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**SmartM2M;
Smart Appliances Extension to SAREF;
Part 2: Environment 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 5
3.1 Definitions 5
3.2 Abbreviations 6
4 SAREF4ENVI ontology and semantics 6
4.1 Introduction 6
4.2 SAREF4ENVI 7
4.2.1 General overview 7
4.2.2 Physical Object Hierarchy 8
4.2.3 Devices and Measurements 9
4.2.4 Devices 11
4.2.5 Systems and Physical Objects 12
4.2.6 Photometers 15
4.2.7 Lampposts, Light Points and Light 15
4.3 Observations about SAREF4ENVI 17
Annex A (informative): Approach 18
Annex B (informative): Bibliography 19
History 20

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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

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 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.

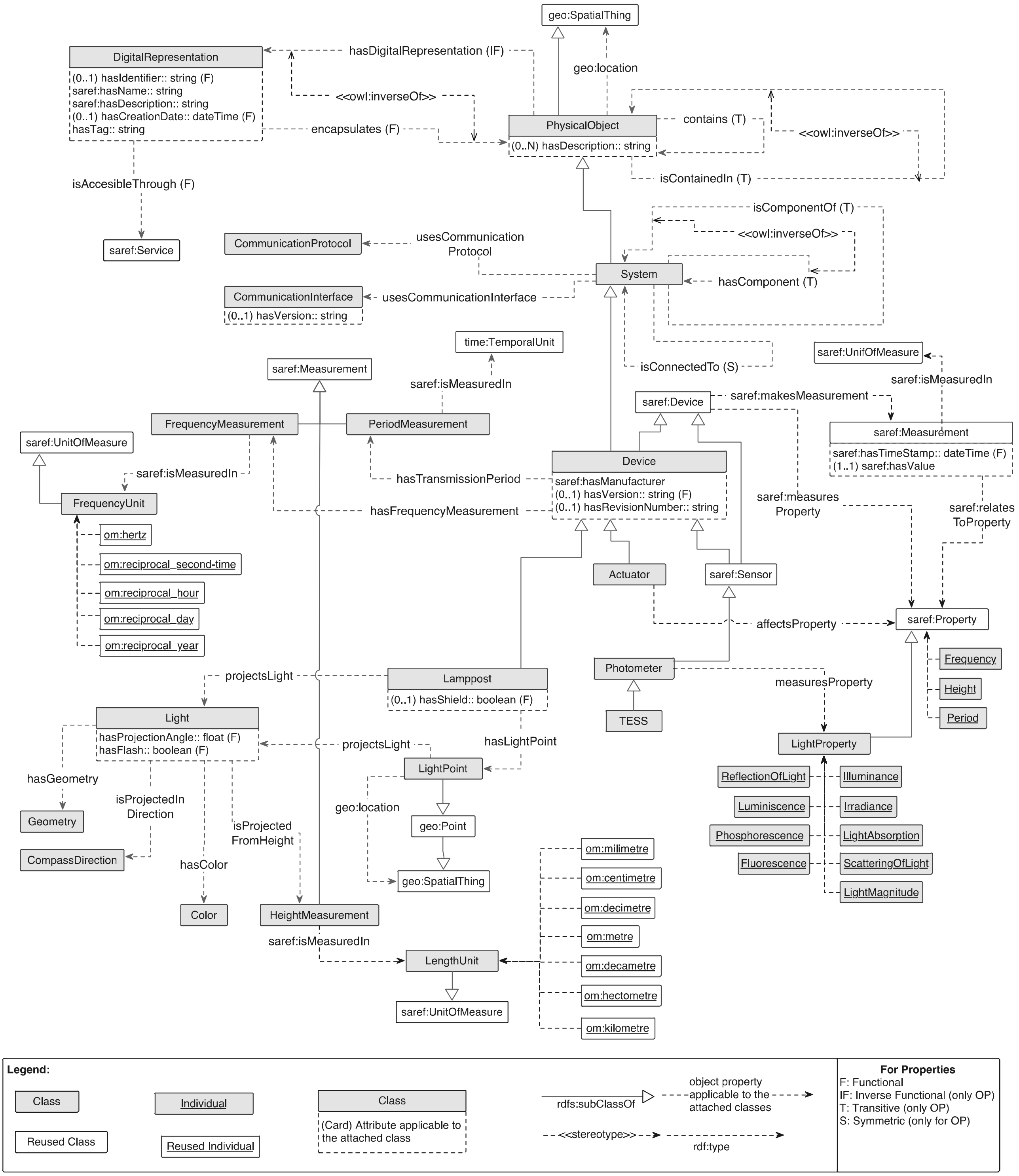

Figure 1: SAREF4ENVI overview

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.

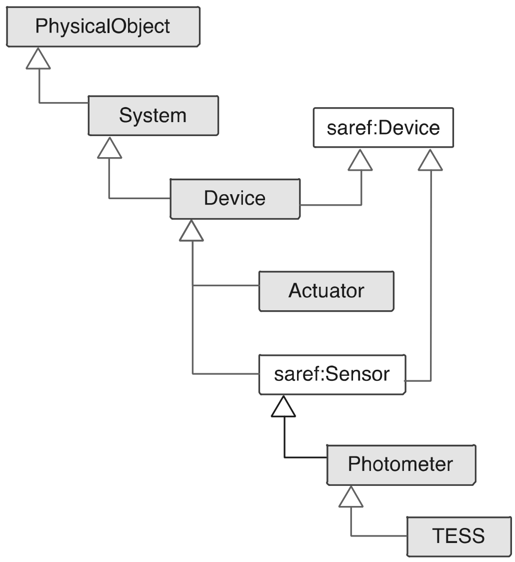

Figure 2: Physical Object hierarchy

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.

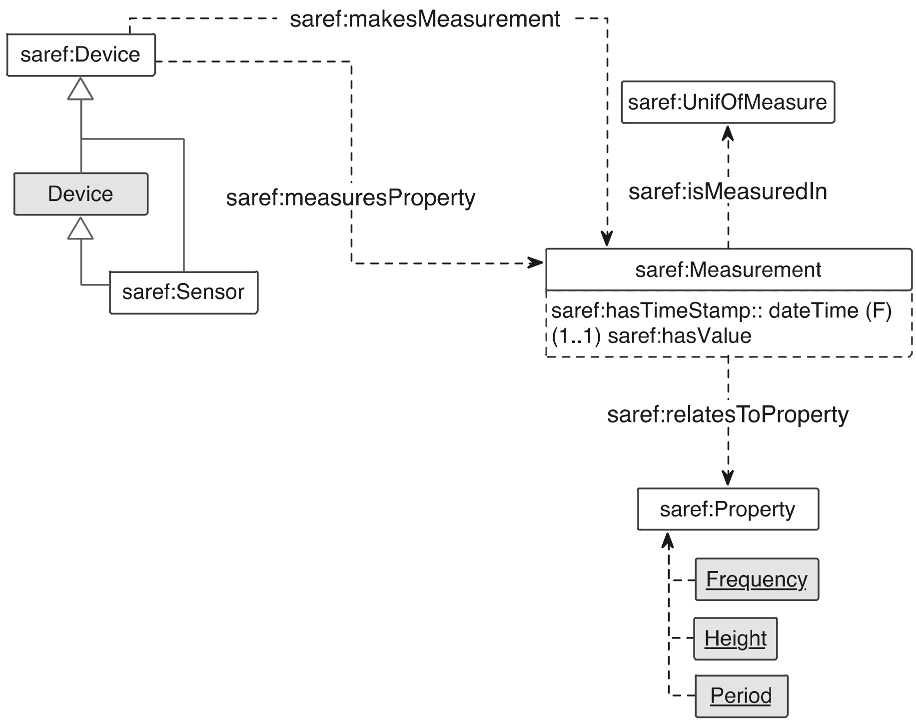

Figure 3: Sensor and measurement model

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.

4.2.4 Devices

Figure 4 represents the `s4envi:Device` class which is extended from `saref:Device`; therefore, the new class inherits the properties defined in the SAREF ontology for `saref:Device`, such as `saref:hasManufacturer`. In addition, the class has been complemented with the properties `s4envi:hasFrequencyMeasurement` and `s4envi:hasTransmissionPeriod` in order to model the frequency with which a device makes measurements and its period for transmitting such measurements. Both relationships are represented by n-ary relationships modelled by the classes `s4envi:FrequencyMeasurement` and `s4envi:PeriodMeasurement`, which are subclasses of `saref:Measurement`. The specific value for the frequency and the period is indicated by the datatype property `saref:hasValue` , which is inherited from the class `saref:Measurement.`

As the temporal units of measurement are already defined in SAREF by means of the class `time:TemporalUnit,` there has been no need for defining new units for `s4envi:PeriodMeasurement`. However, new units of measurement are needed to represent frequencies; therefore, `saref:UnitOfMeasure` class has been extended with the class `s4envi:FrequencyUnit`, including the main instances from the OM units of measurement ontology to measure frequency, such as `om:hertz`, `om:reciprocal_second-time`, `om:reciprocal_hour`, `om:reciprocal_day`, and `om:reciprocal_year`. It is worth noting that the user is free to use other units of measurement if required.

Finally, `s4envi:Actuator` has been added according to the domain expert requirements in order to represent devices that can act (`s4envi:affectsProperty`) over properties as shown in Figure 4.

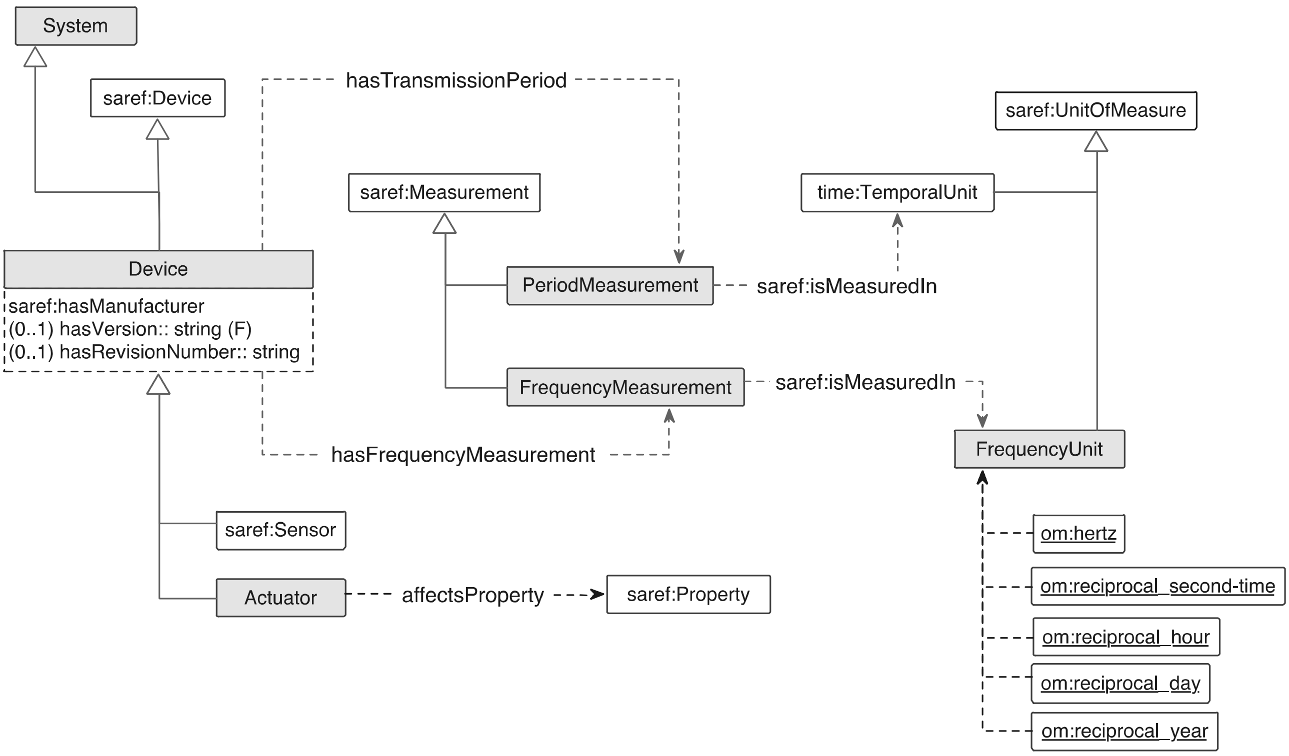

Figure 4: Device model

Table 4 summarizes the restrictions that characterize a `s4envi:Device`.

Table 4: Restrictions of the s4envi:Device class

Property	Definition
saref:hasManufacturer **only** xsd:string	Manufacturers of the device are represented only by xsd:string.
s4envi:hasFrequencyMeasurement **only** s4envi:FrequencyMeasurement	The frequency of a device for making measurements is represented only by instances of s4envi:FrequencyMeasurement.
s4envi:hasRevisionNumber **max** 1 xsd:string	A device can have one revision number at most.
s4envi:hasRevisionNumber **only** xsd:string	The revision number of a device is represented only by xsd:string.
s4envi:hasTransmissionPeriod **only** s4envi:PeriodMeasurement	The transmission period of a device is represented only by instances of s4envi:PeriodMeasurement.
s4envi:hasVersion **max** 1 xsd:string	A device can have one version at most.
s4envi:hasVersion **only** xsd:string	The version of a device is represented only by xsd:string.
s4envi:isContainedin **only** s4envi:PhysicalObject	A device can be contained in entities represented only by instances of s4envi:PhysicalObject.

Table 5 summarizes the restrictions that characterize a `s4envi:FrequencyMeasurement`.

Table 5: Restrictions of the s4envi:FrequencyMeasurement class

Property	Definition
saref:isMeasuredIn **exactly** 1 s4envi:FrequencyUnit	A frequency measurement should have exactly one unit of measurement which should be instance of saref:FrequencyUnit.
saref:relatesToProperty **value** s4envi:Frequency	A frequency measurement relates to a property represented by the instance s4envi:Frequency.

Table 6 summarizes the restrictions that characterize a `s4envi:PeriodMeasurement.`

Table 6: Restrictions of the s4envi:PeriodMeasurement class

Property	Definition
saref:isMeasuredIn **exactly** 1 time:TemporalUnit	A period measurement should have exactly one unit of measurement which should be instance of saref:TemporalUnit.
saref:relatesToProperty **value** s4envi:Period	A period measurement relates to a property represented by the instance s4envi:Period.

Table 7 summarizes the restrictions that characterize a `s4envi:Actuator`.

Table 7: Restrictions of the s4envi:Actuator class

Property	Definition
s4envi:affectsProperty **only** saref:Property	An actuator affects entities represented only by instances of saref:Property.

4.2.5 Systems and Physical Objects

As already observed in Figure 2, according to the requirements extracted from uses cases and domain experts, it was necessary to include more general information about systems and physical objects, which are superclasses of devices, in order to provide a general framework for representing communications, componency, and digital representations. This section focuses on these additional classes included in SAREF4ENVI that model how to access physical objects and their components.

Figure 5 represents the class `s4envi:System` and its properties. It can observed that a system can be composed of other systems and this is represented by the property `s4envi:hasComponent` and its inverse `s4envi:isComponentOf`. A system can also be connected to other systems, represented by the `s4envi:isConnectedTo` property.

The communication protocol and interface that a system might use are represented by the classes `s4envi:CommunicationProtocol` and `s4envi:CommunicationInterface`, respectively.

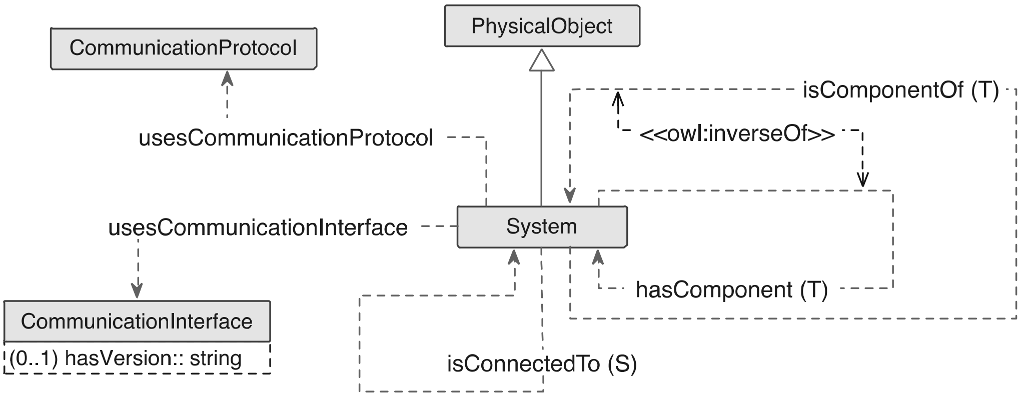

Figure 5: System model

Table 8 summarizes the restrictions that characterize a `s4envi:System.`

Table 8: Restrictions of the s4envi:System class

Property	Definition
s4envi:hasComponent **only** s4envi:System	A system can have as components entities represented only by instances of s4envi:System.
s4envi:isComponentOf **only** s4envi:System	A system can be component of entities represented only by instances of s4envi:System.
s4envi:isConnectedTo **only** s4envi:System	A system can be connected to entities represented only by instances of s4envi:System.
s4envi:usesCommunicationInterface **only** s4envi:CommunicationInterface	A system uses communication interfaces represented only by instances of s4envi:CommunicationInterface.
s4envi:usesCommunicationProtocol **only** s4envi:CommunicationProtocol	A system uses communication protocols represented only by instances of s4envi:CommunicationProtocol.

Table 9 summarizes the restrictions that characterize a `s4envi:CommunicationInterface`.

Table 9: Restrictions of the s4envi:CommunicationInterface class

Property	Definition
s4envi:hasVersion **max** 1 xsd:string	A communication interface can have one version at most.
s4envi:hasVersion **only** xsd:string	The version of a communication interface is represented only by xsd:string.

The model represented in Figure 6 supports the representation of services that allow the access to digital representations of a given physical object (e.g. devices, sensors, etc.). The main entity in this model is `s4envi:PhysicalObject` that represents a general class for devices and systems and any other entity with a physical representation in order to make the model extensible to other domains. Such object can have digital representations (`s4envi:DigitalRepresention`) that can be accessed through services (`saref:Service`).

In addition, the digital representation can be linked back to the physical object that it encapsulates by means of the property `s4envi:encapsulates`, defined as inverse of `s4envi:hasDigitalRepresentation`. It is worth noting that `s4envi:hasDigitalRepresentation` is defined as inverse functional since a digital representation can encapsulate only one object.

Finally, the relation between a physical object and its location is represented by the reused property `geo:location`. In addition, `s4envi:PhysicalObject` is declared to be subclass of `geo:SpatialThing`.

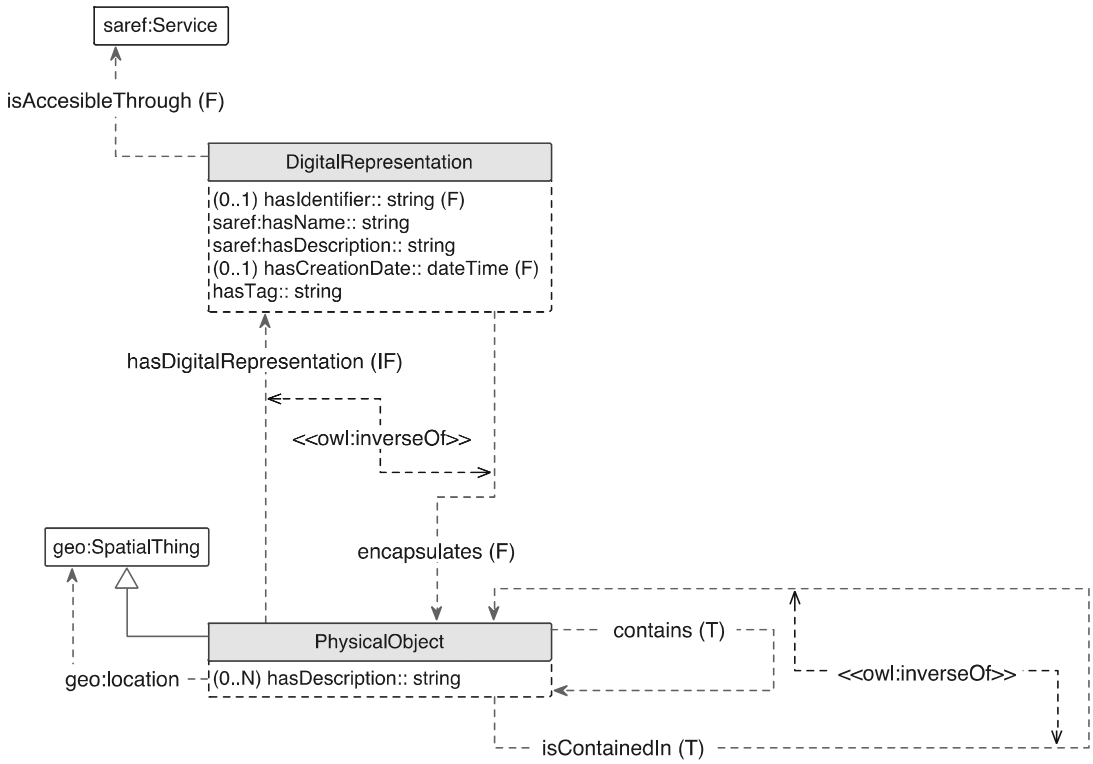

Figure 6: Physical object and digital representation model

Table 10 summarizes the restrictions that characterize a `s4envi:DigitalRepresentation.`

Table 10: Restrictions of the s4envi:DigitalRepresentation class

Property	Definition
s4envi:encapsulates **only** s4envi:PhysicalObject	A digital representation encapsulates objects represented only by instances of s4envi:PhysicalObject.
s4envi:hasCreationDate **max** 1 xsd:dateTime	A digital representation can have one creation date at most.
s4envi:hasCreationDate **only** xsd:dateTime	The value of a creation date is represented only by xsd:dateTime.
hasDescription **only** xsd:string	The value of a description is represented only by xsd:string.
s4envi:hasIdentifier **max** 1 xsd:string	A digital representation can have one identifier at most.
s4envi:hasIdentifier **only** xsd:string	The value of an identifier is represented only by xsd:string.
saref:hasName **only** xsd:string	The value of a name is represented only by xsd:string.
s4envi:hasTag **only** xsd:string	The value of a tag is represented only by xsd:string.
s4envi:isAccesibleThrough **only** saref:Service	A digital representation is accessible through entities represented only by instances of saref:Service.

Table 11 summarizes the restrictions that characterize a `s4envi:PhysicalObject`.

Table 11: Restrictions of the s4envi:PhysicalObject class

Property	Definition
s4envi:contains **only** s4envi:PhysicalObject	A physical object contains entities represented only by instances of s4envi:PhysicalObject.
saref:hasDescription **only** xsd:string	The value of a description is represented only by xsd:string.
s4envi:hasDigitalRepresentation **only** s4envi:DigitalRepresentation	A physical object has a digital representation represented only by instances of s4envi:DigitalRepresentation.
geo:location **only** geo:SpatialThing	A physical object can be located only at entities represented by instances of geo:SpatialThing.

4.2.6 Photometers

A photometer, in general, is an instrument that measures light intensity or optical properties of solutions or surfaces. In general a `s4envi:Photometer` is an entity that observes some `s4envi:LightProperty`, in a way of paraphrasing the axiom shown in Figure 7. In such figure, it can also be observed that a particular case of photometer is a `s4envi:TESS` (Telescope Encoder and Sky Sensor). It is worth noting that other particular photometers could be added by extending the `s4envi:Photometer` class when reusing this extension.

Furthermore, Figure 7 also shows the main light properties that can be observed by a photometer. These properties are represented as instances, for example `s4envi:Luminiscence`, of the class `s4envi:LightProperty`.

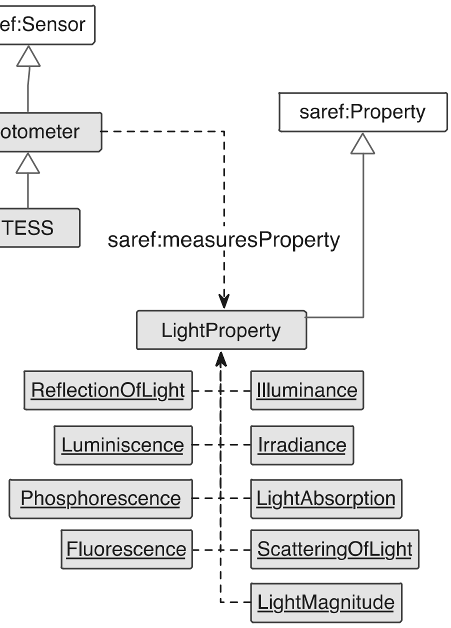

Figure 7: Photometer and light property model

Table 12 summarizes the restrictions that characterize a `s4envi:Photometer.`

Table 12: Restrictions of the s4envi:Photometer class

Property	Definition
saref:measuresProperty **some** s4envi:LightProperty	A photometer should measure some entity represented by an instance of the class s4envi:LightProperty.

4.2.7 Lampposts, Light Points and Light

Figure 8 represents the model to represent lampposts and their possible light points using the classes `s4envi:Lamppost` and `s4envi:LightPoint`. It can also be indicated that a lamppost can have one or more light points by using the `s4envi:hasLightPoint` object property.

In this model both lampost and light points are allowed to be agents that project light (represented by the property `s4envi:projectsLight`). In this sense, one lamppost could directly project light or in a more complex scenario a lamppost could have different light points being these light points in charge of projecting the light.

Finally, `s4envi:LightPoint` has been defined as subclass of `geo:Point` as it is a point located in a given space and it can inherit the mechanism to express its latitude, altitude and longitude from `geo:Point`.

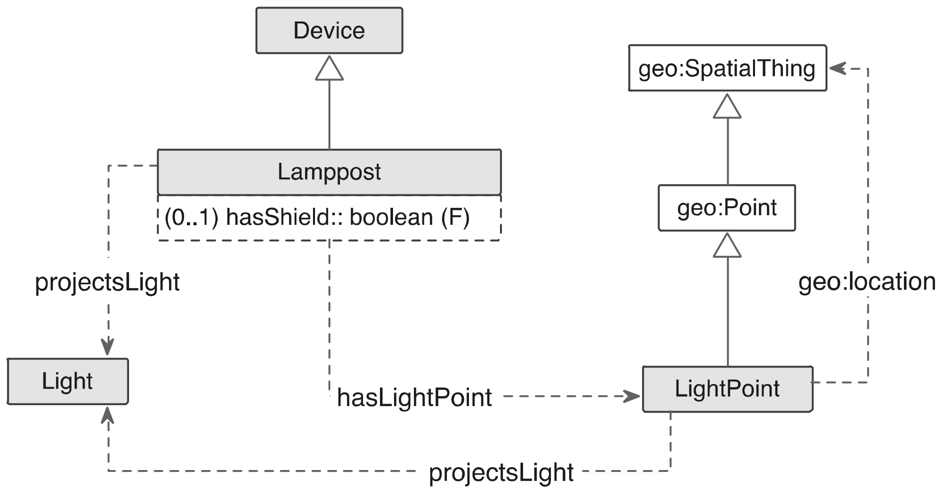

Figure 8: Lamppost and light point model

Table 13 summarizes the restrictions that characterize a `s4envi:Lamppost`.

Table 13: Restrictions of the s4envi:Lamppost class

Property	Definition
s4envi:hasLightPoint **only** s4envi:LightPoint	A lamppost has as light points entities represented only by instances of s4envi:LightPoint.
s4envi:hasShield **only** xsd:boolean	The value of a whether a lamppost has a shield is represented only by xsd:boolean.
s4envi:projectsLight **only** s4envi:Light	A lamppost projects lights that are represented only by instances of s4envi:Light.

Table 14 summarizes the restrictions that characterize a `s4envi:LightPoint`.

Table 14: Restrictions of the s4envi:LightPoint class

Property	Definition
geo:location **only** geo:SpatialThing	A light point can be located only at entities represented by instances of geo:SpatialThing.
s4envi:projectsLight **only** s4envi:Light	A light point projects lights that are represented only by instances of s4envi:Light.

The model depicted in Figure 9 represents the light characteristics. It can be observed that a light is projected in a certain angle, in a given direction and from a given height, represented by the properties `s4envi:hasProjectionAngle` (datatype property), `s4envi:isProjectedInDirection` (object property) and `s4envi:isProjectedFromHeight` (object property), respectively.

The angle is represented by a float indicating the degrees of the cone of light that the light emits. Besides, the direction can be represented by instances of the class `s4envi:CompassDirection` that could represent values such as North, South, Northwest, etc.

The height from which a light is projected is modelled as a subclass of `saref:Measurement`, namely `s4envi:HeightMeasurement`, as in this case it is necessary to indicate the value of such measure, inherited from `saref:Measurement`, and the unit of measurement used. That is, an n-ary pattern is used here.

The colour of the light emitted is represented by the objet property `s4envi:hasColor` and its values should be instantiated as individuals of the class `s4envi:Color`. Similarly, the geometry of a light can be indicated by means of the `s4envi:hasGeometry` object property and its values would belong to the class `s4envi:Geometry`.

Finally, it could be indicated whether a light has a flash by using the `s4envi:hasFlash` datatype property.

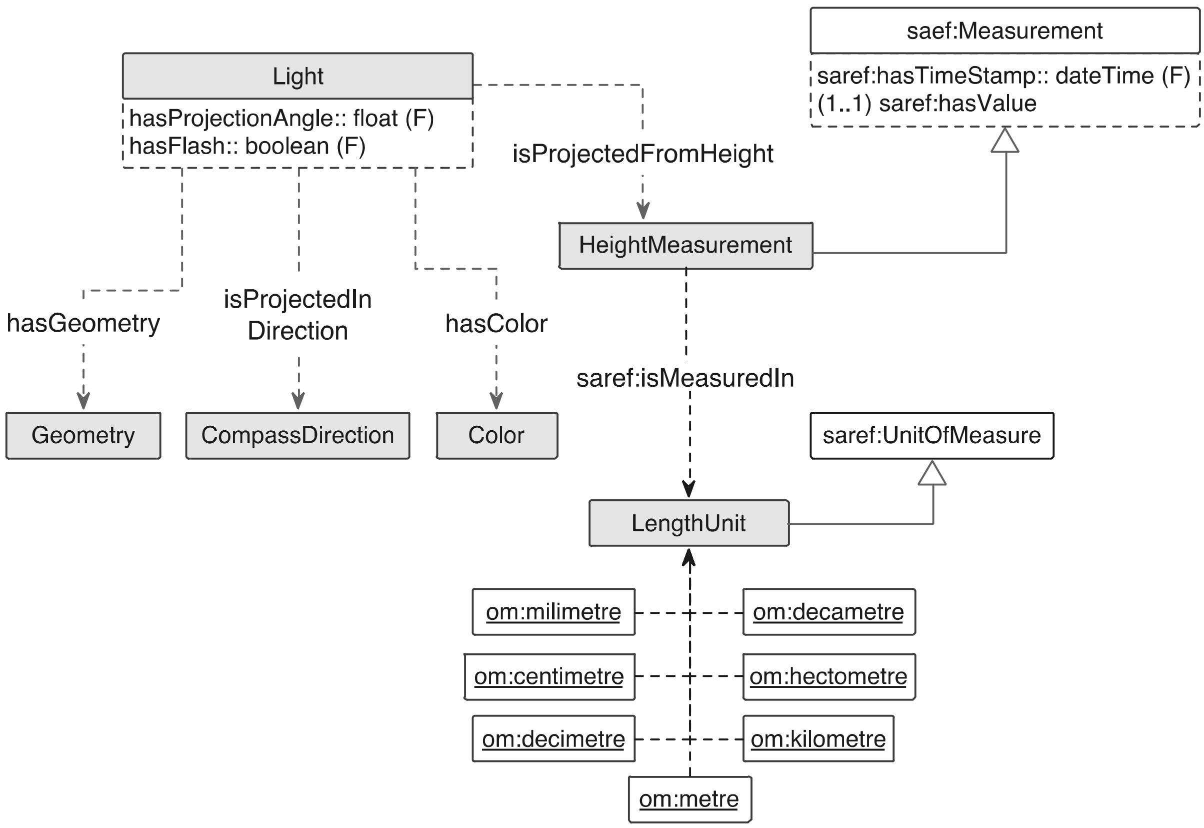

Figure 9: Light model

Table 15 summarizes the restrictions that characterize a `s4envi:Light`.

Table 15: Restrictions of the s4envi:Light class

Property	Definition
s4envi:hasColor **only** s4envi:Color	A light can have a colour represented only by instances of s4envi:Color.
s4envi:hasFlash **only** xsd:boolean	The value of a whether a light has flash is represented only by xsd:boolean.
s4envi:hasGeometry **only** s4envi:Geometry	A light can have a geometry represented only by instances of s4envi:Geometry.
s4envi:hasProjectionAngle **only** xsd:float	The value of the projection angle of a light is represented only by xsd:float.
s4envi:isProjectedFromHeight **only** s4envi:HeightMeasurement	The height from which a light is projected is represented only by instances of the class s4envi:HeightMeasurement.
s4envi:isProjectedInDirection **only** s4envi:CompassDirection	The direction in which a light is projected is represented only by instances of the class s4envi:ComprassDirection.

4.3 Observations about SAREF4ENVI

In the following, several observations about potential uses of the SAREF4ENVI ontology are listed.

First of all, it is worth reminding here that a TESS is an example of a particular photometer, other photometers could be included by extending the class `s4envi:Photometer`.

In addition, in order to include other physical objects or devices related to environmental measurements in other use cases, the different classes included in the ontology could be extended. For example, `s4envi:Photometer` should be extended to represent CO_2 sensors; in that case, the `saref:Property` hierarchy should be extended with the properties that CO_2 sensors might measure following the guidelines presented in this extension.

Annex A (informative): Approach

The approach followed to develop the SAREF4ENVI extension was a mix of approaches:

a) bottom-up in the sense that new models have been developed from a set of requirements and data taken from domain experts and users (as explained in ETSI TR 103 411 [i.1]); and

b) top-down in the sense that the ontology development has been driven by an already existing ontology which defines top concepts and relations that should be extended for a particular domain.

Following the process defined in ETSI TR 103 411 [i.1], ontological engineers analysed the documentation ([i.2] and [i.3]) and data provided from ontology users (in this case software developers) and experts in the light pollution domain through different interviews with them. After that, a first version of the potential requirements for building the ontology was produced. Ontology engineers refined such requirements together with the domain experts and users in order to obtain a stable version, by means of on-line and face-to-face meetings. These iterations were in some cases also needed once the ontology was being implemented in order to check whether the modelling decisions taken by ontology engineers were correct.

As mentioned, SAREF concepts have been extended when they needed to be specialized and properties from SAREF have also been reused. In addition, other ontologies have been reused following the SAREF practices. More precisely the following classes have been extended:

- saref:Device with s4envi:Device
- saref:UnitOfMeasure with s4envi:FrequencyUnit and s4envi:LengthUnit
- geo:SpatialThing with s4envi:PhysicalObject
- geo:Point with s4envi:LightPoint

The following classes and properties have also been directly reused:

- saref:Service
- time:TemporalUnit
- saref:hasName
- saref:hasDescription
- saref:isMeasuredIn
- saref:hasManufacturer
- geo:location
- 12 instances from the OM ontology to represent units of measurement

As already commented some entities firstly defined in the SAREF4ENVI and SAREF4BLDG extensions have been included into SAREF 2.0 and now are directly reused, namely:

- saref:Measurement
- saref:makesMeasurement
- saref:measuresProperty
- saref:relatesToProperty

Annex B (informative): Bibliography

- ETSI TS 103 264: "SmartM2M; Smart Appliances; Reference Ontology and oneM2M mapping".
- ETSI TS 103 267: "SmartM2M; Smart Appliances; Communication Framework".
- ETSI TS 102 689: "Machine-to-Machine communications (M2M); M2M Service Requirements".
- ETSI TS 118 101: "oneM2M; Functional Architecture (oneM2M TS-0001)".
- ETSI TS 118 102: "oneM2M; Requirements (oneM2M TS-0002)".

History

Document history		
V1.1.1	January 2017	Publication