

ETSI GR CIM 038 V1.1.1 (2024-11)



Context Information Management (CIM); YANG and NGSI-LD interoperability

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) cross-cutting Context Information Management (CIM).

Modal verbs terminology

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Executive summary

The present document is intended to provide developers and network operators with guidelines towards achieving interoperability between Yet Another Next Language (YANG) [i.1] and the Next Generation Service Interface Linked Data (NGSI-LD) information model [i.2]. The present document outlines a set of generic rules which can facilitate the translation of YANG data into a knowledge graph based on the NGSI-LD standard [i.2]. Practical examples are included throughout the present document to help readers understand the different types of mappings depending on the characteristics of the network devices.

Introduction

Since the advent of the YANG language within the IETF, the network industry has experienced an evolution towards the management and automation of operation of network devices. Traditional network operations based on CLIs are being replaced with APIs based on the YANG language and network management protocols. The amount and variety of YANG data models developed by vendors, open source projects, and consortia has grown exponentially. This opens the door to vast amounts of network data that operators can collect and integrate to optimize the management of the network. In this sense, the NGSI-LD standard [i.2], with its information model and REST-based API, becomes an enabler for integrating all these network data. To this end, the present document aims to provide guidelines towards improving the interoperability between YANG and NGSI-LD.

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1 Scope

The present document targets developers and operators from the network and telecommunications industry who aim at integrating YANG data in a graph, following the NGSI-LD information model [i.2] and leveraging the capabilities of the NGSI-LD API [i.3]. The present document focuses on the mapping of the YANG metamodel [i.1] to the NGSI-LD information model, proposing generic rules that can achieve an automatic or semi-automatic translation of YANG data onto a graph based on the NGSI-LD standard [i.2]. Interactions with network devices using network management protocols based on YANG are discussed in the present document (see Annex B), albeit implementation details on their usage and mapping to the NGSI-LD API [i.3] are out of scope.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] [IETF RFC 7950](#): "The YANG 1.1 Data Modelling Language".
- [i.2] [ETSI GS CIM 006](#): "Context Information Management (CIM); Information Model (MOD0)".
- [i.3] [ETSI GS CIM 009](#): "Context Information Management (CIM); NGSI-LD API".
- [i.4] [IETF RFC 9254](#): "Encoding of Data Modeled with YANG in the Concise Binary Object Representation (CBOR)".
- [i.5] [IETF RFC 7951](#): "JSON Encoding of Data Modeled with YANG".
- [i.6] [YANG to Protobuf](#): "Transformation Specification".
- [i.7] W3C®: "[SKOS Simple Knowledge Organization System Reference](#)".
- [i.8] [IETF RFC 8342](#): "Network Management Datastore Architecture (NMDA)".
- [i.9] [IETF RFC 8344](#): "A YANG Data Model for IP Management".
- [i.10] [IETF RFC 8340](#): "YANG Tree Diagrams".
- [i.11] [IETF RFC 7277](#): "A YANG Data Model for IP Management".
- [i.12] OpenConfig: "[Vendor-neutral, model-driven network management designed by users](#)".
- [i.13] OpenConfig: "[openconfig-interfaces YANG data model](#)".
- [i.14] [IETF RFC 6241](#): "Network Configuration Protocol (NETCONF)".
- [i.15] [IETF RFC 8040](#): "RESTCONF Protocol".
- [i.16] OpenConfig: "[gRPC Network Management Interface \(gNMI\)](#)".

[i.17] [IETF RFC 3635](#): "Definitions of Managed Objects for the Ethernet-like Interface Types".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

NGSI-LD attribute: reference to both an NGSI-LD Property and to an NGSI-LD Relationship

NGSI-LD attribute type: categorization of an NGSI-LD Property or NGSI-LD Relationships

NGSI-LD element: any JSON element that is defined by the NGSI-LD API

NGSI-LD entity: informational representative of something that is supposed to exist in the real world, physically or conceptually

NGSI-LD entity type: categorization of an NGSI-LD Entity as belonging to a class of similar entities, or sharing a set of characteristic properties

NGSI-LD name: short-hand string (term) that locally identifies an NGSI-LD Entity Type, Property Type or Relationship Type and which can be mapped to a URI which serves as a fully qualified identifier

NGSI-LD property: description instance which associates a main characteristic, i.e. an **NGSI-LD Value**, to either an NGSI-LD Entity, an NGSI-LD Relationship or another NGSI-LD Property and that uses the special *hasValue* property to define its target value

NGSI-LD relationship: description of a directed link between a subject which is either an NGSI-LD Entity, an NGSI-LD Property or another NGSI-LD Relationship on one hand, and an object, which is an NGSI-LD Entity, on the other hand, and which uses the special *hasObject* property to define its target object

YANG data node: node in the schema tree that can be instantiated in a data tree

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

API	Application Programming Interface
CBOR	Concise Binary Object Representation
CLI	Command Line Interface
gNMI	gRPC Network Management Interface
gRPC	Google Remote Procedure Call
HTTP	Hyper Text Transfer Protocol
JSON	JavaScript Object Notation
JSON-LD	JSON Linked Data
NETCONF	Network Configuration protocol
NGS-LD	Next Generation Service Interfaces Linked Data
NMDA	Network Management Datastore Architecture
SSH	Secure SHell
URI	Uniform Resource Identifier
XML	eXtensible Markup Language
YANG	Yet Another Next Generation

4 YANG to NGSI-LD mapping

4.1 Introduction

Clause 4 provides rules for transforming YANG into NGSI-LD. First, generic rules for mapping YANG data nodes into the NGSI-LD meta-model are described. Next, additional rules for managing YANG configuration and operational data are provided.

4.2 Core mapping rules

4.2.0 Foreword

Clause 4.2 introduces rules for mapping YANG data node types to the classes of the NGSI-LD meta-model. The transformation takes as input the effective YANG schema, which means, the compiled set of YANG parent data model, imported data models, and any data models that may introduce augment and deviations to the other data models.

The main advantage with this approach is that mapping rules are defined at the YANG level. This allows for seamless translation of any YANG data to NGSI-LD regardless of the encoding format used for transporting YANG data such as XML, CBOR [i.4], JSON [i.5], or Protobuf [i.6].

Figure 4.2-1 depicts a high level mapping of the main YANG data node types to the core classes of the NGSI-LD meta-model.

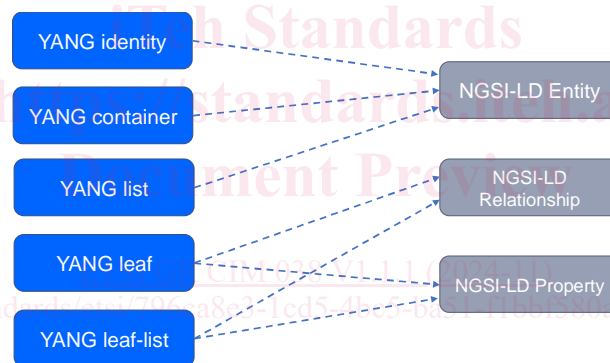


Figure 4.2-1: High-level mapping of main YANG data node types to NGSI-LD meta-model

In general, YANG identity, YANG container, and YANG list will map to NGSI-LD Entity Type, whereas YANG leaf and YANG leaf-list will map either to NGSI-LD Relationship or to NGSI-LD Property.

In the following clauses, the rules for mapping each YANG data node type to its respective NGSI-LD meta-model class are described in detail.

4.2.1 YANG identity

YANG identity introduces a special case as it represents an abstract concept that may inherit from other YANG base identities. In this sense, YANG identities will map to NGSI-LD Entities of a new Entity Type called *YANGIdentity*, which is a subclass of the *Concept* class as defined by the standard SKOS Ontology [i.7]. This allows for managing YANG identities as SKOS concepts, and therefore, composing taxonomies by using a standardized vocabulary. The new *YANGIdentity* NGSI-LD Entity Type defines the following NGSI-LD Properties:

- **namespace:** the namespace URI of the YANG data model where the YANG identity has been defined.
- **identifier:** the identifier of the YANG identity has defined in the YANG data model.
- **description:** the description of the YANG identity has defined in the YANG data model.

And leverages the following relationship inherited from the SKOS Concept:

- **broader**: the target object of the relationship is determined by the *base* statement in the definition of the YANG identity.

Figure 4.2.1-1 depicts the schema of the proposed of the *YANGIdentity* type.

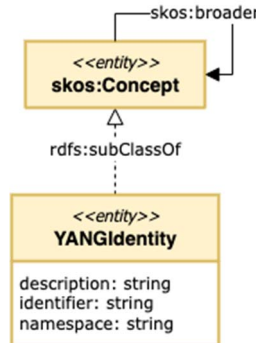


Figure 4.2.1-1: Schema of the new *YANGIdentity* Entity Type

A detailed example of YANG identities mapped to NGSI-LD can be found in clause A.1.

4.2.2 YANG container

A YANG non-presence container that includes child data nodes maps to an NGSI-LD Entity Type. When the YANG container does not contain child nodes but includes the *presence* statement (i.e. a YANG presence container), then the container maps to an NGSI-LD Entity Type.

There are scenarios when a YANG non-presence container has a YANG list as its only child. This modeling technique, commonly known as "enclosing container", has been widely used in YANG as it provides YANG clients with the means to retrieve all members of the child YANG list. For these scenarios, the container can be omitted as it carries no semantic meaning, therefore, it will not be mapped to NGSI-LD. As a result, this design choice makes the graph more compact, thus improving its usability.

Additionally, if the YANG container is the child of another YANG data node (container or list), its mapped NGSI-LD Entity Type will include an NGSI-LD Relationship that points to the NGSI-LD Entity Type representing the parent YANG node. This type of NGSI-LD Relationship captures the hierarchical (child-to-parent) connection between both YANG data nodes. This Relationship carries no semantics but simply a particular structure for organizing the data.

The NGSI-LD Name of the mapped NGSI-LD Entity Type derives from the identifier of the YANG container, following the upper camel case convention. The associated JSON-LD URI for the NGSI-LD Entity Type is generated by combining the namespace of the YANG module that defines the YANG data node with the XPath that identifies the YANG container. In the case of having a hierarchical relationship, the standardized *isPartOf* from Dublin Core ontology is leveraged to represent this NGSI-LD Relationship. Taking the example from clause A.2, the YANG container *statistics*, which is child of the YANG list *interface*, translates to an NGSI-LD Entity Type *Statistics* that includes an NGSI-LD Relationship *isPartOf* with target an NGSI-LD Entity Type *Interface*.

4.2.3 YANG list

A YANG list maps to an NGSI-LD Entity Type, where there will be an NGSI-LD Entity for every member of the YANG list.

Similar to YANG containers, a YANG list might also be contained in a parent YANG container or YANG list. In this case, the NGSI-LD Entity Type representing the child YANG list includes an NGSI-LD Relationship that points to the NGSI-LD Entity Type that represents the parent YANG node.

The NGSI-LD Name of the mapped NGSI-LD Entity Type derives from the identifier of the YANG list, following the upper camel case convention. The associated JSON-LD URI for the NGSI-LD Entity Type is generated by combining the namespace of the YANG module that defines the YANG data node with the XPath that identifies the YANG list. When representing the hierarchical relationship (child-to-parent), the same rule defined in clause 4.2.2 will apply, i.e. the *isPartOf* relationship standardized in the Dublin Core ontology is leveraged.

4.2.4 YANG leaf

A YANG leaf maps to an NGSI-LD Attribute of an NGSI-LD Entity Type that represents the parent YANG data node (container or list) of the child YANG leaf. In this case, the data type of the YANG leaf will determine whether it will map to an NGSI-LD Property or an NGSI-LD Relationship:

- When the data type of the YANG leaf is a considered a **literal**, then the YANG leaf maps to an NGSI-LD Property. Table 4.2.4-1 captures the JSON-LD data types to be used when converting from the different YANG built-in data types. Note in the table that custom data type *yang:date-and-time* (or *oc-type:timeticks64* in data models from OpenConfig [i.12]) has been included as it requires a special mapping. When the data type of the YANG leaf uses this custom data type, then the leaf maps to an NGSI-LD Property whose value will be of *DateTime* type as mandated by clause 4.6.3 in ETSI GS CIM 009 [i.3].

Table 4.2.4-1: Data type conversion

YANG built-in data types	JSON-LD data types (based on JSON Schema)
Integer (see note 1)	Integer
decimal64	Number
string (see note 2)	String (format pattern, if any)
boolean	Boolean
enum	String
bit	String[]
binary	String
empty (see note 3)	String
ietf-yang-types:date-and-time (see note 4)	String (format date-time)
NOTE 1: Integer built-in types as per clause 9.2 in IETF RFC 7950 [i.1] include the following: int8, int16, int32, int64, uint8, uint16, uint32, uint64.	
NOTE 2: If YANG string includes a regex pattern, the mapping to JSON-LD will also include the same string pattern.	
NOTE 3: The <i>empty</i> YANG datatype maps to a literal in JSON-LD represented by an empty string. The reason for this choice is that "null" value is reserved in NGSI-LD for deleting NGSI-LD Attributes.	
NOTE 4: Custom data type defined by IETF for representing timestamps. OpenConfig defines its own data type "openconfig-types:timeticks64", which will have the same mapping to JSON-LD string date-time format.	

- A YANG leaf that uses the *leafref* data type will map to an NGSI-LD Relationship. The target of the NGSI-LD Relationship is an NGSI-LD Entity Type that is identified by the path of the YANG leafref. Note that if the YANG leaf referenced in the *leafref* is not the key of a YANG list, or belongs to YANG container, then the target of the NGSI-LD Relationship may contain multiple NGSI-LD Entities that match the value of the YANG *leafref*.
- When the data type of a YANG leaf is an *identityref*, then the YANG leaf will map to an NGSI-LD Relationship whose target is an NGSI-LD Entity of *YANGIdentity* type that represents the YANG identity.
- Lastly, a YANG leaf that uses the *instance-identifier* data type maps to an NGSI-LD Relationship. In this case, the target of the Relationship is a particular NGSI-LD Entity identified through the path of the instance-identifier.

The NGSI-LD Name of the mapped NGSI-LD Attribute derives from the identifier of the YANG leaf, following the lower camel case convention. For those identifiers using terms that are reserved in NGSI-LD (i.e. "id", "type"), the final Name of the Attribute appends the Name of the Entity in lower camel case convention to plus the original Name of the Attribute. For example, a *type* YANG leaf within *interface* YANG container becomes *interfaceType* in NGSI-LD. The associated JSON-LD URI for the NGSI-LD Attribute Type is generated by combining the namespace of the YANG module that defines the YANG data node with the XPath that identifies the YANG leaf.

4.2.5 YANG leaf-list

Mapping for YANG leaf-list follows the same mapping rules defined for YANG leaf as mandated in clause 4.2.4, but in this case the value of the NGSI-LD Attribute will be an array.