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A YANG Data Model for Network Hardware Inventory

Abstract

This document defines a YANG data model for network hardware inventory data information.

The YANG data model presented in this document is intended to be used as the basis toward a generic YANG data model for network hardware inventory data information which can be augmented, when required, with technology-specific (e.g., optical) inventory data, to be defined either in a future version of this document or in another document.

The YANG data model defined in this document conforms to the Network Management Datastore Architecture (NMDA).

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on 8 January 2024.

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1. Introduction

Network hardware inventory management is a key component in operators' OSS architectures.

Network hardware inventory is a fundamental functionality in network management and was specified many years ago. Given the emergence of data models and their deployment in operator's management and control systems, the traditional function of inventory management is also requested to be defined as a data model.

Network hardware inventory management and monitoring is a critical part for ensuring the network stays healthy, well-planned, and functioning in the operator's network. Network hardware inventory management allows the operator to keep track of which physical devices are deployed in the network including relevant software and hardware versions.

The network hardware inventory management also helps the operator to know when to acquire new assets and what is needed, or to decommission old or faulty ones, which can help to improve network performance and capacity planning.

In [I-D.ietf-teas-actn-poi-applicability] a gap was identified regarding the lack of a YANG data model that could be used at ACTN MPI interface level to report whole/partial network hardware inventory information available at domain controller level towards north-bound systems (e.g., MDSC or OSS layer).

[RFC8345] initial goal was to make possible the augmentation of the YANG data model with network hardware inventory data model but this was never developed and the scope was kept limited to network topology data only.

It is key for operators to drive the industry towards the use of a standard YANG data model for network hardware inventory data instead of using vendors proprietary APIs (e.g., REST API).

In the ACTN architecture, this would bring also clear benefits at MDSC level for packet over optical integration scenarios since this would enable the correlation of the inventory information with the links information reported in the network topology model.

The intention is to define a generic YANG data model that would be as much as possible technology agnostic (valid for IP, optical and microwave networks) and that could be augmented, when required, to include some technology-specific inventory details.

[RFC8348] defines a YANG data model for the management of the hardware on a single server and therefore it is more applicable to

the domain controller South Bound Interface (SBI) towards the network elements rather than at the domain controller's northbound. However, the YANG data model defined in [RFC8348] has been used as a reference for defining the YANG network hardware inventory data model presented in this draft.

For optical network hardware inventory, the network hardware inventory YANG data model should support the use cases (4a and 4b) and requirements as defined in [ONF_TR-547], in order to guarantee a seamless integration at MDSC/OSS/orchestration layers.

The proposed YANG data model has been analysed at the present stage to cover the requirements and use cases for Optical Network Hardware Inventory.

Being based on [RFC8348], this data model should be a good starting point toward a generic data model and applicable to any technology. However, further analysis of requirements and use cases is needed to extend the applicability of this YANG data model to other types of networks (IP and microwave) and to identify which aspects are generic and which aspects are technology-specific for optical networks.

This document defines two YANG modules: "ietf-network-hardware-inventory", defined in Section 4.1, and "ietf-hw-inventory-ref-topo", defined in Section 4.2.

The YANG data models defined in this document conform to the Network Management Datastore Architecture [RFC8342].

1.1. Terminology and Notations

The following terms are defined in [RFC7950] and are not redefined here:

*client

*server

*augment

*data model

*data node

The following terms are defined in [RFC6241] and are not redefined here:

*configuration data

*state data

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

TBD: Recap the concept of chassis/slot/component/board/... in [TMF_SD2-20].

Following terms are used for the representation of the hierarchies in the network hardware inventory.

Network Element:

a device installed on one or several chassis and can afford some specific transmission function independently.

Rack:

a holder of the device and provides power supply for the device in it.

Chassis:

a holder of the device installation.

Slot:

a holder of the board.

Component:

holders and equipment of the network element, including chassis, slot, sub-slot, board and port.

Board/Card:

a pluggable equipment can be inserted into one or several slots/ sub-slots and can afford a specific transmission function independently.

Port:

an interface on board

1.2. 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

BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.3. Tree Diagram

A simplified graphical representation of the data model is used in Section 3 of this document. The meaning of the symbols in this diagram is defined in [RFC8340].

1.4. Prefix in Data Node Names

In this document, names of data nodes and other data model objects are prefixed using the standard prefix associated with the corresponding YANG imported modules, as shown in the following table.

Prefix	Yang Module	Reference
inet	ietf-inet-types	[RFC6991]
yang	ietf-yang-types	[RFC6991]
ianahw	iana-hardware	[IANA_YANG]
ni	ietf-network-hardware-inventory	RFC XXXX
hirt	ietf-hw-inventory-ref-topo	RFC XXXX

Table 1: Prefixes and corresponding YANG modules

RFC Editor Note: Please replace XXXX with the RFC number assigned to this document. Please remove this note.

2. YANG Data Model for Network Hardware Inventory

2.1. YANG Model Overview

Based on TMF classification in [TMF_SD2-20], inventory objects can be divided into two groups, holder group and equipment group. The holder group contains rack, chassis, slot, sub-slot while the equipment group contains network-element, board and port. With the requirement of GIS and on-demand domain controller selection raised, the equipment room becomes a new inventory object to be managed besides TMF classification.

Logically, the relationship between these inventory objects can be described by Figure 1 below:

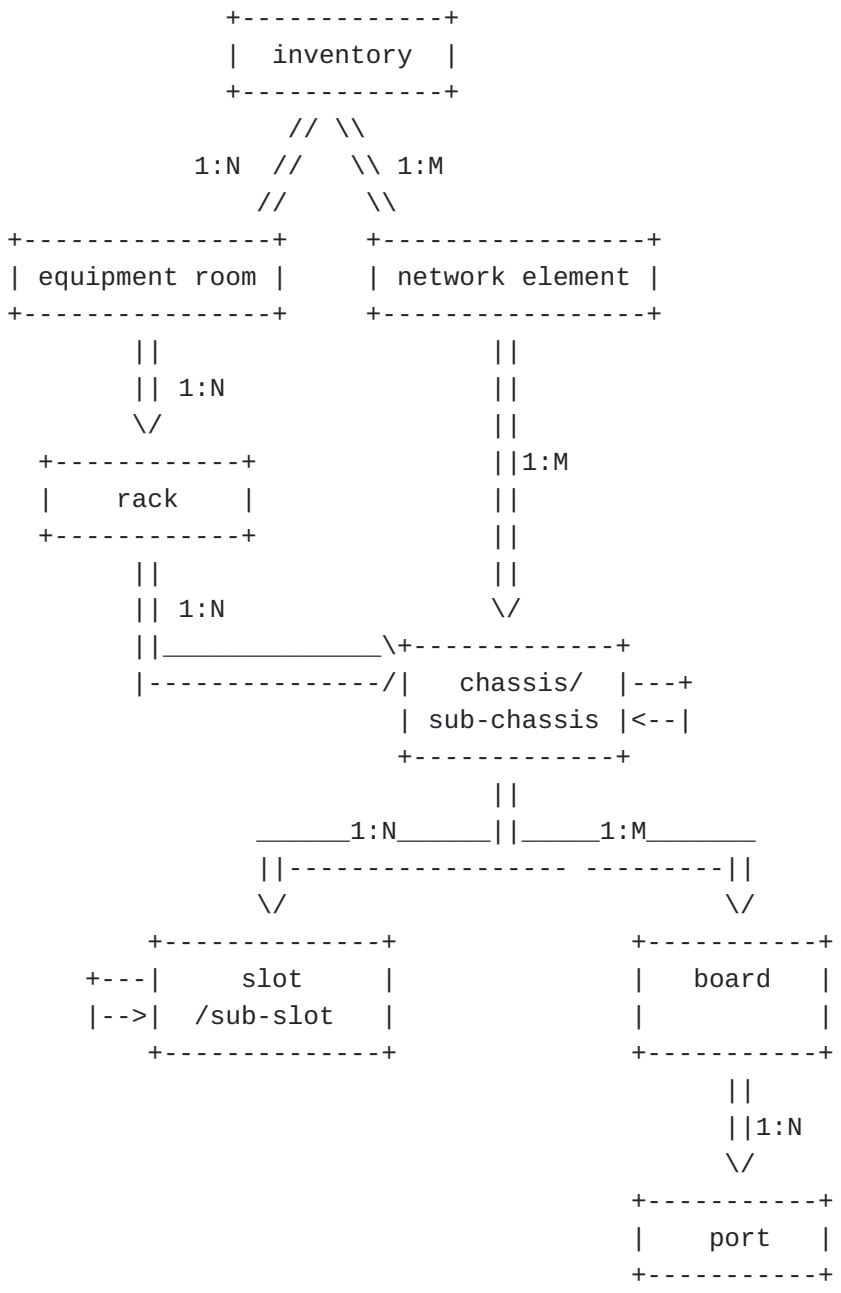

Figure 1: Relationship between inventory objects

In [RFC8348], rack, chassis, slot, sub-slot, board and port are defined as components of network elements with generic attributes.

Considering there are some special scenarios, there is no direct relationship between the rack and network element. In some cases, one network element contains multiple racks while in other cases one rack contains several shelves belonging to one or more network elements.

While [RFC8348] is used to manage the hardware of a single server (e.g., a network element), the Network Hardware Inventory YANG data model is used to retrieve the network hardware inventory information that a controller discovers from all the network elements under its control.

However, the YANG data model defined in [RFC8348] has been used as a reference for defining the YANG network hardware inventory data model. This approach can simplify the implementation of this network hardware inventory model when the controller uses the YANG data model defined in [RFC8348] to retrieve the hardware from the network elements under its control.

Note: review in future versions of this document whether to re-use definitions from [RFC8348] or use schema-mount.

```
+--ro network-hardware-inventory
   +--ro equipment-rooms
   |  +--ro equipment-room* [uuid]
   |     +--ro uuid        yang:uuid
   |     ...................................
   |     +--ro racks
   |        +--ro rack* [uuid]
   |           +--ro uuid           yang:uuid
   |           ...................................
   |           +--ro contained-chassis* [ne-ref component-ref]
   |              +--ro ne-ref?          leafref
   |              +--ro component-ref?   leafref
   +--ro network-elements
      +--ro network-element* [uuid]
         +--ro uuid          yang:uuid
         ...................................
         +--ro components
            +--ro component* [uuid]
               +--ro uuid              yang:uuid
               ...................................
```

2.1.1. Common Design for All Inventory Objects

For all the inventory objects, there are some common attributes existing. Such as:

Identifier: here we suggest to use uuid format which is widely implemented with systems. It is guaranteed to be globally unique.

Name: name is a human-readable label information which could be used to present on GUI. This name is suggested to be provided by server.

Alias: alias is also a human-readable label information which could be modified by user. It could also be present on GUI instead of name.

Description: description is a human-readable information which could be also input by user. Description provides more detailed information to prompt users when performing maintenance operations.

Location: location is a common management requirement of operators. This location could be an absolute position (e.g. mailing address), or a relative position (e.g. port index). Different types of inventory objects may require different types of position.

```
module: ietf-network-hardware-inventory
   +--ro network-hardware-inventory
      +--ro equipment-rooms
      |  +--ro equipment-room* [uuid]
      |     +--ro uuid           yang:uuid
      |     +--ro name?          string
      |     +--ro description?   string
      |     +--ro alias?         string
      |     +--ro location?      string
      |     ..................................
      |     +--ro racks
      |        +--ro rack* [uuid]
      |           +--ro uuid                 yang:uuid
      |           +--ro name?                string
      |           +--ro description?         string
      |           +--ro alias?               string
      |           +--ro rack-location
      |           |  +--ro equipment-room-name?   leafref
      |           |  +--ro row-number?            uint32
      |           |  +--ro column-number?         uint32
      |           ..................................
      +--ro network-elements
         +--ro network-element* [uuid]
            +--ro uuid             yang:uuid
            +--ro name?            string
            +--ro description?     string
            +--ro alias?           string
            +--ro ne-location
            |  +--ro equipment-room-name*   leafref
            ..................................
            +--ro components
               +--ro component* [uuid]
                  +--ro uuid                    yang:uuid
                  +--ro name?                   string
                  +--ro description?            string
                  +--ro alias?                  string
                  +--ro location                string
                  ..................................
```

2.1.2. Reference from RFC8348

The YANG data model for network hardware inventory mainly follows the same approach of [RFC8348] and reports the network hardware inventory as a list of components with different types (e.g., chassis, module, port).

```
+--ro components
   +--ro component* [uuid]
      +--ro uuid              yang:uuid
      +--ro name?             string
      +--ro description?      string
      +--ro class?            identityref
      +--ro contained-child*  -> ../uuid
      +--ro hardware-rev?     string
      +--ro firmware-rev?     string
      +--ro software-rev?     string
      +--ro serial-num?       string
      +--ro mfg-name?         string
      +--ro asset-id?         string
      +--ro is-fru?           boolean
      +--ro mfg-date?         yang:date-and-time
      +--ro uri*              inet:uri
```

Some of the definitions taken from [RFC8348] are actually based on the ENTITY-MIB [RFC6933].

For the component location information, the suggested pattern is the same as the pattern defined in section 4.2 of [ONF_TR-547] for the INVENTORY_ID property.

In this draft the term 'chassis' is used instead of the term 'shelf', used in [ONF_TR-547], since the term 'chassis' has broader applicability than the term 'shelf' and it is aligned with the terminology of [RFC8348]. However, the component location string will use the acronyms 'sh' and 's_sh' for consistency with the [ONF_TR-547] definitions.

Table 2 summarizes the relationship between the <field> defined in [ONF_TR-547] and the components defined in this document.

<field>	**meaning**
ne	network element
r	rack
sh	chassis component
s_sh	sub-chassis component
sl	slot component
s_sl	sub-slot component
p	port component

Table 2: Meaning of <field>

This pattern is a common practice in optical transport networks, but we consider it as also applicable for other technologies.

For state data like admin-state, oper-state and so on, we consider they are related to device hardware management and not hardware inventory. Therefore, they are outside of scope of this document. Same for the sensor-data, they should be defined in some other performance monitoring data models instead of inventory data model.

We re-defined some attributes listed in [RFC8348], based on some integration experience for network wide inventory data.

2.1.3. Changes with respect to RFC8348

2.1.3.1. New Parent Identifiers' Reference

[RFC8348] provided a "parent-ref" attribute, which was an identifier reference to its parent component. When the MDSC or OSS systems want to find this component's grandparent or higher level component in the hierarchy, they need to retrieve this parent-ref step by step. To reduce this iterative work, we decided to provide a list of hierarchical parent components' identifier references.

```
+--ro components
   +--ro component* [uuid]
      ...................................
      +--ro parent-component-references
      |   +--ro component-reference* [index]
      |      +--ro index    uint8
      |      +--ro class?   -> ../../../class
      |      +--ro uuid?    -> ../../../uuid
      ...................................
```

The hierarchical components' identifier could be found by the "component-reference" list. The "index" attribute is used to order the list by the hierarchical relationship from topmost component (with the "index" set to 0) to bottom component.

2.1.3.2. Component-Specific Info Design

According to the management requirements from operators, some important attributes are not defined in [RFC8348]. These attributes could be component-specific and are not suitable to define under the component list node. So, we defined a choice-case structure for this component-specific extension, as follows:

```
+--ro components
   +--ro component* [uuid]
      ...................................
      +--ro (component-class)?
         +--:(chassis)
         |  +--ro chassis-specific-info
         +--:(container)
         |  +--ro slot-specific-info
         +--:(module)
         |  +--ro board-specific-info
         +--:(port)
            +--ro port-specific-info
      ...................................
```

Note: The detail of each *-specific-info YANG container is still under discussion, and the leaf attributes will be defined in future.

2.1.3.3. Part Number

According to the description in [RFC8348], the attribute named "model-name" under the component, is preferred to have a customer-visible part number value. "Model-name" is not straightforward to understand and we suggest to rename it as "part-number" directly.

```
+--ro components
   +--ro component* [uuid]
      ...................................
      +--ro part-number?          string
      ...................................
```

2.1.4. Equipment Room

Usually the information about equipment rooms is not detectable by domain controller and configured manually. Sometimes, this information is not configured in the domain controller but directly in the Operators' owned OSS and therefore reporting information about the equipment rooms is optional when implementing this data model.

Another scenario to analyze is when racks are not located in any equipment room: one possible solution is that the domain controller provides a "default" equipment room that contains all these racks.

Note: add some more attributes about equipment room in the future.

2.1.5. Rack

Likewise for equipment rooms, usually the information about the rack is not detectable by domain controller and configured manually.

Therefore reporting information about the racks is optional when implementing this data model.

Besides the common attributes mentioned in above section, rack could have some specific attributes, such as appearance-related attributes and electricity-related attributes. The height, depth and width are described by the figure below (please consider that the door of the rack is facing the user):

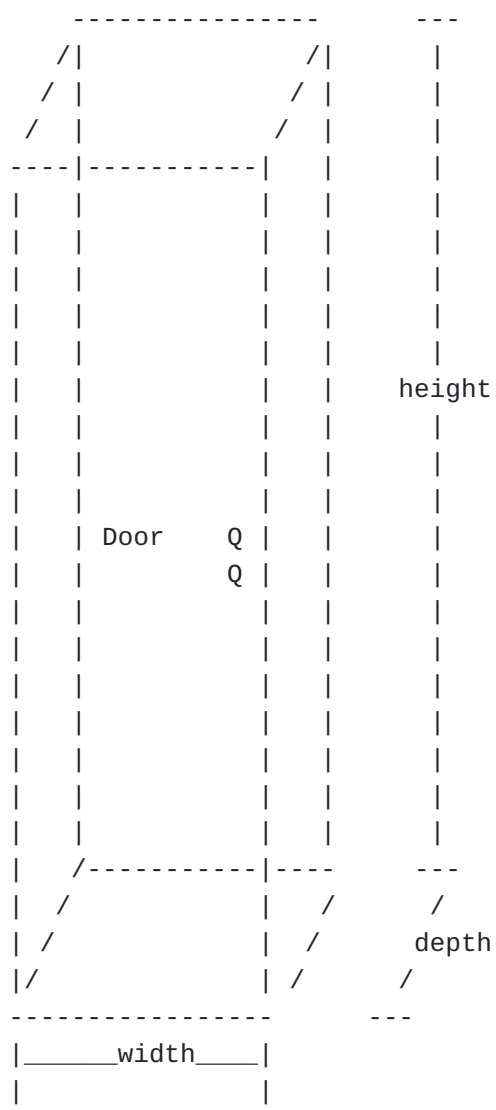

Figure 2: height, width and depth of rack

The rack attributes include:

```
+--ro racks
   +--ro rack* [uuid]
      ..................................
      +--ro height?              uint16
      +--ro width?               uint16
      +--ro depth?               uint16
      +--ro max-voltage?         uint16
      ..................................
```

Max-voltage: the maximum voltage supported by the rack.

2.1.6. Network Element

We consider that some of the attributes defined in [RFC8348] for components are also applicable for network element. These attributes include:

```
   +--ro network-elements
      +--ro network-element* [uuid]
         ...................................
         +--ro hardware-rev?    string
         +--ro software-rev?    string
         +--ro mfg-name?        string
         +--ro mfg-date?        yang:date-and-time
         +--ro part-number?     string
         +--ro serial-number?   string
         +--ro product-name?    string
         ...................................
```

Note: Not all the attributes defined in [RFC8348] are applicable for network element. And there could also be some missing attributes which are not recognized by [RFC8348]. More extensions could be introduced in later revisions after the missing attributes are fully discussed.

2.1.7. Relationship between Hardware Inventory and Network Topology models

Network topology is a logical abstraction based on hardware inventory objects. The abstraction may be based on technology requirements (e.g., layer 0 or layer 1 resources) or on some specific requirements (e.g., for path computation or service provisioning).

Therefore the relationship between hardware inventory objects and network topology objects can be 1:N (N>=1).

Taking the Optical technology as example, an Optical Transport Network (OTN) Network Element (NE) can be installed with several kinds of boards, including an Ethernet client signal switching

board, a line board which is used for OTN layer switching. This line board may also be used as a starting point for the WDM layer. In terms of technologies, this OTN NE supports multi-layer network topology connections, so that it should appear in L0, L1 and L2 network topology.

It is important to describe this relationship for the sake of network Operation and Maintenance (O&M). For example, the actual path of a connection is described by the objects in network topology. When there is a failure along this connection, the O&M engineers are more concerned with the physical location information behind the network objects for troubleshooting.

Generally speaking, a node object in the network topology corresponds to a network element object in the hardware inventory. A Link Termination Point (LTP) object in the network topology corresponds to a port component in the hardware inventory. A link object in the network topology corresponds to a fiber/cable object in the hardware inventory.

NOTE: take fiber&cable object into scope in the future version.

Compared with network topology, hardware inventory objects are the most basic of the network: from an automation perspective, the MDSC or OSS systems would integrate with hardware inventory data before network topology data.

Therefore it is better to keep separated the network topology information and the hardware inventory information: the "ietf-hw-inventory-ref-topo" YANG module provides this relationship augmenting the network topology model, when required, with references between network topology objects and corresponding hardware inventory objects.

This figure below shows the relationship between the three modules:

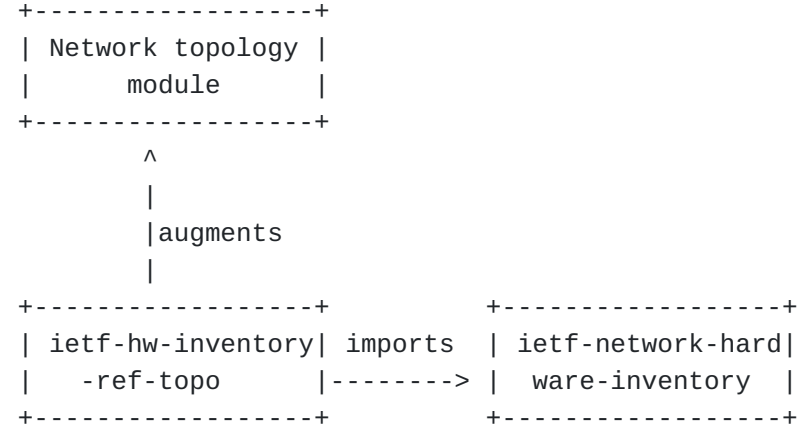

Figure 3: Relationship between the three YANG modules

```
module: ietf-hw-inventory-ref-topo
augment /nw:networks/nw:network/nw:node:
   +--ro inventory-id?   leafref
augment /nw:networks/nw:network/nw:node/nt:termination-point:
   +--ro inventory-id?   leafref
```

NOTE: the association between a link and a fiber&cable object has to be added in the future version.

2.2. Efficiency Issue

During the integration with OSS in some operators, some efficiency/ scalability concerns have been discovered when synchronizing network hardware inventory data for big networks. More discussions are needed to address these concerns.

Considering that relational databases are widely used by traditional OSS systems and also by some network controllers, the inventory objects are most likely to be saved in different tables. With the model defined in current draft, when doing a full synchronization, network controller needs to convert all inventory objects of each NE into component objects and combine them together into a single list, and then construct a response and send to OSS or MDSC. The OSS or MDSC needs to classify the component list and divide them into different groups, in order to save them in different tables. The combining-regrouping steps are impacting the network controller & OSS/MDSC processing, which may result in efficiency/scalability limitations in large scale networks.

An alternative YANG model structure, which defines the inventory objects directly, instead of defining generic components, has also been analyzed. However, also with this model, there still could be some scalability limitations when synchronizing full inventory resources in large scale of networks. This scalability limitation is caused by the limited transmission capabilities of HTTP protocol. We think that this scalability limitation should be solved at protocol level rather than data model level.

The model proposed by this draft is designed to be as generic as possible so to cover future special types of inventory objects that could be used in other technologies, that have not been identified yet. If the inventory objects were to be defined directly with fixed hierarchical relationships in YANG model, this new type of inventory objects needs to be manually defined, which is not a backward compatible change and therefore is not an acceptable approach for implementation. With a generic model, it is only needed to augment a new component class and extend some specific attributes for this new

inventory component class, which is more flexible. We consider that this generic data model, enabling a flexible and backward compatible approach for other technologies, represents the main scope of this draft. Solution description to efficiency/scalability limitations mentioned above is considered as out-of-scope.

2.3. Some Other Considerations

Note: review in future versions of this document whether the component list should be under the network-hardware-inventory instead of the network-element container.

Note that in [RFC8345], topology and inventory are two subsets of network information. However, considering the complexity of the existing topology models and having a better extension capability, we define a separate root for the inventory model. We will consider some other ways to do some associations between the topology model and inventory model in the future.

Note: review in future versions of this document whether network hardware inventory should be defined as an augmentation of the network model defined in [RFC8345] instead of under a new network-hardware-inventory root.

The proposed YANG data model has been analysed so far to cover the requirements and use cases for Optical Network Hardware Inventory.

Further analysis of requirements and use cases is needed to extend the applicability of this YANG data model to other types of networks (IP and microwave) and to identify which aspects are generic and which aspects are technology-specific for optical.

3. Tree Diagrams

3.1. Network Hardware Inventory Tree Diagram

Figure 4 below shows the tree diagram of the YANG data model defined in module "ietf-network-hardware-inventory" (Section 4.1).

```
module: ietf-network-hardware-inventory
  +--ro network-hardware-inventory
     +--ro equipment-rooms
     |  +--ro equipment-room* [uuid]
     |     +--ro uuid           yang:uuid
     |     +--ro name?          string
     |     +--ro description?   string
     |     +--ro alias?         string
     |     +--ro location?      string
     |     +--ro racks
     |        +--ro rack* [uuid]
     |           +--ro uuid                 yang:uuid
     |           +--ro name?                string
     |           +--ro description?         string
     |           +--ro alias?               string
     |           +--ro rack-location
     |           |  +--ro equipment-room-name?   leafref
     |           |  +--ro row-number?            uint32
     |           |  +--ro column-number?         uint32
     |           +--ro height?              uint16
     |           +--ro width?               uint16
     |           +--ro depth?               uint16
     |           +--ro max-voltage?         uint16
     |           +--ro contained-chassis* [ne-ref component-ref]
     |              +--ro ne-ref               leafref
     |              +--ro component-ref        leafref
     |              +--ro relative-position?   uint8
     +--ro network-elements
        +--ro network-element* [uuid]
           +--ro uuid             yang:uuid
           +--ro name?            string
           +--ro description?     string
           +--ro alias?           string
           +--ro ne-location
           |  +--ro equipment-room-name*   leafref
           +--ro hardware-rev?    string
           +--ro software-rev?    string
           +--ro mfg-name?        string
           +--ro mfg-date?        yang:date-and-time
           +--ro part-number?     string
           +--ro serial-number?   string
           +--ro product-name?    string
           +--ro components
              +--ro component* [uuid]
                 +--ro uuid                          yang:uuid
                 +--ro name?                         string
                 +--ro description?                  string
                 +--ro alias?                        string
                 +--ro location?                     string
```

```
+--ro class?                          identityref
+--ro contained-child*                -> ../uuid
+--ro parent-rel-pos?                 int32
+--ro parent-component-references
|  +--ro component-reference* [index]
|     +--ro index    uint8
|     +--ro class?   -> ../../../class
|     +--ro uuid?    -> ../../../uuid
+--ro hardware-rev?                   string
+--ro firmware-rev?                   string
+--ro software-rev?                   string
+--ro serial-num?                     string
+--ro mfg-name?                       string
+--ro part-number?                    string
+--ro asset-id?                       string
+--ro is-fru?                         boolean
+--ro mfg-date?
|       yang:date-and-time
+--ro uri*                            inet:uri
+--ro (component-class)?
   +--:(chassis)
   |  +--ro chassis-specific-info
   +--:(container)
   |  +--ro slot-specific-info
   +--:(module)
   |  +--ro board-specific-info
   +--:(port)
      +--ro port-specific-info
```

Figure 4: Network Hardware inventory tree diagram

3.2. Relationship between Topology and Network Inventory Tree Diagram

Figure 5 below shows the tree diagram of the YANG data model defined in module "ietf-hw-inventory-ref-topo" (Section 4.2).

```
module: ietf-hw-inventory-ref-topo

  augment /nw:networks/nw:network/nw:node:
    +--ro inventory-id?   leafref
  augment /nw:networks/nw:network/nw:node/nt:termination-point:
    +--ro inventory-id?   leafref
```

Figure 5: Relationship between Topology and Network Inventory Tree Diagram

4. YANG Data Models

4.1. YANG Data Model for Network Hardware Inventory

```
<CODE BEGINS> file "ietf-network-hardware-inventory@2023-03-07.yang"

module ietf-network-hardware-inventory {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-network-hardware-inventory";
  prefix nhi;

  import ietf-yang-types {
    prefix yang;
    reference
      "RFC6991: Common YANG Data Types.";
  }

  import iana-hardware {
    prefix ianahw;
    reference
      "https://www.iana.org/assignments/yang-parameters";
  }

  import ietf-inet-types {
    prefix inet;
    reference
      "RFC6991: Common YANG Data Types.";
  }

  organization
    "IETF CCAMP Working Group";
  contact
    "WG Web:   <https://datatracker.ietf.org/wg/ccamp/>
     WG List:  <mailto:ccamp@ietf.org>

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```

```
description
  "This module defines a model for retrieving network hardware
  inventory.

  The model fully conforms to the Network Management
  Datastore Architecture (NMDA).

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  This version of this YANG module is part of RFC XXXX; 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.";

// RFC Ed.: replace XXXX with actual RFC number and remove this
// note.
// RFC Ed.: update the date below with the date of RFC publication
// and remove this note.

revision 2023-03-09 {
  description
    "Initial version";
  reference
    "RFC XXXX: A YANG Data Model for Network Hardware Inventory.";
    //RFC Editor: replace XXXX with actual RFC number, update date
    //information and remove this note
}

container network-hardware-inventory {
  config false;
  description
    "The top-level container for the network inventory
    information.";
  uses equipment-rooms-grouping;
  uses network-elements-grouping;
}

grouping common-entity-attributes {
```

```
  description
    "A set of attributes which are common to all the entities
    (e.g., component, equipment room) defined in this module.";
  leaf uuid {
    type yang:uuid;
    description
      "Uniquely identifies an entity (e.g., component).";
  }
  leaf name {
    type string;
    description
      "A name for an entity (e.g., component), as specified by
      a network manager, that provides a non-volatile 'handle'
      for the entity and that can be modified anytime during the
      entity lifetime.

      If no configured value exists, the server MAY set the value
      of this node to a locally unique value in the operational
      state.";
  }
  leaf description {
    type string;
    description "a textual description of inventory object";
  }
  leaf alias {
    type string;
    description
    "a alias name of inventory objects. This alias name can be
    specified by network manager.";
  }
}

grouping network-elements-grouping {
  description
    "The attributes of the network elements.";
  container network-elements {
    description
      "The container for the list of network elements.";
    list network-element {
      key uuid;
      description
        "The list of network elements within the network.";
      uses common-entity-attributes;
      container ne-location {
        description
          "The location information of this network element.";
        leaf-list equipment-room-name {
          type leafref {
            path "/nhi:network-hardware-inventory/" +
```

```
                "nhi:equipment-rooms/nhi:equipment-room/nhi:name";
          }
          description
            "Names of equipment rooms where the NE is located.
            Please note that a NE could be located in several
            equipment rooms.";
        }
      }
      uses ne-specific-info-grouping;
      uses components-grouping;
    }
  }
}

grouping ne-specific-info-grouping {
  description
    "Attributes applicable to network elements.";
  leaf hardware-rev {
    type string;
    description
      "The vendor-specific hardware revision string for the NE.";
  }
  leaf software-rev {
    type string;
    description
      "The vendor-specific software revision string for the NE.";
  }
  leaf mfg-name {
    type string;
    description "The name of the manufacturer of this NE";
  }
  leaf mfg-date {
    type yang:date-and-time;
    description "The date of manufacturing of the NE.";
  }
  leaf part-number {
    type string;
    description
      "The vendor-specific model name identifier string associated
       with this NE.  The preferred value is the customer-visible
       part number, which may be printed on the NE itself.";
  }
  leaf serial-number {
    type string;
    description
      "The vendor-specific serial number string for the NE";
  }
  leaf product-name {
    type string;
```

```
    description
      "indicates the vendor-spefic device type infomation.";
  }
}

grouping equipment-rooms-grouping {
  description
    "The attributes of the equipment rooms.";
  container equipment-rooms {
    description
      "The container for the list of equipment rooms.";
    list equipment-room {
      key uuid;
      description
        "The list of equipment rooms within the network.";
      uses common-entity-attributes;
      leaf location {
        type string;
        description
          "compared with the location information of the other
          inventory objects, a GIS address is preferred for
          equipment room";
      }
      container racks {
        description
          "Top level container for the list of racks.";
        list rack {
          key uuid;
          description
            "The list of racks within an equipment room.";
          uses common-entity-attributes;
          uses rack-specific-info-grouping;
          list contained-chassis {
            key "ne-ref component-ref";
            description
              "The list of chassis within a rack.";
            leaf ne-ref {
              type leafref {
                path "/nhi:network-hardware-inventory"
                + "/nhi:network-elements/nhi:network-element"
                + "/nhi:uuid";
              }
              description
                "The reference to the network element containing
                the chassis component.";
            }
            leaf component-ref {
              type leafref {
                path "/nhi:network-hardware-inventory"
```

```
                + "/nhi:network-elements/nhi:network-element"
                + "[nhi:uuid=current()/../ne-ref]/nhi:components"
                + "/nhi:component/nhi:uuid";
              }
              description
                "The reference to the chassis component within
                the network element and contained by the rack.";
            }
            leaf relative-position {
              type uint8;
              description "A relative position of chassis within
              the rack";
            }
          }
        }
      }
    }
  }
}

grouping rack-specific-info-grouping {
  description
    "Attributes applicable to racks only.";
  container rack-location {
    description
      "The location information of the rack, which comprises the
      name of the equipment room, row number, and column number.";
    leaf equipment-room-name {
      type leafref {
        path "/nhi:network-hardware-inventory/nhi:equipment-rooms"
        + "/nhi:equipment-room/nhi:name";
      }
      description
      "Name of equipment room where this rack is located.";
    }
    leaf row-number {
      type uint32;
      description
        "Identifies the row within the equipment room where
        the rack is located.";
    }
    leaf column-number {
      type uint32;
      description
        "Identifies the physical location of the rack within
        the column.";
    }
  }
  leaf height {
```

```
    type uint16;
    units millimeter;
    description
      "Rack height.";
  }
  leaf width {
    type uint16;
    units millimeter;
    description
      "Rack width.";
  }
  leaf depth {
    type uint16;
    units millimeter;
    description
      "Rack depth.";
  }
  leaf max-voltage {
    type uint16;
    units volt;
    description
      "The maximum voltage could be supported by the rack.";
  }
}

grouping components-grouping {
  description
    "The attributes of the hardware components.";
  container components {
    description
      "The container for the list of components.";
    list component {
      key uuid;
      description
        "The list of components within a network element.";
      uses common-entity-attributes;
      leaf location {
        type string;
        description
          "A relative location information of this component.
          In optical transport network, the location string is
          using the following pattern:
            '/ne=<nw-ne-name>[/r=<r_index>][/sh=<sh_index>
            [/s_sh=<s_sh_index> ...]][[/sl=<sl_index>
            [/s_sl=<s_sl_index> ...]][/p=<p_index> …]]'
          ";
      }
      leaf class {
        type identityref {
```

```
    base ianahw:hardware-class;
  }
  description
    "An indication of the general hardware type of the
     component.";
  reference
    "RFC 8348: A YANG Data Model for Hardware Management.";
}
leaf-list contained-child {
  type leafref {
    path "../nhi:uuid";
  }
  description
    "The list of the identifiers of the child components
    physically contained within this component.";
}
leaf parent-rel-pos {
  type int32 {
    range "0 .. 2147483647";
  }
  description
    "The relative position with respect to the parent
    component among all the sibling components.";
  reference
    "RFC 6933: Entity MIB (Version 4) -
               entPhysicalParentRelPos";
}

container parent-component-references {
  description
      "The top level container for the list of the
      identifiers of the parents of this component in a
      hierarchy.";
  list component-reference {
    key index;
    description
      "The list of the identifiers of the parents of this
      component in a hierarchy.

      The index parameter defines the hierarchy: the topmost
      parent has an index of 0.";
    leaf index {
      type uint8;
      description
        "The index of the parent with respect to the
        hierarchy.";
    }
    leaf class {
      type leafref {
```

```
        path "../../../nhi:class";
      }
      description
        "Class of the hierarchial parent component.";
    }
    leaf uuid {
      type leafref {
        path "../../../nhi:uuid";
      }
      description
        "The identifier of the parent's component in the
        hierarchy.";
    }
  }
}

leaf hardware-rev {
  type string;
  description
    "The vendor-specific hardware revision string for the
     component.  The preferred value is the hardware revision
     identifier actually printed on the component itself (if
     present).";
  reference
    "RFC 6933: Entity MIB (Version 4) -
               entPhysicalHardwareRev";
}
leaf firmware-rev {
  type string;
  description
    "The vendor-specific firmware revision string for the
     component.";
  reference
    "RFC 6933: Entity MIB (Version 4) -
               entPhysicalFirmwareRev";
}
leaf software-rev {
  type string;
  description
    "The vendor-specific software revision string for the
     component.";
  reference
    "RFC 6933: Entity MIB (Version 4) -
               entPhysicalSoftwareRev";
}
leaf serial-num {
  type string;
  description
    "The vendor-specific serial number string for the
```

```
      component.  The preferred value is the serial number
      string actually printed on the component itself (if
      present).";
    reference
      "RFC 6933: Entity MIB (Version 4) -
      entPhysicalSerialNum";
  }
  leaf mfg-name {
    type string;
    description
      "The name of the manufacturer of this physical component.
       The preferred value is the manufacturer name string
       actually printed on the component itself (if present).

       Note that comparisons between instances of the
       'model-name', 'firmware-rev', 'software-rev', and
       'serial-num' nodes are only meaningful amongst
       components with the same value of 'mfg-name'.

       If the manufacturer name string associated with the
       physical component is unknown to the server, then this
       node is not instantiated.";
    reference
      "RFC 6933: Entity MIB (Version 4) - entPhysicalMfgName";
  }
  leaf part-number {
    type string;
    description
      "The vendor-specific model name identifier string
       associated with this physical component.  The preferred
       value is the customer-visible part number, which may be
       printed on the component itself.

       If the model name string associated with the physical
       component is unknown to the server, then this node is
       not instantiated.";
    reference
      "RFC 6933: Entity MIB (Version 4) -
      entPhysicalModelName";
  }
  leaf asset-id {
    type string;
    description
      "This node is a user-assigned asset tracking identifier
       for the component.

       A server implementation MAY map this leaf to the
       entPhysicalAssetID MIB object.  Such an implementation
       needs to use some mechanism to handle the differences in
```

```
            size and characters allowed between this leaf and
            entPhysicalAssetID.  The definition of such a mechanism
            is outside the scope of this document.";
          reference
            "RFC 6933: Entity MIB (Version 4) - entPhysicalAssetID";
        }
        leaf is-fru {
          type boolean;
          description
            "This node indicates whether or not this component is
             considered a 'field-replaceable unit' by the vendor.  If
             this node contains the value 'true', then this component
             identifies a field-replaceable unit.  For all components
             that are permanently contained within a
             field-replaceable unit, the value 'false' should be
             returned for this node.";
          reference
            "RFC 6933: Entity MIB (Version 4) - entPhysicalIsFRU";
        }
        leaf mfg-date {
          type yang:date-and-time;
          description
            "The date of manufacturing of the managed component.";
          reference
            "RFC 6933: Entity MIB (Version 4) - entPhysicalMfgDate";
        }
        leaf-list uri {
          type inet:uri;
          description
            "This node contains identification information about the
             component.";
          reference
            "RFC 6933: Entity MIB (Version 4) - entPhysicalUris";
        }
        uses component-specific-info-grouping;
      }
    }
  }

  grouping component-specific-info-grouping {
    description
      "In case if there are some missing attributes of component not
      defined by RFC8348. These attributes could be
      component-specific.
      Here we provide a extension structure for all the components
      we recognized. We will enrich these component specifc
      containers in the future.";
    choice component-class {
      description
```

```
      "This extension differs between different component
      classes.";
    case chassis {
      when "./class = 'ianahw:chassis'";
      container chassis-specific-info {
        description
          "This container contains some attributes belong to
          chassis only.";
        uses chassis-specific-info-grouping;
      }
    }
    case container {
      when "./class = 'ianahw:container'";
      container slot-specific-info {
        description
          "This container contains some attributes belong to
          slot or sub-slot only.";
        uses slot-specific-info-grouping;
      }
    }
    case module {
      when "./nhi:class = 'ianahw:module'";
      container board-specific-info {
        description
          "This container contains some attributes belong to
          board only.";
        uses board-specific-info-grouping;
      }
    }
    case port {
      when "./nhi:class = 'ianahw:port'";
      container port-specific-info {
        description
          "This container contains some attributes belong to
          port only.";
        uses port-specific-info-grouping;
      }
    }
  //TO BE ADDED: transceiver
  }
}

grouping chassis-specific-info-grouping {
//To be enriched in the future.
  description
    "Specific attributes applicable to chassis only.";
}

grouping slot-specific-info-grouping {
```

```
  //To be enriched in the future.
    description
      "Specific attributes applicable to slots only.";
  }

  grouping board-specific-info-grouping {
  //To be enriched in the future.
    description
      "Specific attributes applicable to boards only.";
  }

  grouping port-specific-info-grouping {
  //To be enriched in the future.
    description
      "Specific attributes applicable to ports only.";
  }
}

<CODE ENDS>
```

Figure 6: Network Hardware inventory YANG module

4.2. YANG Data Model for Relationship between Topology and Network Inventory

```
<CODE BEGINS> file "ietf-hw-inventory-ref-topo@2023-03-10.yang"

module ietf-hw-inventory-ref-topo {
 yang-version 1.1;
 namespace "urn:ietf:params:xml:ns:yang:ietf-hw-inventory-ref-topo";
 prefix hirt;

  import ietf-network {
    prefix nw;
    reference
      "RFC8345: A YANG Data Model for Network Topologies";
  }

  import ietf-network-topology {
    prefix nt;
    reference
      "RFC8345: A YANG Data Model for Network Topologies";
  }

  import ietf-network-hardware-inventory {
    prefix nhi;
    reference
      "RFC XXXX: A YANG Data Model for Network Hardware Inventory.";
      //RFC Editor: replace XXXX with actual RFC number, update date
      //information and remove this note
  }

 organization
   "IETF CCAMP Working Group";
 contact
   "WG Web:   <https://datatracker.ietf.org/wg/ccamp/>
    WG List:  <mailto:ccamp@ietf.org>

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              <yuchaode@huawei.com>

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              <sergio.belotti@nokia.com>

    Editor:   Jean-Francois Bouquier
              <jeff.bouquier@vodafone.com>

    Editor:   Fabio Peruzzini
              <fabio.peruzzini@telecomitalia.it>

    Editor:   Phil Bedard
              <phbedard@cisco.com>";

 description
   "This module defines a model for navigation between hardware
```

```
  inventory data module and network topology module.

  The model fully conforms to the Network Management
  Datastore Architecture (NMDA).

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  The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL', 'SHALL
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  '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.";

// RFC Ed.: replace XXXX with actual RFC number and remove this
// note.
// RFC Ed.: update the date below with the date of RFC publication
// and remove this note.

 revision 2023-03-10 {
   description
     "Initial revision.";
    reference
      "RFC XXXX: A YANG Data Model for Network Hardware Inventory.";
      //RFC Editor: replace XXXX with actual RFC number, update date
      //information and remove this note
 }

 augment "/nw:networks/nw:network/nw:node" {
   description
     "Information that allows the relationship between the node in
     the topology and the Network Element (NE) in the network
     hardware inventory model from which the node is abstracted";

   leaf inventory-id {
   type leafref {
     path "/nhi:network-hardware-inventory/nhi:network-elements"
     + "/nhi:network-element/nhi:uuid";
   }
   config false;
   description
```

```
      "The identifier of the Network Element (NE) from which this
      node is abstracted";
    }
  }

  augment "/nw:networks/nw:network/nw:node/nt:termination-point" {
    description
      "Information that allows the relationship between the Link
      Termination Point (LTP) and the port component in the network
      hardware inventory model from which this LTP is abstracted.";

    leaf inventory-id {
    type leafref {
      path "/nhi:network-hardware-inventory/nhi:network-elements"
      + "/nhi:network-element/nhi:components/nhi:component"
      + "/nhi:uuid";
    }
    config false;
    description
        "The identifier of the port component from which this Link
        Termination Point (LTP) is abstracted";
    }
  }
}

<CODE ENDS>
```

Figure 7: Relationship between Topology and Network Inventory YANG module

5. Manageability Considerations

<Add any manageability considerations>

6. Security Considerations

<Add any security considerations>

7. IANA Considerations

<Add any IANA considerations>

8. References

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Appendix A. Appendix

A.1. Comparison With Openconfig-platform Data Model

Since more and more devices can be managed by domain controller through OpenConfig, to ensure that our inventory data model can cover these devices' inventory data, we have compared our inventory data model with the "openconfig-platform" model which is the data model used to manage inventory information in OpenConfig.

Openconfig-platform data model is NE-level and uses a generic component concept to describe its inner devices and containers, which is similar to "ietf-hardware" model in [RFC8348]. Since we have also reused the component concept of [RFC8348] in our inventory data model, we can compare the component's attributes between "openconfig-platform" and our model directly , which is stated below:

Attributes in oc-platform	Attributes in our model	remark
name	name	

Attributes in oc-platform	Attributes in our model	remark
type	class	
id	uuid	
location	location	
description	description	
mfg-name	mfg-name	
mfg-date	mfg-date	
hardware-version	hardware-rev	
firmware-version	firmware-rev	
software-version	software-rev	
serial-no	serial-num	
part-no	part-number	
clei-code		TBD
removable	is-fru	
oper-status		state data
empty	contained-child?	If there is no contained child, it is empty.
parent	parent-references	
redundant-role		TBD
last-switchover-reason		state data
last-switchover-time		state data
last-reboot-reason		state data
last-reboot-time		state data
switchover-ready		state data
temperature		performance data
memory		performance data
allocated-power		TBD
used-power		TBD
pcie		alarm data
properties		TBD
subcomponents	contained-child	
chassis	chassis-specific-info	
port	port-specific-info	
power-supply		TBD
fan		Fan is considered as a specific board. And no need to define as a single component
fabric		TBD
storage		

Attributes in oc-platform	Attributes in our model	remark
		For Optical and IP technology, no need to manage storage on network element
cpu		For Optical and IP technology, no need to manage CPU on network element
integrated-circuit	board-specific-info	
backplane		Backplane is considered as a part of board. And no need to define as a single component
software-module		TBD
controller-card		Controller card is considered as a specific functional board. And no need to define as a single component

Table 3: Comparison between openconfig platform and inventory data models

As it mentioned in Section 2.1.2 that state data and performance data are out of scope of our data model, it is same for alarm data and it should be defined in some other alarm data models separately. And for some component specific structures in "openconfig-platform", we consider some of them can be contained by our existing structure, such as fan, backplane, and controller-card, while some others do not need to be included in this network inventory model like storage and cpu.

Mostly, our inventory data model can cover the attributes from OpenConfig.

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