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A Yang Data Model for OAM and Management of ALTO Protocol

Abstract

This document defines a YANG data model for Operations, Administration, and Maintenance (OAM) & Management of Application-Layer Traffic Optimization (ALTO) Protocol. The operator can use the data model to create and update ALTO information resources, manage the access control, configure server-to-server communication and server discovery, and collect statistical data.

Discussion Venues

This note is to be removed before publishing as an RFC.

Discussion of this document takes place on the ALTO Working Group mailing list (alto@ietf.org), which is archived at https://mailarchive.ietf.org/arch/browse/alto/.

Source for this draft and an issue tracker can be found at https://github.com/openalto/draft-alto-oam-yang.

Status of This Memo

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1. Introduction

This document defines a YANG data model for the Operations, Administration, and Maintenance (OAM) & Management of Application-Layer Traffic Optimization (ALTO) Protocol. The basic purpose of this YANG data model is discussed in Section 16 of [RFC7285]. The operator can use the data model to create and update ALTO information resources, manage the access control, configure server-to-server communication and server discovery, and collect statistical data.

The basic structure of this YANG data model is guided by Section 16 of [RFC7285] and [RFC7971]. Although the scope of the YANG data model in this document mainly focuses on the support of the base ALTO protocol [RFC7285] and the existing ALTO standard extensions (including [RFC8189], [RFC8895] and [RFC8896]), the design will also be extensible for future standard extensions (e.g., [I-D.ietf-alto-path-vector], [I-D.ietf-alto-unified-props-new], [I-D.ietf-alto-cdni-request-routing-alto], and [I-D.ietf-alto-performance-metrics]).

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. When the words appear in lower case, they are to be interpreted with their natural language meanings.

3. Terminology

This document uses the following acronyms:

*OAM - Operations, Administration, and Maintainance

*O&M - OAM and Management

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
yang	ietf-yang-types	[RFC6991]
inet	ietf-inet-types	[RFC6991]
key-chain	ietf-key-chain	[RFC8177]

Table 1: Prefixes and corresponding YANG modules

4. Design Scope and Requirements

4.1. Scope of Data Model for ALTO O&M

What is in the scope of this document?

- *Data model for deploy an ALTO server/client.
- *Data model for operate and manage a running ALTO server/client.
- *Data model for functionality/capability configuration for ALTO services.
- *Data model for monitoring ALTO-related performance metrics.

What is not in the scope of this document?

This document does not define any data model related to specific implementation, including:

- *Data structures for how to store/deliver ALTO information resources (e.g., database schema to store a network map).
- *Data structures for how to store information collected from data sources. (e.g., database schema to store topology collected from an Interface to the Routing System (I2RS) client [RFC7921])

4.2. Basic Requirements

Based on discussions and recommendations in [RFC7285] and [RFC7971], the data model provided by this document satisfies basic requirements listed in Table 2.

Requirement	Reference
R1: The data model should support configuration for ALTO server setup.	Section 16.1 of [RFC7285]
R2: The data model should provide logging management.	Section 16.2.1 of [RFC7285]

Requirement	Reference
R3: The data model should provide ALTO-related management information.	Section 16.2.2 of [RFC7285]
R4: The data model should provide metrics for server failures.	Section 16.2.3 of [RFC7285], Section 3.3 of [RFC7971]
R5-1: The data model should support configuration for different data sources.	Section 16.2.4 of [RFC7285], Section 3.2 of [RFC7971]
R5-2: The data model should support configuration for information resource generation algorithms.	Section 16.2.4 of [RFC7285]
R5-3: The data model should support configuration for access control at information resource level.	Section 16.2.4 of [RFC7285]
R6: The data model should provide performance monitoring for ALTO-specific metrics.	Section 16.2.5 of [RFC7285], Section 3.4 of [RFC7971]
R7: The data model should support configuration for security policy management.	Section 16.2.6 of [RFC7285]

Table 2: Basic Requirements of Data Model for ALTO O&M.

4.3. Additional Requirements for Extensibility

R8: As the ALTO protocol is extensible, the data model for ALTO O&M should allow for augmentation to support potential future extensions.

5. Design of ALTO O&M Data Model

5.1. Overview of ALTO O&M Data Model

The ietf-alto module defined in this document provide all the basic ALTO O&M data models fitting the requirements listed in Section 4.

The container "alto-server" in the ietf-alto module contains all the configured and operational parameters of the adminstrated ALTO server instance.

NOTE: So far, the ALTO YANG module only focuses on the ALTO server related configuration. The ALTO client related configuration will be added in a future version of the document.

```
module: ietf-alto
  +--rw alto-server
     +--rw hostname?      inet:host
     +--rw cost-type* [cost-type-name]
     |  +--rw cost-type-name    string
     |  +--rw cost-mode         cost-mode
     |  +--rw cost-metric       cost-metric
     +--rw meta* [meta-key]
     |  +--rw meta-key      string
     |  +--rw meta-value    string
     +--rw resource* [resource-id]
     |  +--rw resource-id                       resource-id
     |  +--rw resource-type                     identityref
     |  +--rw description?                      string
     |  +--rw accepted-group*                   string
     |  +--rw dependency*                       resource-id
     |  +--rw auth
     |  |  +--rw (auth-type-selection)?
     |  |     +--:(auth-key-chain)
     |  |     |  +--rw key-chain?   key-chain:key-chain-ref
     |  |     +--:(auth-key)
     |  |     +--:(auth-tls)
     |  +--rw (resource-params)?
     |     +--:(ird)
     |     |  +--rw alto-ird-params
     |     |     +--rw delegation    inet:uri
     |     +--:(networkmap)
     |     |  +--rw alto-networkmap-params
     |     |     +--rw is-default?   boolean
     |     |     +--rw filtered?     boolean
     |     |     +--rw (algorithm)
     |     +--:(costmap)
     |     |  +--rw alto-costmap-params
     |     |     +--rw filtered?                   boolean
     |     |     +--rw cost-type-names*            string
     |     |     +--rw cost-constraints?           boolean
     |     |     +--rw max-cost-types?             uint32 {multi-cost}?
     |     |     +--rw testable-cost-type-names*   string {multi-cost}?
     |     |     +--rw calendar-attributes {cost-calendar}?
     |     |     |  +--rw cost-type-names*       string
     |     |     |  +--rw time-interval-size     decimal64
     |     |     |  +--rw number-of-intervals    uint32
     |     |     +--rw (algorithm)
     |     +--:(endpointcost)
     |     |  +--rw alto-endpointcost-params
     |     |     +--rw cost-type-names*            string
     |     |     +--rw cost-constraints?           boolean
     |     |     +--rw max-cost-types?             uint32 {multi-cost}?
     |     |     +--rw testable-cost-type-names*   string {multi-cost}?
```

```
|     |     +--rw calendar-attributes {cost-calendar}?
|     |     |  +--rw cost-type-names*       string
|     |     |  +--rw time-interval-size     decimal64
|     |     |  +--rw number-of-intervals    uint32
|     |     +--rw (algorithm)
|     +--:(endpointprop)
|     |  +--rw alto-endpointprop-params
|     |     +--rw prop-types*   string
|     |     +--rw (algorithm)
|     +--:(propmap) {propmap}?
|     |  +--rw alto-propmap-params
|     |     +--rw (algorithm)
|     +--:(cdni) {cdni}?
|     |  +--rw alto-cdni-params
|     |     +--rw (algorithm)
|     +--:(update) {incr-update}?
|        +--rw alto-update-params
|           +--rw (algorithm)
+--rw data-source* [source-id]
   +--rw source-id                             string
   +--rw source-type                           identityref
   +--rw (update-policy)
   |  +--:(reactive)
   |  |  +--rw reactive                        boolean
   |  +--:(proactive)
   |     +--rw poll-interval                   uint32
   +--rw (source-params)?
      +--:(yang-datastore)
      |  +--rw yang-datastore-source-params
      |     +--rw source-path    yang:xpath1.0
      +--:(prometheus)
         +--rw prometheus-source-params
            +--rw source-uri    inet:uri
            +--rw query-data?   string
```

5.2. Meta Information of ALTO Server

The ALTO server instance contains the following basic configurations for the server setup.

The hostname is the name that is used to access the ALTO server. It will be also used in the URI of each information resource provided by the ALTO server.

The cost type list is the registry for the cost types that can be used in the ALTO server.

The meta list contains the customized meta data of the ALTO server. It will be populated into the meta field of the default Information Resource Directory (IRD).

TODO: As suggested by [RFC7286] and [RFC8686], the configuration related to ALTO server discovery should also be included here.

```
module: ietf-alto
  +--rw alto-server
     +--rw hostname?      inet:host
     +--rw cost-type* [cost-type-name]
     |  +--rw cost-type-name    string
     |  +--rw cost-mode         cost-mode
     |  +--rw cost-metric       cost-metric
     +--rw meta* [meta-key]
     |  +--rw meta-key      string
     |  +--rw meta-value    string
     ...
```

5.3. ALTO Information Resources Configuration Management

The ALTO server instance contains a list of resource entries. Each resource entry contains the configurations of an ALTO information resource (See Section 8.1 of [RFC7285]). The operator of the ALTO server can use this model to create, update, and remove the ALTO information resource.

Each resoruce entry provide configuration defining how to create or update an ALTO information resource. Adding a new resource entry will submit an ALTO information resource creation intent to the intent system to create a new ALTO information resource. Updating an existing resource entry will update the corresponding ALTO information resource creation intent. Removing an existing resource entry will remove the corresponding ALTO information resource creation intent and also the created ALTO information resource.

The parameter of the intent interface defined by a resource entry MUST include a unique resource-id and a resource-type.

It can also include an accepted-group node containing a list of user-groups that can access this ALTO information resource.

As section 15.5.2 of [RFC7285] suggests, the module also defines authentication related configuration to employ access control at information resource level. The ALTO server returns the IRD to the ALTO client based on its authentication information.

For some resource-type, the parameter of the intent interface MUST also include the a dependency node containing the resource-id of the dependent ALTO information resources (See Section 9.1.5 of [RFC7285]).

For each type of ALTO information resource, the creation intent MAY also need type-specific parameters. These type-specific parameters include two categories:

1. One categories of the type-specific parameters are common for the same type of ALTO information resource. They declare the Capabilities of the ALTO information resource (See Section 9.1.3 of [RFC7285]).

2. The other categories of the type-specific parameters are algorithm-specific. The developer of the ALTO server can implement their own creation altorithms and augment the algorithm node to declare algorithm-specific input parameters.

Except for the ird resource, all the other types of resource entries have augmented algorithm node. The augmented algorithm node can reference data sources subscribed by the data-source entries (See Section 5.4).

The developer cannot customize the creation algorithm of the ird resource. The default ird resource will be created automatically based on all the added resource entries. The delegated ird resource will be created as a static ALTO information resource (See Section 9.2.4 of [RFC7285]).

```
module: ietf-alto
  +--rw alto-server
     ...
     +--rw resource* [resource-id]
     |  +--rw resource-id                       resource-id
     |  +--rw resource-type                     identityref
     |  +--rw description?                      string
     |  +--rw accepted-group*                   string
     |  +--rw dependency*                       resource-id
     |  +--rw auth
     |  |  +--rw (auth-type-selection)?
     |  |     +--:(auth-key-chain)
     |  |     |  +--rw key-chain?   key-chain:key-chain-ref
     |  |     +--:(auth-key)
     |  |     +--:(auth-tls)
     |  +--rw (resource-params)?
     |     +--:(ird)
     |     |  +--rw alto-ird-params
     |     |     +--rw delegation    inet:uri
     |     +--:(networkmap)
     |     |  +--rw alto-networkmap-params
     |     |     +--rw is-default?   boolean
     |     |     +--rw filtered?     boolean
     |     |     +--rw (algorithm)
     |     +--:(costmap)
     |     |  +--rw alto-costmap-params
     |     |     +--rw filtered?                   boolean
     |     |     +--rw cost-type-names*            string
     |     |     +--rw cost-constraints?           boolean
     |     |     +--rw max-cost-types?             uint32 {multi-cost}?
     |     |     +--rw testable-cost-type-names*   string {multi-cost}?
     |     |     +--rw calendar-attributes {cost-calendar}?
     |     |     |  +--rw cost-type-names*       string
     |     |     |  +--rw time-interval-size     decimal64
     |     |     |  +--rw number-of-intervals    uint32
     |     |     +--rw (algorithm)
     |     +--:(endpointcost)
     |     |  +--rw alto-endpointcost-params
     |     |     +--rw cost-type-names*            string
     |     |     +--rw cost-constraints?           boolean
     |     |     +--rw max-cost-types?             uint32 {multi-cost}?
     |     |     +--rw testable-cost-type-names*   string {multi-cost}?
     |     |     +--rw calendar-attributes {cost-calendar}?
     |     |     |  +--rw cost-type-names*       string
     |     |     |  +--rw time-interval-size     decimal64
     |     |     |  +--rw number-of-intervals    uint32
     |     |     +--rw (algorithm)
     |     +--:(endpointprop)
     |     |  +--rw alto-endpointprop-params
```

```
|     |     +--rw prop-types*   string
|     |     +--rw (algorithm)
|     +--:(propmap) {propmap}?
|     |  +--rw alto-propmap-params
|     |     +--rw (algorithm)
|     +--:(cdni) {cdni}?
|     |  +--rw alto-cdni-params
|     |     +--rw (algorithm)
|     +--:(update) {incr-update}?
|        +--rw alto-update-params
|           +--rw (algorithm)
...
```

5.4. Data Sources

The ALTO server instance contains a list of data-source entries to subscribe the data sources from which ALTO information resources are derived (See Section 16.2.4 of [RFC7285]).

A data-source entry MUST include:

- a unique source-id for resource creation algorithms to reference,
- the source-type attribute to declare the type of the data source,
- the update-policy to specify how to get the data update from the data source,
- the source-params to specify where and how to query the data.

The update policy can be either reactive or proactive. For the reactive update, the ALTO server gets the update as soon as the data source changes. For the proactive update, the ALTO server has to proactively fetch the data source periodically.

To use the reactive update, the reactive attribute MUST be set true. To use the proactive update, the poll-interval attribute MUST be greater than zero. The value of poll-interval specifies the interval of fetching the data in milliseconds. If reactive is false or poll-interval is zero, the ALTO server will not update the data source.

The data-source/source-params node can be augmented for different types of data sources. This data model only includes import interfaces for a list of predefined data sources. More data sources can be supported by future documents and other third-party providers.

```
module: ietf-alto
  +--rw alto-server
     ...
     +--rw data-source* [source-id]
        +--rw source-id                              string
        +--rw source-type                            identityref
        +--rw (update-policy)
        |  +--:(reactive)
        |  |  +--rw reactive                         boolean
        |  +--:(proactive)
        |     +--rw poll-interval                    uint32
        +--rw (source-params)?
           +--:(yang-datastore)
           |  +--rw yang-datastore-source-params
           |     +--rw source-path    yang:xpath1.0
           +--:(prometheus)
              +--rw prometheus-source-params
                 +--rw source-uri    inet:uri
                 +--rw query-data?   string
```

Note: Current source configuration still has limitations. It should be revised to support more general southbound and data retrieval mechanisms.

5.4.1. Yang DataStore Data Source

The yang-datastore-source-params is used to import the YANG data which is located in the same YANG model-driven data store supplying the current ALTO O&M data model. The source-path is used to specify the XPath of the data source node.

5.4.2. Prometheus Data Source

The prometheus-source-params is used to import common performance metrics data which is provided by a Prometheus server. The source-uir is used to establish the connection with the Prometheus server. The query-data is used to speficify the potential query expression in PromQL.

5.5. Model for ALTO Server-to-server Communication

TBD.

6. Design of ALTO O&M Statistics Data Model

As section 16.2.5 of [RFC7285] suggests, the YANG data module defined in this document also contains statistics for ALTO-specific performance metrics.

More specifically, this data model contains the following measurement information suggested by [RFC7971]:

- Measurement of impact
  - Total amount and distribution of traffic
  - Application performance
- System and service performance
  - Requests and responses for each information resource
  - CPU and memory utilization
  - ALTO map updates
  - Number of PIDs
  - ALTO map sizes

Besides the measurement information suggested by [RFC7971], this data model also contains useful measurement information for other ALTO extensions:

- Number of generic ALTO entities (for [I-D.ietf-alto-unified-props-new] and [I-D.ietf-alto-cdni-request-routing-alto])
- Statistics for update sessions and events (for [RFC8189])
- Statistics for calendar (for [RFC8896])

The module, "ietf-alto-stats", augments the ietf-alto module to include statistics at the ALTO server and information resource level.

```
module: ietf-alto-stats

  augment /alto:alto-server/alto:resource:
    +--ro num-res-upd?    yang:counter32
    +--ro res-mem-size?   yang:counter32
    +--ro res-enc-size?   yang:counter32

  augment /alto:alto-server/alto:resource/alto:resource-params
            /alto:networkmap/alto:alto-networkmap-params:
    +--ro num-map-pid?    yang:counter32

  augment /alto:alto-server/alto:resource/alto:resource-params
            /alto:propmap/alto:alto-propmap-params:
    +--ro num-map-entry?  yang:counter32

  augment /alto:alto-server/alto:resource/alto:resource-params
            /alto:cdni/alto:alto-cdni-params:
    +--ro num-base-obj?   yang:counter32

  augment /alto:alto-server/alto:resource/alto:resource-params
            /alto:update/alto:alto-update-params:
    +--ro num-upd-sess    yang:counter32
    +--ro num-event-total yang:counter32
    +--ro num-event-max?  yang:counter32
    +--ro num-event-min?  yang:counter32
    +--ro num-event-avg?  yang:counter32
```

7. Extension of ALTO O&M Data Model

As ALTO protocol is extensible, new protocol extensions can be developed after this data model is published. To support future ALTO protocol extensions, the extension documents can augment the existing cases of the resource-params choice with new configuration parameters for existing ALTO information resource extensions, or augment the resource-params with new cases for new ALTO information resources.

Developers and operators can also extend this ALTO O&M data model to align with their own implementations. Specifically, the following nodes of the data model can be augmented:

- *The algorithm choice of the resource-params of each resource.

- *The data-source choice.

The following example shows how the developer augments the algorithm choice of alto-networkmap-params with a creation algorithm for the network map resource.

```
module: example-ietf-alto-alg

  augment /alto:alto-server/alto:resource/alto:resource-params
            /alto:networkmap/alto:alto-networkmap-params
            /alto:algorithm:
    +--:(l3-unicast-cluster)
       +--rw l3-unicast-cluster-algorithm
          +--rw l3-unicast-topo
          |       -> /alto:alto-server/data-source/source-id
          +--rw depth?             uint32
```

This example defines a creation algorithm called l3-unicast-cluster-algorithm for the network map resource. It takes two algorithm-specific parameters:

l3-unicast-topo This parameter refers to the source id of a data source node subscribed in the data-source list (See Section 5.4). The corresponding data source is assumed to be an internel data source (See Section 5.4.1) for an IETF layer 3 unicast topology defined in [RFC8346]. The algorithm uses the topology data from this data source to compute the ALTO network map resource.

depth This optional parameter sets the depth of the clustering algorithm. For example, if the depth sets to 1, the algorithm will generate PID for every l3-node in the topology.

The creation algorithm can be reactively called once the referenced data source updates. Therefore, the ALTO network map resource can be updated dynamically. The update of the reference data source depends on the used update-policy (See Section 5.4).

8. ALTO OAM YANG Module

8.1. The ietf-alto Module

```
<CODE BEGINS> file "ietf-alto@2022-03-07.yang"

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

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

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

  import ietf-key-chain {
    prefix key-chain;
    reference
      "RFC 8177: YANG Data Model for Key Chains";
  }

  organization
    "IETF ALTO Working Group";

  contact
    "WG Web:   <https://datatracker.ietf.org/wg/alto/about/>
     WG List:  <alto@ietf.org>";

  description
    "This YANG module defines all the configured and operational
     parameters of the administrated ALTO server instance.

     Copyright (c) 2022 IETF Trust and the persons identified as
     authors of the code.  All rights reserved.

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

```
   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.";

revision "2022-03-07" {
  description
    "Initial Version.";
  reference
    "RFC XXXX: A YANG Data Model for OAM and Management of ALTO
     Protocol.";
}

typedef cost-mode {
  type enumeration {
    enum numerical {
      value 1;
      description
        "This mode indicates that it is safe to perform numerical
         operations";
    }
    enum ordinal {
      value 2;
      description
        "This mode indicates that the cost values in a cost map
         represent ranking";
    }
  }
  description
    "The cost mode attribute indicates how costs should be
     interpreted. Specifically, the cost mode attribute indicates
     whether returned costs should be interpreted as numerical
     values or ordinal rankings.";
  reference
    "Section 6.1.2 of RFC 7285.";
}

typedef cost-metric {
  type string;
  description
    "The cost metric attribute indicates what the cost
     represents.";
  reference
    "Section 6.1.1 of RFC 7285.";
}

typedef resource-id {
```

```
  type string {
    length "1..64";
    pattern "[0-9a-zA-Z\\-:@_]*";
  }
  description
    "Format of Resource ID";
  reference
    "Section 9.1.1 of RFC 7285.";
}

identity resource-types {
  description
    "Base identity for type of information resource.";
}

identity source-types {
  description
    "Base identity for type of data source.";
}

identity network-map {
  base resource-types;
  description
    "Identity for network map.";
}

identity cost-map {
  base resource-types;
  description
    "Identity for cost map.";
}

identity property-map {
  base resource-types;
  description
    "Identity for property map.";
}

identity yang-datastore {
  base source-types;
  description
    "Identity for data source of YANG-based datastore.";
}

identity prometheus {
  base source-types;
  description
    "Identity for data source of prometheus system.";
}
```

```
feature multi-cost {
  description
    "Support multi-cost extension.";
  reference
    "RFC 8189: Multi-Cost Application-Layer Traffic Optimization
     (ALTO)";
}

feature cost-calendar {
  description
    "Support cost calendar extension.";
  reference
    "RFC 8896: Application-Layer Traffic Optimization (ALTO) Cost
     Calendar";
}

feature propmap {
  description
    "Support entity property map extension.";
  reference
    "RFC XXXX: An ALTO Extension: Entity Property Maps";
}

feature cdni {
  description
    "Support CDNi extension.";
  reference
    "RFC XXXX: Content Delivery Network Interconnection (CDNI)
     Request Routing: CDNI Footprint and Capabilities
     Advertisement using ALTO";
}

feature incr-update {
  description
    "Support incremental update extension.";
  reference
    "RFC 8896: Application-Layer Traffic Optimization (ALTO)
     Incremental Updates Using Server-Sent Events (SSE)";
}

grouping filt-costmap-cap {
  description
    "This grouping defines data model for
     FilteredCostMapCapabilities.";
  reference
    "Sec 11.3.2.4 of RFC 7285.";
  leaf-list cost-type-names {
    type string;
    min-elements 1;
```

```
  description
    "Supported cost types";
}
leaf cost-constraints {
  type boolean;
  description
    "If true, then the ALTO server allows cost
     constraints to be included in requests to the
     corresponding URI. If not present, this field MUST
     be interpreted as if it specified false.";
}
leaf max-cost-types {
  if-feature "multi-cost";
  type uint32;
  default 0;
  description
    "If present with value N greater than 0, this resource
     understands the multi-cost extensions in this document and
     can return a multi-cost map with any combination of N or
     fewer cost types in the 'cost-type-names' list. If omitted,
     the default value is 0.";
}
leaf-list testable-cost-type-names {
  if-feature "multi-cost";
  type string;
  description
    "If present, the resource allows constraint tests, but only
     on the cost type names in this array.";
}
container calendar-attributes {
  if-feature "cost-calendar";
  leaf-list cost-type-names {
    type string;
    min-elements 1;
    description
      "An array of one or more elements indicating the cost type
       names in the IRD entry to which the values of
       'time-interval-size' and 'number-of-intervals' apply.";
  }
  leaf time-interval-size {
    type decimal64 {
      fraction-digits 4;
    }
    mandatory true;
    description
      "The duration of an ALTO Calendar time interval in a unit
       of seconds.";
  }
  leaf number-of-intervals {
```

```
      type uint32 {
        range "1..max";
      }
      mandatory true;
      description
        "A strictly positive integer (greater or equal to 1) that
         indicates the number of values of the Cost Calendar
         array.";
    }
    description
      "Configuration for CalendarAttributes.";
    reference
      "Section 4.1 of RFC 8896.";
  }
}

grouping algorithm {
  choice algorithm {
    mandatory true;
    description
      "Information resource creation algorithm to be augmented.";
  }
  description
    "This grouping defines base data model for information
     resource creation algorithm.";
}

container alto-server {
  description
    "The ALTO server instance.";
  leaf hostname {
    type inet:host;
    description
      "The name that is used to access the ALTO server.";
  }
  list cost-type {
    key "cost-type-name";
    leaf cost-type-name {
      type string;
      description
        "The name to reference cost type";
    }
    leaf cost-mode {
      type cost-mode;
      mandatory true;
      description
        "The referenced cost mode";
    }
    leaf cost-metric {
```

```
    type cost-metric;
    mandatory true;
    description
      "The referenced cost metric";
  }
  description
    "Mapping between name and referenced cost type";
}
list meta {
  key "meta-key";
  leaf meta-key {
    type string;
    description
      "Custom meta key";
  }
  leaf meta-value {
    type string;
    mandatory true;
    description
      "Custom meta value";
  }
  description
    "Mapping of custom meta information";
  reference
    "Section 8.4.1 of RFC 7285.";
}
list resource {
  key "resource-id";
  leaf resource-id {
    type resource-id;
    description
      "resource-id to be defined.";
  }
  leaf resource-type {
    type identityref {
      base resource-types;
    }
    mandatory true;
    description
      "identityref to be defined.";
  }
  leaf description {
    type string;
    description
      "The optional description for this information resource.";
  }
  leaf-list accepted-group {
    type string;
    description
```

```
    "Access list for authenticated clients.";
}
leaf-list dependency {
  type resource-id;
  description
    "A list of dependent information resources.";
}
container auth {
  description
    "The authentication options";
  choice auth-type-selection {
    description
      "Options for expressing authentication
       setting.";
    case auth-key-chain {
      leaf key-chain {
        type key-chain:key-chain-ref;
        description
          "key-chain name.";
      }
    }
    case auth-key {
    }
    case auth-tls {
    }
  }
}
choice resource-params {
  description
    "Resource-specific configuration.";
  case ird {
    container alto-ird-params {
      leaf delegation {
        type inet:uri;
        mandatory true;
        description
          "Upstream IRD to be delegated";
      }
      description
        "IRD-specific configuration";
    }
  }
  case networkmap {
    container alto-networkmap-params {
      description
        "(Filtered) Network Map specific configuration";
      reference
        "Section 11.2.1 and Section 11.3.1 of RFC 7285.";
      leaf is-default {
```

```
      type boolean;
      description
        "Set whether this is the default network map";
    }
    leaf filtered {
      type boolean;
      default false;
      description
        "Configure whether filtered network map is
         supported.";
    }
    uses algorithm;
  }
}
case costmap {
  container alto-costmap-params {
    description
      "(Filtered) Cost Map specific configuration";
    reference
      "Section 11.2.2 and Section 11.3.2 of RFC 7285.";
    leaf filtered {
      type boolean;
      description
        "Configure whether filtered cost map is supported.";
    }
    uses filt-costmap-cap;
    uses algorithm;
  }
}
case endpointcost {
  container alto-endpointcost-params {
    description
      "Endpoint Cost Service specific configuration";
    reference
      "Section 11.5 of RFC 7285";
    uses filt-costmap-cap;
    uses algorithm;
  }
}
case endpointprop {
  container alto-endpointprop-params {
    description
      "Endpoint Cost Service specific configuration";
    reference
      "Section 11.5 of RFC 7285";
    leaf-list prop-types {
      type string;
      min-elements 1;
      description
```

```
            "Supported endpoint properties.";
        }
        uses algorithm;
      }
    }
    case propmap {
      if-feature "propmap";
      container alto-propmap-params {
        uses algorithm;
        description
          "(Filtered) Entity Property Map specific
           configuration";
      }
    }
    case cdni {
      if-feature "cdni";
      container alto-cdni-params {
        uses algorithm;
        description
          "CDNi specific configuration";
      }
    }
    case update {
      if-feature "incr-update";
      container alto-update-params {
        uses algorithm;
        description
          "Incremental Updates specific configuration";
      }
    }
  }
  description
    "ALTO information resources to be defined";
}
list data-source {
  key "source-id";
  leaf source-id {
    type string;
    description
      "Data source id that can be referenced by information
       resource creation algorithms.";
  }
  leaf source-type {
    type identityref {
      base source-types;
    }
    mandatory true;
    description
      "Source-type to be defined";
```

```
}
choice update-policy {
  mandatory true;
  case reactive {
    leaf reactive {
      type boolean;
      mandatory true;
      description
        "Reactive mode";
    }
  }
  case proactive {
    leaf poll-interval {
      type uint32;
      mandatory true;
      description
        "Polling interval in seconds for proactive mode";
    }
  }
  description
    "Policy to get updates from data sources";
}
choice source-params {
  case yang-datastore {
    container yang-datastore-source-params {
      leaf source-path {
        type yang:xpath1.0;
        mandatory true;
        description
          "XPath to subscribed YANG datastore node";
      }
      description
        "YANG datastore specific configuration";
    }
  }
  case prometheus {
    container prometheus-source-params {
      leaf source-uri {
        type inet:uri;
        mandatory true;
        description
          "URI to prometheus agent";
      }
      leaf query-data {
        type string;
        description
          "Query expression";
      }
      description
```

```
              "Prometheus specific configuration";
          }
        }
        description
          "Data source specific configuration";
      }
      description
        "List of subscribed data sources.";
    }
  }
}
```

<CODE ENDS>

8.2. The ietf-alto-stats Module

```
<CODE BEGINS> file "ietf-alto-stats@2022-03-07.yang"

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

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

  import ietf-alto {
    prefix alto;
    reference
      "RFC XXXX: A YANG Data Model for OAM and Management of ALTO
       Protocol.";
  }

  organization
    "IETF ALTO Working Group";

  contact
    "WG Web:   <https://datatracker.ietf.org/wg/alto/about/>
     WG List:  <alto@ietf.org>";

  description
    "This YANG module defines all the configured and operational
     parameters of the administrated ALTO server instance.

     Copyright (c) 2022 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 "2022-03-07" {
    description
      "Initial Version.";
    reference
```

```
    "RFC XXXX: A YANG Data Model for Operations, Administration,
     and Maintenance of ALTO Protocol.";
}

augment "/alto:alto-server/alto:resource" {
  description
    "Common statistics for each information resource.";
  leaf num-res-upd {
    type yang:counter32;
    config false;
    description
      "The number of version updates since the information resource
       was created.";
  }
  leaf res-mem-size {
    type yang:counter32;
    config false;
    description
      "Memory size (Bytes) utilized by the information resource.";
  }
  leaf res-enc-size {
    type yang:counter32;
    config false;
    description
      "Size (Bytes) of JSON encoded data of the information
       resource.";
  }
}

augment "/alto:alto-server/alto:resource/alto:resource-params"
      + "/alto:networkmap/alto:alto-networkmap-params" {
  description
    "Augmented statistics for network maps only.";
  leaf num-map-pid {
    type yang:counter32;
    config false;
    description
      "Number of PIDs contained by the network map.";
  }
}

augment "/alto:alto-server/alto:resource/alto:resource-params"
      + "/alto:propmap/alto:alto-propmap-params" {
  description
    "Augmented statistics for property maps only.";
  leaf num-map-entry {
    type yang:counter32;
    config false;
    description
```

```
      "Number of ALTO entities contained by the property map.";
  }
}

augment "/alto:alto-server/alto:resource/alto:resource-params"
      + "/alto:cdni/alto:alto-cdni-params" {
  description
    "Augmented statistics for CDNi resources only.";
  leaf num-base-obj {
    type yang:counter32;
    config false;
    description
      "Number of base CDNi advertisement objects contained by the
       CDNi resource.";
  }
}

augment "/alto:alto-server/alto:resource/alto:resource-params"
      + "/alto:update/alto:alto-update-params" {
  description
    "Augmented statistics for incremental updates only.";
  leaf num-upd-sess {
    type yang:counter32;
    config false;
    description
      "Number of sessions connected to the incremental update
       service.";
  }
  leaf num-event-total {
    type yang:counter32;
    config false;
    description
      "Total number of update events sent to all the connected
       clients.";
  }
  leaf num-event-max {
    type yang:counter32;
    config false;
    description
      "The maximum number of update events sent to the connected
       clients.";
  }
  leaf num-event-min {
    type yang:counter32;
    config false;
    description
      "The minimum number of update events sent to the connected
       clients.";
  }
```

```
    leaf num-event-avg {
      type yang:counter32;
      config false;
      description
        "The average number of update events sent to the connected
         clients.";
    }
  }
}

<CODE ENDS>
```

9. Security Considerations

TBD.

10. IANA Considerations

This document registers two URIs in the "IETF XML Registry" [RFC3688]. Following the format in RFC 3688, the following registrations are requested.

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

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

This document registers two YANG modules in the "YANG Module Names" registry [RFC6020].

```
Name: ietf-alto
Namespace: urn:ietf:params:xml:ns:yang:ietf-alto
Prefix: alto
Reference: [RFCthis]

Name: ietf-alto-stats
Namespace: urn:ietf:params:xml:ns:yang:ietf-alto-stats
Prefix: alto
Reference: [RFCthis]
```

[RFC Editor: Please replace RFCthis with the published RFC number for this document.]

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Appendix A. Example Module for Information Resource Creation Algorithm

The base data model defined by ietf-alto.yang does not include any choice cases for information resource creation algorithms. But developers may augment the ietf-alto.yang data model with definitions for any custom creation algorithms for different information resources. The following example module demonstrates the parameters of a network map creation algorithm that translates an IETF layer 3 unicast topology into a network map.

```
module example-ietf-alto-alg {

  namespace "urn:example:ietf-alto-alg";
  prefix "alto-alg";

  import ietf-alto {
    prefix "alto";
  }

  augment "/alto:alto-server/alto:resource/alto:resource-params"
        + "/alto:networkmap/alto:alto-networkmap-params"
        + "/alto:algorithm" {
    case l3-unicast-cluster {
      container l3-unicast-cluster-algorithm {
        leaf l3-unicast-topo {
          type leafref {
            path "/alto:alto-server/data-source/source-id";
          }
          mandatory true;
          description
            "The data source to an IETF layer 3 unicast topology.";
        }
        leaf depth {
          type uint32;
          description
            "The depth of the clustering.";
        }
      }
    }
  }
}
```

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