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TECHNICAL SPECIFICATION

## SmartM2M; Smart Appliances Extension to SAREF; Part 3: Building Domain

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# Contents

Intellectual Property Rights .....	4
Foreword.....	4
Modal verbs terminology.....	4
1 Scope .....	5
2 References .....	5
2.1 Normative references .....	5
2.2 Informative references.....	5
3 Definitions and abbreviations.....	6
3.1 Definitions.....	6
3.2 Abbreviations .....	6
4 SAREF4BLDG ontology and semantics.....	6
4.1 Introduction .....	6
4.2 SAREF4BLDG.....	7
4.2.1 General overview .....	7
4.2.2 Device Taxonomy.....	9
4.2.3 Measurements .....	12
4.2.4 Device Properties.....	13
4.3 Observations about S4BLDG.....	20
<b>Annex A (informative): Approach .....</b>	<b>21</b>
<b>Annex B (informative): Bibliography.....</b>	<b>23</b>
History .....	24

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## Foreword

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

The present document is part 3 of a multi-part deliverable covering SmartM2M; Smart Appliances Extension to SAREF, as identified below:

- Part 1: "Energy Domain";
- Part 2: "Environment Domain";
- Part 3: "Building Domain".**

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## Modal verbs terminology

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# 1 Scope

The present document presents the SAREF extension for the building domain, based on the ISO 16739 [i.2] standard (IFC).

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## 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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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] ISO 16739:2013: "Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries".

NOTE: Available at [http://www.iso.org/iso/catalogue\\_detail.htm?csnumber=51622](http://www.iso.org/iso/catalogue_detail.htm?csnumber=51622).

[i.3] Industry Foundation Classes (IFC) - Version 4 - Addendum 1. buildingSMART.

NOTE: Available at <http://www.buildingsmart-tech.org/ifc/IFC4/Add1/html/>.

[i.4] Villazón-Terrazas, B. Method for Reusing and Re-engineering Non-ontological Resources for Building. Ph.D. Dissertation. Universidad Politécnica de Madrid. 2011.

NOTE: Available at <http://oa.upm.es/6338/>.

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## 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 explicit 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

### 3.2 Abbreviations

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

HTML	Hyper Text Markup Language
IFC	Industry Foundation Classes
ISO	International Standardization Organisation
OWL	Web Ontology Language
OWL-DL	Web Ontology Language Description Logic
PROV-O	The PROV Ontology RDF Resource Description Format
SAREF	Smart Appliances REFerence ontology
TR	Technical Report
TS	Technical Specification
URI	Uniform Resource Identifier
W3C	World Wide Web Consortium
WGS84	World Geodetic System 1984

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## 4 SAREF4BLDG ontology and semantics

### 4.1 Introduction

The present document is a technical specification of SAREF4BLDG, 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.

The IFC specification is developed and maintained by buildingSMART International as its "Data standard" and, since its version IFC4, it is published as the ISO 16739 [i.2] standard. SAREF4BLDG is meant to enable the (currently missing) interoperability among various actors (architects, engineers, consultants, contractors, and product component manufacturers, among others) and applications managing building information involved in the different phases of the building life cycle (Planning and Design, Construction, Commissioning, Operation, Retrofitting/Refurbishment/Reconfiguration, and Demolition/Recycling). By using SAREF4BLDG, smart appliances from manufacturers that support the IFC data model will easily communicate with each other. Towards this aim, SAREF4BLDG should be used to annotate (or generate) neutral device descriptions to be shared among various stakeholders.

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 focuses on extending the SAREF ontology to include those devices defined by the IFC version 4 - Addendum 1 [i.3] and to enable the representation of such devices and other physical objects in building spaces.

The prefixes and namespaces used in SAREF4BLDG and along the present document are listed in Table 1.

**Table 1: Prefixes and namespaces used within the SAREF4BLDG ontology**

Prefix	Namespace
base (s4bldg)	<a href="https://w3id.org/def/saref4bldg">https://w3id.org/def/saref4bldg</a>
saref	<a href="https://w3id.org/saref">https://w3id.org/saref</a>
geo	<a href="http://www.w3.org/2003/01/geo/wgs84_pos">http://www.w3.org/2003/01/geo/wgs84_pos</a>
owl	<a href="http://www.w3.org/2002/07/owl">http://www.w3.org/2002/07/owl</a>
prov	<a href="http://www.w3.org/ns/prov">http://www.w3.org/ns/prov</a>
rdf	<a href="http://www.w3.org/1999/02/22-rdf-syntax-ns">http://www.w3.org/1999/02/22-rdf-syntax-ns</a>
rdfs	<a href="http://www.w3.org/2000/01/rdf-schema">http://www.w3.org/2000/01/rdf-schema</a>
xsd	<a href="http://www.w3.org/2001/XMLSchema">http://www.w3.org/2001/XMLSchema</a>

## 4.2 SAREF4BLDG

### 4.2.1 General overview

Figure 1 presents an overview of the classes (only the top levels of the hierarchy) and the properties included in the SAREF4BLDG extension. As it can be observed the classes `s4bldg:Building`, `s4bldg:BuildingSpace` and `s4bldg:PhysicalObject` have been declared as subclasses of the class `geo:SpatialThing` in order to reuse the conceptualization for locations already proposed by the geo ontology. The modelling of building objects and building spaces has been adapted from the SAREF ontology; in this sense, the new classes deprecate the `saref:BuildingObject` and `saref:BuildingSpace` classes. In addition, a new class has been created, the `s4bldg:Building` class, to represent buildings.

The concepts `s4bldg:Building` and `s4bldg:BuildingSpace` are related to each other by means of the properties `s4bldg:hasSpace` and `s4bldg:isSpaceOf`; such properties are defined as inverse properties among them. These properties might also be used to declare that a `s4bldg:BuildingSpace` has other spaces belonging to the class `s4bldg:BuildingSpace`.

The relationship between building spaces and devices and building objects has also been transferred and generalized from the SAREF ontology. In this regard, a `s4bldg:BuildingSpace` can contain (represented by the property `s4bldg:contains`) individuals belonging to the class `s4bldg:PhysicalObject`. This generalization has been implemented in order to support building spaces to contain both building objects and devices. Accordingly, the classes `s4bldg:BuildingObject` and `saref:Device` are declared as subclasses of `s4bldg:PhysicalObject`.

Finally, the class representing building devices, namely `s4bldg:BuildingDevice`, is defined as a subclass of both `saref:Device` and `s4bldg:BuildingObject`. This class is a candidate for replacing the `saref:BuildingRelated` class.

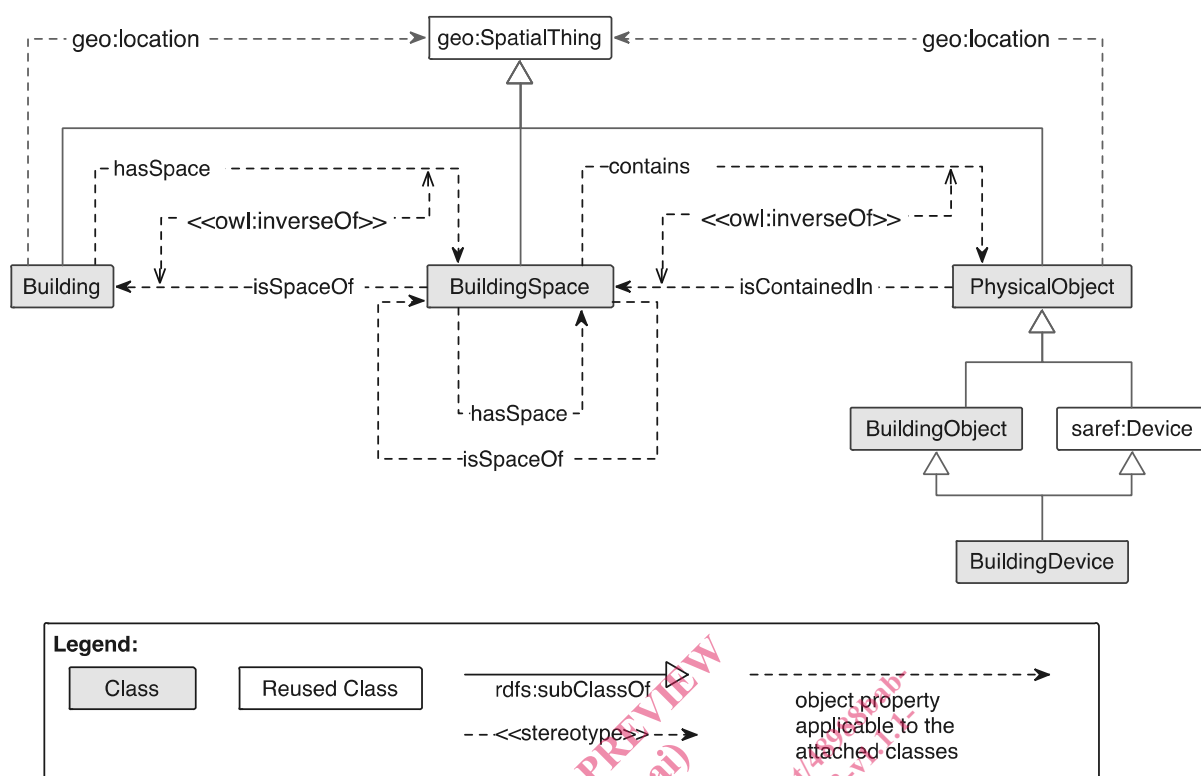


Figure 1: General overview of the top levels of the SAREF4BLDG extension

Table 2 summarizes the restrictions that characterize a `s4bldg:Building`.

Table 2: Restrictions of the `s4bldg:Building` class

Property	Definition
<code>geo:location</code> <b>only</b> <code>geo:SpatialThing</code>	The location of a building is represented only by instances of <code>geo:SpatialThing</code> .
<code>s4bldg:hasSpace</code> <b>only</b> <code>s4bldg:BuildingSpace</code>	A building has spaces represented only by instances of <code>s4bldg:BuildingSpace</code> .

Table 3 summarizes the restrictions that characterize a `s4bldg:BuildingSpace`.

Table 3: Restrictions of the `s4bldg:BuildingSpace` class

Property	Definition
<code>s4bldg:contains</code> <b>only</b> <code>s4bldg:PhysicalObject</code>	A building space contains entities represented only by instances of <code>s4bldg:PhysicalObject</code> .
<code>s4bldg:hasSpace</code> <b>only</b> <code>s4bldg:BuildingSpace</code>	A building has spaces represented only by instances of <code>s4bldg:BuildingSpace</code> .
<code>s4bldg:isSpaceOf</code> <b>only</b> ( <code>s4bldg:Building</code> or <code>s4bldg:BuildingSpace</code> )	A building is spaces of entities represented only by instances of the classes <code>s4bldg:Building</code> or <code>s4bldg:BuildingSpace</code> .

Table 4 summarizes the restrictions that characterize a `s4bldg:PhysicalObject`.



**Table 4: Restrictions of the s4bldg:PhysicalObject class**

Property	Definition
s4bldg:contains <b>only</b> s4bldg:PhysicalObject	A physical object contains entities represented only by instances of s4bldg:PhysicalObject.
geo:location <b>only</b> geo:SpatialThing	The location of a physical object is represented only by instances of geo:SpatialThing.
s4bldg:isContained <b>only</b> (s4bldg:Building or s4bldg:BuildingSpace)	A physical object is contained in entities represented only by instances of the classes s4bldg:Building or s4bldg:BuildingSpace.

## 4.2.2 Device Taxonomy

The main contribution of this extension is the representation of the devices defined in the IFC standard and their connections to SAREF. In this sense, a hierarchy consisting in 62 classes has been created taking into account the subset of the IFC hierarchy related to devices, as defined in the buildingSMART documentation (<http://www.buildingsmart-tech.org/ifc/IFC4/Add1/html/annex/annex-c/common-use-definitions/all.htm>), and adding several classes to clarify its categorization. The device classes are organized into 6 hierarchical levels that, for the sake of clarity, will be displayed in Figure 2 and Figure 3.

Figure 2 shows the first five levels of the hierarchy. Since transport elements (s4bldg:TransportElement) and vibration isolations (s4bldg:VibrationIsolation) are not classified under IFC elements, they belong directly to the class s4bldg:Device. The building elements are divided into s4bldg:ShadingDevice and s4bldg:DistributionDevice. In fact, most of the device types included in IFC belong to the distribution device category which contains the classes s4bldg:DistributionControlDevice and s4bldg:DistributionFlowDevice. The hierarchy under the s4bldg:DistributionFlowDevice is depicted in Figure 3.

As can be observed in Figure 2, some classes defined in SAREF4BLDG are also defined in the SAREF ontology. More precisely, this occurs in the classes s4bldg:Actuator and s4bldg:Sensor that extend the classes saref:Actuator and saref:Sensor, respectively. This decision has been taken because in the SAREF4BLDG extension these concepts refer to specific sensors and actuators that are placed in or related to buildings.

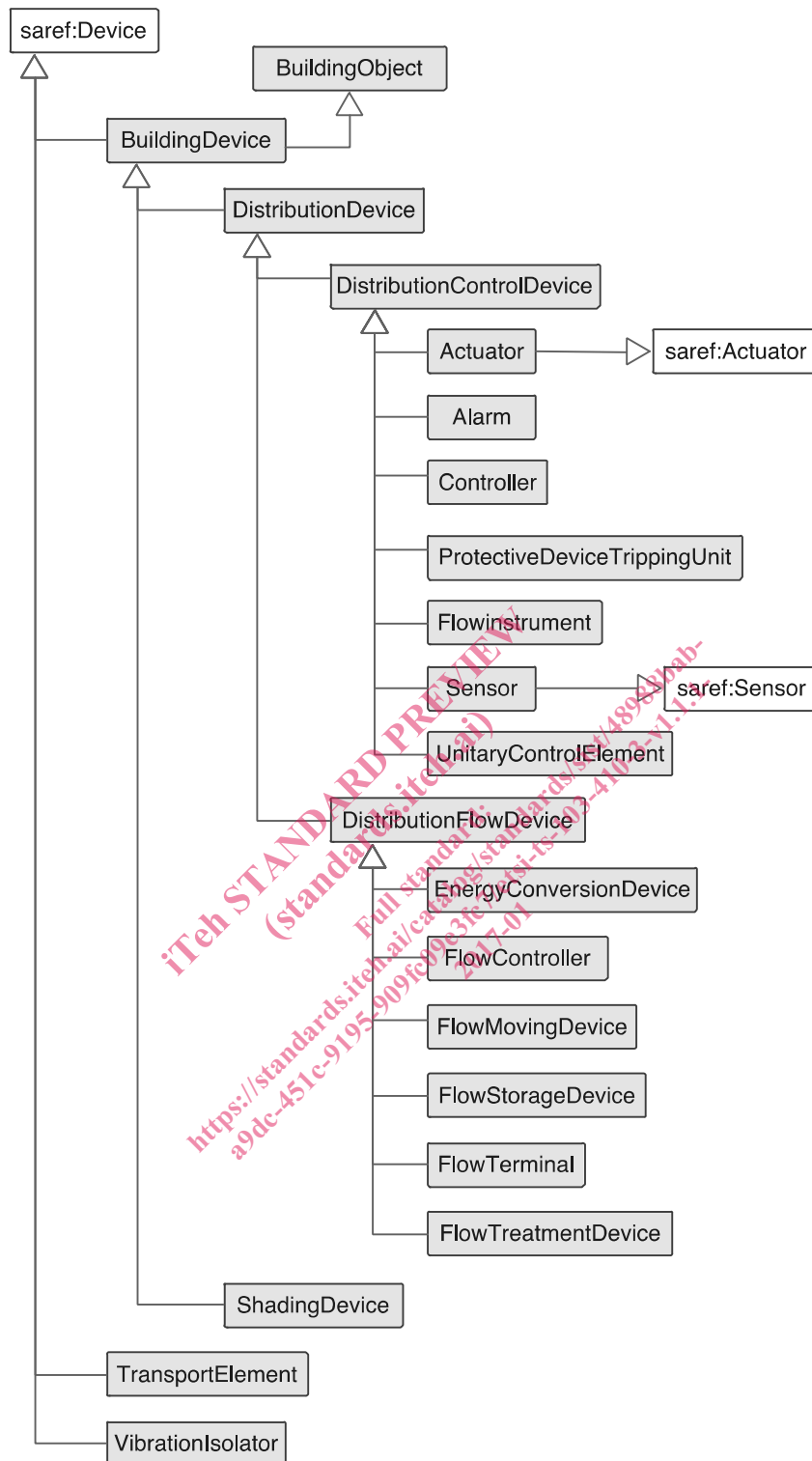


Figure 2: Device hierarchy in SAREF4BLDG (Part 1)