



TECHNICAL SPECIFICATION

**SmartM2M;  
Smart Appliances;  
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).

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## Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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# 1 Scope

The present document provides a standardized framework for the Smart Appliances Reference Ontology based on the results of a European Commission Study Group on Smart Appliances ontologies and of a Specialist Task Force on the maintenance and evolution of the Reference 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 Appliances Reference Ontology and the oneM2M Base Ontology.

## 2 References

### 2.1 Normative references

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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] European Commission and TNO: "Smart Appliances REFerence ontology (SAREF)", April 2015.

NOTE: Available at <https://w3id.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)".

### 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] 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".

## 3 Definitions and abbreviations

### 3.1 Definitions

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

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

**smart appliances:** devices, which are used in the household, e.g. for performing domestic work, and which have the ability to communicate with each other and which can be controlled via Internet

NOTE: The following appliances are covered: Home and buildings sensors (temperature, humidity, energy-plugs, energy clams, energy meters, water-flow, water quality, presence, occupancy, air monitors, environmental sensors, CO<sub>2</sub> sensors, weather stations, etc.) and actuators (windows, doors, stores); white goods, as classified by CECED; HVAC (heating, ventilation, and air conditioning), classified by Eu.bac; lighting, with use cases as defined by LightingEurope; micro renewable home solutions (solar panels, solar heaters, wind, etc.).

### 3.2 Abbreviations

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

CECED	European Committee of Domestic Equipment Manufacturers
CENELEC	European Committee for Electrotechnical Standardization
DUL	DOLCE+DnS Ultralite
EC	European Commission
eu.bac	European building automation controls association
FAN	Flexible power Alliance Network
FIEMSER	Friendly Intelligent Energy Management Systems in Residential Buildings
HVAC	Heating, Ventilation, and Air Conditioning
Mirabel	Micro-request-based aggregation, forecasting and scheduling of energy demand, supply and distribution
OM	Ontology of units of Measure
oneM2M	oneM2M Partnership Project
OSGi™ DAL	Open Services Gateway initiative Device Abstraction Layer
OWL	Web Ontology Language
SAREF	Smart Appliances REference ontology
SAREF4BLDG	SAREF for Building domain
SAREF4ENER	SAREF for Energy domain
SAREF4ENVI	SAREF for Environment domain
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 Appliances Reference Ontology and Semantics

### 4.1 Introduction and Overview

A study on "Available Semantics Assets for the Interoperability of Smart Appliances: Mapping into a Common Ontology as a M2M Application Layer Semantics" had been tendered by the European Commission and was carried out by TNO. Parts of the final report of this study [1] are copied to clauses 4.1 to 4.4.

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:

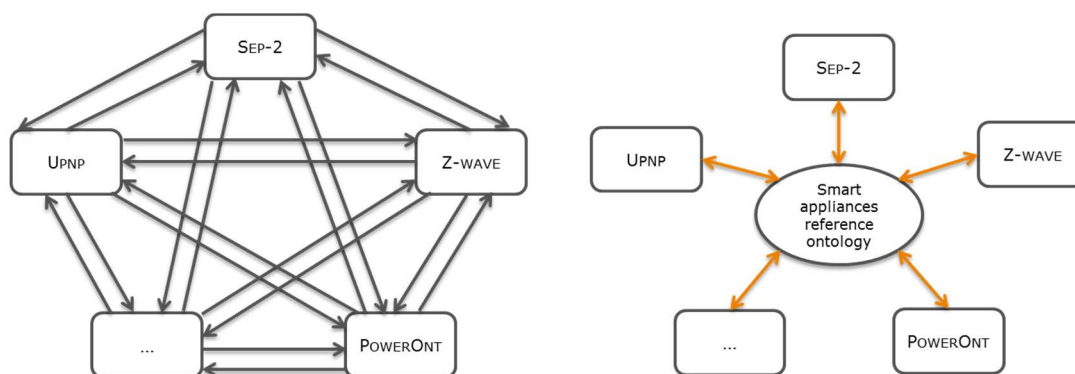
- **Task 1:** Take stock of existing semantic assets and use case assets.
- **Task 2:** Perform a translation exercise of each model (or use case) to a common ontology language and a mapping or matching exercise between all the models.
- **Task 3:** Propose a reference ontology and document the ontology 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 Appliances 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 Appliances 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, Washing Machine).
- 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 Appliances REFerence ontology (SAREF) is conceived as a shared model of consensus that facilitates the matching of existing semantic assets in the smart appliances domain, 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 terminologies and data models, but still can relate to each other through their common semantics. In other words, SAREF enables semantic interoperability in the smart appliances domain through its shared, core concepts.



SAREF explicitly specifies recurring core concepts in the smart appliances domain, 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 domain, 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 in the smart appliances domain.

SAREF reuses the following resources:

- based on 20 domain-specific ontologies, e.g. W3C<sup>®</sup> SSN ontology, Echonet, EnOcean<sup>®</sup>, SEP2, UPnP<sup>®</sup> (<https://sites.google.com/site/smartappliancesproject/ontologies>);
  - reuse of W3C<sup>®</sup> Time ontology;
  - reuse W3C<sup>®</sup> 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, 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].

## 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.

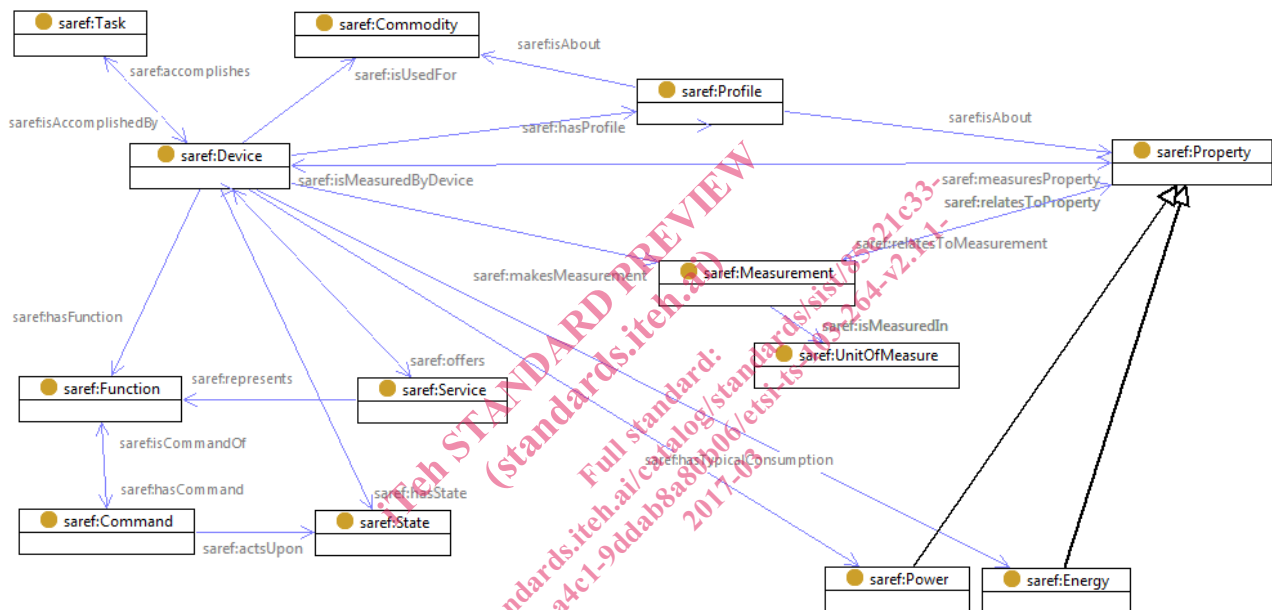


Figure 2