Ontological requirement specification for smart irrigation system: a SSN and SAREF comparison

María POVEDA-VILLALÓN
Ontology Engineering Group

Quang-Duy NGUYEN
Catherine ROUSSEY
Jean-Pierre CHANET
irstea

Christophe de VAULX
LIMOS

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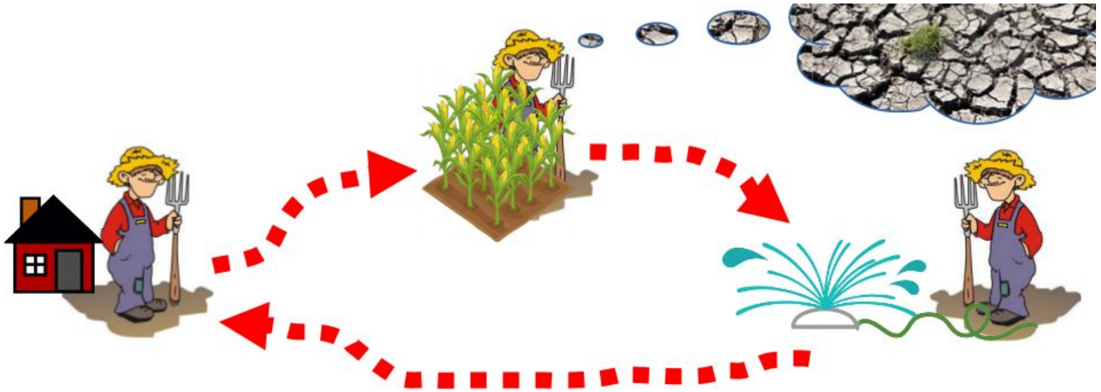
Plan

Introduction

SSN-2018
Monterey
October 2018

Farmer Needs

- Decisions are made based on natural phenomenon observations: soil, crop growth stage, rain, etc.

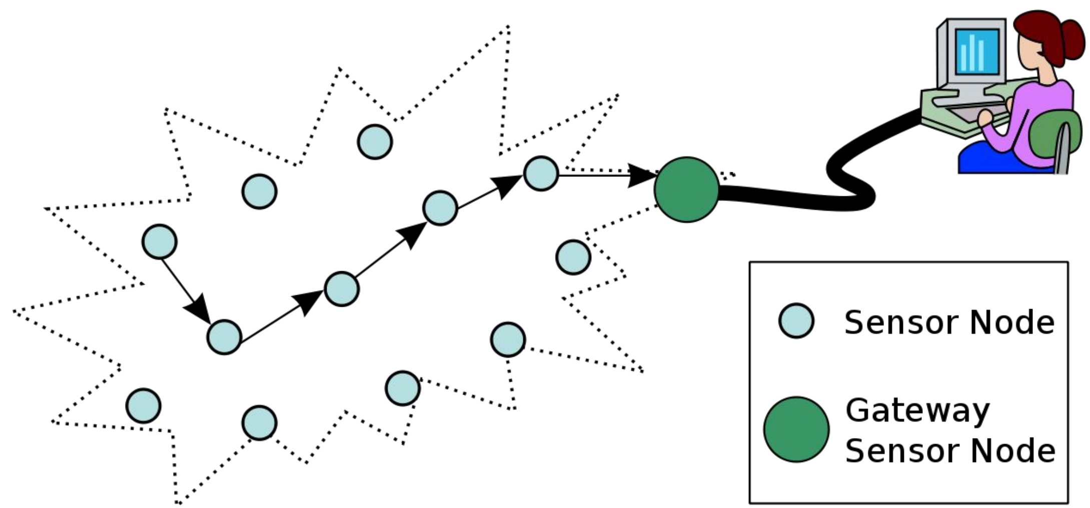


Smart Irrigation System:

- Automate irrigation
- Precision Agriculture: put the right dose at the right time in the right place
- Components:
  - Wireless Sensor Network (WSN)
  - Decision Support System (DSS)
  - Watering Equipment
- Connexion between components → data and services interoperability

Sensor Node and WSN

Wireless Sensor Network



Watermark probe

- *Observed Phenomenon*: Soil
- *Property*: soil moisture

Vantage pro 2

Weather station composed of several sensors

Pluviometer

- *Observed Phenomenon*: rain
- *Property*: rainfall amount

Context

“*any information that can be used to characterize the **situation** of an **entity**. An entity could be a person, a place, or an object that is considered relevant to the interaction between a user and an **application**, including the user and applications themselves.*” (Abowd et al., 1999)

Context: *set of **entities** characterized by their **state**, plus all information that can help to derive any **state changes** of these entities*

Types of entity:

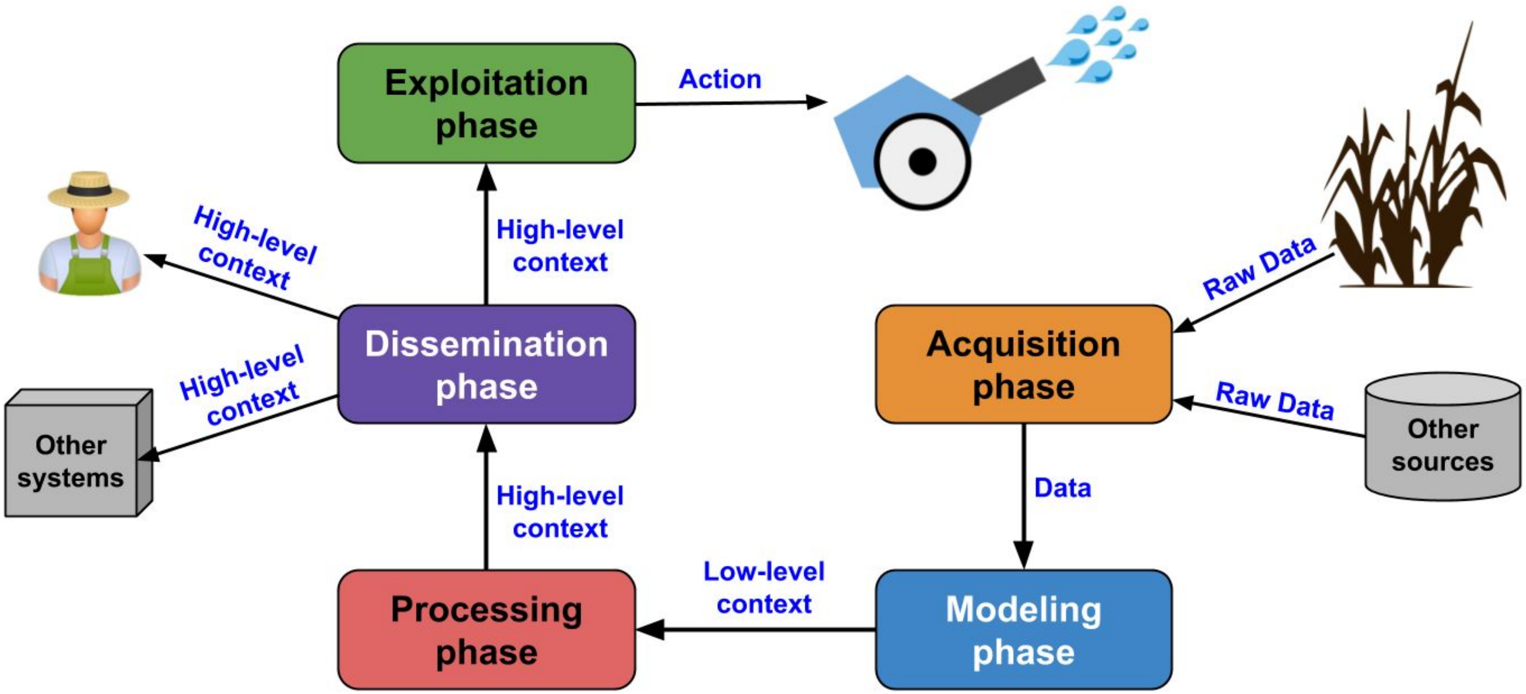
- **Observed Entity:** *entity that is directly **observed** by **sensors***.
- **Entity of Interest:** *entity whose characterization is obtained from one or many other entities and **required by the application***.

Types of context:

- **Low-level context**: ***quantitative data** such as sensor measurements.*
- **High-level context**: ***qualitative data** which is specified according to the application*. (Sun et al., 2016)

Sun, J., De Sousa, G., Roussey, C., Chanet, J.-P., Pinet, F., & Hou, K. M. (2016). ***A new formalisation for wireless sensor network adaptive context-aware system: Application to an environmental use case***. In Tenth International Conference on Sensor Technologies and Applications SENSORCOMM 2016 (pp. 49–55).
Abowd, G. D., Dey, A. K., Brown, P. J., Davies, N., Smith, M., & Steggles, P. (1999). ***Towards a better understanding of context and context-awareness***. In H. W. Gellersen (Ed.), Handheld and Ubiquitous Computing, Proceedings (Vol. 1707, pp. 304–307). Berlin: Springer-Verlag Berlin.

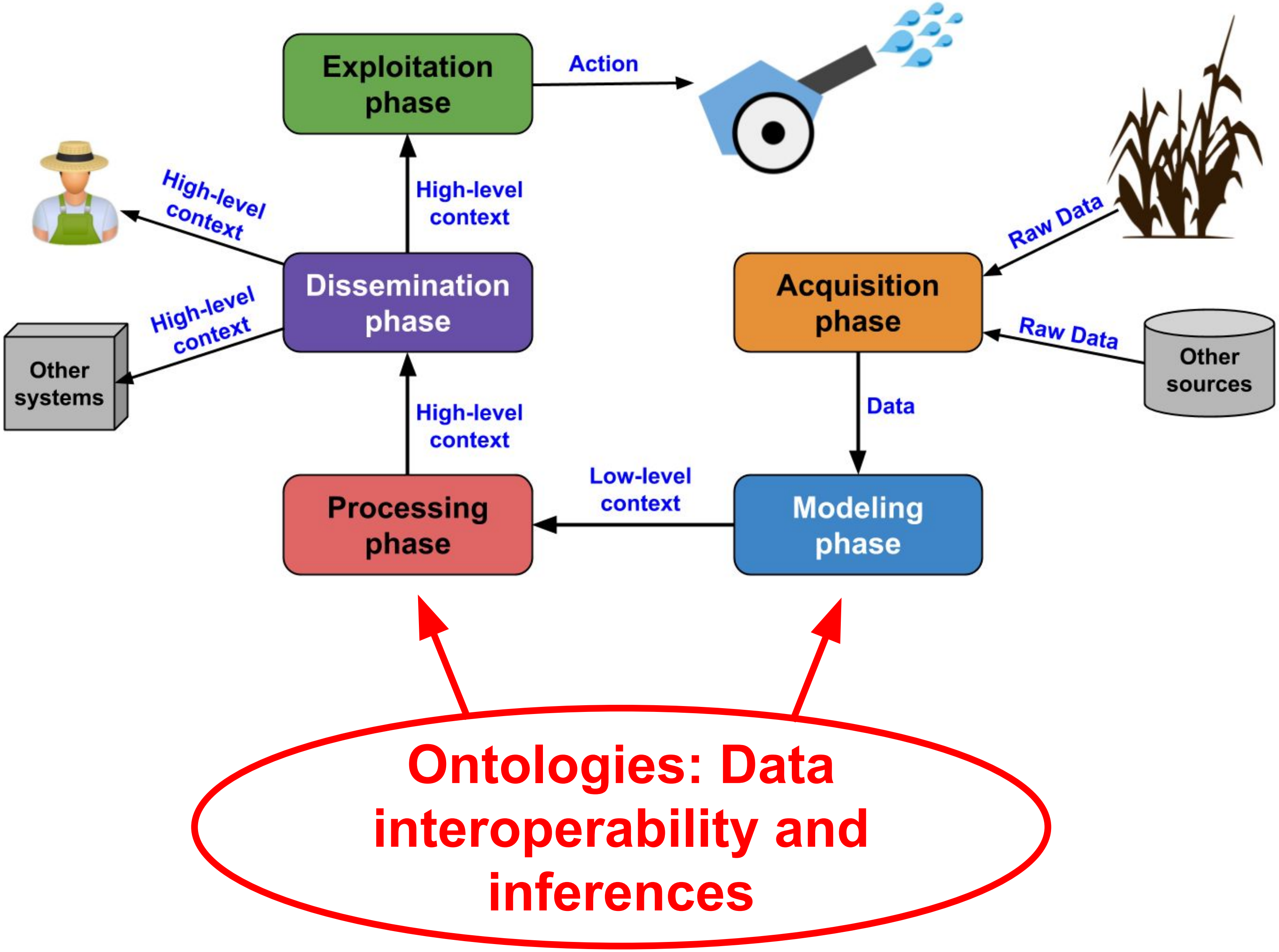
Context-aware System



A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task. (Abowd et al., 1999)

Abowd, G. D., Dey, A. K., Brown, P. J., Davies, N., Smith, M., & Steggles, P. (1999). ***Towards a better understanding of context and context-awareness***. In H. W. Gellersen (Ed.), Handheld and Ubiquitous Computing, Proceedings (Vol. 1707, pp. 304–307). Berlin: Springer-Verlag Berlin.

Needs of Ontologies



Sensor Ontologies

Ontology is " *a formal explicit specification of a shared conceptualization.*" (Studer et al., 1998)

Sensor Ontologies: SOSA/SSN, SAREF, CESN, CSIRO, Sensei O&M, OOSTethys, MMI, SWAMO, SEEK, SDO, SeReS O&M, OntoSensor, etc. (Bendadouche et al., 2012)

SSN *(Semantic Sensor Network)*
- SSN last version = SOSA/SSN
- W3C and OGC Recommendation
- (sosa) http://www.w3.org/ns/sosa (ssn) http://www.w3.org/ns/ssn

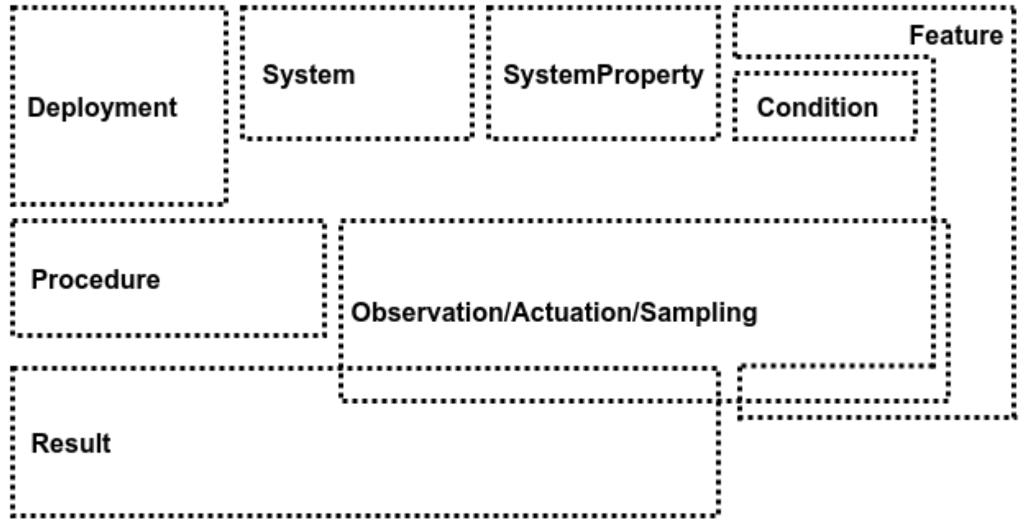
SAREF *(Smart Appliances REFerence)*
- Standard from European Telecommunication Standardization Institute (ETSI)
- (saref) https://www.w3id.org/saref

Studer, R., Benjamins, V. R., & Fensel, D. (1998). **Knowledge engineering: principles and methods**. Data & Knowledge Engineering, 25(1–2), 161–197.
Bendadouche, R., Roussey, C., De Sousa, G., Chanet, J.-P., & Hou, K. M. (2012). **Etat de l'art sur les ontologies de capteurs pour une intégration intelligente des données**. INFORSID 2012, 89–104.

SSN and SAREF overview

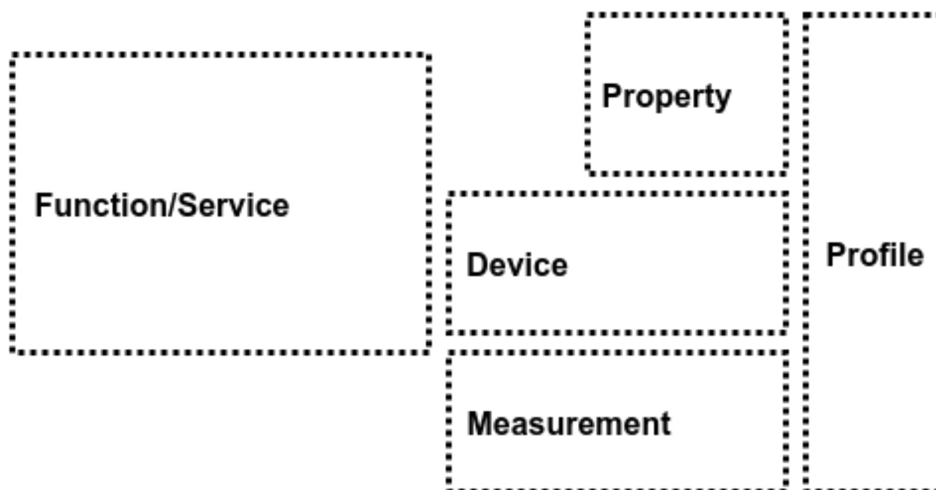
SSN

- SSN is composed of several modules
- Sensor, Observation, Sample, and Actuator (SOSA) is the central module of SSN
- SSN is mapped to OBOE, DUL, etc...



SAREF

- SAREF provides a core model for IoT
- it is extended in order to cover specific domains.
- Extensions : SAREF4ENER, SAREF4ENVI, SAREF4BLDG, SAREF4AGRI, etc.
- SAREF is mapped to OneM2M Base ontology.



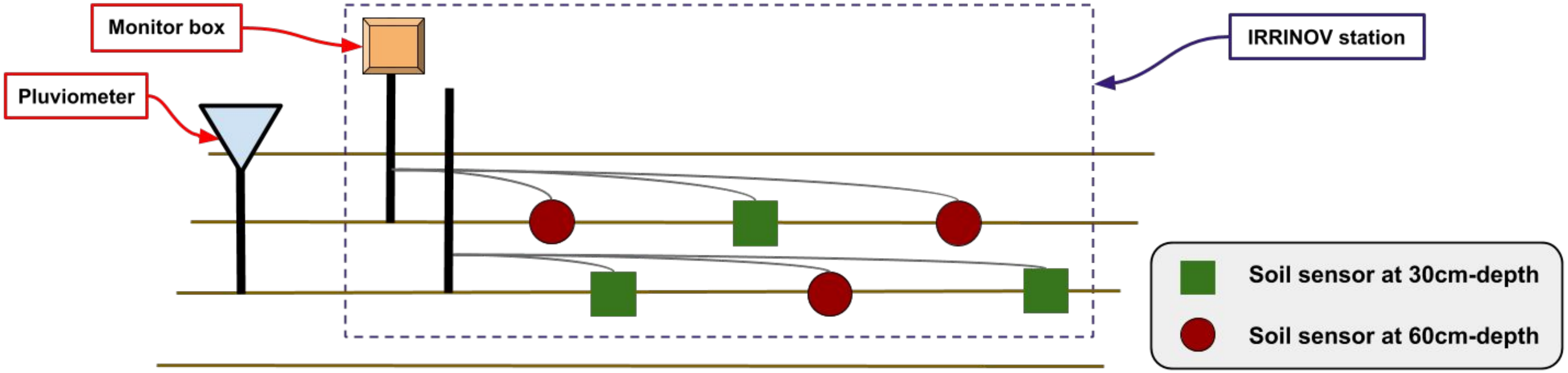
IRRINOV® Method *(Arvalis, 2005)*

1. Presentation

- Human decision
- Set of guidelines and decision tables to determine the date for the next irrigation
- Depend: soil type and crop type

2. Location of probes and equipments

- Irrinov station= 6 watermark probes
  - 3 at 30 cm depth
  - 3 at 60 cm depth
- 2 pluviometers: a mobile one + weather station



Arvalis. (2005). **Guide de l'utilisateur Carnet de terrain**

IRRINOV® Method (2)

3. Soil moisture measurement

- **Measurement-cbar** = probe_value * correction_coefficient
- Checking constraint: **Measurement-cbar <= *199***
- **Probe30** = value reached by 2 probes out of 3 probes at 30 cm depth
- **Probe60** = value reached by 2 probes out of 3 probes at 60 cm depth

4. Installation time and measurement frequency

- Installation of watering equipments and sensors: when crop reaches the growth stage V2 or “2 leaves”
- Uninstall equipements when crop reaches the growth stage R5 “grain at 50% humidity”
- Measurement starts: 2 or 3 days after equipment installation.
- Measurement is mandatory :
    - Before irrigation
    - 24h or 36h after one irrigation
    - After significant rainfall

IRRINOV® Method (3)

5. Decision table to run an irrigation turn

Several tables are proposed to determine when to run an irrigation

Example of table: growth stage V7, (2) soil type: *clay-limestone*, (3) crop type: *maïze (corn grain)*

Time between two irrigation	9 to 10 days	6 to 8 days	below 5 days
Probe30	30 cbar	50 cbar	60 cbar
Probe60	10 cbar	20 cbar	20 cbar
Total	40 cbar	70 cbar	80 cbar

If ((8 < TimeIrrigation < 11) and (growthStage < V7)
and (Probe30 + Probe60 >= 40))
Then (Irrigation.state = ON)

Ontological requirements

R1. Deployment
- R1.1. Deployment time
- R1.2. Deployment location

R2. Plot

R3. Network configuration
- R3.1. Network topology
- R3.2. Network communication
- R3.3. Node status
- R3.4. Node role
- R3.5. Node location

R4. Device
- R4.1. Sensor
- R4.2. Actuator
- R4.3. System componency
- R4.4. Domain specific devices

R5. Measurement
- R5.1. Domain specific units of measurement

R6. Property
- R6.1. Domain specific properties

R7. Feature of interest
- R7.1. Feature of interest depth

R8. Action
- R8.1. Domain specific actions

R9. Crop

Requirements coverage using SSN

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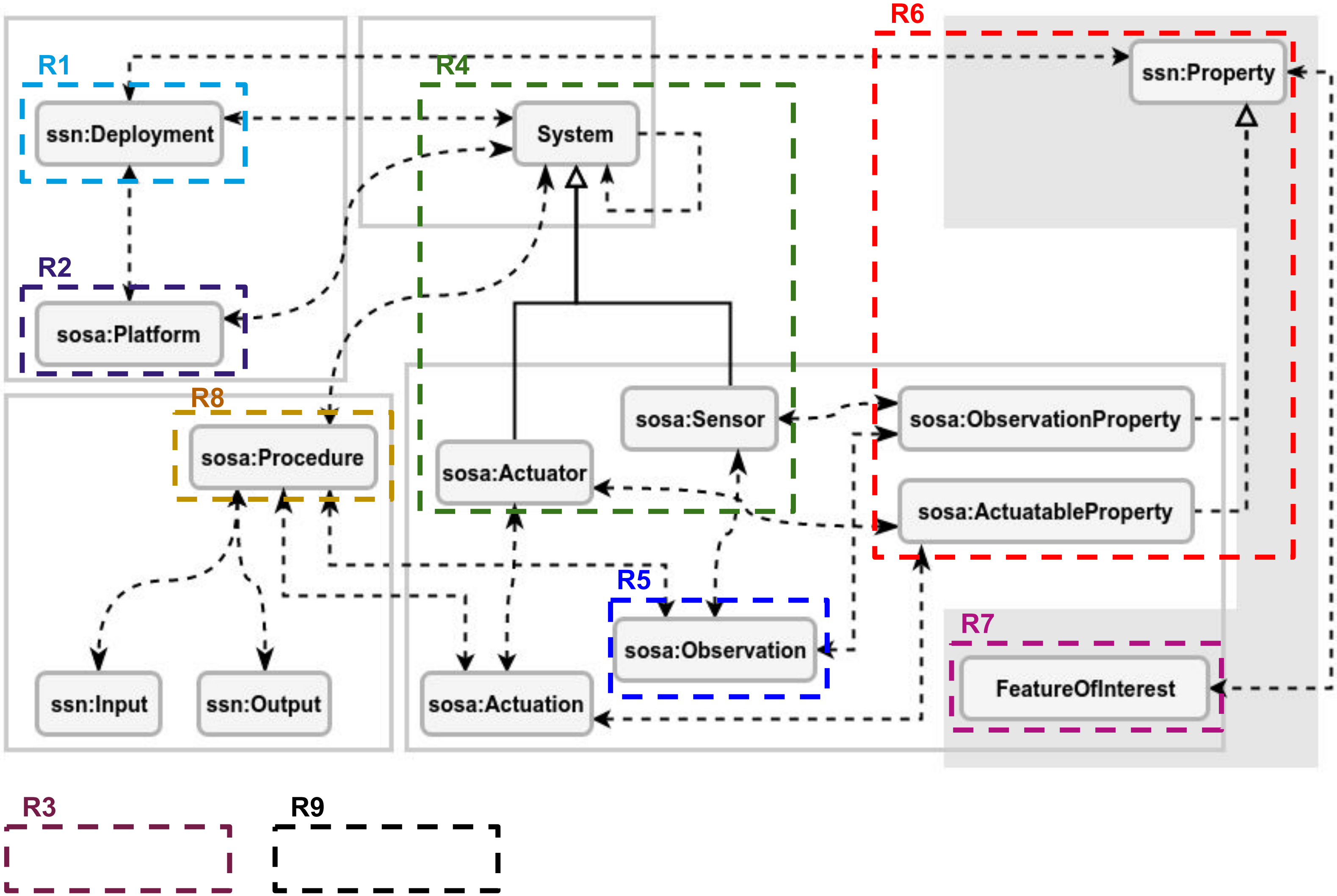
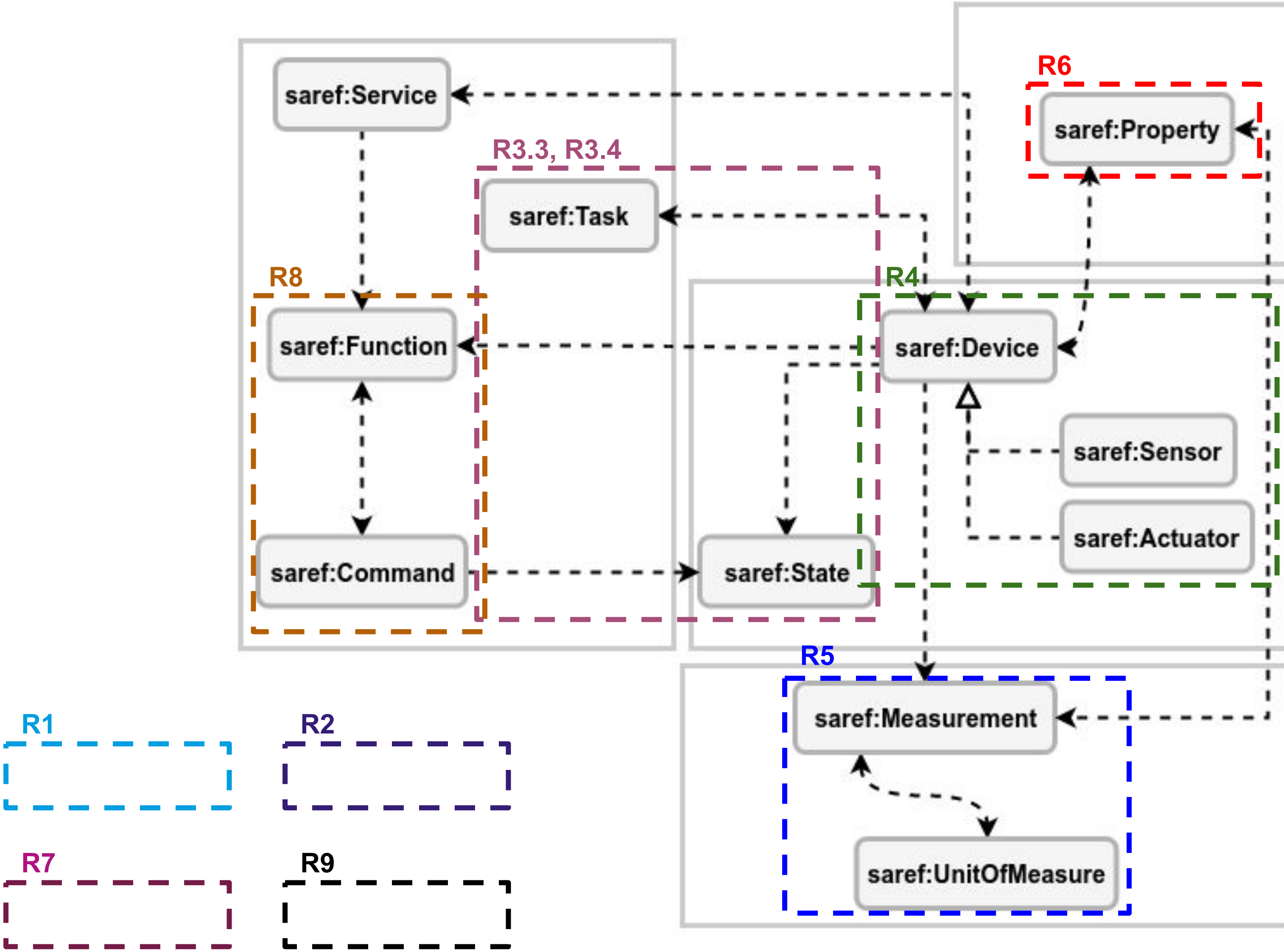


Requirements coverage using SAREF



Analysis (1)

Requirement	SOSA/SSN	SAREF
R1. Deployment	ssn:Deployment	
R1.1. Deployment time		
R1.2. Deployment location	(1)	
R2. Plot	sosa:Platform	
R3. Network configuration		
R3.1. Network topology		
R3.2. Network communication		
R3.3. Node status		saref:State
R3.4. Node role		saref:Task
R3.5. Node location	(1)	

(1) SOSA/SSN recommends using geoSPARQL *(Perry et Herring, 2012)*

Perry M. & Herring J. (2012). **Ogc geosparql-a geographic query language for rdf data**. OGC implementation standard

Analysis (2)

Requirement	SOSA/SSN	SAREF
R4. Device	ssn:System	saref:Device
R4.1. Sensor	sosa:Sensor	saref:Sensor
R4.2. Actuator	sosa:Actuator	saref:Actuator
R4.3. System componency	ssn:hasSubSystem	saref:consistsOf
R4.4. Domain specific devices		
R5. Measurement	sosa:Observation (2)	saref:Measurement saref:UnitOfMeasure (3)
R5.1. Domain specific units of measurement		

(2) SOSA/SSN recommends using the following ontologies et vocabularies : QUDT *(Hodgson et al., 2014)*, OM *(Rijgersberg et al., 2013)*, UCUM *(Lefrançois et Zimmermann, 2018)*

(3) SAREF recommends using the ontology OM *(Rijgersberg et al., 2013)*

Hodgson R., Keller P. J., Hodges J. & Spivak J. (2014). **Qudt-quantities, units, dimensions and data types ontologies**. USA.
Rijgersberg H., Van assem M. & Top J. (2013). **Ontology of units of measure and related concepts**. Semantic Web 2012, 4(1) 3–13.
Lefrancois M. & Zimmermann A.. (2018). **The unified code for units of measure in RDF: cdt:ucum and other UCUM Datatypes**. ESWC 2018.

Analysis (3)

Requirement	SOSA/SSN	SAREF
R6. Property	ssn:Property	saref:Property
R6.1. Domain specific properties		
R7. Feature of interest	sosa:FeatureOfInterest	
R7.1. Feature of interest depth	(1)	
R8. Action	sosa:Procedure	saref:Function saref: Command
R8.1. Domain specific actions		
R9. Crop	Platform or FoI?	

(1) SOSA/SSN recommends using geoSPARQL

Discussion

Comparison between SSN et SAREF

- SSN and SAREF are ontologies about sensor that cover generic use cases. They are not dedicated to our specific agricultural use case
- SSN et SAREF have no network description
- SSN contains information about:
    - **Deployment**
    - Data flow and procedures
    - **Observed phenomenon**
- SAREF contains information about:
    - Device **function** and **services**
    - Device **state** and **command** = “open”, “close”

IRRINOV Use Case

- Needs not covered:
    - Deployment description = spatio temporal entity
    - Network and node description
    - Plot and Crop description (*cf Platform or FeatureOfInterest SSN*)

Conclusion

Synthesis

- Requirements about smart irrigation use case
- Model of context to automate an irrigation system
- **SSN** and **SAREF** are two possible ontologies

Perspectives

- OEG:
  - **SAREF** Extension for agriculture: SAREF4AGRI
  - Ontologies network development
- Irstea:
  - Select **SOSA/SSN** for our irrigation use case
  - Ontologies network development
  - Rule to automate irrigation decision
  - Develop an automatic irrigation system in **AgroTechnoPole: experimental farm of Montoldre.**

Thank you

Merci

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- **the ETSI project STF534 "SAREF extensions"**
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