied to MPLS.";
       reference
         "[I-D.ietf-mpls-inband-pm-encapsulation]: Application of the
             Alternate Marking Method to the MPLS Label Stack";
     }
     identity nsh  {
       base protocol;
       description
         "The described IOAM data is embedded in NSH.";
       reference
         "RFC 9452: Network Service Header (NSH)
         Encapsulation for In-situ OAM (IOAM) Data";
      }
     identity node-action {
       description
         "Base identity to represent the node actions. It's used to
          indicate what action the node will take.";
     }
     identity action-marking {
       base node-action;
       description
         "It indicates that the node must mark the AltMark data field,
             according to the operations described in RFC 9341 and
             RFC 9342";
     }
     identity action-unmarking {
       base node-action;
       description
         "It indicates that the node must unmark the AltMark data field,
             according to the operations described in RFC 9341 and
             RFC 9342";
     }
```

```
    identity action-read {
      base node-action;
      description
        "It indicates the node only reads the AltMark data,
            according to the operations described in RFC 9341 and
            RFC 9342";
    }
    identity action-encapsulate {
      base node-action;
      description
        "It indicates the node is to encapsulate the IOAM packet";
    }
    identity action-decapsulate {
      base node-action;
      description
        "It indicates the node is to decapsulate the IOAM packet";
    }
    identity action-transit {
      base node-action;
      description
        "It indicates the node is to transit the IOAM packet";
    }
    identity period {
      description
        "It indicates the On-Path Telemetry Period.";
    }
    identity period-number {
      description
        "It indicates the Period Number.";
    }
    identity flow-mon-id {
      description
        "It indicates the FlowMonID.";
    }
    identity method {
      description
        "Base identity to represent the AltMark method type.";
    }
    identity trace-data {
      description
```


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```
        "Base identity to represent trace data.";
    }
    identity pot-data {
      description
        "Base identity to represent POT data.";
     }
    identity e2e-data {
      description
        "Base identity to represent E2E data.";
     }
    identity telemetry-param-type {
      description
         "Base identity for telemetry param types";
     }
    identity loss-measurement {
      base telemetry-param-type;
      description
        "To specify loss counters according to RFC 9341";
     }
    identity delay-measurement {
      base telemetry-param-type;
      description
        "To specify timestamps for delay according to RFC 9341";
     }
   /*
    * TYPE DEFINITIONS
    */
    typedef telemetry-filter-type {
      type identityref {
        base filter;
      }
      description
        "It specifies a known type of filter.";
    }
    typedef telemetry-node-action {
      type identityref {
        base node-action;
      }
      description
```

```
        "It specifies a node action.";
    }
    typedef telemetry-protocol-type {
      type identityref {
        base protocol;
      }
      description
        "It specifies a known type of carrier protocol for the On-path
        Telemetry data.";
    }
    typedef altmark-method-type {
      type identityref {
        base method;
      }
      description
        "It specifies the AltMark method used.";
    }
    typedef ioam-trace-data {
      type identityref {
        base trace-data;
      }
      description
        "It specifies the trace data.";
    }
    typedef ioam-pot-data {
      type identityref {
        base pot-data;
      }
      description
        "It specifies the pot data.";
    }
    typedef ioam-e2e-data {
      type identityref {
        base e2e-data;
      }
      description
        "It specifies the edge-to-edge data.";
    }
   /*
    * GROUP DEFINITIONS
    */
```


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```
     grouping timestamp {
       description
         "Grouping for identifying the time.";
        leaf timestamp {
          type yang:date-and-time;
          description
            "Specify the time.";
        }
      }
     grouping telemetry-filter {
       description "A grouping for On-path Telemetry filter definition";
       leaf filter-type {
         type telemetry-filter-type;
         description "filter type";
       }
       leaf ace-name {
         when "derived-from-or-self(../filter-type,
             'on-path-telemetry:acl-filter')";
         type leafref {
           path "/acl:acls/acl:acl/acl:aces/acl:ace/acl:name";
         }
         description "The Access Control Entry name is used to
         refer to an ACL specification.";
       }
     }
     grouping telemetry-setup {
       description
         "A grouping for On-path Telemetry profile.";
       leaf node-action {
         type telemetry-node-action;
         description
           "This object indicates the action that the node needs to
            take, i.e.
marking/read/unmarking/encapsulate/transit/decapsulate.";
       }
       leaf period {
         type uint64;
         description
         "It sSpecifies the On-path Telemetry period.
            It is the marking period for AltMark.";
       }
       leaf period-number {
```


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```
          type uint64;
          description
          "It sSpecifies the On-path Telemetry period number.";
        }
           leaf flowmonid {
          type uint32;
          description
          "It sSpecifies the 20-bit FlowMonID.";
        }
        leaf method-type {
          type altmark-method-type;
          description
          "It sSpecifies the AltMark method type.";
        }
           }
      grouping loss-counters {
        description
          "The set of counters for RFC 9341 loss calculation.";
        leaf in-traffic-pkts {
          type yang:counter64;
          description
            "Total inbound packets of the period according to RFC 9341";
        }
        leaf out-traffic-pkts {
          type yang:counter64;
          description
            "Total outbound packets of the period according to RFC 9341";
        }
        leaf in-traffic-bytes {
          type uint64;
          description
            "Total inbound bytes of the period according to RFC 9341";
        }
        leaf out-traffic-bytes {
          type uint64;
          description
            "Total outbound bytes of the period according to RFC 9341";
        }
           }
```

```
     grouping delay-timestamps {
       description
         "~~It i~~Indicates the set of timestamps for RFC 9341 delay
calculation.";
       container pkts-timestamps {
         description
           "The list of timestamps of the period according to RFC 9341";
         leaf pkt-timestamp {
           type yang:date-and-time;
           description
             "~~To specify~~Specifies the timestamp of the delay packet for
delay measurements";
         }
        }
           }
     grouping path-delay-metrics {
       description
         "~~It i~~Indicates the path delay measurements.";
       leaf path-delay-mean {
         type uint32;
         description
           "mean path delay as per [I-D.ietf-opsawg-ipfix-on-path-
telemetry]";
       }
       leaf path-delay-min {
         type uint32;
         description
           "min path delay as per [I-D.ietf-opsawg-ipfix-on-path-
telemetry]";
       }
       leaf path-delay-max {
         type uint32;
         description
           "max path delay as per [I-D.ietf-opsawg-ipfix-on-path-
telemetry]";
       }
       leaf path-delay-sum {
         type uint64;
         description
           "sum of the path delay as per [I-D.ietf-opsawg-ipfix-on-path-
telemetry]";
       }
           }
     grouping ioam-incremental-tracing-data {
       description
         "~~A g~~Grouping for incremental tracing data.";
```

```
       leaf incremental-tracing-data {
          type ioam-trace-data;
          description
            "This object iIndicates the incremental tracing data.";
       }
      }
     grouping ioam-preallocated-tracing-data {
       description
         "A gGrouping for pre-allocated tracing data.";
       leaf preallocated-tracing-data {
          type ioam-trace-data;
          description
            "This object iIndicates the preallocated-tracing-data.";
       }
      }
     grouping ioam-direct-export-tracing-data {
       description
         "A gGrouping for direct export data.";
       leaf direct-export-data {
          type ioam-trace-data;
          description
            "This object iIndicates the direct export data.";
       }
      }
      grouping ioam-edge-to-edge-data {
       description
          "A gGrouping for edge-to-edge data.";
       leaf e2e-data {
          type ioam-e2e-data;
          description
            "This object iIndicates the edge-to-edge data.";
       }
      }
      grouping ioam-proof-of-transit-data {
       description
          "A gGrouping for proof of transit data.";
       leaf pot-data {
          type ioam-pot-data;
          description
            "This object iIndicates the proof of transit data.";
```

```
       }
      }
    /*
     * DATA NODES
     */
      container on-path-telemetry-data {
        description "On-path Path Telemetry top level container";
        uses timestamp;
        container interfaces {
         description
           "Contains the list of available interfaces that support
                   Alternate-Marking.";
         list interface {
         key "if-name";
         description
            "It dDescribes the list of the interfaces activated for
AltMark";
           leaf if-name {
             type if:interface-ref;
             description "This is a rReference to the Interface name as
in ifName of RFC2863.";
           }
                  leaf profile-name {
             type string{
               length "1..300";
             }
           description
               "Unique identifier for the On-path Telemetry profile.";
           }
           container filter {
             uses telemetry-filter;
             description
               "The filter which is used to indicate the flow where
                           the On-path Path Telemetry is applied.";
           }
           leaf protocol-type {
             type telemetry-protocol-type;
             description
               "This item is used to indicate the carrier protocol where
               the On-path Path Telemetry is applied.";
           }
```

```
            uses telemetry-setup;
            container altmark-loss-measurement {
                      if-feature altmark;
               description
                 "It rReports the loss measurement data.";
               uses loss-counters;
            }
            container altmark-delay-measurement {
                      if-feature altmark;
               description
                 "It rReports the delay measurement data.";
               uses delay-timestamps;
            }
            container path-delay {
                      if-feature pathdelay;
               description
                 "It rReports the path delay measurements.";
               uses path-delay-metrics;
            }
            container ioam-incremental-tracing {
               if-feature incremental-trace;
               presence "Enables incremental tracing option.";
               description
                 "It rReports the incremental tracing option data.";
               uses ioam-incremental-tracing-data;
            }
            container ioam-preallocated-tracing {
               if-feature preallocated-trace;
               presence "Enables preallocated tracing option.";
               description
                 "It rReports the preallocated tracing option data.";
               uses ioam-preallocated-tracing-data;
            }
            container ioam-direct-export {
               if-feature direct-export;
               presence "Enables direct-export option.";
               description
```


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```
                "It reports the direct-export option data";
              uses ioam-direct-export-tracing-data;
            }
            container ioam-proof-of-transit {
              if-feature proof-of-transit;
              presence "Enables Proof of Transit option.";
              description
                "It rReports the PoT option data.";
              uses ioam-proof-of-transit-data;
            }
            container ioam-edge-to-edge {
              if-feature edge-to-edge;
              presence "Enables edge-to-edge option.";
              description
                "It rReports the edge-to-edge option data.";
              uses ioam-edge-to-edge-data;
            }
          }
        }
      }
    }
    <CODE ENDS>
```

6. Security Considerations

IOAM [RFC9197], Alternate Marking [RFC9341] and Multipoint Alternate Marking [RFC9342] analyze different security concerns and related solutions. These aspects are valid and applicable also to this document. In particular ~~the fundamental security requirement is~~ that Alternate Marking MUST only be applied in a specific limited domain, as also mentioned in [RFC8799].

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~~, ~~R~~RESTCONF [RFC8040] or YANG-PUSH configured subscriptions [RFC8639]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446]. The YANG-Push configured subscription mandatory-to-implement secure transport encryption is TLS [RFC8446]or DTLS [RFC9147].

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

The top level administrative configurations related to the AltMark and IOAM functionalities are already reported in [I-D.ydt-ippm-alt-mark-yang] and [RFC9617]. Unexpected changes to those items could lead to the AltMark and IOAM function disruption and/ or misbehavior of the AltMark.

There are ~~a number of~~several data nodes defined in this YANG module. 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:

* /on-path-telemetry-data/interface

The entries in the container above include the AltMark and IOAM profile telemetry data which can 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. It is also important to control read access (e.g., via get, get-config, or notification) to the readable data nodes.

7. IANA Considerations

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-on-path-telemetry
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-on-path-telemetry
namespace: urn:ietf:params:xml:ns:yang:ietf-on-path-telemetry
prefix: on-path-telemetry
reference: RFC XXXX
```

8. Acknowledgements

TBD

9. Contributors

TBD

10. References

10.1. Normative References

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