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H. Birkholz
Fraunhofer SIT
N. Cam-Winget
Cisco Systems
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YANG subscribed notifications via SACM Statements
draft-birkholz-sacm-yang-content-01

Abstract

This document summarizes a subset of the emerging generic SACM Data Model for inter-component distribution of SACM Content in and between SACM Domains. The subset defined in this document is covering every information element that can be acquired using YANG based protocols, i.e. NETCONF, RESTCONF, COMI or derived mechanisms that transfer YANG modeled data, such as MUD. As subscriptions to data origins in a SACM domain are one of the architectural corner-stones of the SACM architecture, this document recommends the use of YANG Push, YANG subscribed Notifications and corresponding Notification Headers and Bundles. Analogously, a mapping of Notification Header content to SACM Metadata is provided in this document.

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[1.](#) Introduction

This document defines an XML encoding of SACM Statements that contain SACM Content composed of YANG modeled data (i.e. NETCONF messages). Correspondingly, this document provides a standardized mapping to derive SACM Metadata from YANG Subscribed Notifications [[I-D.ietf-netconf-subscribed-notifications](#)] using Notification Message Headers and Bundles [[I-D.ietf-netconf-notification-messages](#)] content.

Every message defined in the generic SACM Data Model is a SACM Statement. The SACM Statement structure is provided by the SACM Information Model. In consequence, a SACM Statement is an Information Element not acquired by, but created by SACM Components for inter-component distribution of SACM Content (Information Elements on the Data Plane that represent information about Target Endpoints (TE) or Guidance. Examples include: software identifiers, assessment guidance/results, ECA Policy rules, or VDD).

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YANG modules are a powerful established tool to provide Information Elements about Target Endpoints with well-defined semantics. YANG Push [[I-D.ietf-netconf-yang-push](#)] and the corresponding YANG Subscribed Notifications [[I-D.ietf-netconf-subscribed-notifications](#)] drafts make use of these modules to create streams of notifications (YANG telemetry). Subscriptions to YANG data stores or YANG streams are Data Sources that provide Information Elements that can be acquired by SACM Collectors to provide SACM Content on the Data Plane.

Analogously, filter expressions used in the context of YANG subscriptions constitute SACM Content that is Imperative Guidance consumed by SACM Components on the Management Plane in order to create YANG telemetry.

In this document (not including the abstract, of course), terms that are Capitalized or prefixed with SACM are defined in the SACM Terminology document.

2. Requirements notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#), [BCP 14](#) [[RFC2119](#)].

3. Brokering of YANG Push Telemetry via SACM Statements

Every SACM Content is published into a SACM Domain using a statement envelope/encapsulation. The general structure of a SACM Statement is based on the Information Element definition found in [[I-D.ietf-sacm-information-model](#)] and can be summarized as follows:

- o a sacm-statement encapsulates statement-metadata and content-elements
- o a content-element encapsulates content-metadata and SACM Content

In the scope of this document, only one type of SACM Content is covered: YANG modeled data. Correspondingly, the minimal required structure of statements, statement-metadata, content-elements, and content-metadata are defined. A complete XML schema definition of this subset of the generic SACM Data Model can be found in [Appendix A](#).

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[4.](#) Encapsulation of YANG notifications in SACM content-elements

A YANG notification is associated with a set of YANG specific metadata as defined in [[I-D.ietf-netconf-notification-messages](#)]. Hence, SACM Content that is derived from a YANG notification published to a SACM Domain MUST be encapsulated with its corresponding Metadata in a content-element as defined below.

YANG output that is SACM Content MUST be represented according to the XSD definition included in the content choice of the content-element.

```
<CODE BEGINS>
<xs:complexType name="content-element">
  <xs:sequence>
    <xs:element name="content-metadata" type="content-metadata" maxOccurs="unbounded"/>
    <xs:choice>
      <xs:element name="yang-output" type="yang-output" />
      <!-- There is only one element here now, but virtually every other content
           will go here, i.e. data models, such as OVAL, SCAP, SWID, etc. -->
    </xs:choice>
  </xs:sequence>
</xs:complexType>
<CODE ENDS>
```

[4.1.](#) Enumeration definition for content-type

An occurrence of the yang-output element MUST be instantiated in the content-metadata element, if YANG Push output is to be transferred. Also, the content-type MUST be set to the enumeration value "yang-output", respectively.

In general, the list of content-type enumerations is including every subject as defined in the SACM Information Model. Regarding the definition of the subset of the generic SACM Data Model provided by this document, the list of potential content-types is reduced to "yang-output". Please note, that the complete generic SACM Data Model includes additional content-type enumerations next to the definition provided by this document.

<CODE BEGINS>

```
<xs:simpleType name="content-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="yang-output" />
    <!-- There is only one type here now, but virtually every other content-
          will go here, i.e. data models, such as OVAL, SCAP, SWID, etc. -->
  </xs:restriction>
</xs:simpleType>
<CODE ENDS>
```

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[4.2.](#) Element definition for content-metadata

The list of optional elements included in content-metadata will incorporate any every potential metadata type. For the scope of this document, the list of elements is also limited to the minimal required set of metadata elements and the yang-output metadata element to support the encapsulation of NETCONF encoded subscribed notifications or YANG query result. As defined above, one occurrence of the yang-output element has to be included in the content-metadata element.

A more complete content-metadata element definition is illustrated in the [Appendix A](#).

<CODE BEGINS>

```
<xs:complexType name="content-metadata">
  <xs:sequence>
    <xs:element name="content-element-guid" type="content-element-guid"/>
```

```

    <xs:element name="content-creation-timestamp" type="content-creation-timest
    <xs:element name="content-topic" type="content-topic"/>
    <xs:element name="content-type" type="content-type"/>
    <xs:element name="data-source" type="data-source" minOccurs="0"/>
    <xs:element name="data-origin" type="data-origin" minOccurs="0"/>
    <xs:element name="relationship" type="relationship" minOccurs="0" maxOccurs
    <xs:element name="yang-output-metadata" type="yang-output-metadata" minOccu
  </xs:sequence>
</xs:complexType>
<CODE ENDS>

```

4.3. Definition of the yang-output-metadata element included in content-metadata

The composition of metadata that can be associated with a XML NETCONF result depends on multiple factors:

- o acquisition method: query / subscription
- o encoding: XML # more content encodings will be supported as indicated by the definition
- o subscription interval: periodic / on-change
- o filter-type: xpath / subtree

Additionally, the actual filter expression (or in future iterations of this work, a referencing Label, such as a URI, UUID or other composed identifier) has to be included in the content-metadata.

```

<CODE BEGINS>
<xs:complexType name="yang-output-metadata">
  <xs:sequence>
    <xs:choice maxOccurs="1">
      <xs:element name="yang-query" type="yang-query-value" />
      <xs:element name="yang-subscription" type="yang-subscription-type" />
    </xs:choice>
    <xs:element name="encoding" type="yang-encoding" />
    <xs:element name="module-names" type="module-name" minOccurs="0" maxOccurs=
    <xs:element name="filter-expression" type="filter-expression-value" minOccu
  </xs:sequence>

```

```

</xs:complexType>

<xs:complexType name="yang-subscription-type">
  <xs:restriction base="xs:NMTOKEN">
    <xs:enumeration value="periodic" />
    <xs:enumeration value="on-change" />
  </xs:restriction>
  <xs:restriction base="xs:NMTOKEN">
    <xs:enumeration value="xpath" />
    <xs:enumeration value="subtree" />
  </xs:restriction>
</xs:complexType>

<xs:simpleType name="filter-expression-value">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="yang-query-value">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="yang-encoding">
  <xs:restriction base="xs:NMTOKEN">
    <xs:enumeration value="netconf" />
    <xs:enumeration value="restconf" />
    <xs:enumeration value="comi" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="module-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>
<CODE ENDS>

```

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[5.](#) Mapping of YANG Bundled Notifications to SACM Metadata

[I-D.ietf-netconf-notification-messages] includes the following definition:

```

yang-data bundled-message
  +-- bundled-message-header
  | +-- message-time                yang:date-and-time
  | +-- message-id?                 uint32
  | +-- previous-message-id?        uint32
  | +-- message-generator-id?       string
  | +-- signature?                  string
  | +-- notification-count?          uint16
  +-- notifications*
    +-- notification-header
    | +-- notification-time           yang:date-and-time
    | +-- subscription-id*            uint32
    | +-- notification-id?            uint32
    | +-- module?                    yang-identifier
    | +-- notification-type?          notification
    | +-- observation-domain-id?      string
    +-- receiver-record-contents?

```

The corresponding mapping MUST be used when deriving SACM Content Metadata for content-metadata items from YANG modeled data corresponding to YANG Notification Message Headers and Bundles:

```

notification-time -> content-creation-timestamp
subscription-id + (observation-domain-id OR "SACM Component Label") ->
module -> module-names
notification-type -> yang-subscription-type
receiver-record-contents -> content-elements

```

If there are more than one receiver-record-contents instanced included in the received Notification Message Bundle, multiple content-elements MUST be instantiated, accordingly.

The following mapping MUST be used when deriving SACM Statement Metadata (see [Appendix A](#)) statement-metadata items representing NETCONF instances adhering to the definition of YANG Notification Message Headers and Bundles:

```

message-id -> statement-guid
"SACM Component Label" -> data-origin
message-time -> statement-creation-timestamp
"SACM Component Publication Time" -> statement-publish-timestamp
statement-type -> "Observation"

```


"SACM Component Publication Time" can only be inferred by the SACM Component using its "most trustworthy source of time".

If there is not receiver-record-contents included in the YANG notification, a SACM Component MUST NOT publish a corresponding SACM Statement to the SACM Domain.

6. SACM Component Composition

A SACM Component able to process YANG subscribed notifications requires at least two functions:

- o a SACM Function supporting YANG Push and YANG Notification Headers and
- o Bundles function [[I-D.ietf-netconf-yang-push](#)], [[I-D.ietf-netconf-subscribed-notifications](#)], and
- o an xmpp-grid provider function [[I-D.ietf-mile-xmpp-grid](#)]

Orchestration of functions inside a component, their discovery as capabilities and the internal distribution of SACM Content inside a SACM Component is out of scope of this document. # for now

7. IANA considerations

This document includes requests to IANA.

8. Security Considerations

TBD

9. Acknowledgements

Christoph Vigano, Guangying Zheng, Eric Voit, Alexander Clemm

10. Change Log

First version -00

Second version -01 * generalized the content of the document, detaching it from the implementation created at the Hackaton of IETF 99 * included a mapping of the -03 version of the YANG Notification Headers and Bundles draft to this draft

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[11](#). Contributors

Eric Voit

[12](#). Normative References

[I-D.ietf-mile-xmpp-grid]

Cam-Winget, N., Appala, S., Pope, S., and P. Saint-Andre, "Using XMPP for Security Information Exchange", [draft-ietf-mile-xmpp-grid-04](#) (work in progress), October 2017.

[I-D.ietf-netconf-notification-messages]

Voit, E., Bierman, A., Clemm, A., and T. Jenkins, "Notification Message Headers and Bundles", [draft-ietf-netconf-notification-messages-02](#) (work in progress), October 2017.

[I-D.ietf-netconf-subscribed-notifications]

Voit, E., Clemm, A., Prieto, A., Nilsen-Nygaard, E., and A. Tripathy, "Custom Subscription to Event Streams", [draft-ietf-netconf-subscribed-notifications-08](#) (work in progress), December 2017.

[I-D.ietf-netconf-yang-push]

Clemm, A., Voit, E., Prieto, A., Tripathy, A., Nilsen-Nygaard, E., Bierman, A., and B. Lengyel, "YANG Datastore Subscription", [draft-ietf-netconf-yang-push-12](#) (work in progress), December 2017.

[I-D.ietf-sacm-information-model]

Waltermire, D., Watson, K., Kahn, C., Lorenzin, L., Cokus, M., Haynes, D., and H. Birkholz, "SACM Information Model", [draft-ietf-sacm-information-model-10](#) (work in progress), April 2017.

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

[Appendix A](#). Minimal SACM Statement Definition for YANG Output

The definitions of statements, statement-metadata, content-element, and content-metadata are provided by the SACM Information Model [[I-D.ietf-sacm-information-model](#)].

Due to the stripping down of content-elements to YANG output, the enumerations still included in the relationship-type are not able to

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point to other types of content in the scope of this document, but are able to reference other content-types in the scope of the generic SACM Data Model.

<CODE BEGINS>

```
<?xml version="1.0"?>
```

```
<xs:schema version="1.0"
```

```
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  elementFormDefault="qualified">
```

```
  <xs:complexType name="StatementMetadata">
```

```
    <xs:sequence>
```

```
      <xs:element name="statement-guid" type="statement-guid" />
```

```
      <xs:element name="data-origin" type="data-origin" />
```

```
      <xs:element name="statement-creation-timestamp" type="statement-creation-t
```

```
      <xs:element name="statement-publish-timestamp" type="statement-creation-t
```

```
      <xs:element name="statement-type" type="statement-type" />
```

```
      <xs:element name="content-elements" type="content-elements" />
```

```
    </xs:sequence>
```

```
  </xs:complexType>
```

```
  <xs:complexType name="sacm-statement">
```

```
    <xs:sequence>
```

```
      <xs:element name="statement-metadata" type="StatementMetadata" />
```

```
      <xs:element name="content-element" type="content-element" minOccurs="1" m
```

```
    </xs:sequence>
```

```
  </xs:complexType>
```

```
  <xs:element name="sacm-statement" type="sacm-statement">
```

```
  </xs:element>
```

```
  <xs:simpleType name="statement-guid">
```

```
    <xs:restriction base="xs:string" />
```

```

</xs:simpleType>

<xs:simpleType name="decimal-fraction-denominator">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:simpleType name="decimal-fraction-numerator">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:simpleType name="content-elements">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:complexType name="statement-creation-timestamp">

```

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```

  <xs:sequence>
    <xs:element name="decimal-fraction-denominator" type="decimal-fraction-de
    <xs:element name="decimal-fraction-numerator" type="decimal-fraction-nume
  </xs:sequence>
</xs:complexType>

<xs:complexType name="content-creation-timestamp">
  <xs:sequence>
    <xs:element name="decimal-fraction-denominator" type="decimal-fraction-de
    <xs:element name="decimal-fraction-numerator" type="decimal-fraction-nume
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="statement-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Observation" />
    <xs:enumeration value="DirectoryContent" />
    <xs:enumeration value="Correlation" />
    <xs:enumeration value="Assessment" />
    <xs:enumeration value="Guidance" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="content-topic">
  <xs:restriction base="xs:string">
    <xs:enumeration value="Session" />

```

```

    <xs:enumeration value="User" />
    <xs:enumeration value="Interface" />
    <xs:enumeration value="PostureProfile" />
    <xs:enumeration value="Flow" />
    <xs:enumeration value="PostureAssessment" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="content-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="EndpointConfiguration" />
    <xs:enumeration value="EndpointState" />
    <xs:enumeration value="DirectoryEntry" />
    <xs:enumeration value="Event" />
    <xs:enumeration value="Incident" />
    <xs:enumeration value="yang-output" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="content-element-guid">
  <xs:restriction base="xs:string" />
</xs:simpleType>

```

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```

<xs:complexType name="yang-output-metadata">
  <xs:sequence>
    <xs:choice maxOccurs="1">
      <xs:element name="yang-query" type="yang-query" />
      <xs:element name="yang-subscribe" type="yang-subscribe" />
    </xs:choice>
    <xs:element name="encoding" type="yang-encoding" />
    <xs:element name="module-names" type="module-name" minOccurs="0" maxOccurs="1" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="yang-subscribe">
  <xs:restriction base="xs:NMTOKEN">
    <xs:enumeration value="periodic" />
    <xs:enumeration value="on-change" />
  </xs:restriction>
  <xs:restriction base="xs:NMTOKEN">
    <xs:enumeration value="xpath" />
    <xs:enumeration value="subtree" />
  </xs:restriction>
</xs:complexType>

```

```

    </xs:restriction>
</xs:complexType>

<xs:simpleType name="filter-expression">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="yang-query">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="yang-encoding">
  <xs:restriction base="xs:NMTOKEN">
    <xs:enumeration value="netconf" />
    <xs:enumeration value="restconf" />
    <xs:enumeration value="comi" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="module-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="relationship-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="associated_with_user" />
    <xs:enumeration value="applies_to_session" />
    <xs:enumeration value="seen_on_interface" />
    <xs:enumeration value="associated_with_flow" />
  </xs:restriction>
</xs:simpleType>

```

```

  <xs:enumeration value="contains_virtual_device" />
</xs:restriction>
</xs:simpleType>

<xs:simpleType name="relationship-content-element-guid">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="relationship-statement-guid">
  <xs:restriction base="xs:string" />
</xs:simpleType>

```

```

<xs:simpleType name="relationship-object-label">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="data-source-label">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="data-origin">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="host-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="administrative-domain-label">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="sub-administrative-domain">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="super-administrative-domain">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="relationship">
  <xs:sequence>
    <xs:element name="relationship-type" type="relationship-type" />
    <xs:element name="relationship-content-element-guid" type="relationship-c
    <xs:element name="relationship-statement-guid" type="relationship-stateme
    <xs:element name="relationship-object-label" type="relationship-object-la
  </xs:sequence>
</xs:complexType>

```

```

<xs:complexType name="flow-element">
  <xs:sequence>
    <xs:element name="network-address" type="network-address"/>
    <xs:element name="layer4-port-address" type="layer4-port-address" />
  </xs:sequence>

```

```

</xs:complexType>

<xs:complexType name="flow-record">
  <xs:sequence>
    <xs:element name="src-flow-element" type="flow-element" />
    <xs:element name="dst-flow-element" type="flow-element" />
    <xs:element name="protocol" type="protocol" />
    <xs:element name="layer4-protocol" type="layer4-protocol" />
    <xs:element name="flow-statistics" type="flow-statistics" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="content-metadata">
  <xs:sequence>
    <xs:element name="content-element-guid" type="content-element-guid" />
    <xs:element name="content-creation-timestamp" type="content-creation-time" />
    <xs:element name="content-topic" type="content-topic" />
    <xs:element name="content-type" type="content-type" />
    <xs:element name="data-source" type="data-source" minOccurs="0" />
    <xs:element name="data-origin" type="data-origin" minOccurs="0" />
    <xs:element name="relationship" type="relationship" minOccurs="0" maxOccurs="1" />
    <xs:element name="yang-output-metadata" type="yang-output-metadata" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="content-element">
  <xs:sequence>
    <xs:element name="content-metadata" type="content-metadata" maxOccurs="1" />
    <xs:choice maxOccurs="unbounded">
      <xs:element name="yang-output" type="yang-output" />
      <xs:element name="flow" type="flow-record" />
      <xs:element name="posture" type="xs:string" />
      <xs:element name="user" type="user" />
      <xs:element name="session" type="session" />
      <xs:element name="ethernet-interface" type="ethernet-interface" />
      <xs:element name="target-endpoint" type="target-endpoint" />
      <xs:element name="port" type="port" />
      <xs:element name="posture-assessment" type="posture-assessment" />
    </xs:choice>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="posture-assessment"></xs:complexType>

```



```

<xs:complexType name="target-endpoint">
  <xs:sequence>
    <xs:element name="host-name" type="host-name" />
    <xs:element name="te-label" type="te-label" />
    <xs:element name="administrative-domain" type="administrative-domain" minOccurs="1" />
    <xs:element name="application-instance" type="application-instance" minOccurs="1" />
    <xs:element name="ethernet-interface" type="ethernet-interface" minOccurs="1" />
    <xs:element name="address-association" type="address-association" minOccurs="1" />
    <xs:element name="data-source" type="data-source" minOccurs="0" />
    <xs:element name="operating-system" type="operating-system" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="te-label">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="application-instance">
  <xs:sequence>
    <xs:element name="application-label" type="application-label" />
    <xs:element name="target-endpoint" type="target-endpoint" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="attribute-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="attribute-value">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="attribute-value-pair">
  <xs:sequence>
    <xs:element name="attribute-name" type="attribute-name" />
    <xs:element name="attribute-value" type="attribute-value" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="application-label">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="application-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="application-version">

```

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```
<xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="application-manufacturer">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<!-- TODO: is it possible to declare this as an enumeration or is that un
<xs:simpleType name="application-type">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="application-component">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="application">
  <xs:sequence>
    <xs:element name="application-label" type="application-label" minOccurs="0" />
    <xs:element name="application-name" type="application-name" />
    <xs:element name="application-type" type="application-type" minOccurs="0" />
    <xs:element name="application-component" type="application-component" minOccurs="0" />
    <xs:element name="application-manufacturer" type="application-manufacturer" />
    <xs:element name="application-version" type="application-version" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="address-association">
  <xs:sequence>
    <xs:element name="address" type="address" />
    <xs:element name="address-association-type" type="address-association-type" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="address">
  <xs:sequence>
    <xs:element name="address-mask-value" type="address-mask-value" />
    <xs:element name="address-type" type="address-type" />
    <xs:element name="address-value" type="address-value" />
  </xs:sequence>
```

```
</xs:complexType>
```

```
<xs:simpleType name="address-type">  
  <xs:restriction base="xs:string">  
    <xs:enumeration value="Ethernet" />  
    <xs:enumeration value="ZigBee" />
```

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```
    <xs:enumeration value="ModBus" />  
  </xs:restriction>  
</xs:simpleType>
```

```
<xs:simpleType name="session-state-type">  
  <xs:restriction base="xs:string">  
    <xs:enumeration value="Authenticating"></xs:enumeration>  
    <xs:enumeration value="Authenticated"></xs:enumeration>  
    <xs:enumeration value="Postured"></xs:enumeration>  
    <xs:enumeration value="Started"></xs:enumeration>  
    <xs:enumeration value="Disconnected"></xs:enumeration>  
  </xs:restriction>  
</xs:simpleType>
```

```
<xs:complexType name="session">  
  <xs:sequence>  
    <xs:element name="session-state-type" type="session-state-type" />  
    <!-- TODO: add additional elements for Session Type -->  
  </xs:sequence>  
</xs:complexType>
```

```
<xs:simpleType name="user-id">  
  <xs:restriction base="xs:string" />  
</xs:simpleType>
```

```
<xs:simpleType name="username">  
  <xs:restriction base="xs:string" />  
</xs:simpleType>
```

```
<xs:simpleType name="user-directory">  
  <xs:restriction base="xs:string" />  
</xs:simpleType>
```

```
<xs:complexType name="user">  
  <xs:sequence>
```

```

    <xs:element name="user-id" type="user-id" />
    <xs:element name="username" type="username" minOccurs="0" />
    <xs:element name="data-source" type="data-source" minOccurs="0" />
    <xs:element name="user-directory" type="user-directory" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="ethernet-interface">
  <xs:sequence>
    <xs:element name="interface-label" type="interface-label" />
    <xs:element name="network-interface-name" type="network-interface-name" />
    <xs:element name="mac-address" type="mac-address" />
    <xs:element name="network-name" type="network-name" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>

```

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```

    <xs:element name="network-id" type="network-id" minOccurs="0"/>
    <xs:element name="layer2-interface-type" type="layer2-interface-type" minOccurs="0" />
    <xs:element name="sub-interface-label" type="sub-interface-label" minOccurs="0" />
    <xs:element name="super-interface-label" type="super-interface-label" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="event-type">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="event-threshold">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:simpleType name="event-threshold-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="event-trigger">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="timestamp-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="discovered" />
    <xs:enumeration value="classified" />
    <xs:enumeration value="collected" />
  </xs:restriction>
</xs:simpleType>

```

```

        <xs:enumeration value="published" />
    </xs:restriction>
</xs:simpleType>

<xs:complexType name="typed-timestamp">
    <xs:sequence>
        <xs:element name="decimal-fraction-denominator" type="decimal-fraction-de
        <xs:element name="decimal-fraction-numerator" type="decimal-fraction-nume
        <xs:element name="timestamp-type" type="timestamp-type" />
    </xs:sequence>
</xs:complexType>

<xs:complexType name="event">
    <xs:sequence>
        <xs:element name="event-type" type="event-type" minOccurs="0" />
        <xs:element name="event-threshold" type="event-threshold" minOccurs="0" />
        <xs:element name="event-threshold-name" type="event-threshold-name" minOccurs="0" />
        <xs:element name="event-trigger" type="event-trigger" minOccurs="0" />
        <xs:element name="typed-timestamp" type="typed-timestamp" />
        <xs:element name="content" type="xs:anySimpleType" />
    </xs:sequence>
</xs:complexType>

```

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```

    </xs:sequence>
</xs:complexType>

<xs:simpleType name="os-label">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="os-name">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="os-type">
    <xs:restriction base="xs:string">
        <xs:enumeration value="real-time" />
        <xs:enumeration value="consumer" />
        <xs:enumeration value="server" />
        <xs:enumeration value="security-enhanced" />
    </xs:restriction>
</xs:simpleType>

<xs:simpleType name="os-component">

```

```

    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="os-manufacturer">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="os-version">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="operating-system">
    <xs:sequence>
        <xs:element name="os-label" type="os-label" minOccurs="0" />
        <xs:element name="os-name" type="os-name" />
        <xs:element name="os-type" type="os-type" minOccurs="0" maxOccurs="unbound" />
        <xs:element name="os-component" type="os-component" minOccurs="0" maxOccurs="unbound" />
        <xs:element name="os-manufacturer" type="os-manufacturer" minOccurs="0" />
        <xs:element name="os-version" type="os-version" minOccurs="0" />
    </xs:sequence>
</xs:complexType>

<xs:simpleType name="sub-interface-label">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="super-interface-label">

```

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```

    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="address-association-type">
    <xs:restriction base="xs:string">
        <xs:enumeration value="broadcast-domain-member-list" />
        <xs:enumeration value="ip-subnet-member-list" />
        <xs:enumeration value="ip-mac" />
        <xs:enumeration value="shared-backhaul-interface" />
    </xs:restriction>
</xs:simpleType>

<xs:simpleType name="address-mask-value">
    <xs:restriction base="xs:string" />

```

```

</xs:simpleType>
<xs:simpleType name="address-value">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="interface-label">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="network-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="network-id">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="network-interface-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="layer2-interface-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="fastEther" />
    <xs:enumeration value="fastEtherFX" />
    <xs:enumeration value="gigabitEthernet" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="ipv6-address-subnet-mask-cidrnot">
  <xs:restriction base="xs:string">
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="ipv6-address-value">

```

```

  <xs:restriction base="xs:string">
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="ipv4-address-subnet-mask-cidrnot">
  <xs:restriction base="xs:string">
  </xs:restriction>

```

```

</xs:simpleType>
<xs:simpleType name="ipv4-address-subnet-mask">
  <xs:restriction base="xs:string">
    </xs:restriction>
  </xs:simpleType>
<xs:simpleType name="ipv4-address-value">
  <xs:restriction base="xs:string">
    </xs:restriction>
  </xs:simpleType>

<xs:complexType name="network-address">
  <xs:choice>
    <xs:element name="ipv4-address" type="ipv4-address" />
    <xs:element name="ipv6-address" type="ipv6-address" />
    <xs:element name="mac-address" type="mac-address" />
  </xs:choice>
</xs:complexType>

<xs:complexType name="endpoint-identifier">
  <xs:choice>
    <xs:element name="certificate" type="certificate" />
    <xs:element name="firmware-id" type="firmware-id" />
    <xs:element name="hardware-serial-number" type="hardware-serial-number" />
    <xs:element name="host-name" type="host-name" />
    <xs:element name="ipv4-address-value" type="ipv4-address-value" />
    <xs:element name="ipv6-address-value" type="ipv6-address-value" />
    <xs:element name="mac-address" type="mac-address" />
    <xs:element name="public-key" type="public-key" />
    <xs:element name="username" type="username" />
  </xs:choice>
</xs:complexType>

<xs:complexType name="ipv4-address">
  <xs:sequence>
    <xs:element name="ipv4-address-value" type="ipv4-address-value" />
    <xs:element name="ipv4-address-subnet-mask-cidrnot" type="ipv4-address-su
    <xs:element name="ipv4-address-subnet-mask" type="ipv4-address-subnet-mas
  </xs:sequence>
</xs:complexType>

<xs:complexType name="ipv6-address">

```



```
<xs:sequence>
  <xs:element name="ipv6-address-value" type="ipv6-address-value" />
  <xs:element name="ipv6-address-subnet-mask-cidrnot" type="ipv6-address-su
</xs:sequence>
</xs:complexType>

<xs:simpleType name="mac-address">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="layer4-port-address">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="protocol">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="layer4-protocol">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="bytes-received">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:simpleType name="bytes-sent">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:simpleType name="units-received">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:simpleType name="units-sent">
  <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:complexType name="flow-statistics">
  <xs:sequence>
    <xs:element name="bytes-received" type="bytes-received" />
    <xs:element name="bytes-sent" type="bytes-sent" />
    <xs:element name="units-received" type="units-received" />
    <xs:element name="units-sent" type="units-sent" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="person">
```

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```
<xs:sequence>
  <xs:element name="person-first-name" type="person-first-name" />
  <xs:element name="person-last-name" type="person-last-name" />
  <xs:element name="person-middle-name" type="person-middle-name" minOccurs="0" maxOccurs="1" />
  <xs:element name="phone-contact" type="phone-contact" minOccurs="0" maxOccurs="1" />
  <xs:element name="email-address" type="email-address" minOccurs="0" maxOccurs="1" />
</xs:sequence>
</xs:complexType>

<xs:simpleType name="person-first-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="person-last-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="person-middle-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="email-address">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="phone-contact">
  <xs:sequence>
    <xs:element name="phone-number" type="phone-number" />
    <xs:element name="phone-number-type" type="phone-number-type" minOccurs="0" maxOccurs="1" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="phone-number">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="phone-number-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="DSN" />
    <xs:enumeration value="Fax" />
    <xs:enumeration value="Home" />
    <xs:enumeration value="Mobile" />
    <xs:enumeration value="Pager" />
  </xs:restriction>
</xs:simpleType>
```

```
<xs:enumeration value="Secure" />
<xs:enumeration value="Unsecure" />
<xs:enumeration value="Work" />
<xs:enumeration value="Other" />
</xs:restriction>
```

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```
</xs:simpleType>

<xs:complexType name="privilege">
  <xs:sequence>
    <xs:element name="privilege-name" type="privilege-name" />
    <xs:element name="privilege-value" type="privilege-value" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="privilege-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="privilege-value">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="location">
  <xs:sequence>
    <xs:element name="WGS84-longitude" type="WGS84-longitude" />
    <xs:element name="WGS84-latitude" type="WGS84-latitude" />
    <xs:element name="WGS84-altitude" type="WGS84-altitude" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="WGS84-longitude">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="WGS84-latitude">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="WGS84-altitude">
  <xs:restriction base="xs:string" />
</xs:simpleType>
```

```

<xs:simpleType name="organization-id">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="organization-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:complexType name="organization">
  <xs:sequence>
    <xs:element name="organization-id" type="organization-id" />

```

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```

  <xs:element name="organization-name" type="organization-name" />
  <xs:element name="location" type="location" minOccurs="0" />
</xs:sequence>
</xs:complexType>

<xs:complexType name="data-source">
  <xs:sequence>
    <xs:element name="data-source-label" type="data-source-label" minOccurs="0" />
    <xs:element name="endpoint-identifier" type="endpoint-identifier" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="administrative-domain">
  <xs:sequence>
    <xs:element name="administrative-domain-label" type="administrative-domain-label" />
    <xs:element name="sub-administrative-domain" type="sub-administrative-domain" />
    <xs:element name="super-administrative-domain" type="super-administrative-domain" />
    <xs:element name="location" type="location" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="access-privilege-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="read" />
    <xs:enumeration value="write" />
    <xs:enumeration value="none" />
  </xs:restriction>
</xs:simpleType>

```

```
<xs:simpleType name="account-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="authenticator">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="authentication-type">
  <xs:restriction base="xs:string">
    <!-- To be done -->
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="birthdate">
  <xs:restriction base="xs:date" />
</xs:simpleType>

<xs:simpleType name="certificate">
```

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```
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="collection-task-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="network-observation" />
    <xs:enumeration value="remote-acquisition" />
    <xs:enumeration value="self-reported" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="confidence">
  <xs:restriction base="xs:float">
    <xs:minInclusive value="0" />
    <xs:maxInclusive value="1" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="content-action">
  <xs:restriction base="xs:string">
    <xs:enumeration value="add" />
    <xs:enumeration value="delete" />
```

```
        <xs:enumeration value="update" />
    </xs:restriction>
</xs:simpleType>

<xs:simpleType name="country-code">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="default-depth">
    <xs:restriction base="xs:integer" />
</xs:simpleType>

<xs:simpleType name="discoverer">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="firmware-id">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="hardware-serial-number">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="location-name">
    <xs:restriction base="xs:string" />
</xs:simpleType>
```

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```
</xs:simpleType>

<xs:simpleType name="method-label">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="method-repository">
    <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="network-access-level-type">
    <xs:restriction base="xs:string">
        <xs:enumeration value="block" />
        <xs:enumeration value="quarantine" />
    </xs:restriction>
</xs:simpleType>
```

```

</xs:simpleType>

<xs:simpleType name="patch-id">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="patch-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<!-- FIXME: is this type appropriate? -->
<xs:simpleType name="public-key">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="role-name">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="status">
  <xs:restriction base="xs:string">
    <xs:enumeration value="true" />
    <xs:enumeration value="false" />
    <xs:enumeration value="error" />
    <xs:enumeration value="unknown" />
    <xs:enumeration value="not applicable" />
    <xs:enumeration value="not evaluated" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="te-assessment-state">
  <xs:restriction base="xs:string">
    <xs:enumeration value="in-discovery" />

```

```

  <xs:enumeration value="discovered" />
  <xs:enumeration value="in-classification" />
  <xs:enumeration value="classified" />
  <xs:enumeration value="in-assessment" />
  <xs:enumeration value="assessed" />
</xs:restriction>
</xs:simpleType>

```

```
<xs:simpleType name="timestamp">
  <xs:restriction base="xs:dateTime" />
</xs:simpleType>

<xs:simpleType name="web-site">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="port-id">
  <xs:restriction base="xs:string" />
</xs:simpleType>

<xs:simpleType name="atm-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="lowSpeed" />
    <xs:enumeration value="highSpeed" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="enet-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="enet" />
    <xs:enumeration value="1genet" />
    <xs:enumeration value="10genet" />
    <xs:enumeration value="100genet" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="wifi-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="11n" />
    <xs:enumeration value="11a" />
    <xs:enumeration value="11gb" />
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="virtual-type">
  <xs:restriction base="xs:string">
    <xs:enumeration value="virtual-1g" />
  </xs:restriction>
</xs:simpleType>
```

```
</xs:simpleType>
```



```
<xs:complexType name="port">
  <xs:sequence>
    <xs:element name="port-id" type="port-id"/>
    <xs:element name="atm-type" type="atm-type" maxOccurs="1" minOccurs="0" />
    <xs:element name="enet-type" type="enet-type" maxOccurs="1" minOccurs="0" />
    <xs:element name="wifi-type" type="wifi-type" maxOccurs="1" minOccurs="0" />
    <xs:element name="virtual-type" type="virtual-type" maxOccurs="1" minOccurs="0" />
  </xs:sequence>
</xs:complexType>

<xs:complexType name="user-account">
  <xs:sequence>
    <xs:element name="user" type="user"/>
  </xs:sequence>
</xs:complexType>
</xs:schema>
<CODE ENDS>
```

Authors' Addresses

Henk Birkholz
Fraunhofer SIT
Rheinstrasse 75
Darmstadt 64295
Germany

Email: henk.birkholz@sit.fraunhofer.de

Nancy Cam-Winget
Cisco Systems
3550 Cisco Way
San Jose, CA 95134
USA

Email: ncamwing@cisco.com