Unified IoT Ontology to Enable Interoperability and Federation of Testbeds

*Rachit Agarwal, **David Gómez Fernández**, Tarek Elsaleh, Amelie Gyrard, Jorge Lanza, Luis Sánchez, Nikolaos Georgantas, Valerie Issarny*

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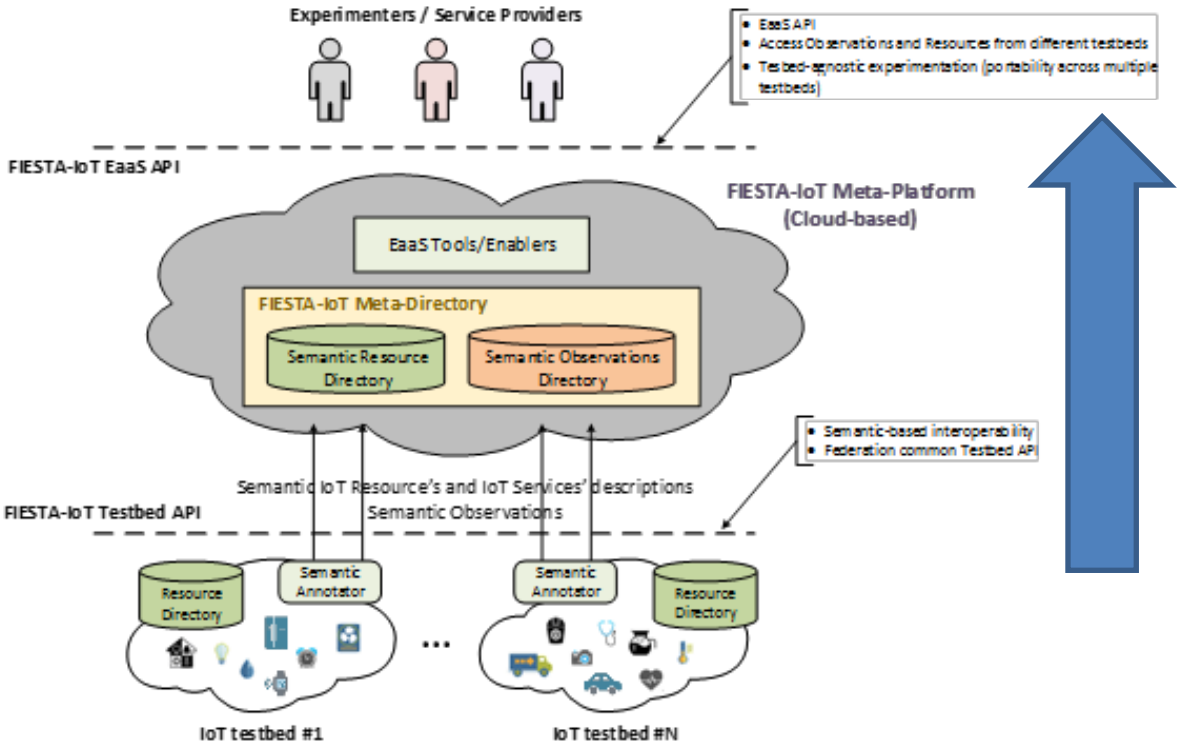
Outline

- Introduction
- FIESTA-IoT platform overview
- FIESTA-IoT ontology
- Tools (Annotator + validator + iot-registry API)
- Conclusions and future lines

Brief overview

- Lack of standards in IoT's first years → Large heterogeneity among the different platforms
- Up to now, none of the mainstream ontologies fulfils the complete "IoT" picture
- Reuse of concepts from them to fill their main gaps
- FIESTA-IoT → semantic layer on top of the platforms, providing the foundations for diverse IoT domains
- Outcome → Interoperable, tuneable & lightweight ontology: **FIESTA-IoT ontology**

FIESTA-IoT testbed federation & EaaS enablers (i)



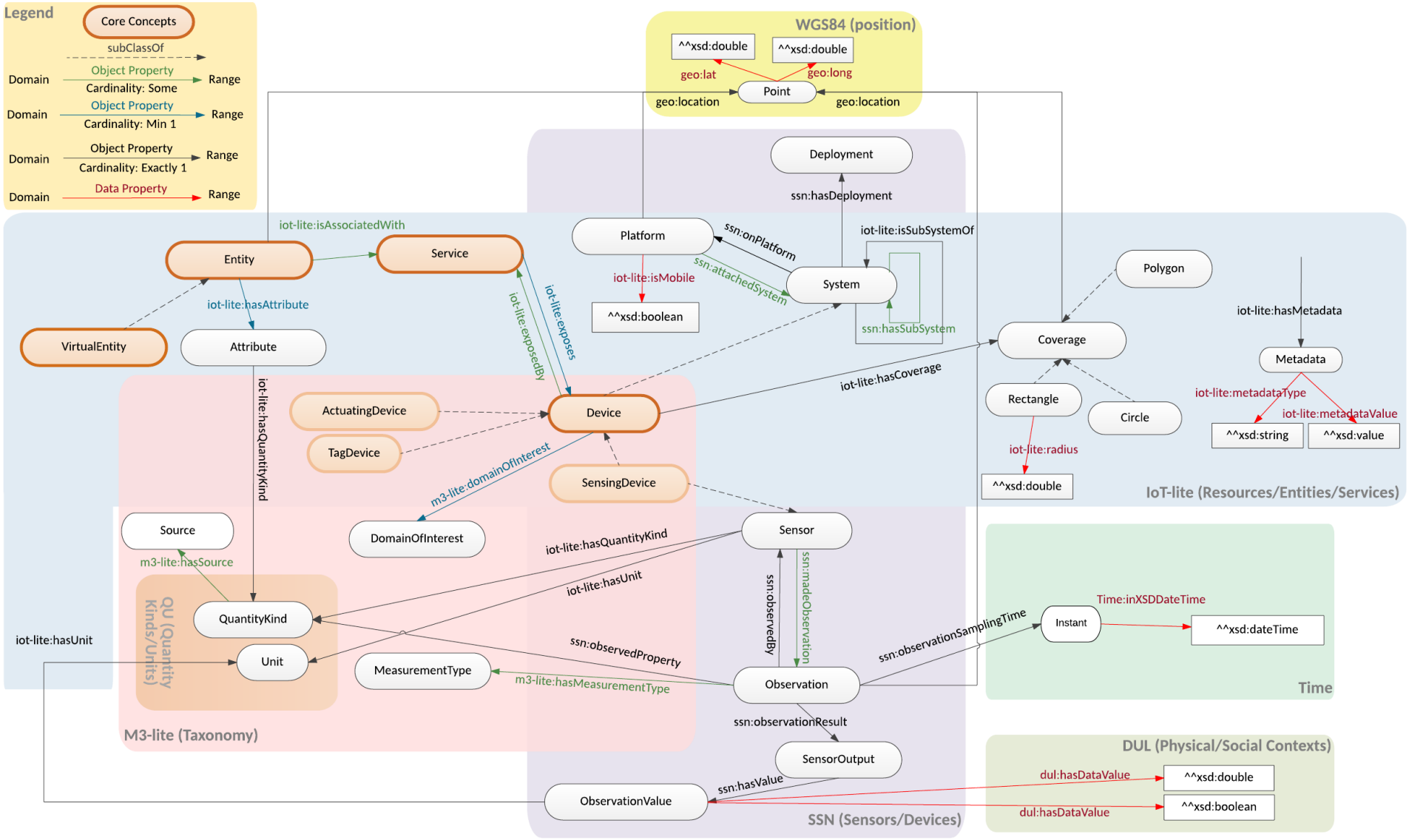
- Heterogeneous testbeds feed the platform
- Cloud-based repository stores the info
- Testbed agnostic access to get the data

FIESTA-IoT testbed federation & EaaS enablers (ii)

- First approach from consortium's assets
  - 4 heterogeneous testbeds (SmartSantander, Smart ICS, Com4Innov & KETI), covering various IoT domains
  - 3 "in-house" experiments
- 4 Open Calls processes to foster testbeds & experiments:
  - http://fiesta-iot.eu/opencall/
- Key performance indicators (project's lifetime)
  - Testbeds : +10 (4 + 6)
  - Experiments: +27 (3 + 24)

FIESTA-IoT Ontology

- Two big realms: Resources & Observations
- Borrowed concepts from well-known ontologies:
  - Core (*ssn*)
  - Geographical position (*WSG84*)
  - Timing (*Time*)
  - Resources/entities/services (*iot-lite)*
  - Data output (DUL)
- M3-lite taxonomy for *quantity kinds* (i.e. physical phenomena), *units of measurement* and *domains of interest*


Legend
Core Concepts
subClassOf
Domain
Object Property
Cardinality: Some
Range
Domain
Object Property
Cardinality: Min 1
Range
Domain
Object Property
Cardinality: Exactly 1
Range
Domain
Data Property
Range
WGS84 (position)
^^xsd:double
^^xsd:double
geo:lat
geo:long
Point
geo:location
geo:location
Deployment
ssn:hasDeployment
iot-lite:isAssociatedWith
Entity
Service
Platform
ssn:onPlatform
iot-lite:isSubSystemOf
iot-lite:isMobile
ssn:attachedSystem
System
^^xsd:boolean
ssn:hasSubSystem
Polygon
iot-lite:hasMetadata
iot-lite:hasAttribute
iot-lite:exposedBy
iot-lite:exposes
VirtualEntity
Attribute
Coverage
Metadata
iot-lite:hasCoverage
ActuatingDevice
Device
Rectangle
Circle
iot-lite:metadataType
iot-lite:metadataValue
TagDevice
iot-lite:radius
^^xsd:string
^^xsd:value
^^xsd:double
IoT-lite (Resources/Entities/Services)
iot-lite:hasQuantityKind
m3-lite:domainOfInterest
SensingDevice
Source
DomainOfInterest
Sensor
iot-lite:hasQuantityKind
m3-lite:hasSource
iot-lite:hasUnit
ssn:observedBy
ssn:madeObservation
QU (Quantity Kinds/Units)
QuantityKind
Time:inXSDDateTime
Instant
^^xsd:dateTime
iot-lite:hasUnit
ssn:observedProperty
ssn:observationSamplingTime
Unit
MeasurementType
m3-lite:hasMeasurementType
Observation
Time
M3-lite (Taxonomy)
ssn:observationResult
SensorOutput
DUL (Physical/Social Contexts)
dul:hasDataValue
^^xsd:double
ssn:hasValue
ObservationValue
dul:hasDataValue
^^xsd:boolean
SSN (Sensors/Devices)

Best practices

- Proposed to enhance the efficiency, re-usability and interoperability

1. Creation/management of the ontology
   - Web documentation
   - Online maintenance
2. Guidelines for testbeds to publish data
   - Web of Things paradigm (dereferenceable identifiers)
   - Semantic annotation (RDF format)
   - “Validate before inject”

Reference Annotator Tool (*RAT*)

- Federated testbeds MUST be compliant with the FIESTA-IoT ontology
- Module to be run on the testbed side
- Annotators from our testbeds available (or ASAP)
  - FIWARE (Com4Innov)
  - OneM2M (KETI)
  - Proprietary (SmartSantander & Smart ICS)
- Unique output format → FIESTA-IoT semantically annotated data (for both resources & observations)

Annotation Validation Tool (AVT)

- Semantic & syntactic validation process
- Implementation based on Eyeball
- Objective: To avoid the injection of erroneous data into the core of the system
- Boolean operation
  - True: Data forwarded to the meta-directory
  - False: Data dropped out the system
- Graph-based operations → Computational cost!!
- Online *vs* Offline validation

FIESTA-IoT iot-registry API

- Core of the system → FIESTA-IoT meta-directory
- Solution based on *JENA* framework *(triplestore + API)*
- Resources & observations under a single graph
- Multiple RDF serialization formats handled (e.g. JSON-LD, RDF/XML, Turtle…)
- *REST-based API towards testbeds and experimenters*
- *In charge of the registration and storage of:*
  - *Resource descriptions*
  - *Observations*
- *Semantic queries based on SPARQL*

Wrap-up

- FIESTA-IoT ontology built upon these requirements:
  - Concepts borrowed from mainstream ontologies
  - To be lightweight in order not to slow down the overall performance
  - Tailored from off-the-shelf testbeds
  - Adaptable to potential incoming testbeds' assets
  - m3-lite taxonomy to embrace qks, units and domains
- Tools and services on top of the data model:
  - Resource annotator (@ testbed level)
  - Semantic & syntactic validator
  - iot-registry API

Future lines

- To support direct interoperability with potential standards, i.e. OneM2M
- To foster the new concepts and classes coming from external testbeds (through the Open Calls)
- To optimize the performance of registration and validation operations
- To assess the scalability of the platform as long as more and more data is stored
- To be integrated in other research projects in the mid-term (e.g. WISE-IoT)

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