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Part 2: Environment Domain

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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 2 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".

Modal verbs terminology

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1 Scope

The present document presents the SAREF extension for the environment domain, focused in a light pollution scenario from the STARS4ALL H2020 project.

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] Zamorano, J., García, C., González, R, Gallego, J., Pascual, S., Tapia, C., Nievas, M., Sánchez, A., Cardiel, N. Deliverable D4.1. Photometer sensor (prototype). STARS4ALL project. March 30th, 2016.

[i.3] Variación espacial, temporal y espectral de la contaminación lumínica y sus fuentes: Metodología y resultados. Ph.D. thesis. Universidad Complutense de Madrid. February, 2015.

NOTE: Available at http://eprints.ucm.es/31436/.

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:

ESCP	École Supérieure de Commerce de Paris
OM	Ontology of units of Measure
OWL	Web Ontology Language
OWL-DL	Web Ontology Language Description Logic
RDF	Resource Description Format
RDF-S	Resource Description Format Schema
SAREF	Smart Appliances REFerence ontology
TESS	Telescope Encoder and Sky Sensor
TR	Technical Report
TS	Technical Specification
WGS84	World Geodetic System 1984

4 SAREF4ENVI ontology and semantics

4.1 Introduction

The present document is the technical specification of SAREF4ENVI, an extension of SAREF for the environment domain. The extension was created in collaboration with domain experts in the field of light pollution currently working in the STARS4ALL European H2020 project (http://www.stars4all.eu/index.php/lpi/). The STARS4ALL project is composed by partners such as Universidad Politécnica de Madrid, Universidad Complutense de Madrid, ESCP Europe, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Instituto de Astrofísica de Canarias, University of Southampton, Europan Crowdfunding Network, and CEFRIEL (Società Consortile a Responsabilita Limitata).

SAREF4ENVI has two main aims: on the one hand, to be the basis for enabling the use of SAREF in the environment domain and, on the other hand, to exemplify how to enable interoperability between environmental devices in cooperation.

SAREF4ENVI is an OWL-DL ontology that extends SAREF with 32 classes (24 defined in SAREF4ENVI and 7 reused from the time, SAREF and geo ontologies), 24 object properties (22 defined in SAREF4ENVI and 2 reused from the SAREF and geo ontologies), 13 data type properties (9 defined in SAREF4ENVI and 4 reused from the SAREF ontology), and 24 individuals (9 defined in SAREF4ENVI and 12 reused from the OM ontology). SAREF4ENVI focuses on extending SAREF for photometers to solve the lack of interoperability between sensors that can measure and share information about light pollution. Such extension involves the following use cases (more details can be found in ETSI TR 103 411 [i.1]):

- **Use case 1:** Monitor light pollution in a city, through the data collected by photometers about the magnitude of the light emitted in a given area.
- **Use case 2:** Adjust lampposts light intensity due to high pollution, after identifying the most contaminating lampposts and therefore the areas where more energy is being thrown away.
- **Use case 3**: Register a photometer, in which a new collection of photometers is incorporated into an existing sensor network.

The prefixes and namespaces used in SAREF4ENVI and along this document are listed in Table 1.

Table 1: Prefixes and namespaces used within the SAREF4ENVI ontology

Prefix	Namespace
base (s4envi)	https://w3id.org/def/saref4envi#
saref	https://w3id.org/saref#
geo	http://www.w3.org/2003/01/geo/wgs84_pos#
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#
om	http://www.wurvoc.org/vocabularies/om-1.8/
xsd	http://www.w3.org/2001/XMLSchema#

4.2 SAREF4ENVI

4.2.1 General overview

A graphical overview of the SAREF4ENVI ontology is provided in Figure 1.

In such figure, grey rectangles are used to denote classes created in the ontology while white rectangles denote reused classes. For all the entities, it is indicated whether they are defined in the extension or in other ontologies by the prefix included before their identifier, that is, if the element is defined in SAREF4ENVI there is no prefix added and if the element is reused from another ontology it is indicated by a prefix according to Table 1.

Arrows are used represent properties between classes and to represent some RDF, RDF-S and OWL constructs, more precisely:

- Plain arrows with white triangles represent the `rdfs:subClassOf` relation between two classes. The origin of the arrow is the class to be declared as subclass of the class at the destination of the arrow.
- Dashed arrows between two classes indicate a local restriction in the origin class, i.e. that the object property can be instantiated between the classes in the origin and the destination of the arrow. The identifier of the object property is indicated within the arrow.
- Dashed arrows with identifiers between stereotype signs (i.e. "<< >>") refer to OWL constructs that are applied to some ontology elements, that is, they can be applied to classes or properties depending on the OWL construct being used.
- Dashed arrows with no identifier are used to represent the `rdf:type` relation, indicating that the element in the origin of the arrow is an instance of the class in the destination of the arrow.

Datatype properties are denoted by rectangles attached to the classes, in an UML-oriented way. Dashed boxes represent local restrictions in the class, i.e. datatype properties that can be applied to the class it is attached to.

Individuals are denoted by grey rectangles (or white ones in the case of being reused from other ontologies) in which the identifier is underlined.

The representation of additional property axioms (functional, inverse functional, transitive, and symmetric) that are being used in the diagram is shown in the legend of Figure 1.

Clause 4.2.2 to clause 4.2.7 describe the different parts of the SAREF4ENVI extension describing the different conceptual modules of the ontology.

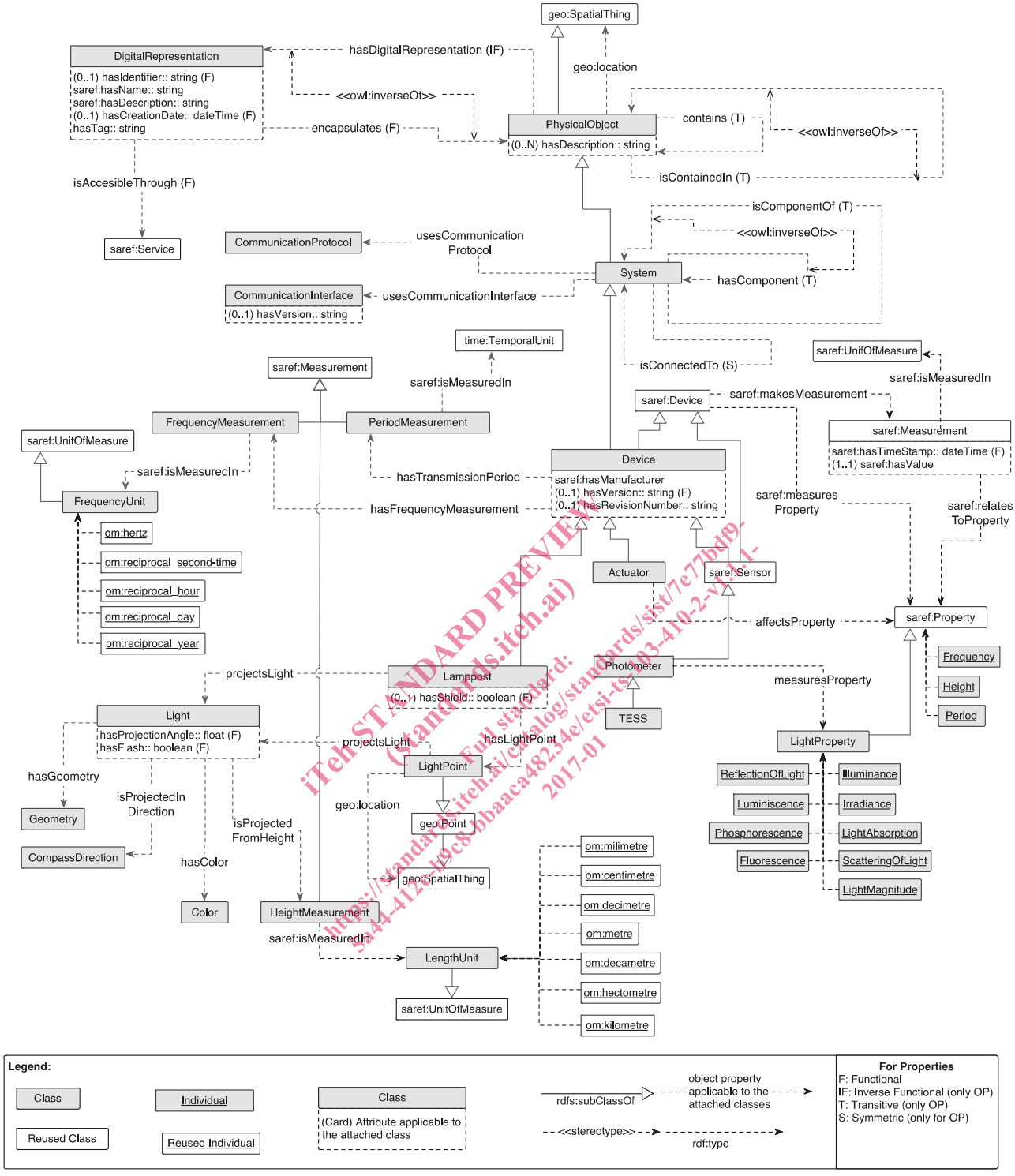

Figure 1: SAREF4ENVI overview

4.2.2 Physical Object Hierarchy

In SAREF4ENVI, the SAREF ontology has been extended with various elements to describe different physical objects, devices, and their characteristics.

Apart from extending the `saref:Device` class with the `s4envi:Device` class, a hierarchy has been defined also including the classes `s4envi:PhysicalObject`, `s4envi:System` and `s4envi:Actuator` in the upper levels. In order to represent sensors from the light pollution domain, the classes `s4envi:Photometer` and `s4envi:TESS` (a specific type of photometer) have been included extending the hierarchy. Such classes are organized in the hierarchy shown in Figure 2.

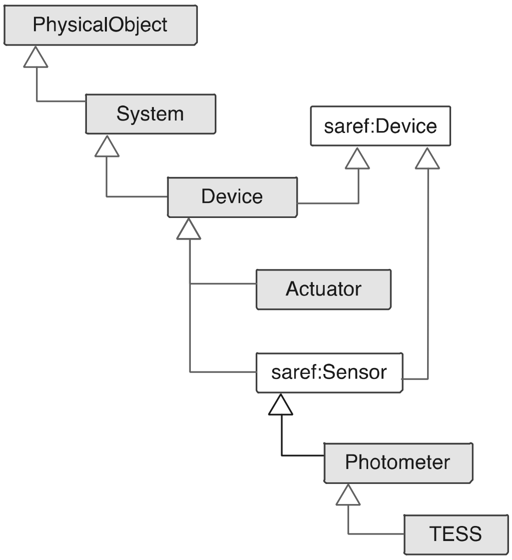

Figure 2: Physical Object hierarchy

4.2.3 Devices and Measurements

Devices and measurements are depicted in Figure 3. This model represents an n-ary pattern that allows users to relate different measurements from a given sensor for different properties measured in different units. That is, the `saref:Measurement` class aims at describing a measurement of a physical quantity (using the `saref:hasValue` property) for a given `saref:Property` and according to a given `saref:UnitOfMeasure`.

This pattern enables to differentiate between properties and the measurements made for such properties and to store measurements for a concrete property in different units of measurement.

Furthermore, it allows adding a timestamp (using the `saref:hasTimeStamp` property) to identify when the measurement applies to the property, which can be used either for single measurements or for series of measurements (e.g. measurement streams).

It is worth noting that this modelling was included in SAREF 2.0 after the SAREF4ENVI extension was developed. This pattern was first included in the SAREF4ENVI and SAREF4BLDG extensions and then proposed to be extrapolated to SAREF 2.0; this explains why the prefix used for this part of the model refers to SAREF instead of to SAREF4ENVI. However, as its origin is in the SAREF4ENVI and SAREF4BLDG extensions requirements and models, the explanations are kept in the present document.

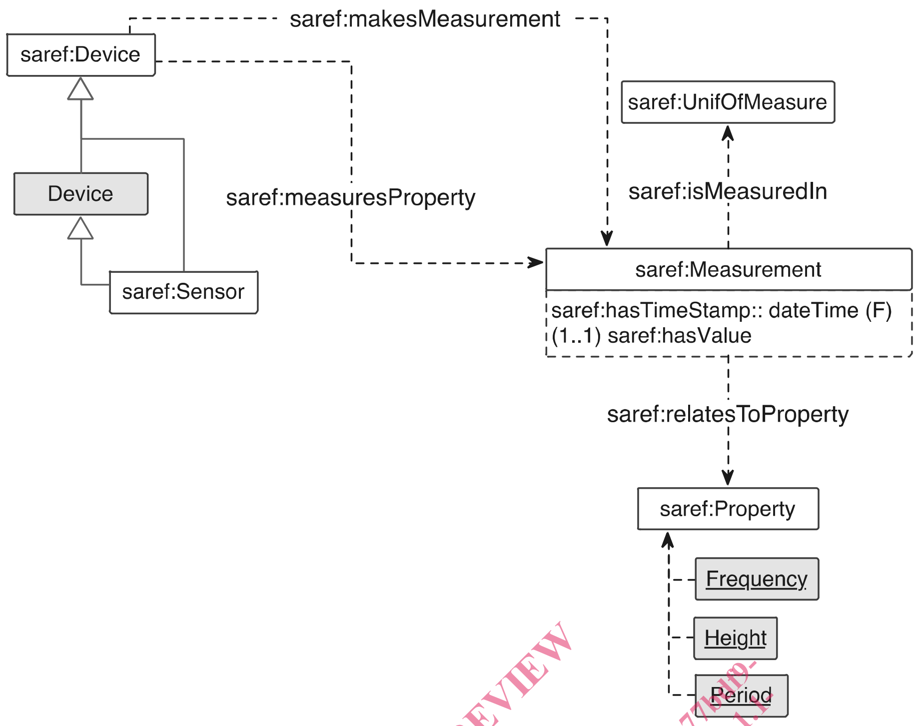

Figure 3: Sensor and measurement model

Table 2 summarizes the restrictions that characterize a `saref:Measurement`.

Table 2: Restrictions of the saref:Measurement class

Property	Definition
saref:hasTimestamp **only** xsd:dateTime	The timestamp of a measurement is represented only by xsd:dateTime.
saref:hasValue **exactly** 1 xsd:float	A measurement should have exactly one value represented using xsd:float.
saref:hasValue **only** xsd:float	The value of a measurement is represented only by xsd:float.
saref:isMeasuredIn **exactly** 1 saref:UnitOfMeasure	A measurement should have exactly one unit of measurement which should be instance of saref:UnitOfMeasure.
saref:isMeasuredIn **only** saref:UnitOfMeasure	The unit of measurement of a measurement is represented only by instances of the class saref:UnitOfMeasure.
saref:relatesToProperty **exactly** 1 saref:Property	A measurement should be related exactly to one property which should be instance of saref:Property.
saref:relatesToProperty **only** saref:Property	The property to which a measurement is related to is represented only by instances of the class saref:Property.

Table 3 summarizes the restrictions that characterize a `saref:Sensor`.

Table 3: Restrictions of the saref:Sensor class

Property	Definition
saref:makesMeasurement **only** saref:Measurement	The measurement made by a sensor is represented only by instances of the class saref:Measurement.
saref:measuresProperty **only** saref:Property	The property measured by a sensor is represented only by instances of the class saref:Property.