ETSI GR CIM 021 V1.1.1 (2022-08)

cross-cutting Context Information Management (CIM); usage of external data models with NGSI-LD API

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Foreword

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

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Executive summary

The present document provides an analysis of a small representative of data models that maps different domains (Smart Cities, Communities, Geo-spatial Objects, etc.) and that are defined in different technologies (OWL, SKOS, RDF, JSON Schema). The goal of the analysis was to retrieve and formulate recommendations to use external data models with NGSI-LD (see ETSI GS CIM 009 [i.26]). Recommendations come as examples, suggestions and guidelines to allow users to link external data models inside NGSI-LD [i.26] Entities. Lastly, the analysis highlighted possible new features to add inside NGSI-LD [i.26]. Each proposal comes with a brief description of the use case and the reasons to support its addition inside the NGSI-LD [i.26] specification.

Introduction

There is a tremendous amount of data models being developed the needs of businesses in all verticals. The complexity of these models and the associated technologies can vary from simple tabular files (e.g. .csv) to complex OWL 2 ontologies. NGSI-LD aims at providing a cross-domain meta model based on property graphs together with an API to interact with context information.

It is important to empower NGSI-LD users how to use various ontologies: it is **not** the intent to create **new** ontologies, but to describe options to **make use of external vocabularies, taxonomies**, thesauri and ontologies within an NGSI-LD context and to describe how to articulate them with the NGSI-LD graph-based meta-model and cross-domain ontology. Some are relatively simple, providing multi-lingual definitions of terms in a structure way. This is the case of the Agrovoc [i.17] thesaurus based on SKOS. Others adds restrictions on the fields of a data model, such as defining the allowed data range of a data field. This is the case of the schema.org initiative. And others go further providing means for reasoning over the data structure which can provide means for data quality control, new properties discovery, etc. This is provided by for example, OWL 2 ontologies.

It is thus very important to make clear the potential of approaches listed above and illustrate their use within a NGSI-LD deployment to increase the usage of the cross-domain capabilities of NGSI-LD, by using working examples.

1 Scope

The present document considers a selection of relevant and representative knowledge organization systems, to provide an illustrative basis of data schemas and vocabularies relevant to be used in a NGSI-LD context. It provides recommendations on how to link external data models in NGSI-LD, considering the illustration of their use with the NGSI-LD API in complex environments, such as system-of-system models for Digital Twins. The present document also provides suggestions for changes or enhancements to the NGSI-LD specification (API and data model).

Unless expressly stated, the NGSI-LD version referenced in the present document is 1.5.1.

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 nonspecific. 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] ETSI TS 103 264 (V3.1.1): "SmartM2M; Smart Applications; Reference Ontology and oneM2M Mapping".

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[i.2] ETSI TS 103 410-4 (V1.1.2): "SmartM2M; Extension to SAREF; Part 4: Smart Cities Domain".

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[i.4] ETSI TS 103 410-10 (V1.1.1): "SmartM2M; Extension to SAREF; Part 10: Water Domain".

NOTE: Available at: https://www.etsi.org/deliver/etsi_ts/103400_103499/10341010/01.01.01_60/ts_10341010v010101p.pdf.

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NOTE: Available at: https://www.etsi.org/deliver/etsi_ts/103400_103499/10341008/01.01.01_60/ts_10341008v010101p.pdf.

[i.6] ETSI TR 103 509: "SmartM2M; SAREF extension investigation; Requirements for eHealth/Ageing-well".

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[i.9] ETSI TS 103 410-6 (V1.1.2): "SmartM2M; Extension to SAREF; Part 6: Smart Agriculture and Food Chain Domain".

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[i.10] ETSI TS 103 410-7 (V1.1.1): "SmartM2M; Extension to SAREF; Part 7: Automotive Domain".

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[i.11] ETSI TS 103 410-9 (V1.1.1): "SmartM2M; Extension to SAREF; Part 9: Wearables Domain".

NOTE: Available at: https://www.etsi.org/deliver/etsi_ts/103400_103499/10341009/01.01.01_60/ts_10341009v010101p.pdf.

[i.12] ETSI TS 103 410-11 (V1.1.1): "SmartM2M; Extension to SAREF; Part 11: Lift Domain".

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[i.16] SKOS Simple Knowledge Organization System RDF Schema.

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[i.17] Agrovoc About Web Page.

NOTE: Available at: https://agrovoc.fao.org/browse/en/about.

[i.18] Smart Data Models About Web Page.

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[i.39] ETSI TR 103 508: "SmartM2M; SAREF extension investigation; Requirements for Automotive".

[i.40] ETSI TR 103 510: "SmartM2M; SAREF extension investigation; Requirements for Wearables".

[i.41] ETSI TR 103 546: "SmartM2M; Requirements & Feasibility study for Smart Lifts in IoT".

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[i.45] ISO 17442:2019: "Financial services -- Legal entity identifier (LEI)".

NOTE: See https://www.iso.org/standard/75998.html.

[i.46] Website of DATEX II.

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[i.47] ETSI GS CIM 006: "Context Information Management (CIM); Information Model (MOD0)".

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[i.49] ISO 19107:2019: "Geographic information -- Spatial schema".

[i.50] ISO 19156:2011: "Geographic information -- Observations and measurements".

[i.51] IETF RFC 7946: "The GeoJSON Format".

[i.52] STARS4ALL European H2020 project.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

DATEX: European standard for the exchange of traffic information and traffic data [i.46]

3.2 Symbols

Void.

3.3 Abbreviations

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

AEF	Agricultural industry Electronics Foundation
API	Application Programming Interface
ASC	Ascending order
ASNE	American Society of Newspaper Editors
BCP	Best Current Practice
CIDOC	Centro Intercultural de Documentación
CIDOC-CRM	CIDOC Conceptual Reference Model
CIF	Código de Identificación Fiscal

NOTE: The Tax/Fiscal ID of the organization or person in Spain (CIF/NIF).

DCAT	Data Catalog Vocabulary (Version 1)
DCAT2	Data Catalog Vocabulary Version 2
DCAT-AP	DCAT Application profile
DE-9IM	Dimensionally Extended 9-Intersection Model
DTDL	Digital Twins Definition Language
ECGs	ElectroCardioGram(s)
EHAW	eHEALTH and Ageing-Well
FAO	Food and Agriculture Organization of the United Nations
FoaF	Friend of a Friend
GBFS	General Bikeshare Feed Specification
GeoJSON	Geographic JSON
GeoSPARQL	A Geographic Query Language for RDF Data
GIS	Geographic Information System
GLN	Global Location Number
GML	Geography Markup Language
GQL	Graph Query Language
GTFS	General Transit Feed Specification
HTTP	Hypertext Transfer Protocol
ICAR	International Committee for Animal Recording
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IRI	Internationalized Resource Identifier
IETF	Internet Engineering Task Force
IFC	Industry Foundation Classes
ILN	International Location Number
IoT	Internet of Things
ISIC	International Standard of Industrial Classification of All Economic Activities
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
IUDX	India Urban Data Exchange
JSON	JavaScript Object Notation

JSON-LD	JSON Linked Data
JTC	Joint Techncial Committee
NAICS	North American Industry Classification System
NGSI	Next Generation Service Interfaces
NGSI-LD	NGSI-Linked Data
NIF	Número de Identificación Fiscal

NOTE: The Tax/Fiscal ID of the organization or person in Spain (CIF/NIF).

NLP	Natural Language Processing
OASC	Open and Agile Smart Cities
OCF	Open Connectivity Foundation
OGC	Open Geospatial Consortium
OGC GeoSPARQL	OGC Geographic Query Language for RDF Data
OM	Ontology of units of Measure (OM ontology)
OWL	Web Ontology Language
OWL-DL	Web Ontology Language Description Logic
RAMI	Reference Architecture Model for Industry
RDBMS	Relational Database Management System
RDF	Resource Description Format
RDFS	Resource Description Framework Schema
RTDNA	Radio Television Digital News Association
SAREF	Smart Applications REFerence ontology
SAREF4CITY	SAREF for Smart Cities
SAREF4ENER	SAREF for Engergy
SAREF4WATR	SAREF for Water
SAREF4EHAW	SAREF for eHealth/Ageing-well
SAREF4BLDG	SAREF for Building
SAREF4INMA	SAREF for Industry and Manufacturing
SAREF4AGRI	SAREF for Agriculture and Food Chain
SAREF4AUTO	SAREF for Automotive
SAREF4WEAR	SAREF for Wearables
SAREF4LIFT	SAREF for Lift
SAREF4SYST	SAREF for System
SAREF4ENVI	SAREF for Environment
SC	Sub Committee
SEO	Search Engine Optimization
SKOS	Simple Knowledge Organization System
SPARQL	SPARQL Protocol and RDF Query Language
SQL	Structured Query Language
TC	Technical Committee
TCP/IP	Transaction Control Protocol/Internet Protocol
TD	Thing Description
TIN	Taxpayer Identification Number

NOTE: Tax/fiscal ID of organization or person in USA.

URI	Uniform Resource Identifier
URL	Universal Resource Locator
USA	United States of America
V2V	Vehicle(s) to Vehicle(s)
W3C®	World Wide Web Consrtium
W3C® SSN	W3C Semantic Sensor Network

NOTE: W3C SSN ontology includes W3C SOSA.

W3C® SOSA	W3C Sensor, Observation, Sample, and Actuator
WG	Working Group
WKT	Well-Known Text
WoT	Web of Things
WoT TD	Web of Things Thing Description
WSN	Wireless Specialty Networks

NOTE: See IEEE 802.15™ [i.35] Working Group WSN.

ZIP Zone Improvement Plan
XML Extensible Markup Language

4 Existing Relevant Semantic Models

4.1 Classification of Data Models

There are a lot of different technologies used to define and maintain data models (OWL, SKOS, RDFS, etc.). The way to map each type of data model in NGSI-LD may differ depending on the structure of the data model itself. In the present document, the following data models have been analysed:

- JSON-Schema:
  - SmartDataModels Program
- OWL:
  - SAREF family
  - GeoSPARQL Ontology
  - FoaF
- SKOS:
  - Agrovoc
- RDF:
  - DCAT
  - WoT

NOTE: Informative references to all these data models can be found in the following detailed clauses.

4.2 SAREF Family

4.2.1 SAREF Core

SAREF (ETSI TS 103 264 [i.1]) and its eleven derived extensions in different domains aims at facilitating the matching of existing assets (standards/protocols/data models/etc.) in smart applications. They are created and maintained by the ETSI TC SmartM2M. The starting point of SAREF is the concept of a device (e.g. a switch). The SAREF ontology offers lists of basic functions that can be eventually combined in order to have more complex functions in a single device. Each function has some associated commands, which can also be picked up as building blocks from a list. Depending on the functions it accomplishes, a device can be found in some corresponding states that are also listed as building blocks. When connected to a network, a device offers a service, which is the representation of a function which allows by other devices in the network to discover the function, register to it and control it remotely. A service can represent one or more functions and it is offered to any device that needs a certain set of functions. A device in the SAREF ontology is also characterized by a profile that can be used to optimize some property, such as Energy, in a home or office that is part of a building. Thus, the elements depicted by the ontology can be represented in NGSI-LD as Properties of Entities, and the connection between the different elements as Relationships. Additionally, SAREF core also describes the measurement element that relates the Device class to the SAREF Property and allows the storage of the values measured by the device.

Most relevant ones are depicted in next paragraphs including the ones for Smart Cities, Energy, Water management, and Health and ageing-well. The Smart Applications REFerence ontology (SAREF) is developed for interoperability between solutions from different providers and among various activity sectors for the Internet of Things (IoT) domain. In this clause, SAREF core and extension ontologies are described.

The core ontology defined within the SAREF core is shown in Figure 4.2.1-1.

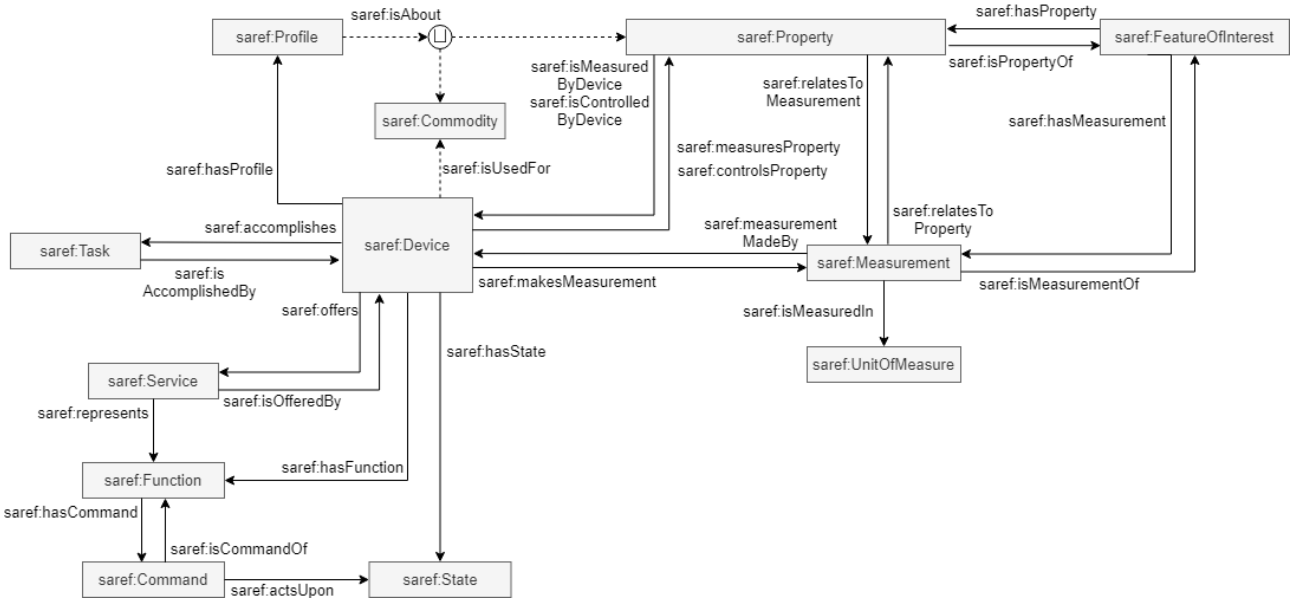

Figure 4.2.1-1: An overview of the SAREF core ontology

SAREF is designed as a domain-independent ontology for IoT applications. Thus, SAREF core ontology is designed as a set of simple core ontology patterns, including definitions for general fields. The SAREF core ontology is defined as device-centric including essential classes for IoT devices such as *saref:Device*, *saref:Function*, *saref:Task*, etc. This core ontology can be used with any real device, which is a tangible object designed to accomplish a particular task in households, common public buildings, or offices such as light switches, temperature sensors, and energy meters.

4.2.2 SAREF Extensions

4.2.2.1 Introduction

SAREF extensions are domain specific applications of the SAREF ontology identifying specific elements of the domains. Here is the list of extensions available in June 2022.

4.2.2.2 SAREF4CITY

SAREF4CITY (ETSI TS 103 410-4 [i.2]) focuses on extending SAREF in order to create a common core of general concepts for Smart City data-oriented IoT applications. SAREF4CITY has defined the classes for city management such as *s4city:AdministrativeArea*, *s4city:City*, and *s4city:Facility* that can be used for city stakeholders or various city services. SAREF4CITY is in its version 1.1.2.

4.2.2.3 SAREF4ENER

SAREF4ENER (ETSI TS 103 410-1 [i.3]) is the extension of SAREF for the energy domain that can be enabled to interconnect facilities (e.g. Italy-based and Germany-based industry associations). Classes and relationships included in SAREF4ENER can express all the powers and states of energy-related devices such as *s4ener:PowerSequence*, *s4ener:Energy*, and *s4ener:EnergyExpected*. SAREF4ENER is in its version 1.1.2.

4.2.2.4 SAREF4WATR

SAREF4WATR (ETSI TS 103 410-10 [i.4]) is an extension for the water domain which is based on a limited set of use cases and from available existing data models. SAREF4WATR has been developed in the context of the STF 566 which was established with the goal to create SAREF extensions. The water meter can be depicted as an example of extension uses. It can be described by a set of static classes and properties either reused from SAREF or from SAREF4WATR such as saref:Measurement and s4watr:WaterMeter. SAREF4WATR is in its version 1.1.1.

4.2.2.5 SAREF4EHAW

SAREF4EHAW (ETSI TS 103 410-8 [i.5]) extension has been specified and formalized by investigating EHAW (**eH**EALTH and **A**geing-**W**ell) domain related resources, as reported in ETSI TR 103 509 [i.6]. Therefore, SAREF4EHAW modular ontology has to allow the implementation of a limited set of typical EHAW related use cases, i.e.:

- Use case 1: "monitoring and support of healthy lifestyles for citizens".
- Use case 2: "Early Warning System (EWS) and Cardiovascular Accidents detection".

SAREF4EHAW mainly reuses the following existing ontologies: SAREF, SmartBAN, SAREF4ENVI, SAREF4WEAR and SAREF4health ontology which is a very first try to somehow extend SAREF ontology for the health vertical. SAREF4EHAW extension, specified and formalized as reported in ETSI TR 103 509 [i.6]. SAREF4EHAW is in its version 1.1.1.

4.2.2.6 SAREF4BLDG

SAREF4BLDG (ETSI TS 103 410-3 [i.7]), an extension of the SAREF ontology that was created based on the Industry Foundation Classes (IFC) standard for building information. It should be noted that not the whole standard has been transformed since it exceeds the scope of this extension, which is limited to devices and appliances within the building domain.

SAREF4BLDG is an OWL-DL ontology that extends SAREF with 72 classes (67 defined in SAREF4EBLDG and 5 reused from the SAREF and geo ontologies), 179 object properties (177 defined in SAREF4EBLDG and 2 reused from the SAREF and geo ontologies), and 83 data type properties (82 defined in SAREF4EBLDG and 1 reused from the SAREF ontology). SAREF4BLDG is in its version 1.1.2.

4.2.2.7 SAREF4INMA

SAREF4INMA (ETSI TS 103 410-5 [i.8]) is an extension of SAREF that was created for the industry and manufacturing domain. SAREF4INMA was created to be aligned with related initiatives in the smart industry and manufacturing domain in terms of modelling and standardization, such as the Reference Architecture Model for Industry 4.0 (RAMI), which combines several standards used by the various national initiatives in Europe that support digitalization in the manufacturing. These initiatives include but are not limited to, the platform Industrie 4.0 Germany, the Smart Industry initiative in the Netherlands, Industria 4.0 in Italy, the 'Industrie du future initiative' in France and more.

SAREF4INMA is an OWL-DL ontology that extends SAREF with 24 classes (in addition to a number of classes directly reused from the SAREF ontology and the SAREF4BLDG extension), 20 object properties (in addition to a number of object properties reused from the SAREF ontology and the SAREF4BLDG extension) and 11 data type properties.

SAREF4INMA solves the lack of interoperability between various types of production equipment to produce items in a factory and, once outside the factory, allows to uniquely track back the produced items to the corresponding production equipment, batches, material and precise time in which they were manufactured. SAREF4INMA is in its version 1.1.2.

4.2.2.8 SAREF4AGRI

SAREF4AGRI (ETSI TS 103 410-6 [i.9]) is an OWL-DL ontology that extends SAREF for the Smart Agriculture and Food Chain domain. The intention of SAREF4AGRI is to connect SAREF with existing ontologies (such as W3C SSN, W3C SOSA, GeoSPARQL, etc.) and important standardization initiatives and ontologies in the Smart Agriculture and Food Chain domain, including ICAR for livestock data (see https://www.icar.org/), AEF for agricultural equipment (see http://www.aef-online.org), Plant Ontology Consortium for plants (see http://archive.plantontology.org), AgGateway for IT support for arable farming (see http://www.aggateway.org/), as mentioned in the associated SAREF4AGRI requirements document ETSI TR 103 511 [i.38]. SAREF4AGRI is in its version 1.1.2.