

SAREF tutorial

- Hedge-IoT WP4 Semantic Interoperability

- 25 March 2025

Cornelis Bouter, Roderick van der Weerdt, Laura Daniele

Outline

- Introduction to SAREF
- Methodology
- SAREF overview
- Specific SAREF classes
 - Graphs
 - Examples
 - Interactive learning moment
- References and further reading

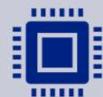
What you will learn

- What is SAREF
- How to use SAREF (methodology)
- Where to find SAREF and its documentation
- What are the main concepts specified in SAREF (core module)
- How to relate the core elements of your pilot's data to SAREF core main concepts
- How to interpret a simple SAREF knowledge graph (ontology + data) made of nodes (things) and edges (relationships between things)
- Bonus: read SAREF triples (subject, predicate, object) that represent nodes and edges in a SAREF knowledge graph

What is SAREF?



Smart Applications REference ontology



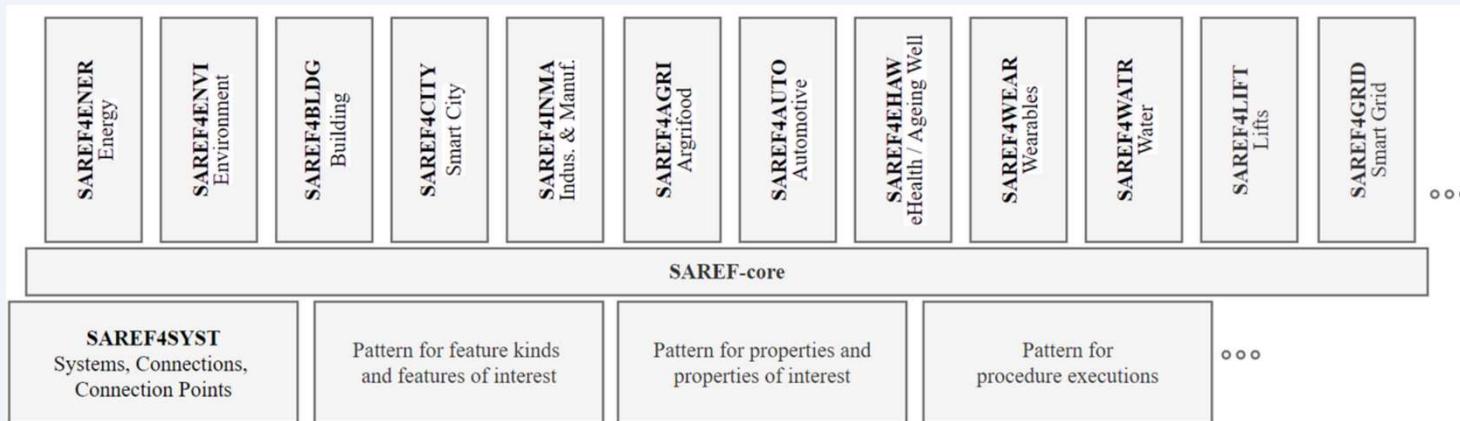
A **modular framework of ontologies** that facilitates interoperability among IoT devices and applications



An **open standard** developed, maintained and evolved by ETSI (European Telecommunications Standards Institute) at <https://saref.etsi.org/>

SAREF as a modular framework

- It comprises a generic **core ontology** for IoT and 12 **domain-specific extensions**, including SAREF for Energy, Smart Grid and Buildings



Why SAREF

1

Interoperability:
Enables different IoT devices and systems to communicate effectively

2

Standardization:
Provides a common framework for IoT solutions that is standardized with well-established governance

3

Industry Adoption:
Widely adopted by various industry sectors for smart applications and deployed in real world applications

4

Policy: Used as basis for regulation in Europe, for example EU Code of Conduct for Energy Smart Appliances manufacturers

Technological fundamental principles

1

Reuse and alignment: leverages existing concepts from other ontologies

2

Modularity: ability to separate and recombine (different parts of) the ontology framework based on specific needs

3

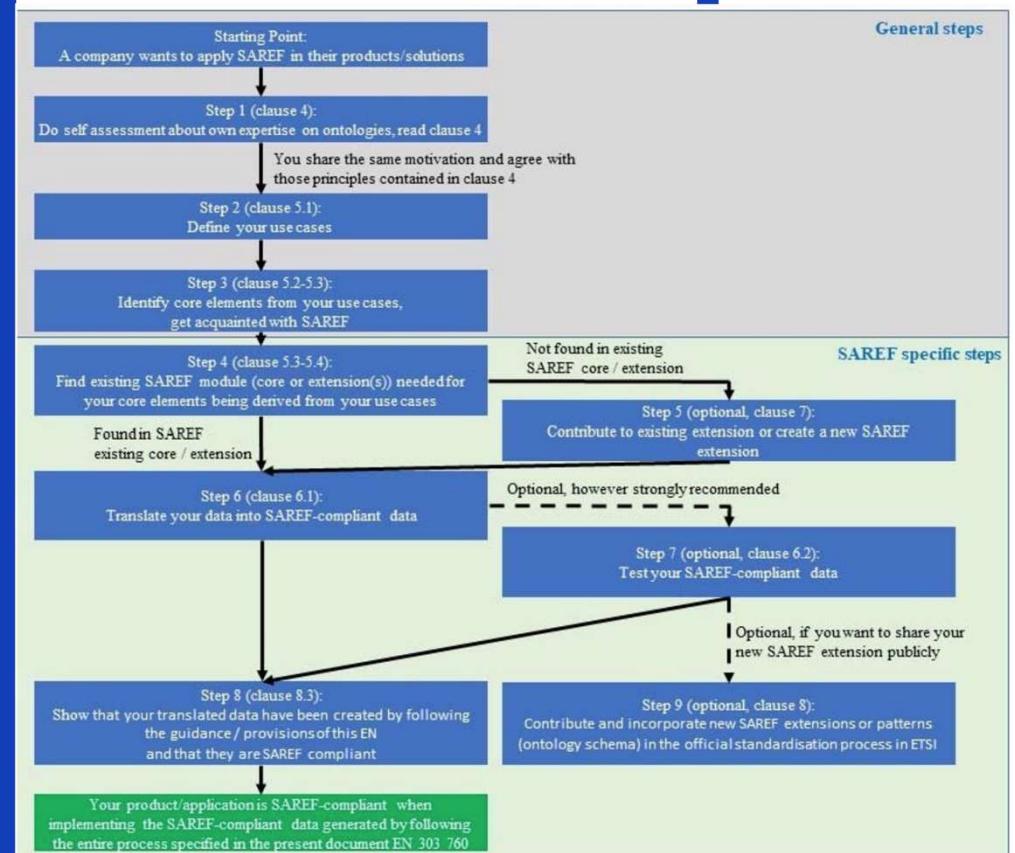
Extensibility: ability to expand and grow over time to accommodate new requirements and changes in various domains

4

Type-token distinction: differentiation between class (type) of objects, individual instances (tokens), generic catalogues and specific entities

How to use and extend SAREF

- ETSI EN 303 760 provides guidelines to develop, apply and evolve Smart Applications ontologies for IoT Semantic Interoperability
- For Hedge-IoT partners interested in using and applying SAREF in their pilots:
 - Step 2 (use case definition): already done in the SUCs
 - Steps 3 & 4: part of current T4.3 activities (including this tutorial)
 - Step 6: part of upcoming T4.3 activities
 - Step 7: nice to have, but optional
 - Steps 5 & 9: in case we discover that some important concepts for Hedge-IoT SUCs are missing in SAREF and want to contribute them to ETSI for standardization



Source: ETSI EN 303 760 V1.1.1 (2024-10) Figure4-1

https://www.etsi.org/deliver/etsi_en/303700_303799/303760/01.01.01_60/en_303760v010101p.pdf

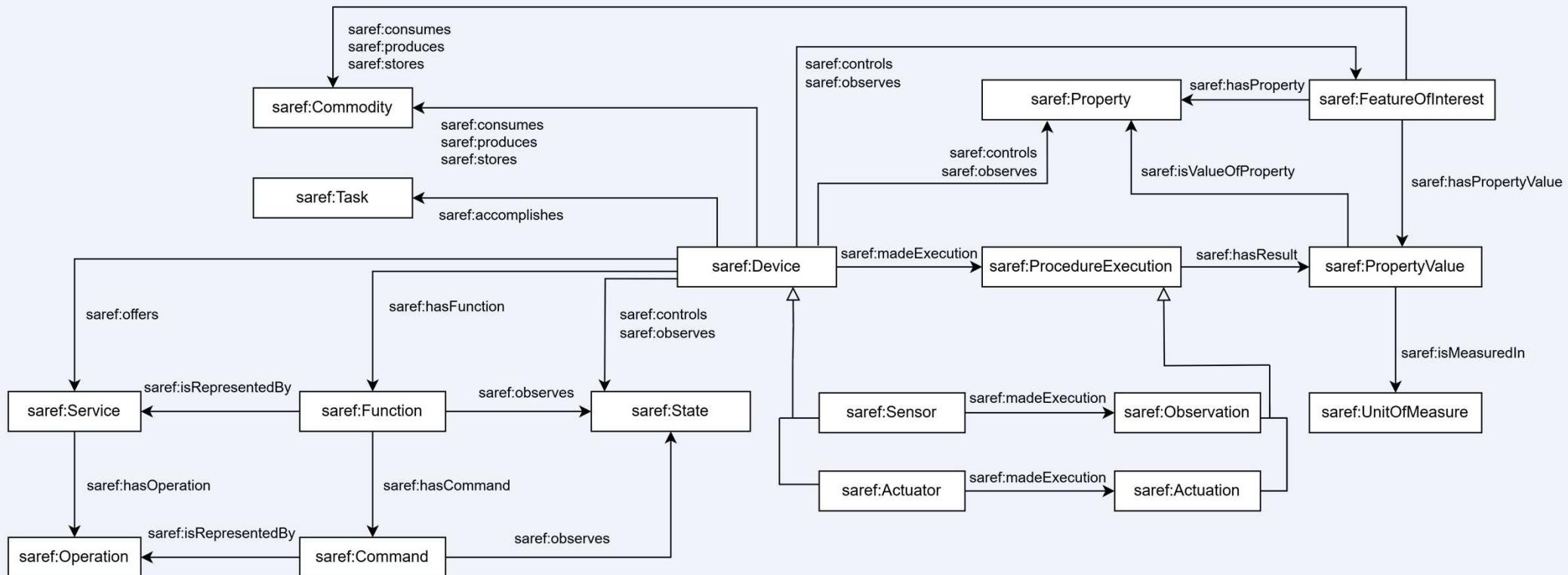
SAREF core

Overview

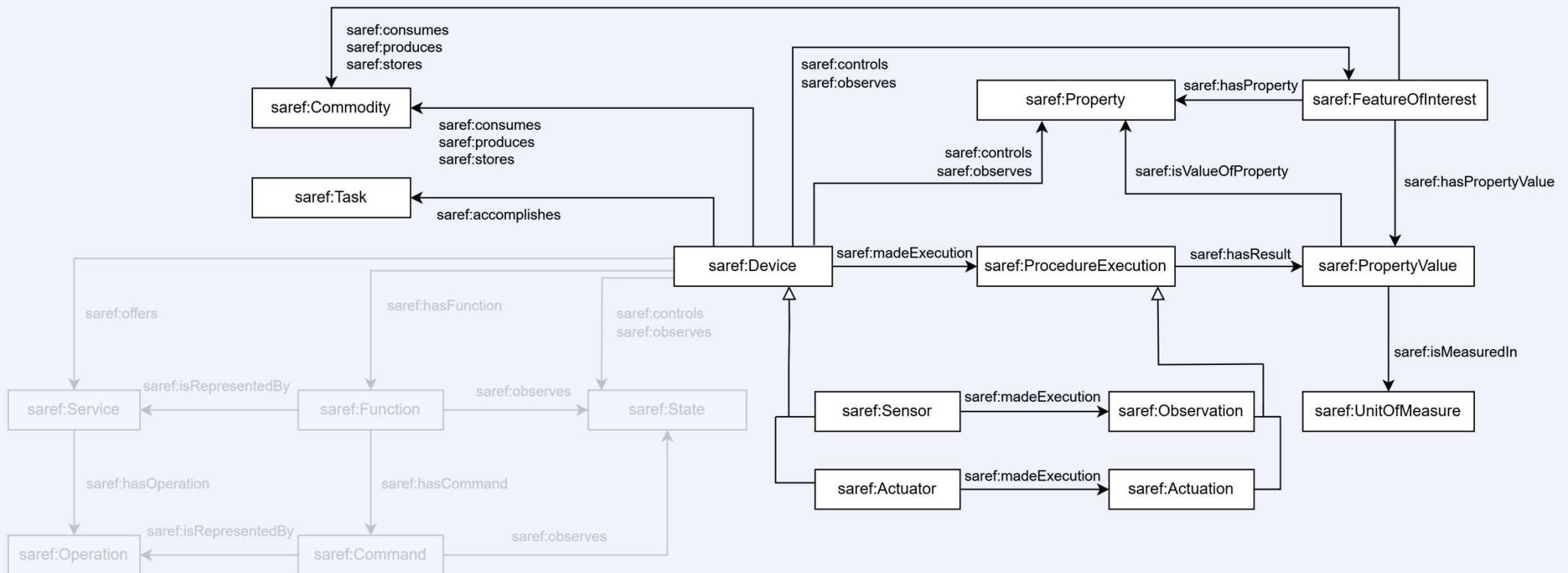
IMPORTANT: website documentation at
<https://saref.etsi.org/core> to be
updated to v4.1.1 (coming soon)

Current version, just released: SAREF core V4.1.1 (March 2025)

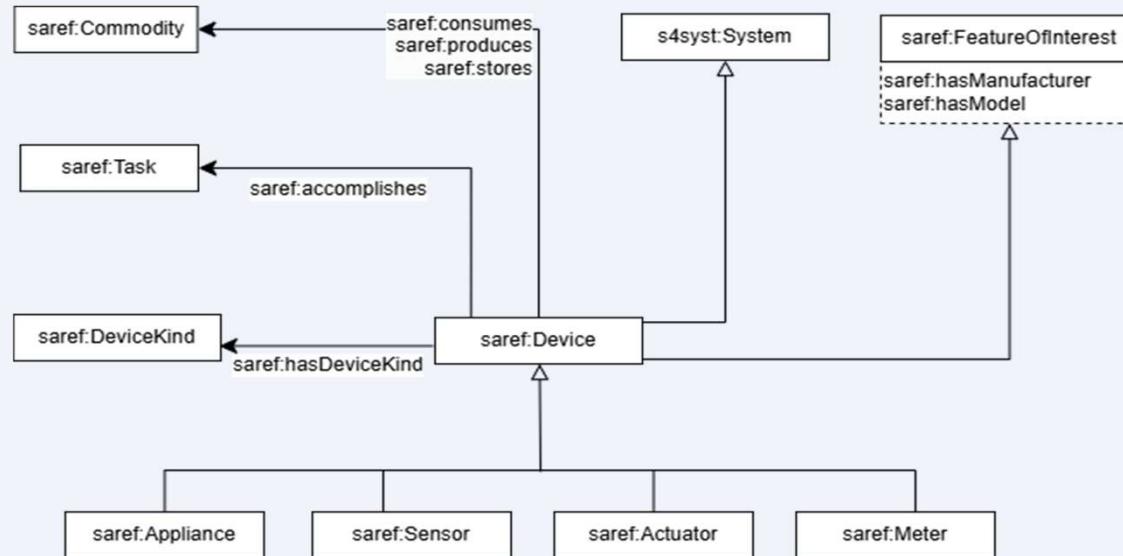
https://www.etsi.org/deliver/etsi_ts/103200_103299/103264/04.01.01_60/ts_103264v040101p.pdf



Focus of this tutorial



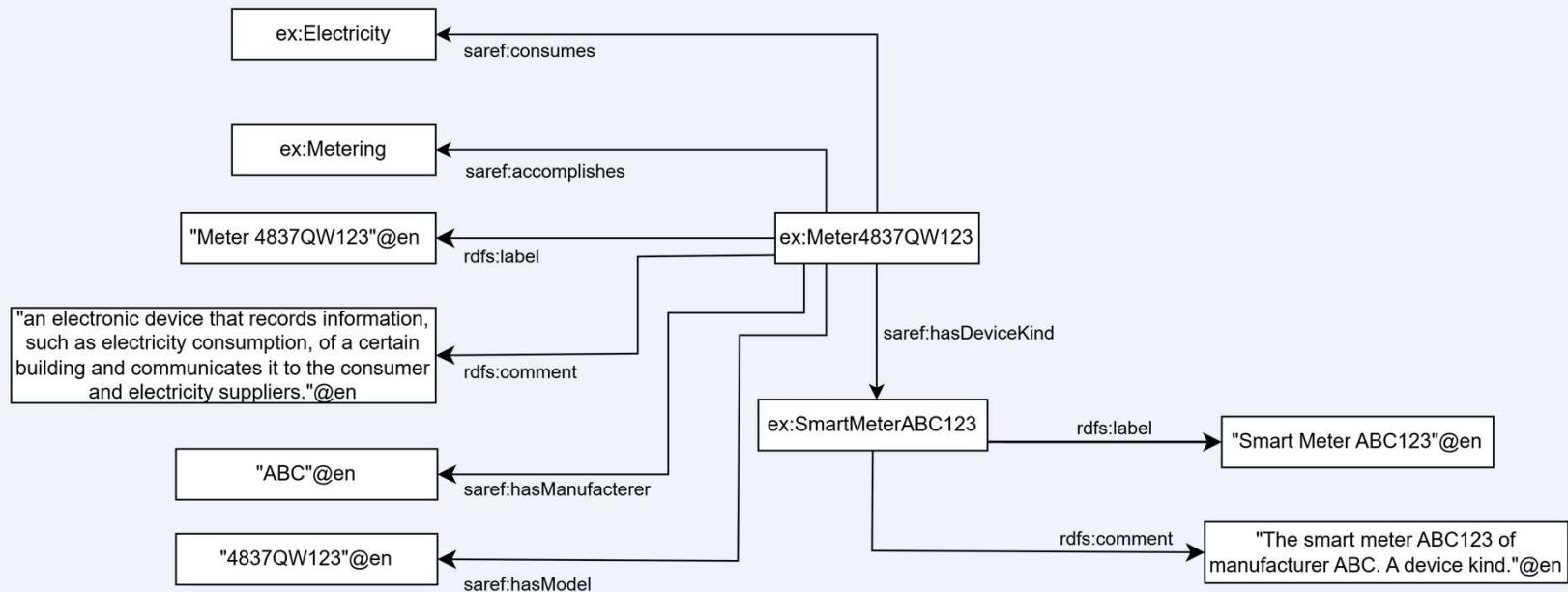
Device



Device

Concept	Definition	Example
saref:Device (specific)	It represents any tangible object designed to accomplish a particular task by performing one or more functions. An instance of saref:Device represents one specific real-world entity.	Sensors, actuators, white goods, meters
saref:Appliance	The class of devices designed to accomplish a particular task for occupant use. It consumes, produces, or stores, some commodity.	Washing machine, dryer, heat pump
saref:Sensor	A device designed to observe and measure one or more properties or states of one or more features of interest.	Temperature sensor, CO2 sensor, accelerometer sensor
saref:Actuator	A device designed to control one or more properties or states of one or more features of interest.	Light switch, doors/blinds opener, start/stop EV charger
saref:Meter	A device designed to observe and additionally do some computation and/or display one or more properties or states of one or more features of interest.	Electricity meter, gas meter, water meter
saref:Task	It represents goals for which a device is designed, from a user perspective	Cleaning, metering, comfort, entertainment
saref:Commodity	It represents marketable items which may be supplied without qualitative differentiation. Commodities may be consumed, produced, or stored, by some feature of interest or device.	Energy, Gas, Coal, Water
saref:DeviceKind (generic)	It allows to describe kinds of devices, with common properties and common states having the same value, and with common functions and services. Devices kinds may be used to describe models of devices in online catalogues.	Smart meter series 123 from manufacturer ABC, washing machine series iYZ from manufacturer DEF
s4syst:System	The class of systems, i.e., systems virtually isolated from the environment, whose behaviour and interactions with the environment are modeled. Systems can be connected to other systems. Systems can also have subsystems.	Energy Management System (EMS), Building Management System (BMS), but also a washing machine is a system itself (depending on the granularity one wants to look at it)

Device - smart meter

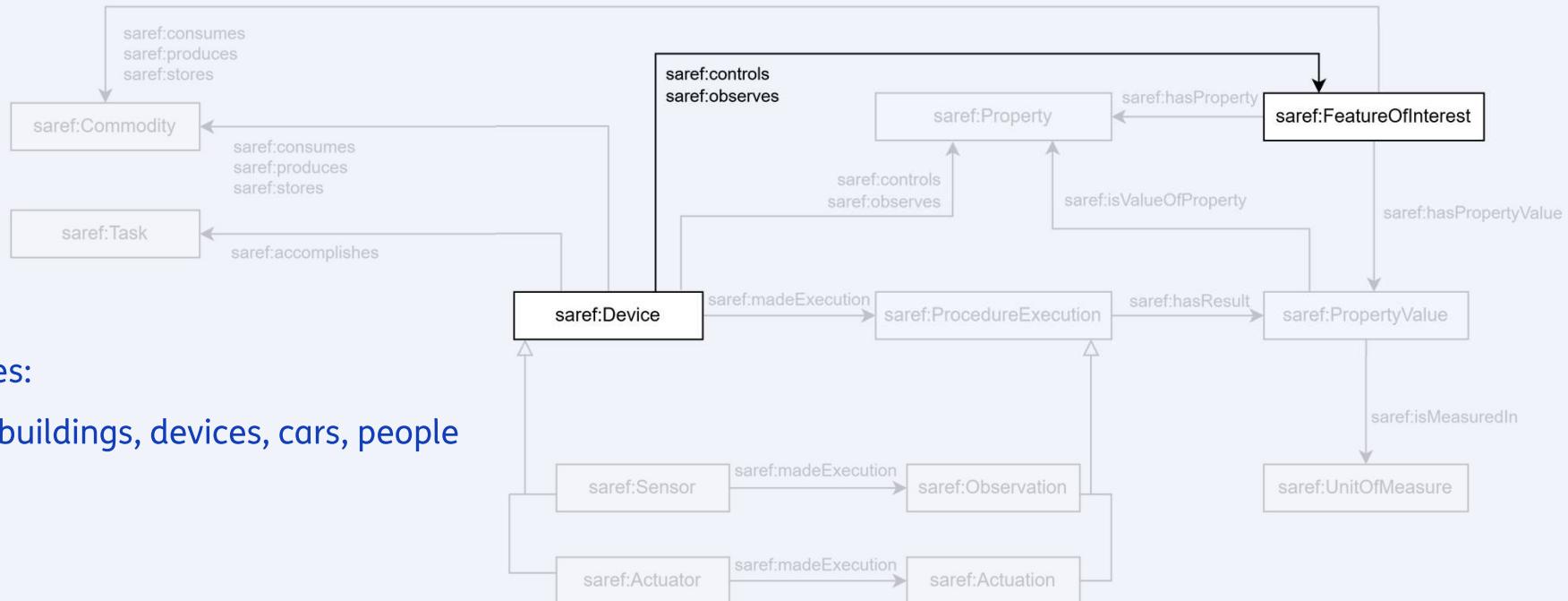


Interactive moment

- What type of devices/systems do you use in your pilots? Please list your devices in the chat of the meeting.

Pilot	Type of Devices	Type of Systems
Netherlands	electricity meters, gas meters, solar panels, EV charging stations, heat pumps	Energy Management System (EMS), Building Management System (BMS)
Portugal		
Italy		
Greece		
Finland		
Slovenia		

Feature of Interest



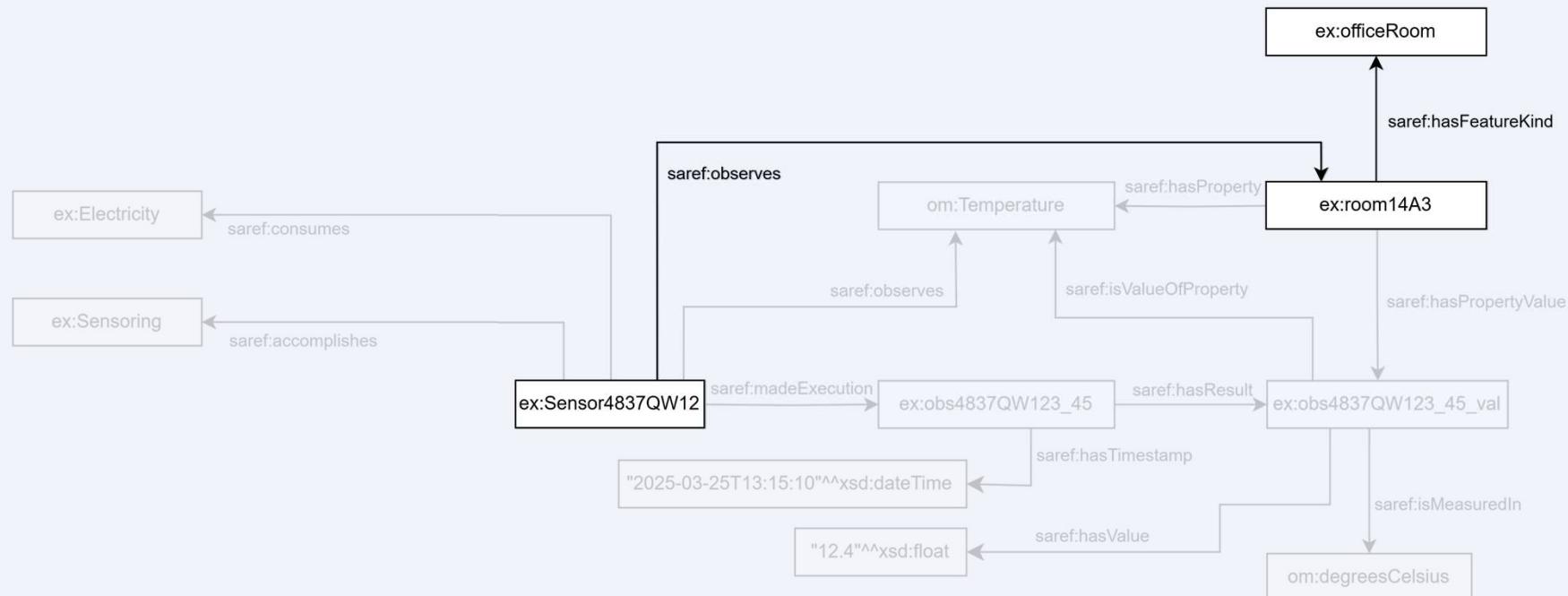
Examples:

Rooms, buildings, devices, cars, people

Feature of Interest

Concept	Definition	Examples
saref:FeatureOfInterest (specific)	It represents any real world entity from which a property or a state may be acted upon, such as observed and controlled. An instance of saref:FeatureOfInterest represents one specific real-world entity.	A certain building (e.g., Building 14) at the Arnhems Buiten electricity campus
		A certain room (e.g., Room A3 of Building 14) at the Arnhems Buiten electricity campus
		A certain window (e.g., Window 5 of Room A3 in Building 14) at the Arnhems Buiten electricity campus
saref:FeatureKind (generic)	This class has been introduced (from SAREF V3.2.1 onwards) for the prototypical description of features of interest that can populate online taxonomies, vocabularies, and catalogues.	The kind of windows with dimension 1000x2000mm, such as the Window 5 installed in Room A3 of Building 14 at the Arnhems Buiten electricity campus

Feature of Interest

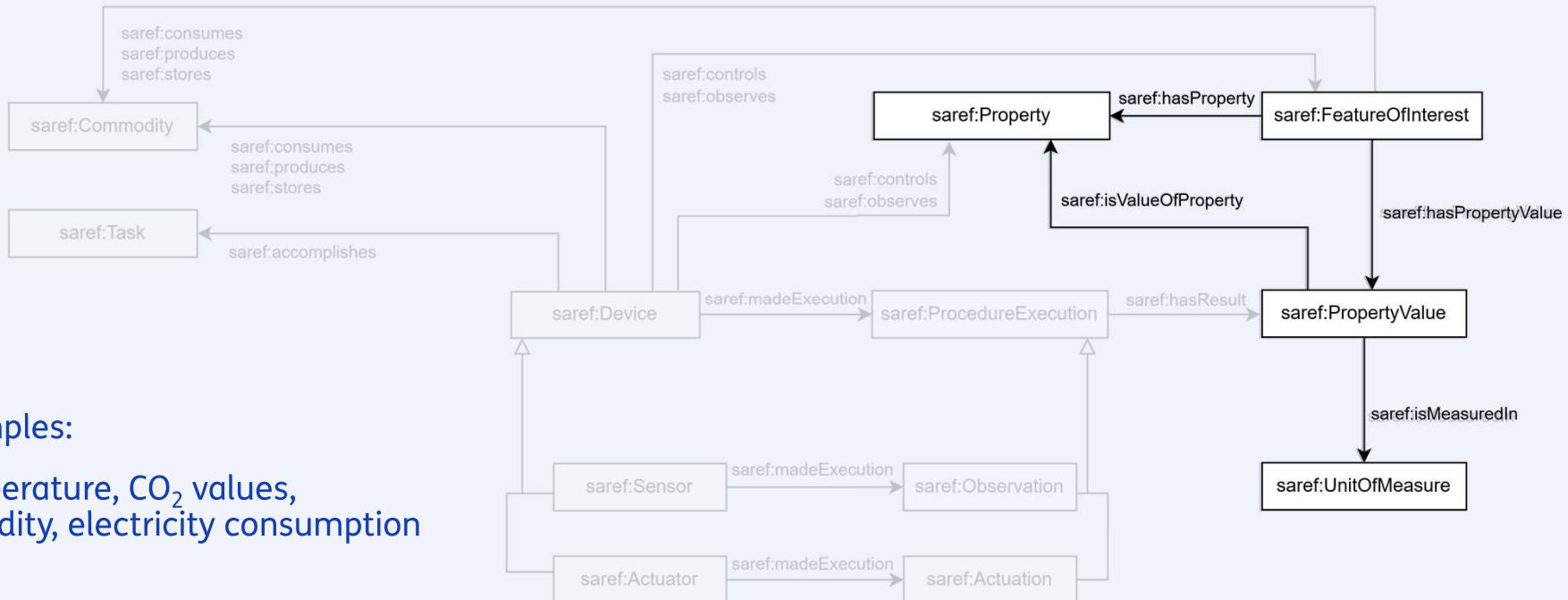


Interactive moment

- What type of Features of Interest do you use in your pilots? Please list your Features of Interest in the chat of the meeting.

Pilot	Type of Feature Of Interest
Netherlands	Buildings, solar panels, parking spots, metering points
Portugal	
Italy	
Greece	
Finland	
Slovenia	

Property



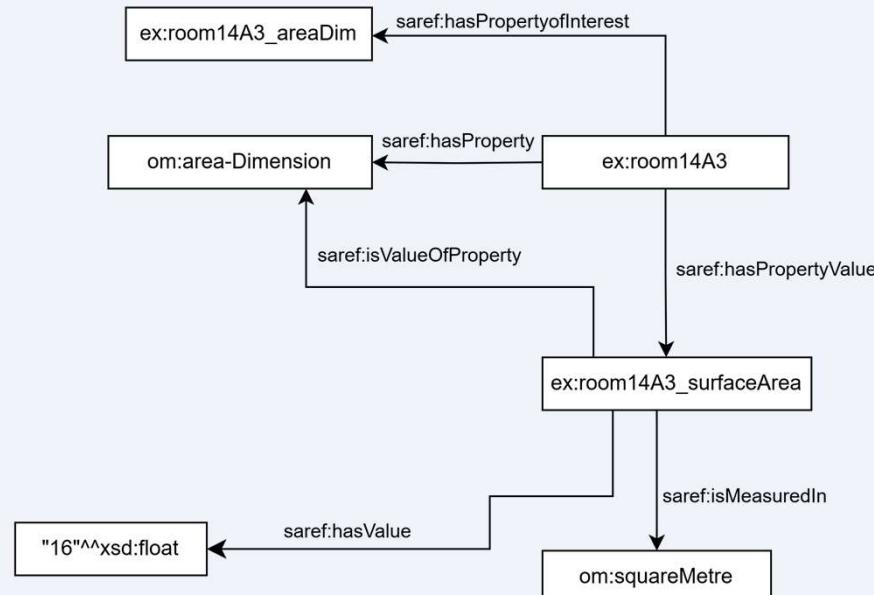
Examples:

Temperature, CO₂ values,
humidity, electricity consumption

Property

Concept	Definition	Example
saref:Property (generic)	It represents identifiable qualities or features of interest that can be acted upon by devices, such as being observed or controlled. Properties can apply to different features of interest.	Temperature as physical property that quantitatively expresses the degree of hotness or coldness of an object or substance
		Surface as the area that defines the extent of an object's exterior
saref:PropertyOfInterest (specific)	It represents specific properties that are linked to a particular feature of interest.	Room temperature, as the temperature (property) specific to a room (feature of interest)
		Body temperature, as the temperature (property) specific to a person (feature of interest)
		Room size, as the surface (property) of a room (feature of interest)
saref:PropertyValue	It describes the value of a property.	<p>22.7 36.2 16</p>  <p>Important: values without unit of measures lead to misinterpretation!</p>
saref:UnitOfMeasure	The unit used for measuring a property.	Temperature can be measured using various scales, such as Celsius (°C), Fahrenheit (°F), and Kelvin (K)
		Surface area can be measured in square meters (m ²)
		Power can be measured in watt (W) or horsepower (hp)

Property

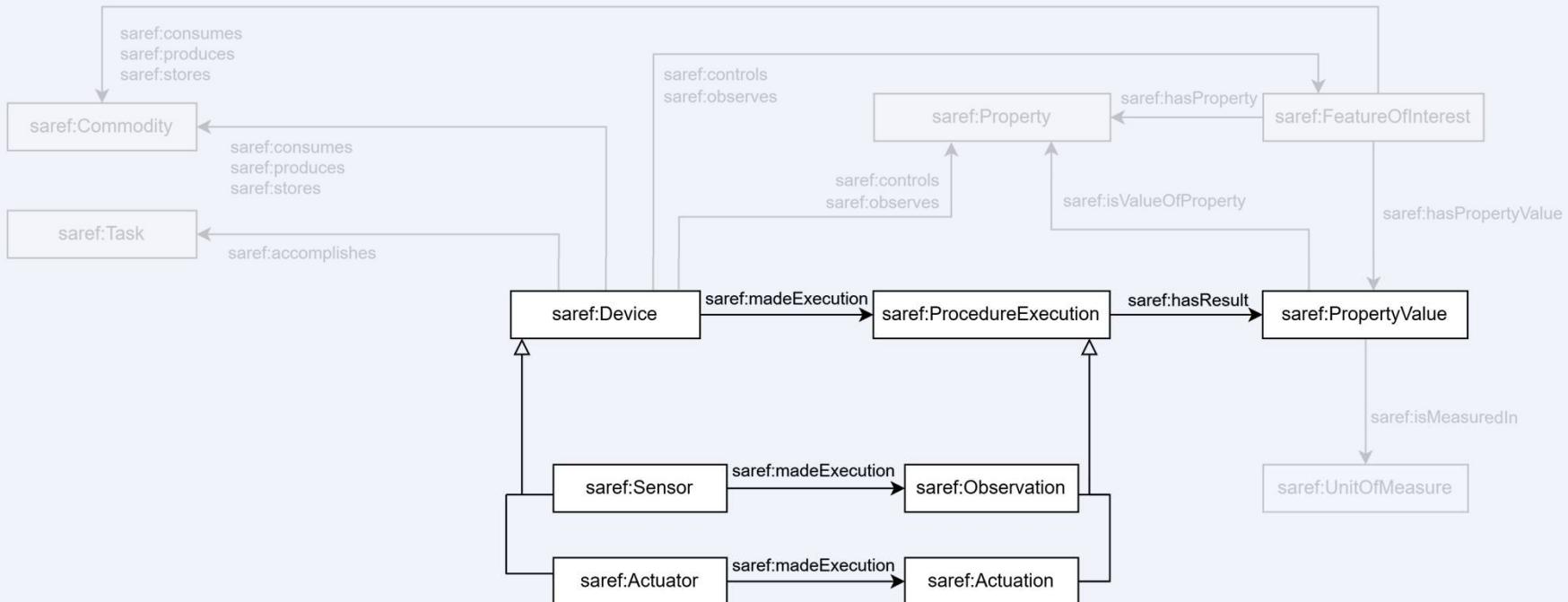


Interactive moment

- What type of properties do you use in your pilots? Please list your properties in the chat of the meeting.

Pilot	Type of Properties
Netherlands	Energy, temperature, gas
Portugal	
Italy	
Greece	
Finland	
Slovenia	

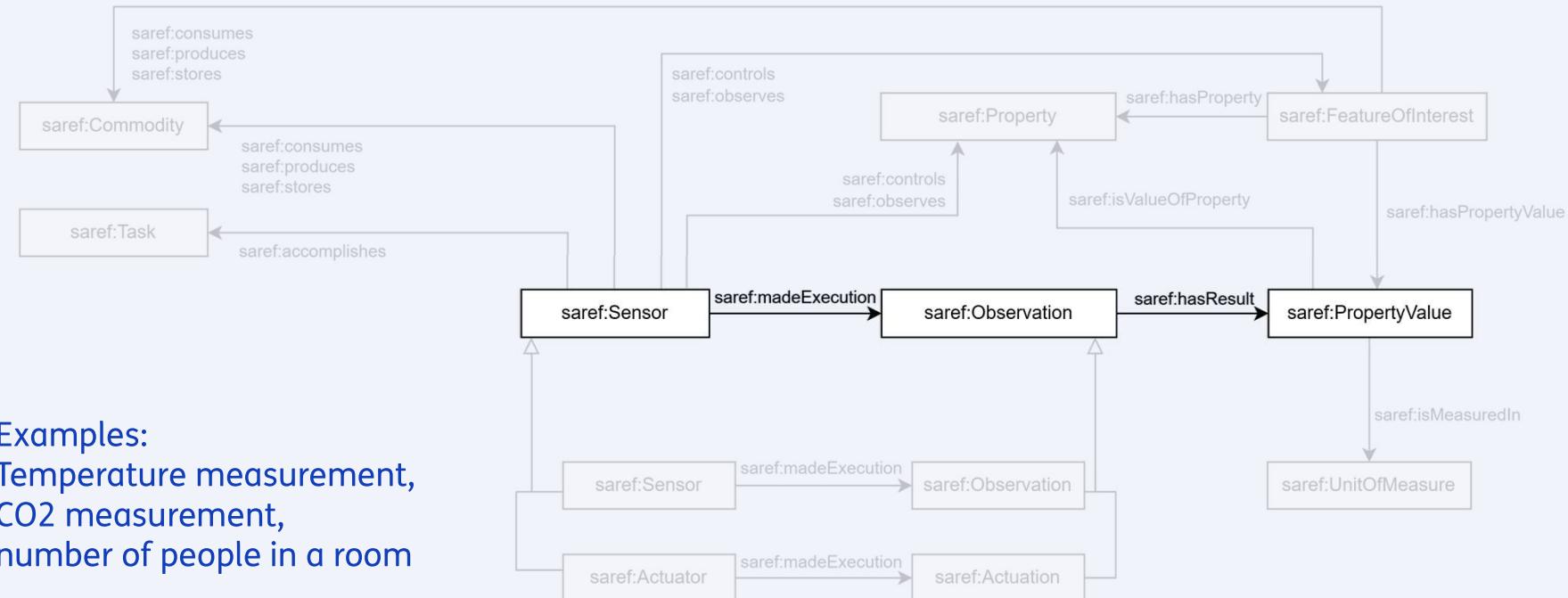
Procedure Execution



Procedure Execution

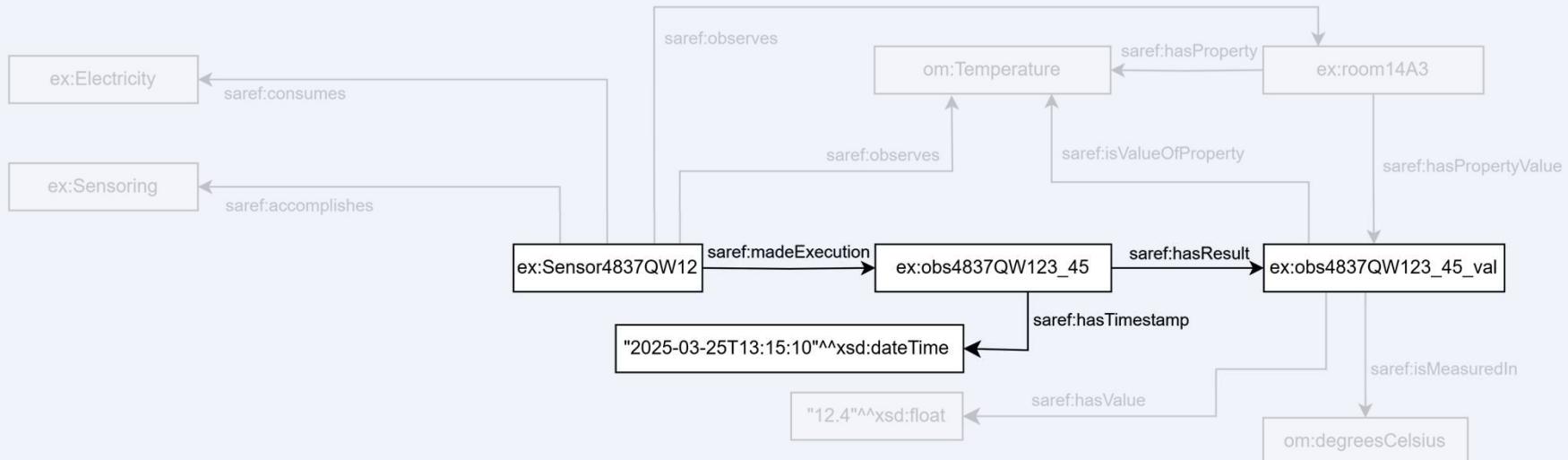
Concept	Definition	Example
saref:ProcedureExecution	It represents the act of carrying out a procedure	Observation, actuation
saref:Observation	It represents the act of carrying out a procedure to estimate or calculate a value of a property of a feature of interest, or a state of a feature of interest. It links to a sensor to describe what made the observation, and to the observed feature, property, property of interest, state, or state of interest. Typically, its result is a property value or a state value.	The observation of the temperature in a room made by a temperature sensor
		The weather forecast made by a software application
		A manual measurement of the circumference of a branch of a tree made by a person
saref:Actuation	It represents the act of carrying out a procedure to control the state of the world using an actuator. It links to an actuator to describe what made the actuation, and to the controlled feature, property, property of interest, state, or state of interest.	The act of starting of a washing machine (pressing a button or via an app)
		The act of switching a light (via a manual switch or via an app)
		The act of opening a door or a blind (manually or via an app or triggered by an observation of a sensor)

Observation



Examples:
 Temperature measurement,
 CO2 measurement,
 number of people in a room

Observation

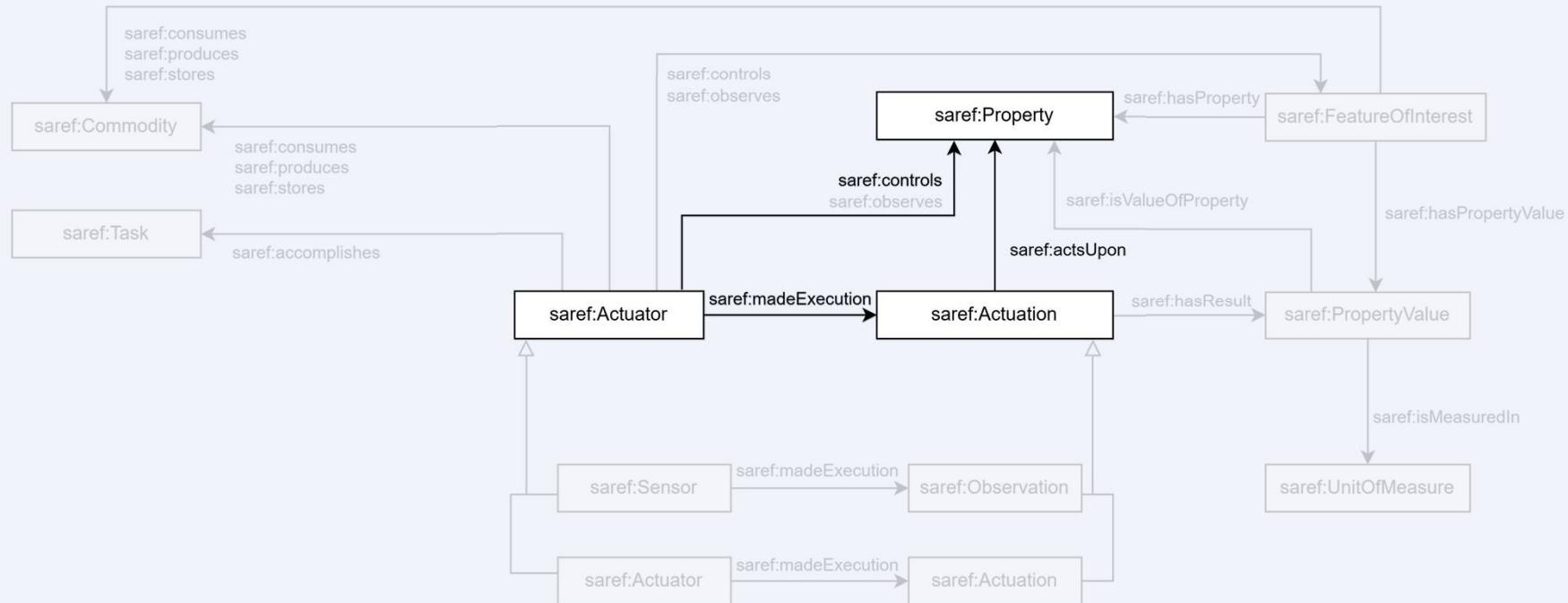


Interactive moment

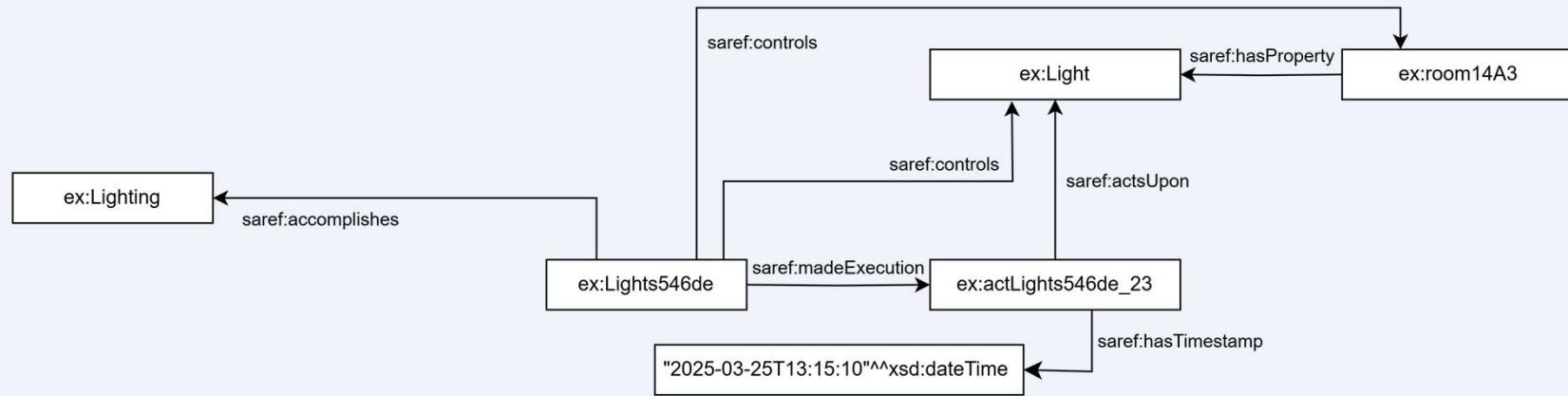
- What type of observations/measurements do you use in your pilots? Please list your observations in the chat of the meeting.

Pilot	Type of observations / measurements
Netherlands	Energy consumed, energy produced, free spots at charging station
Portugal	
Italy	
Greece	
Finland	
Slovenia	

Actuation



Actuation



Interactive moment

- What type of actuations do you use in your pilots? Please list your actuations in the chat of the meeting.

Pilot	Type of actuations
Netherlands	Start/stop EV charging, limit PV energy production, opening doors/blinds, temperature setpoints
Portugal	
Italy	
Greece	
Finland	
Slovenia	

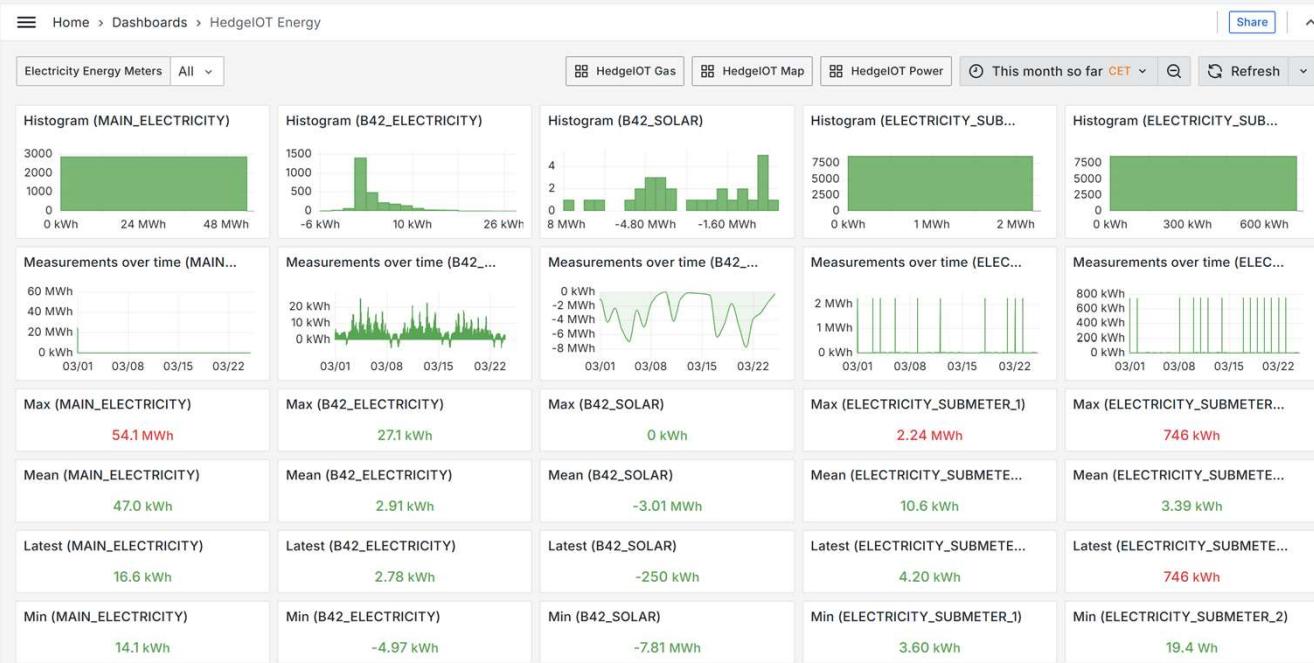
Example application of SAREF



<https://www.hedge-iot.labs.vu.nl/grafana/>

- **Domains:** Smart homes, buildings and grids
- **Project:** Hedge-IoT (<https://hedgeiot.eu>)
- **Location:** Arnhems Buiten, Netherlands
- **Partners:** Arnhems Buiten, TNO, VU Amsterdam

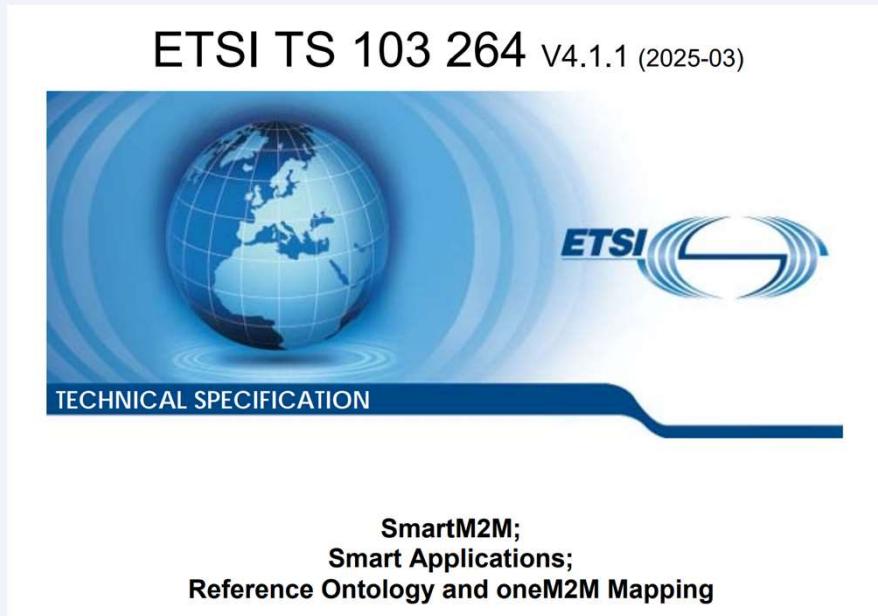
Example application of SAREF



- **Domains:** Smart homes, buildings and grids
- **Project:** Hedge-IoT (<https://hedgeiot.eu>)
- **Location:** Arnhems Buiten, Netherlands
- **Partners:** Arnhems Buiten, TNO, VU Amsterdam

<https://www.hedge-iot.labs.vu.nl/grafana/>

SAREF core



- **Technical Specification**
- ETSI TS 103 264
- Smart Applications Reference Ontology

https://www.etsi.org/deliver/etsi_ts/103200_103299/103264/04.01.01_60/ts_103264v040101p.pdf

Further reading



- a **European Standard**
- ETSI EN 303 760
- Guidelines to develop, apply and evolve Smart Applications ontologies for IoT Semantic Interoperability

https://www.etsi.org/deliver/etsi_en/303700_303799/303760/01.01.01_60/en_303760v010101p.pdf

How to read SAREF triples – Device

Subject	Predicate	Object
ex:Meter4837QW123	rdf:type	saref:Device ;
	rdfs:label	"Meter 4837QW123"@en ;
	rdfs:comment	"an electronic device that records information, such as electricity consumption, of a certain building and communicates it to the consumer and electricity suppliers."@en ;
	saref:hasManufacturer	"ABC"@en ;
	saref:hasModel	"4837QW123"@en ;
	saref:hasDeviceKind	ex:SmartMeterABC123;
	saref:accomplishes	ex:Metering ;
	saref:consumes	ex:Electricity .
ex:SmartMeterABC123	rdf:type	saref:DeviceKind .
ex:Metering	rdf:type	saref:Task .
ex:Electricity	rdf:type	ex:EnergyCommodity .

How to read SAREF triples – Feature Of Interest

Subject	Predicate	Object
ex:arnhems_buiten_B14	rdf:type	saref:FeatureOfInterest ;
	rdfs:label	"Building 14"@en
	rdfs:comment	"Building 14 at the Arnhems Buiten premises."@en .
ex:arnhems_buiten_B14_A3	rdf:type	saref:FeatureOfInterest ;
	rdfs:label	"Room A3 of building 14"@en ;
	rdfs:comment	"Building 14 room A3 at Arnhems Buiten. "@en ;
ex:arnhems_buiten_B14_A3_window5	rdf:type	saref:FeatureOfInterest ;
	rdfs:label	"Window 5 of room A3 in building 14 at Arnhems Buiten. "@en ;
	rdfs:comment	"Window 5 of room A3 in building 14 at Arnhems Buiten."@en .
ex:1000x2000mmWindow	rdf:type	"1000x2000mm window"@en ;
	rdfs:comment	"The kind of windows with dimensions 1000x2000mm ."@en .
ex:arnhems_buiten_B14_A3_window5	saref:hasFeatureKind	ex:1000x2000mmWindow.