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Reference Ontology and oneM2M Mapping

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

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1 Scope

The present document provides a standardized framework for the Smart Applications REFerence ontology based on the results of a European Commission Study Group on Smart Appliances ontologies and of different Specialist Task Forces that have supported the maintenance and evolution of the ontology taking into account all the interest of the relevant stakeholders. This reference ontology contains recurring concepts that are used in several domains and is a basis for extensions in particular domains.

The present document also defines the equivalent mapping between the Smart Applications REFference Ontology and the oneM2M Base Ontology.

2 References

2.1 Normative 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.

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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 necessary for the application of the present document.

[1] European Commission and TNO: "Study on Semantic Assets for Smart Appliances Interoperability", final report, April 2015.

NOTE: Available at https://sites.google.com/site/smartappliancesproject/deliverables.

[2] "SAREF: the Smart Applications REFerence ontology".

NOTE: Available at https://saref.etsi.org/saref.

[3] European Commission and TNO D-S4 - SMART 2013-0077: "Smart Appliances - Mapping SAREF to short list assets.xlsx", February 2015.

NOTE: Available at https://sites.google.com/site/smartappliancesproject/documents.

[4] ETSI TS 118 112: "oneM2M; Base Ontology (oneM2M TS-0012)".

[5] ETSI TS 103 267 (V2.1.1): "SmartM2M; Smart Appliances; Communication Framework".

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.

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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 TR 103 411: "SmartM2M Smart Appliances SAREF Extension Investigation".

[i.2] ETSI TS 103 410-1: "SmartM2M; Smart Appliances Extension to SAREF; Part 1: Energy Domain".

[i.3] ETSI TS 103 410-2: "SmartM2M; Smart Appliances Extension to SAREF; Part 2: Environment Domain".

[i.4] ETSI TS 103 410-3: "SmartM2M; Smart Appliances Extension to SAREF; Part 3: Building Domain".

[i.5] ETSI TS 103 410-4: "SmartM2M Extension to SAREF Part 4: Smart Cities Domain".

[i.6] ETSI TS 103 410-5: "SmartM2M; Extension to SAREF Part 5: Industry and Manufacturing Domains".

[i.7] ETSI TS 103 410-6: "SmartM2M; Extension to SAREF; Part 6: Smart Agriculture and Food Chain Domain".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

ontology: formal specification of a conceptualization, used to explicitly capture the semantics of a certain reality

smart application: any application in an IoT system making use of the SAREF ontology as specified in the present document and making use of the SAREF communication framework as specified in ETSI TS 103 267 [5]

3.2 Symbols

Void.

3.3 Abbreviations

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

DUL	DOLCE+DnS Ultralite
HVAC	Heating, Ventilation and Air Conditioning
OM	Ontology of units of Measure
oneM2M	oneM2M Partnership Project
OWL	Web Ontology Language
SAREF	Smart Applications REFerence ontology
SAREF4BLDG	SAREF for the Building domain
SAREF4ENER	SAREF for the Energy domain
SAREF4ENVI	SAREF for the Environment domain
SAREF4CITY	SAREF for the Smart Cities domain
SAREF4INMA	SAREF for the Industry and Manufacturing domain
SAREF4AGRI	SAREF for the Smart Agriculture and Food Chain domain
SEAS	Smart Energy Aware Systems
SEP2	Smart Energy Profile 2.0
SSN	Semantic Sensor Network
STF	Specialist Task Force
SUMO	Suggested Upper Merged Ontology
TNO	Netherlands Organisation for Applied Scientific Research
UPnP®	Universal Plug and Play
W3C®	World Wide Web Consortium
WGS84	World Geodetic System 1984

4 Smart Applications Reference Ontology and Semantics

4.1 Introduction and Overview

The Smart Applications REFerence ontology (SAREF) is intended to enable interoperability between solutions from different providers and among various activity sectors in the Internet of Things (IoT), thus contributing to the development of the global digital market.

SAREF shall use the SAREF Communication framework as defined in ETSI TS 103 267 [5].

The SAREF initiative started with a study on "Available Semantics Assets for the Interoperability of Smart Appliances: Mapping into a Common Ontology as a M2M Application Layer Semantics", which was tendered by the European Commission and was carried out by TNO.

Such study acknowledged that the energy utilization of Smart Appliances can be reduced if they are managed and controlled on a system level. The system needs standardized interfaces to ensure interoperability. Many of the required standards already exist, but a common architecture does not, resulting in a market which is too fragmented and powerless. Therefore, a reference ontology of consensus was designed to cover the needs of all appliances relevant for energy efficiency.

The study consisted of three tasks:

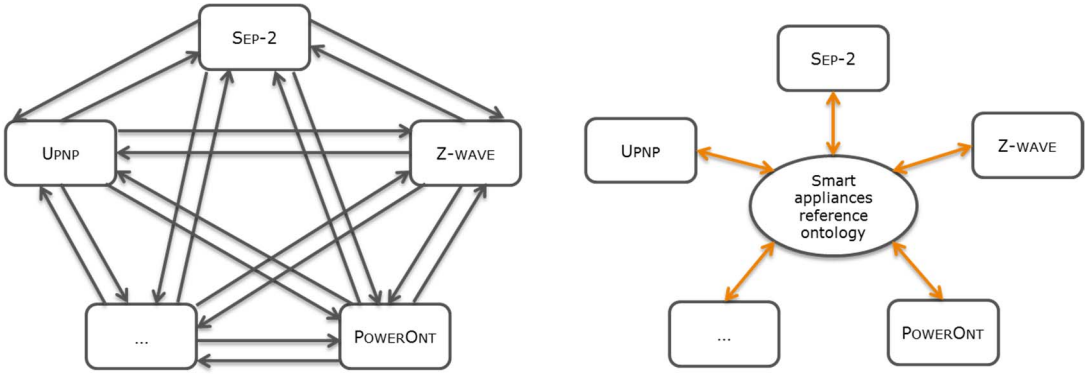
- **Task 1:** Take stock of existing semantic assets and use case assets.
- **Task 2:** Perform a translation exercise of each model (or use case) to a common ontology language and a mapping or matching exercise between all the models.
- **Task 3:** Propose a reference ontology and document the ontology into the ETSI M2M architecture.

NOTE: The ETSI M2M architecture has evolved into the oneM2M architecture, therefore the latter one is the one to be considered.

About 50 different semantic assets (i.e. standards, protocols, data models, ontologies) had been identified that describe various properties of Smart Appliances in residential environments. After translating half of these semantic assets into Web Ontology Language (OWL) (https://sites.google.com/site/smartappliancesproject/ontologies), 20 recurring concepts were used as initial building blocks for creating the Smart Applications REFerence ontology (SAREF). For SAREF in OWL, see [2]. The concepts were mapped from the semantic assets to SAREF to allow for translations between different semantic assets.

SAREF explicitly specifies the recurring core concepts in the Smart Applications domain, the main relationships between these concepts, and axioms to constrain the usage of these concepts and relationships. SAREF is based on the fundamental principles of **reuse and alignment** of concepts and relationships that are defined in existing assets, **modularity** to allow separation and recombination of different parts of the ontology depending on specific needs, **extensibility** to allow further growth of the ontology, and **maintainability** to facilitate the process of identifying and correcting defects, accommodate new requirements, and cope with changes in (parts of) SAREF.

Mappings to other concepts used by different semantic assets allow translation from the reference ontology to specific assets, reducing the effort of translating from one asset to another, since the reference ontology requires one set of mappings to each asset, instead of a dedicated set of mappings for each pair of assets. Figure 1 shows the role of the reference ontology in the mapping by means of sample assets. The mappings of SAREF to various assets are available in [3].



NOTE: UPnP® and Z-Wave® are examples of suitable products available commercially. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of these products.

Figure 1: The role of SAREF in the mapping among different assets

SAREF is based on the following main concepts (in alphabetical order):

- Command (e.g. OnCommand, OffCommand, PauseCommand, GetCommand, NotifyCommand, SetLevelCommand).
- Commodity (e.g. Electricity, Gas, Water).
- Device (e.g. Switch, Meter, Sensor).
- FeatureOfInterest.
- Function (i.e. Actuating Function, Event Function, Metering Function, Sensing Function).
- Measurement.
- Profile.
- Property (e.g. Energy, Humidity, Light, Motion, Occupancy, Power, Pressure, Price, Smoke, Temperature, Time).
- Service (e.g. Switch On Service).
- State (e.g. On Off State, Open Close State, Start Stop State, Multi Level State).
- Task (e.g. Cleaning, Comfort, Lighting, Safety, Entertainment, Energy Efficiency).
- UnitOfMeasure (e.g. Currency, Energy Unit, Power Unit, Temperature Unit).

4.2 Principles

The Smart Applications REFerence ontology (SAREF) is conceived as a shared model of consensus that facilitates the matching of existing semantic assets for building smart applications, reducing the effort of translating from one asset to another, since SAREF requires one set of mappings to each asset, instead of a dedicated set of mappings for each pair of assets.

Different semantic assets share some recurring, core concepts, but they often use different terminologies and adopt different data models to represent these concepts. Using SAREF, different assets can keep using their own terminology and data models, but still can relate to each other through their common semantics. In other words, SAREF enables semantic interoperability in smart applications through its shared, core concepts.

SAREF explicitly specifies recurring core concepts in smart applications, the main relationships between these concepts, and axioms to constrain the usage of these concepts and relationships. SAREF has been created based on the following fundamental principles:

- **Reuse and alignment** of concepts and relationships that are defined in existing assets. Since a large amount of work was already being done in the smart appliances and in the Internet of Things domains, nothing has been re-invented, but harmonized and aligned what was already there. SAREF is based on the core concepts that were identified as especially relevant to describe the existing semantic assets for smart applications and is aligned to the main classes and properties of the oneM2M base ontology [4] and of the W3C® Semantic Sensor Network (SSN) ontology.

  SAREF reuses the following resources:

  - based on 20 domain-specific ontologies, e.g. W3C® SSN ontology, Echonet, EnOcean®, SEP2, UPnP® (https://sites.google.com/site/smartappliancesproject/ontologies);
  - reuse of W3C® Time ontology;
  - reuse W3C® WGS84 geo positioning vocabulary (through the SAREF4BLDG extension in ETSI TS 103 410-3 [i.4]);
  - reuse of Ontology of units of Measure (OM) individuals.

- **Modularity** to allow separation and recombination of different parts of the ontology depending on specific needs. SAREF provides building blocks that can be combined to accommodate different needs and points of view. The starting point is the concept of **device**, which is actually common to all the semantic assets considered in the study, although some assets may refer to it with different names, such as **resource** or **product,** but mappings for that are provided in [3]. For example, a "switch" is a device. A device is always designed to perform one or more **functions**, therefore, SAREF offers a list of basic functions that can be eventually combined in order to have more complex functions in a single device. For example, the switch mentioned above offers an actuating function of type "on/off function". Each function has some associated **commands**, which can also be selected as building blocks from a list. For example, the "on/off function" is associated with the commands "on", "off" and "toggle". Depending on the function(s) it performs, a device can be found in some corresponding **states** that are also listed as building blocks, so that it is easy and intuitive to combine devices, functions and states. The switch considered in our example can be found in one of the two states "on" or "off". SAREF also provides a list of **properties** that can be used to further specialize the functioning of a device. For example, a "light switch" specializes the more general "switch" described above for the purpose of controlling the "light" property. An extensive explanation of SAREF, describing its classes and relationships, is presented in the next clause.

- **Extensibility** to allow further growth of the ontology. Different stakeholders can specialize the SAREF concepts according to their needs and points of view, add more specific relationships and axioms to refine the general (common) semantics expressed in the reference ontology, and create new concepts, as long as they explicitly link these extensions to at least one existing concept and/or relationship in SAREF. The minimum requirement is that any extension/specialization shall comply with SAREF. Examples of extensions of SAREF in different domains are SAREF4ENER (energy domain) [i.2], SAREF4ENVI (environment domain) [i.3] and SAREF4BLDG (building domain) [i.4].

- **Maintainability** to facilitate the process of identifying and correcting defects, accommodate new requirements, and cope with changes in (parts of) SAREF. According to the extensibility criterion mentioned above, a new module/ontology can be created to further extend/specialize concepts of SAREF. The party that creates the extension should also be responsible for the maintenance of this extension and its evolution over time. For the strategy proposed in ETSI to extend, maintain and evolve SAREF (and its extensions), see ETSI TR 103 411 [i.1].

The prefixes and namespaces used in SAREF and in the present document are listed in Table 1.

Table 1: Prefixes and namespaces used within the SAREF ontology

Prefix	Namespace
saref	https://saref.etsi.org/core/
dcterms	http://purl.org/dc/terms/
foaf	http://xmlns.com/foaf/0.1/
owl	http://www.w3.org/2002/07/owl#
rdf	http://www.w3.org/1999/02/22-rdf-syntax-ns#
rdfs	http://www.w3.org/2000/01/rdf-schema#
vann	http://purl.org/vocab/vann/
xsd	http://www.w3.org/2001/XMLSchema#

4.3 SAREF

4.3.1 General Overview

Figure 2 shows an overview of the main classes of SAREF and their relationships. A detailed explanation of each class is presented in clause 4.3.2 to clause 4.3.8.

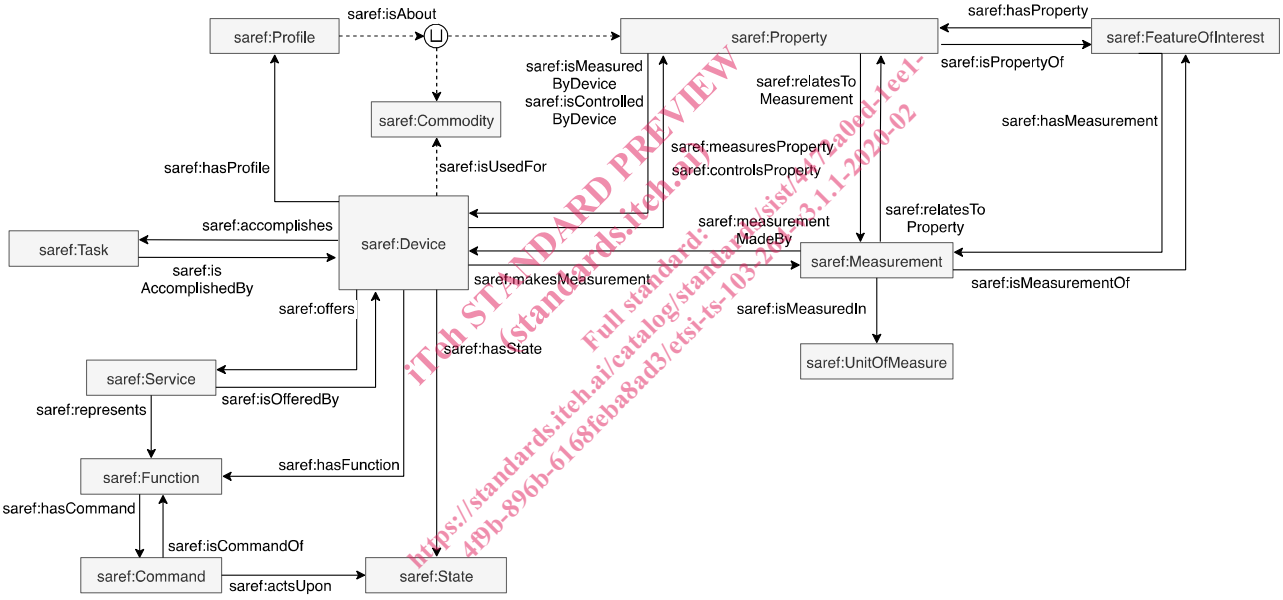


Figure 2: Overview of the SAREF ontology

Table 2 provides a summary of definitions for the main classes of SAREF.

Table 2: Summary of main SAREF definitions

Concept	Definition
Command	A directive that a device shall support to perform a certain function. A command may act upon a state, but does not necessarily act upon a state. For example, the ON command acts upon the ON/OFF state, but the GET command does not act upon any state, it simply gives a directive to retrieve a certain value. A list of commands that are relevant for the purpose of SAREF is proposed, but this list can be extended.
Commodity	A marketable item for which there is demand, but which is supplied without qualitative differentiation across a market. SAREF refers to energy commodities such as electricity, gas, coal and oil.
Device	A tangible object designed to accomplish a particular task in households, common public buildings or offices. In order to accomplish this task, the device performs one or more functions. For example, a washing machine is designed to wash (task) and to accomplish this task it performs a start and stop function.
Feature of interest	A feature of interest represents any real world entity from which a property is measured. It is linked to the different properties it has and to its measurements.