Contents

Background: RDF and Turtle

This cannot be interpreted by a machine

Timothy John Berners-Lee,

Born June 8th 1955 in Londres.

Is the principal inventor of the World Wide Web.

President of the World Wide Web Consortium (W3C), which he founded.

Author of the book a Framework for Web Science.

Identification : Ressources & Relations

Timothy John Berners-Lee,

Born June 8th 1955 in Londres.

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President of the World Wide Web Consortium (W3C),

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Author of the book a Framework for Web Science.

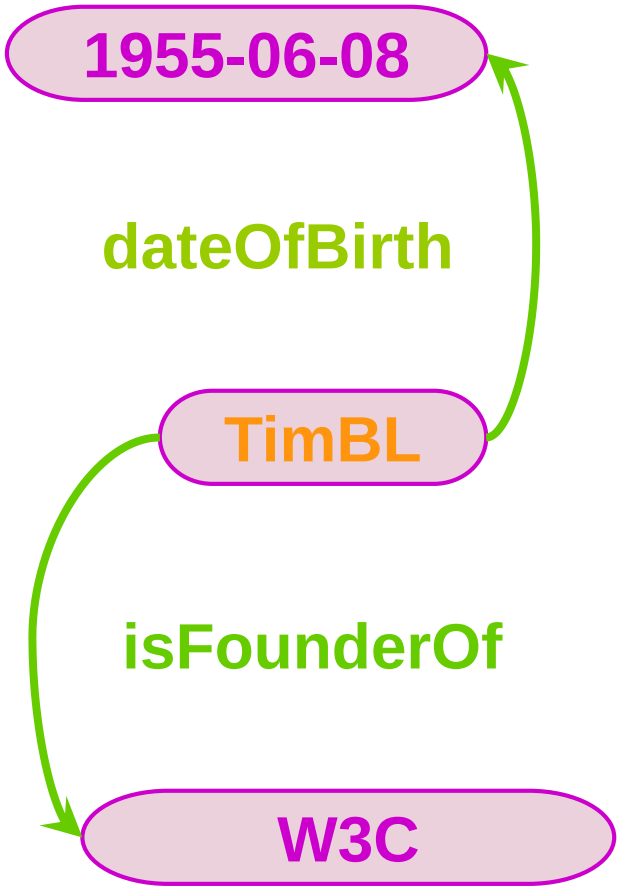
Simple sentence

TimBL has date of birth 1955-06-08.
TimBL has place of birth London.
TimBL is inventor of WWW.
TimBL is director of W3C.
TimBL is founder of W3C.
TimBL is author of Framework for Web Sience

RDF Triples: interpretable by the machine

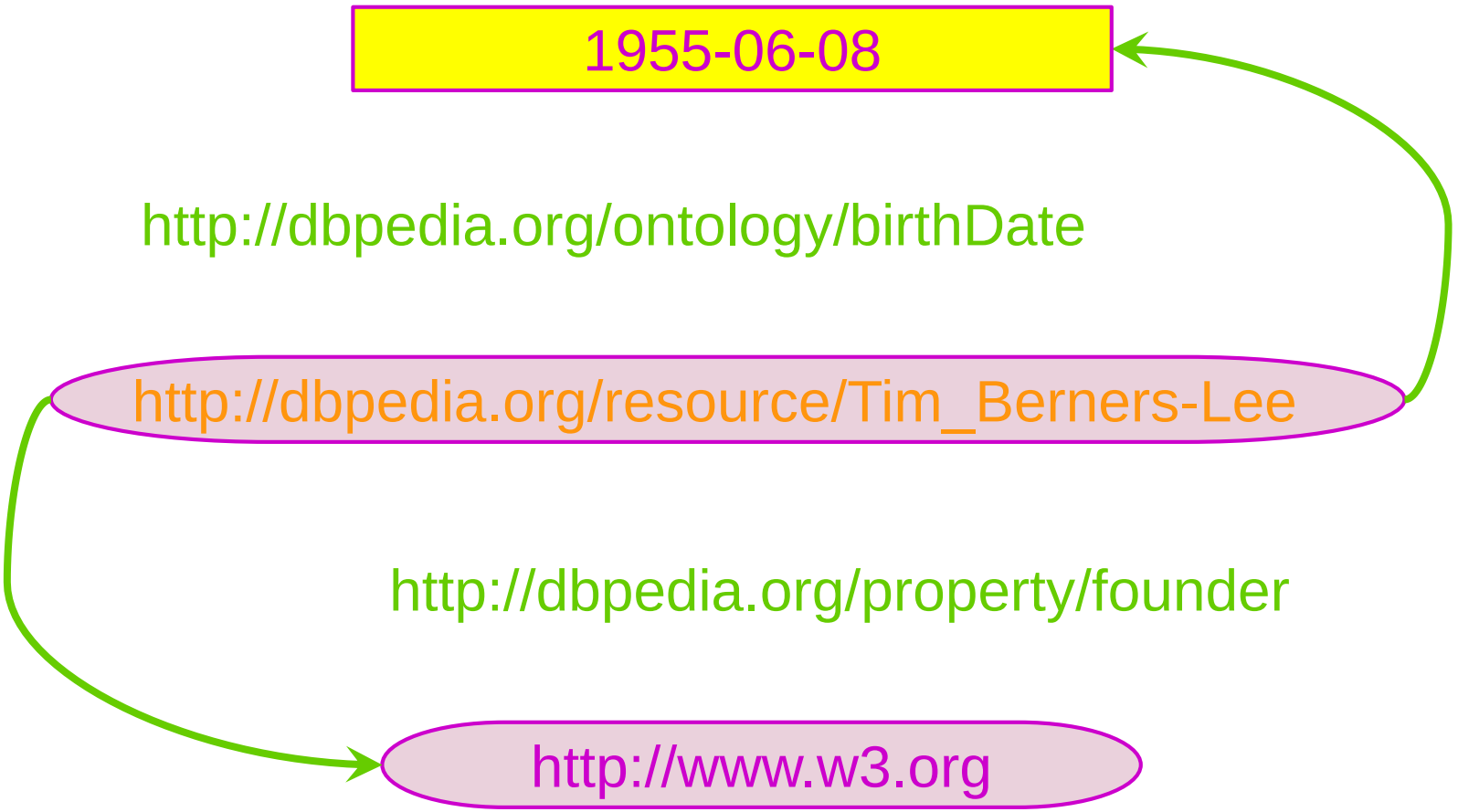
(TimBL, dateOfBirth, 1955-06-08)
(TimBL, placeOfBirth, London)
(TimBL, isInventorOf, WWW)
(TimBL, isDirectorOf, W3C)
(TimBL, isFounderOf, W3C)
(TimBL, isAuthorOf, Web_Science)

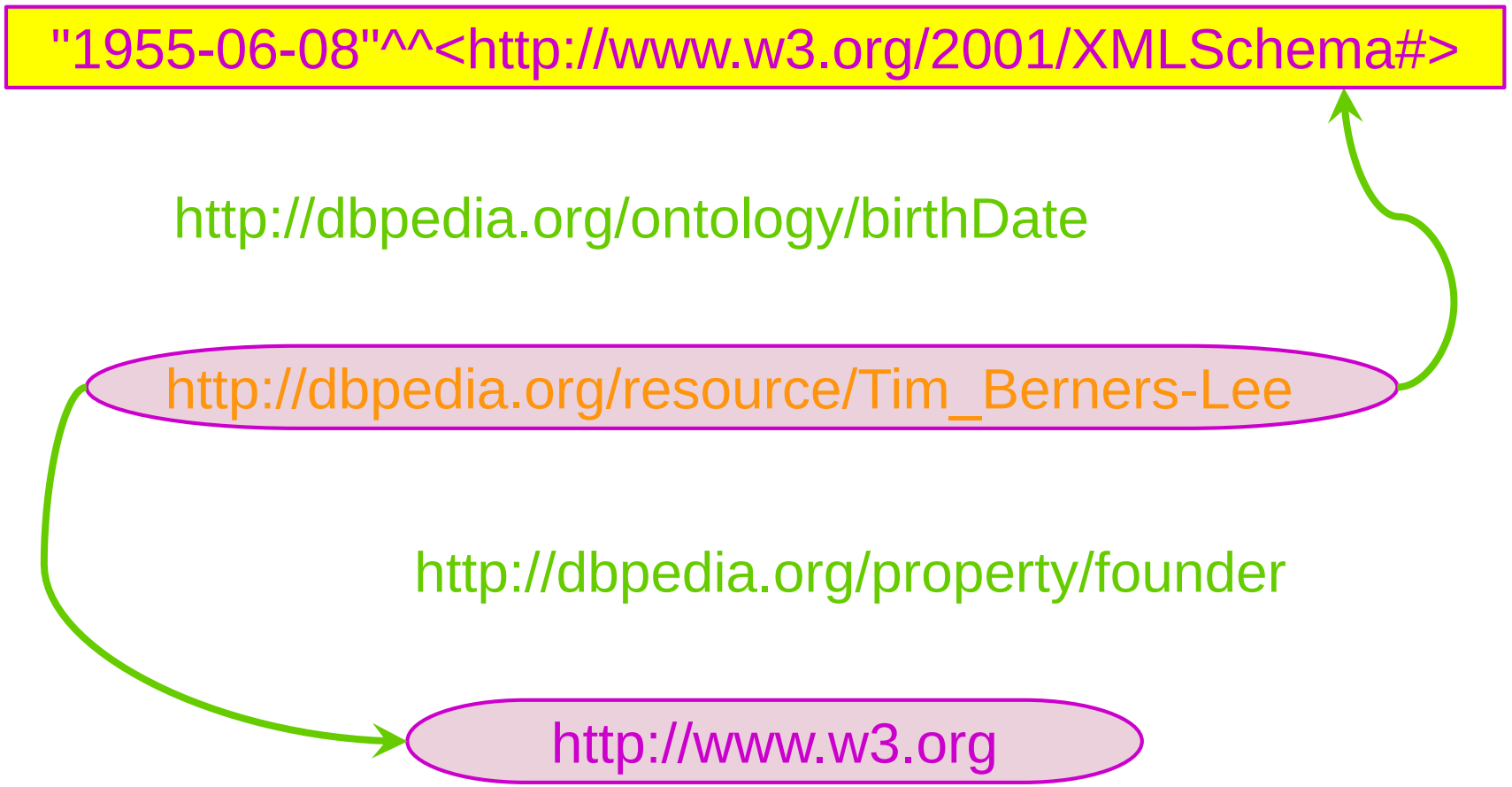
(Subject, predicate, Object)


1955-06-08
dateOfBirth
TimBL
isFounderOf
W3C

Rules to write RDF triples

- The subject is always a resource (never a literal)
- The predicates are binary relations identified by URIs
- The object is a resource or a literal


1955-06-08
http://dbpedia.org/ontology/birthDate
http://dbpedia.org/resource/Tim_Berners-Lee
http://dbpedia.org/property/founder
http://www.w3.org


"1955-06-08"^^<http://www.w3.org/2001/XMLSchema#>
http://dbpedia.org/ontology/birthDate
http://dbpedia.org/resource/Tim_Berners-Lee
http://dbpedia.org/property/founder
http://www.w3.org

(one of ~) RDF syntaxes - N-Triple

- <http://dbpedia.org/resource/Tim_Berners-Lee>
- <http://purl.org/dc/terms/creator>
- <http://www.w3.org>.

- <http://dbpedia.org/resource/Tim_Berners-Lee>
- <http://dbpedia.org/property/dateOfBirth>
- “1955-06-08”^^<http://www.w3.org/2001/XMLSchema#date>.

- <http://dbpedia.org/resource/Tim_Berners-Lee>
- <http://dbpedia.org/property/placeOfBirth>
- <http://dbpedia.org/resource/London>.

- <http://dbpedia.org/resource/London>
- <http://dbpedia.org/property/isPartOf>
- <http://dbpedia.org/resource/England>.

(one of ~) RDF syntaxes - Turtle

Syntactic sugar ++

Turtle prefixes and bases

```
<http://example.org/instances/appartement418>
 <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
    <http://example.org/vocabulary/T2> .
```

=

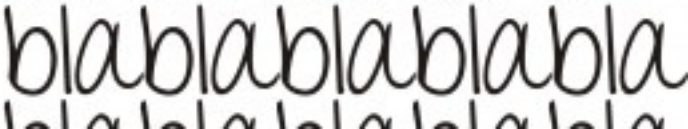
```
@Prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@Prefix : <http://example.org/vocabulary/> .
@Base <http://example.org/instances/> .

  <appartement418> rdf:type :T2 .
```

Turtle prefixes and bases

```
@Prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@Prefix dbp: <http://dbpedia.org/property/>.
@Prefix dbr: <http://dbpedia.org/resource/>.
@Prefix dc: <http://purl.org/dc/terms/>.
@Prefix xsd: <http://www.w3.org/2001/XMLSchema#>.

dbr:Tim_Berners-Lee rdf:type dbo:Scientist .
dbr:Tim_Berners-Lee dc:creator <http://www.w3.org> .
dbr:Tim_Berners-Lee dbp:dateOfBirth “1955-06-08”^^xsd:date .
dbr:Tim_Berners-Lee dbp:placeOfBirth dbr:London .
dbr:Tim_Berners-Lee dbp:placeOfBirth dbr:England .

dbr:London dbp:isPartOf dbr:England .
```

Separators « . » - « ; »

```
@Prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@Prefix dbp: <http://dbpedia.org/property/>.
@Prefix dbr: <http://dbpedia.org/resource/>.
@Prefix dc: <http://purl.org/dc/terms/>.
@Prefix xsd: <http://www.w3.org/2001/XMLSchema#>.

dbr:Tim_Berners-Lee rdf:type dbo:Scientist ;
                    dc:creator <http://www.w3.org> ;
                    dbp:dateOfBirth “1955-06-08”^^xsd:date ;
                    dbp:placeOfBirth dbr:London ;
                    dbp:placeOfBirth dbr:England .

dbr:London dbp:isPartOf dbr:England .
```



Separators « . » - « ; » - « , »

```
@Prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@Prefix dbp: <http://dbpedia.org/property/>.
@Prefix dbr: <http://dbpedia.org/resource/>.
@Prefix dc: <http://purl.org/dc/terms/>.
@Prefix xsd: <http://www.w3.org/2001/XMLSchema#>.

dbr:Tim_Berners-Lee rdf:type dbo:Scientist ;
                    dc:creator <http://www.w3.org> ;
                    dbp:dateOfBirth “1955-06-08”^^xsd:date ;
                    dbp:placeOfBirth dbr:London ,
                                     dbr:England .

dbr:London dbp:isPartOf dbr:England .
```

Anonymous nodes (blank node)

```
dbr:Tim_Berners-Lee dbo:marriedTo _:bnode1 .

_:bnode1 foaf:firstName "Nancy" ;
   foaf:lastName "Carlson" .
```

Anonymous nodes (blank node)

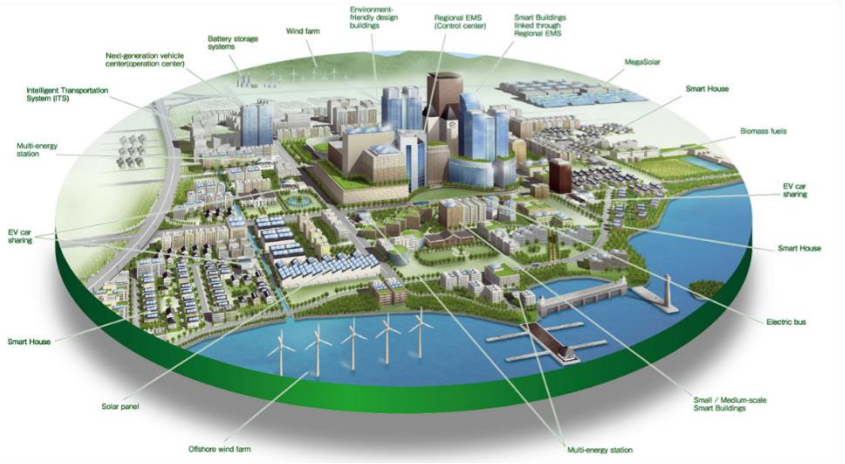
```
dbr:Tim_Berners-Lee dbo:marriedTo  [
   foaf:firstName "Nancy" ;
   foaf:lastName "Carlson"  ] .
```

```
@Prefix foaf: <http://xmlns.com/foaf/0.1/> .
 # Someone knows someone else, who has the name "Bob".

[ ] foaf:knows [ foaf:name "Bob" ] .
```

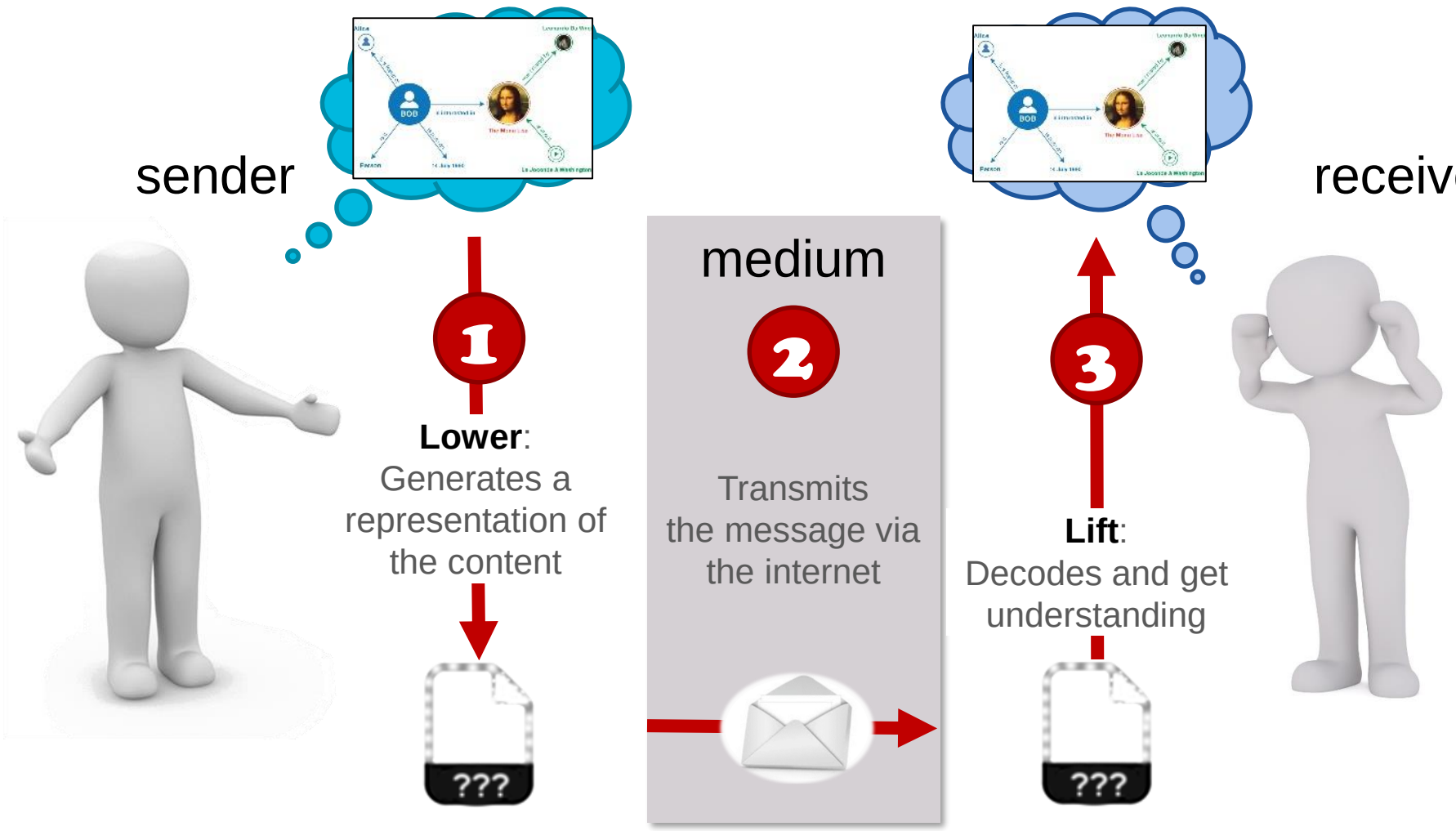
Contents

- Generalities on the Internet of Things
- Web and web principles
- From the Internet of Things to the Web of Things
- Interaction protocols for the Web of Things
- Architectural styles for the Web of Things
- Document formats for the Web of Things
- Some ontologies for the Web of Things / Using RDF as a *lingua franca*

How to reach semantic interoperability at the data level between heterogeneous things and services?

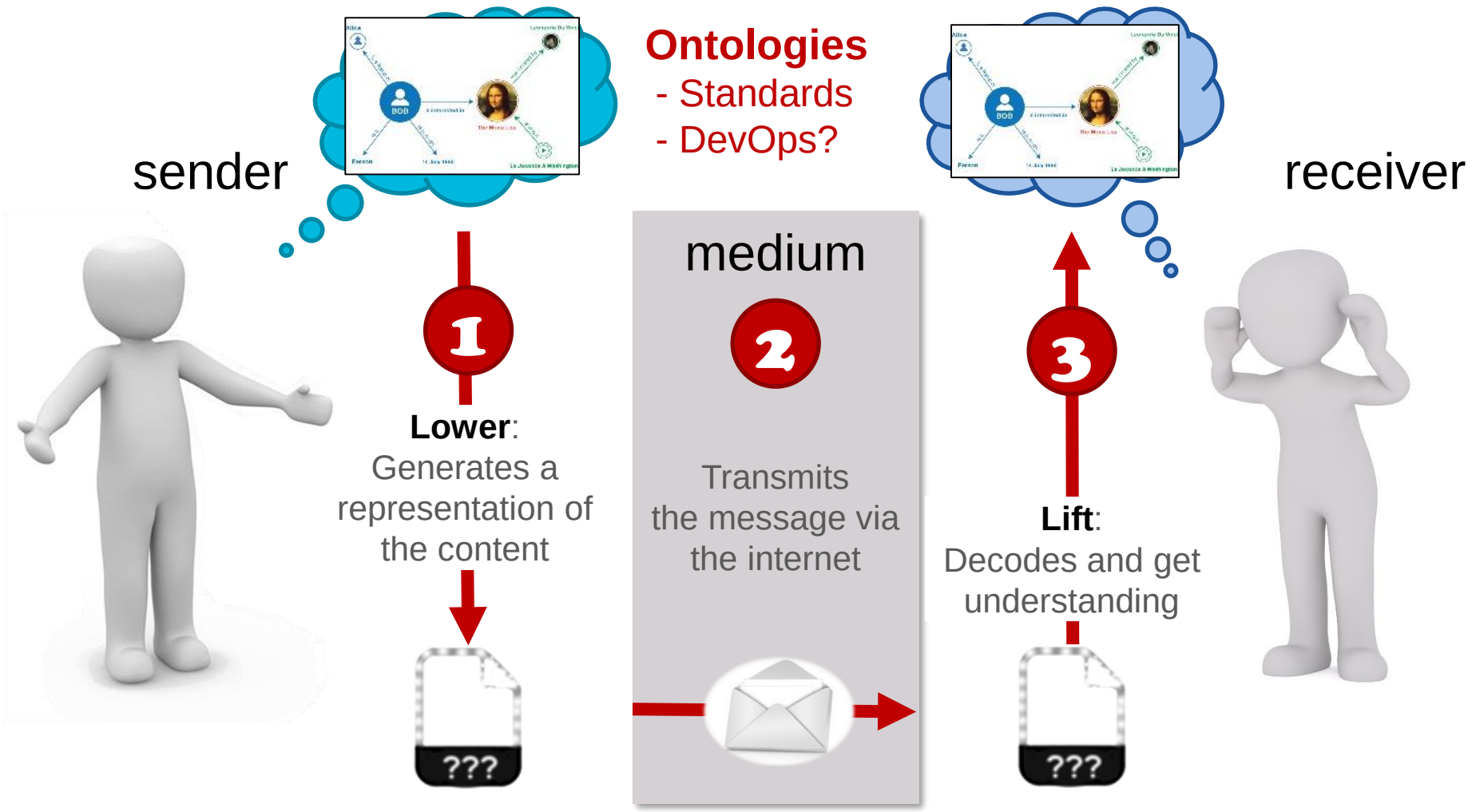


Communication between heterogeneous agents on the Web: conceptualization, scenarios, challenges



M. Lefrançois, RDF presentation and correct content conveyance for legacy services and the web of things. IOT 2018

Communication between heterogeneous agents on the Web: conceptualization, scenarios, challenges



The OGC&W3C
Semantic Sensor Networks Ontology

W3C Recommendation

Semantic Sensor Network Ontology

OGC® Making location count. W3C

W3C Recommendation 19 October 2017 (Link errors corrected 08 December 2017)

This version:
https://www.w3.org/TR/2017/REC-vocab-ssn-20171019/

Latest published version:
https://www.w3.org/TR/vocab-ssn/

Latest editor's draft:
https://w3c.github.io/sdw/ssn/

Implementation report:
https://w3c.github.io/sdw/ssn-usage/

Previous version:
https://www.w3.org/TR/2017/PR-vocab-ssn-

Editors:
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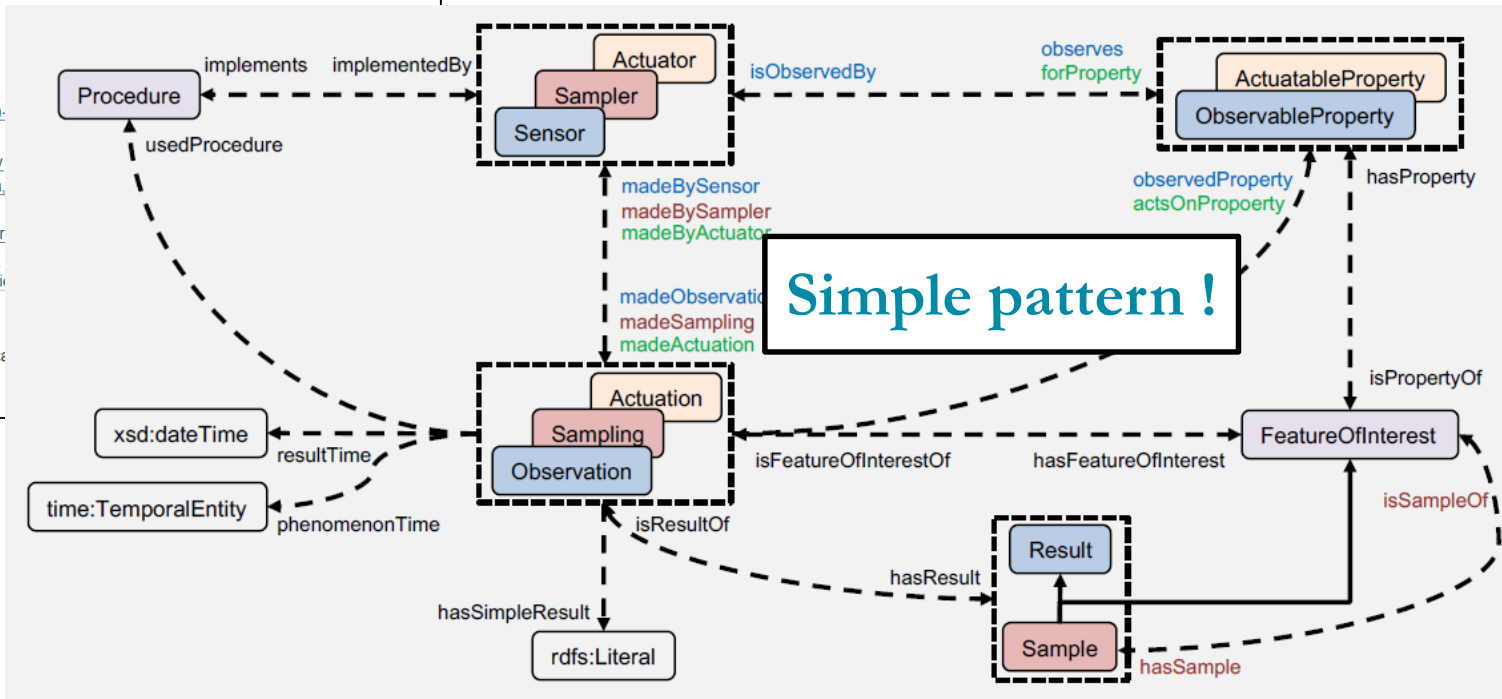
Joshua Lieberman, Tumbling Walls
Claus Stadler, Universität Leipzig



A. Haller, K. Janowicz, S. Cox, D. Le Phuoc, K. Taylor, and M. Lefrançois, Semantic Sensor Network Ontology, W3C Recommendation, W3C, 19 October 2017

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Latest published version:
https://www.w3.org/TR/vocab-ssn/

Latest editor's draft:
https://w3c.github.io/sdw/ssn/

Implementation report:
https://w3c.github.io/sdw/ssn-usage/

Previous version:
https://www.w3.org/TR/2017/PR-vocab-ssn-20170907/

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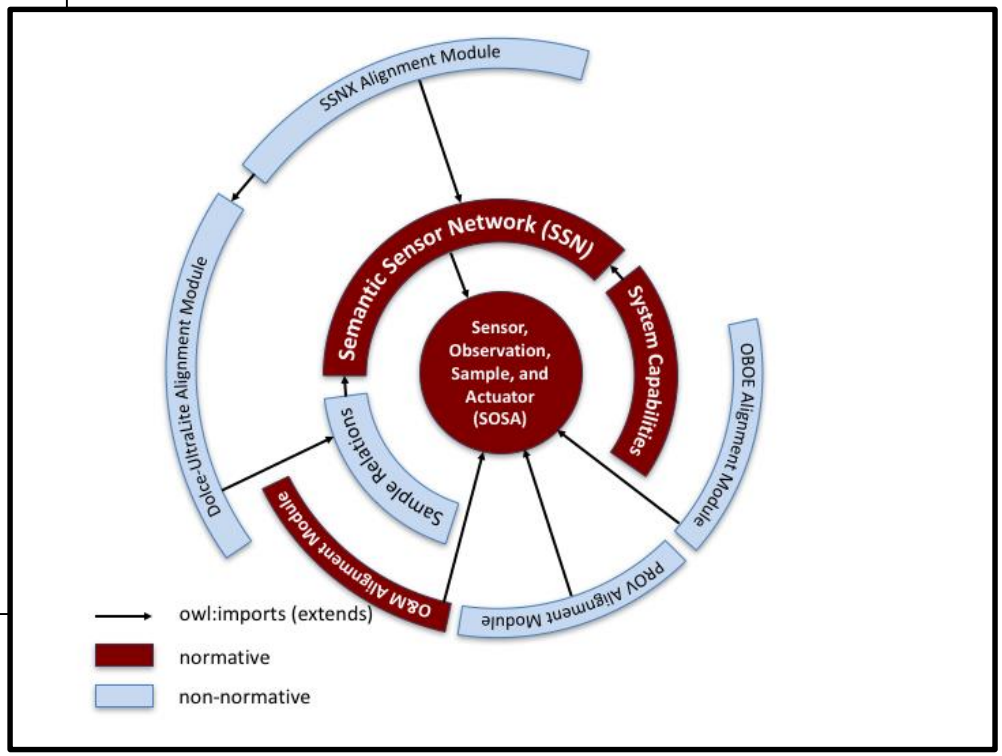


Modular with a simple core

SOSA = Sensor, Observation, Sample, Actuator

A. Haller, K. Janowicz, S. Cox, D. Le Phuoc, K. Taylor, and M. Lefrançois, Semantic Sensor Network Ontology, W3C Recommendation, W3C, 19 October 2017

Origins of SSN

2002 OGC's Sensor Web Enablement initiative

→ Sensor Model Language (SensorML)

'provider-centric': sensor + raw data

Sensor Observation Service - API REST Specification

→ Observations and Measurements (O&M)

'user-centric': feature of interest and observed property

2005 W3C Semantic Sensor Network Incubator Group

References and compares several existing proposed ontologies

First version of SSN published in 2011

Widely used, but juged too complicated and not well documented

TITRE	CITÉE PAR	ANNÉE
The ssn ontology of the w3c semantic sensor network incubator group M Compton, P Barnaghi, L Bermudez, R Garcia-Castro, O Corcho, S Cox, ... Web Semantics: Science, Services and Agents on the World Wide Web	800	2012
A survey of the semantic specification of sensors M Compton, C Henson, L Lefort, H Neuhaus, A Sheth Proceedings of the 2nd International Conference on Semantic Sensor Networks ...	214	2009
The stimulus-sensor-observation ontology design pattern and its integration into the semantic sensor network ontology K Janowicz, M Compton Proceedings of the 3rd International Conference on Semantic Sensor Networks ...	114	2010
Sensor search techniques for sensing as a service architecture for the internet of things C Perera, A Zaslavsky, CH Liu, M Compton, P Christen, ... IEEE Sensors Journal 14 (2), 406-420	106	2014
Semantic Sensor Network XG Final Report, W3C Incubator Group Report (2011) L Lefort, C Henson, K Taylor, P Barnaghi, M Compton, O Corcho, ...	104 *	

Origins of SSN

2015 OGC/W3C Spatial Data on the Web Working Group

Use Cases and Requirements (Working Group Note)
Spatial Data on the Web Best practices (Working Group Note)
Time ontology (Recommendation)
Semantic Sensor Network ontology (Recommendation)
3 other Working Group Note

Origins of SSN

Semantic Sensor Network ontology subgroup

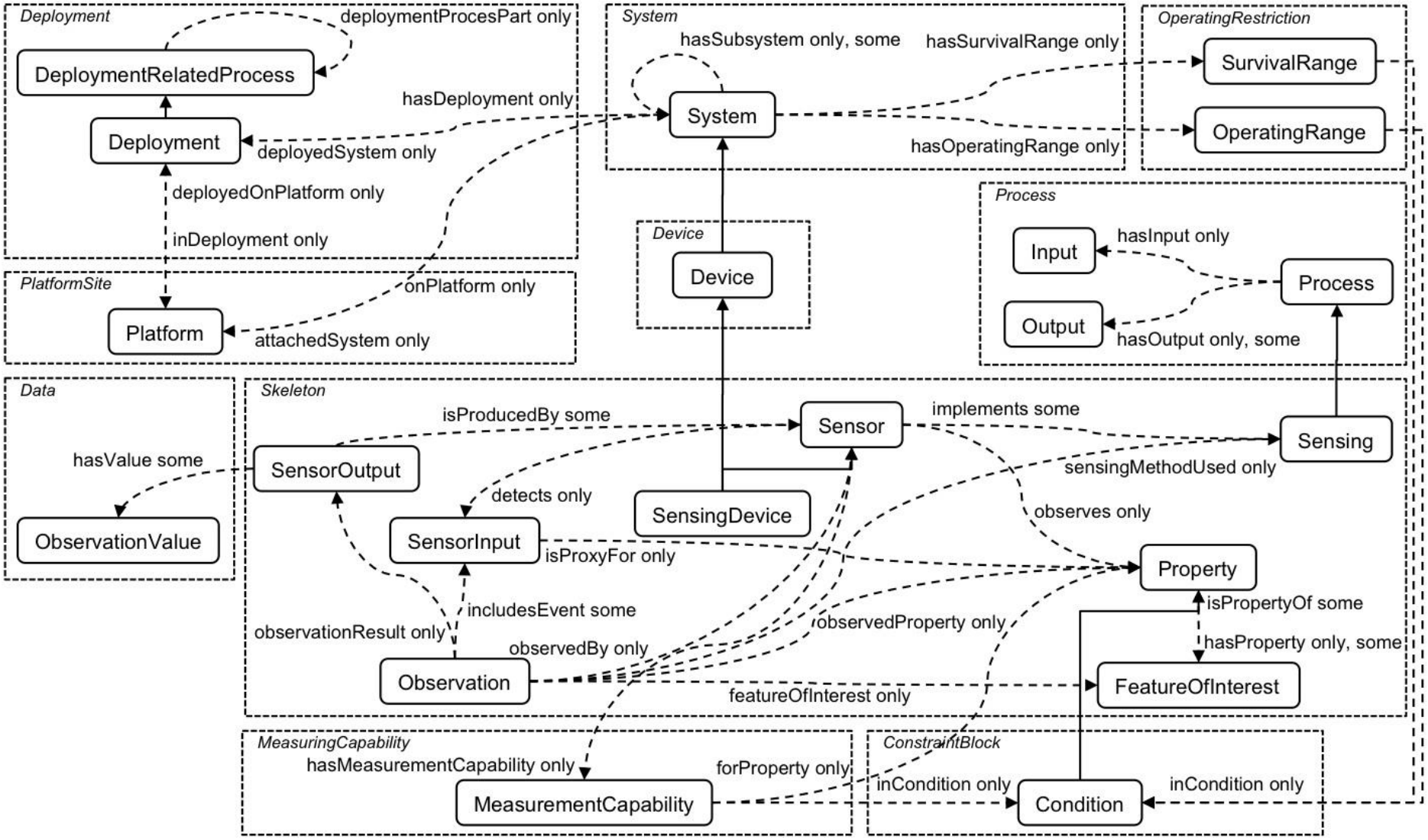
Objectives:

- better document and exemplify
- weaken dependency to Dolce Ultralite ontology
- modularize
- clean
- extend to cover new use cases

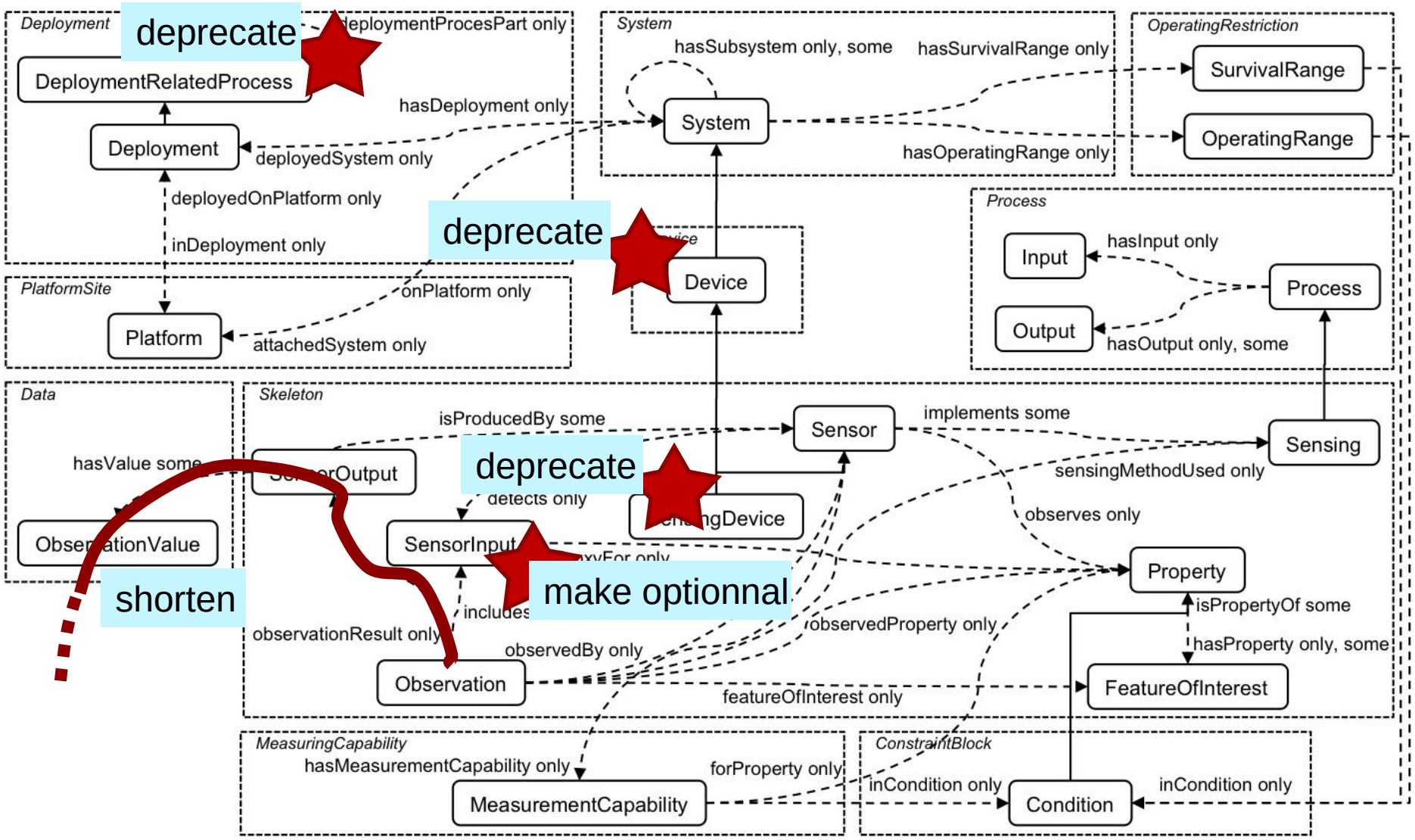
Samplers – Sampling – Samples

Actuator – Actuating

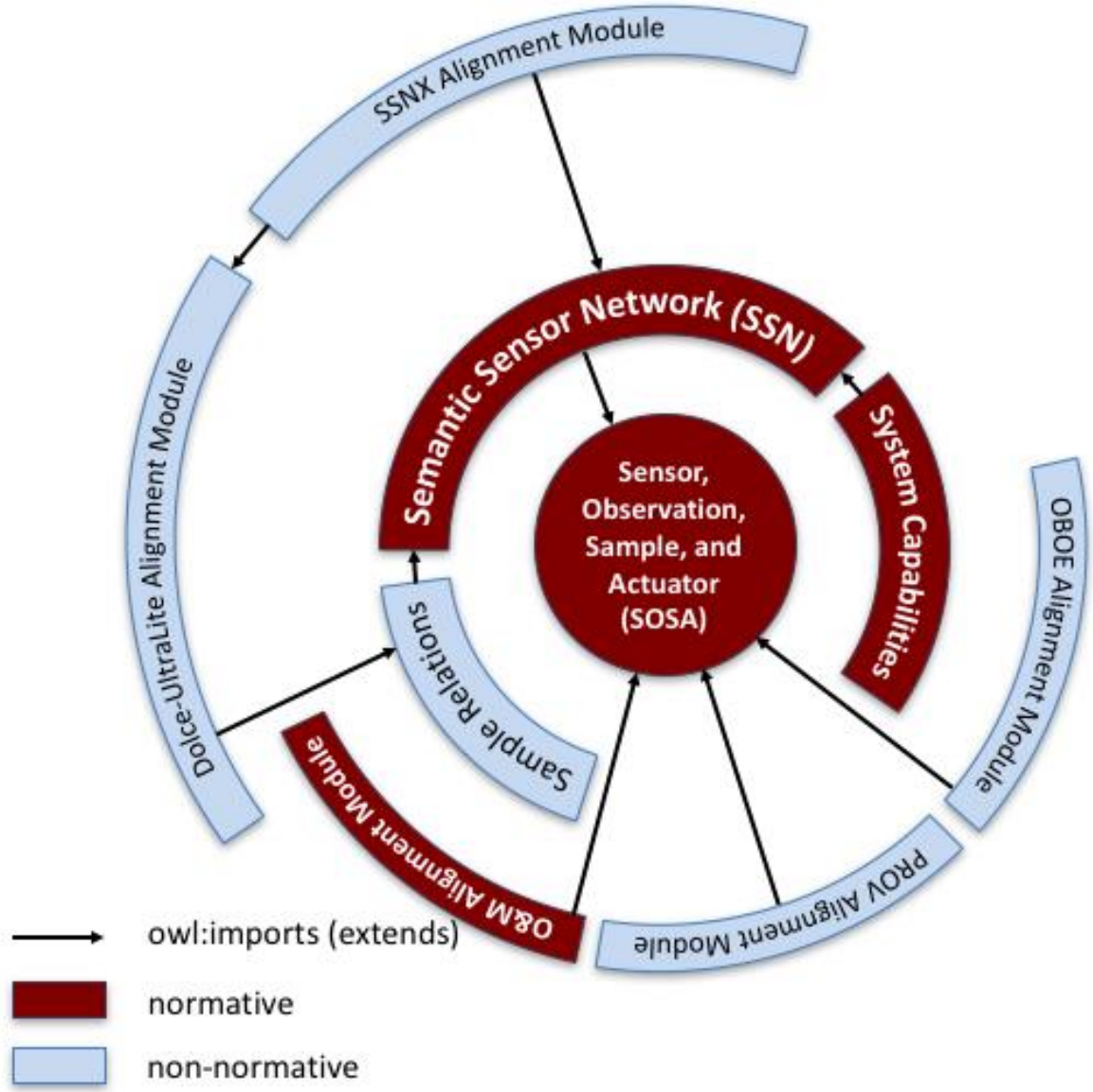
W3C Semantic Sensor Network (old)



W3C Semantic Sensor Network



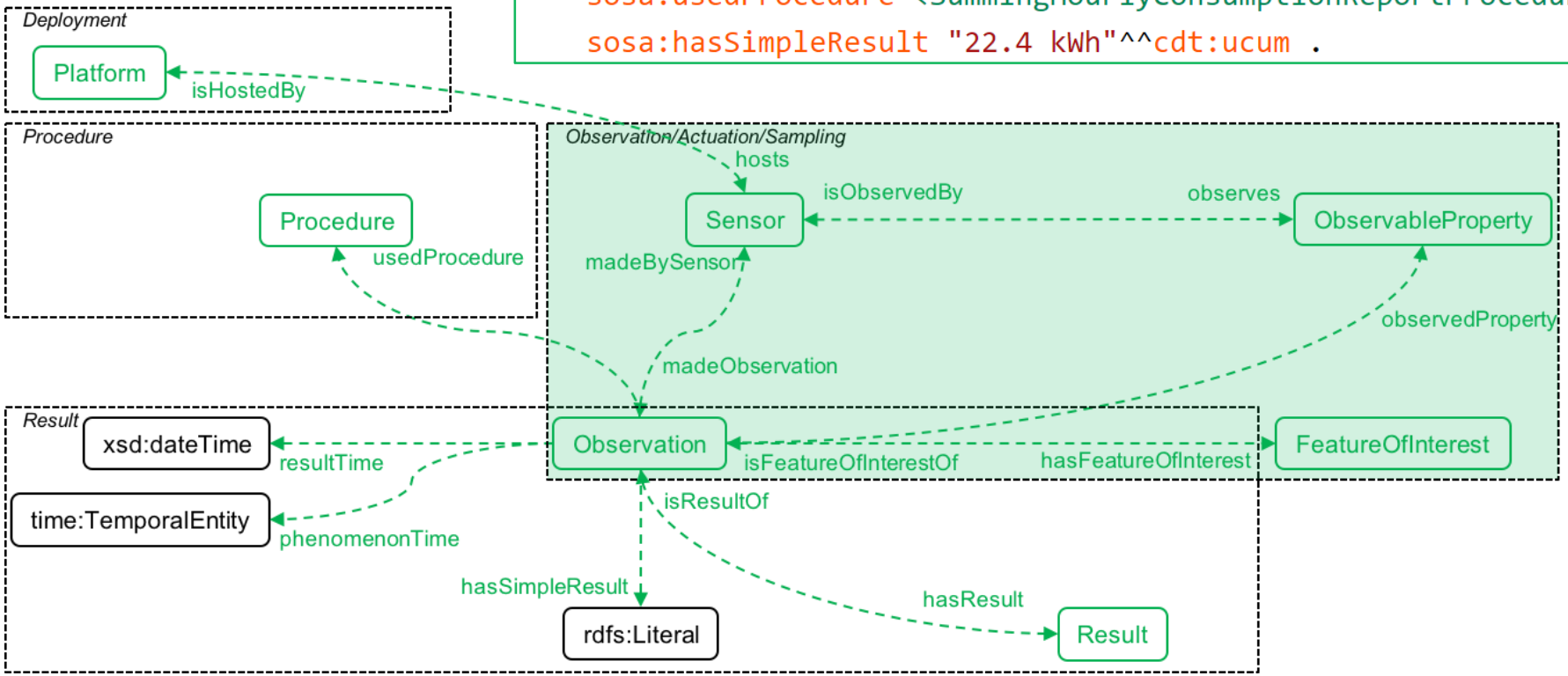
New SSN: a modular ontology



SOSA: simple core module

SOSA = Sensor, Observation, Sample, Actuator

```
<Observation/235714> a sosa:Observation ;
    sosa:hasFeatureOfInterest <Apartment/134> ;
    sosa:observedProperty <Apartment/134#electricConsumption>;
    sosa:madeBySensor <Sensor/926>;
    sosa:usedProcedure <SummingHourlyConsumptionReportProcedure>;
    sosa:hasSimpleResult "22.4 kWh"^^cdt:ucum .
```



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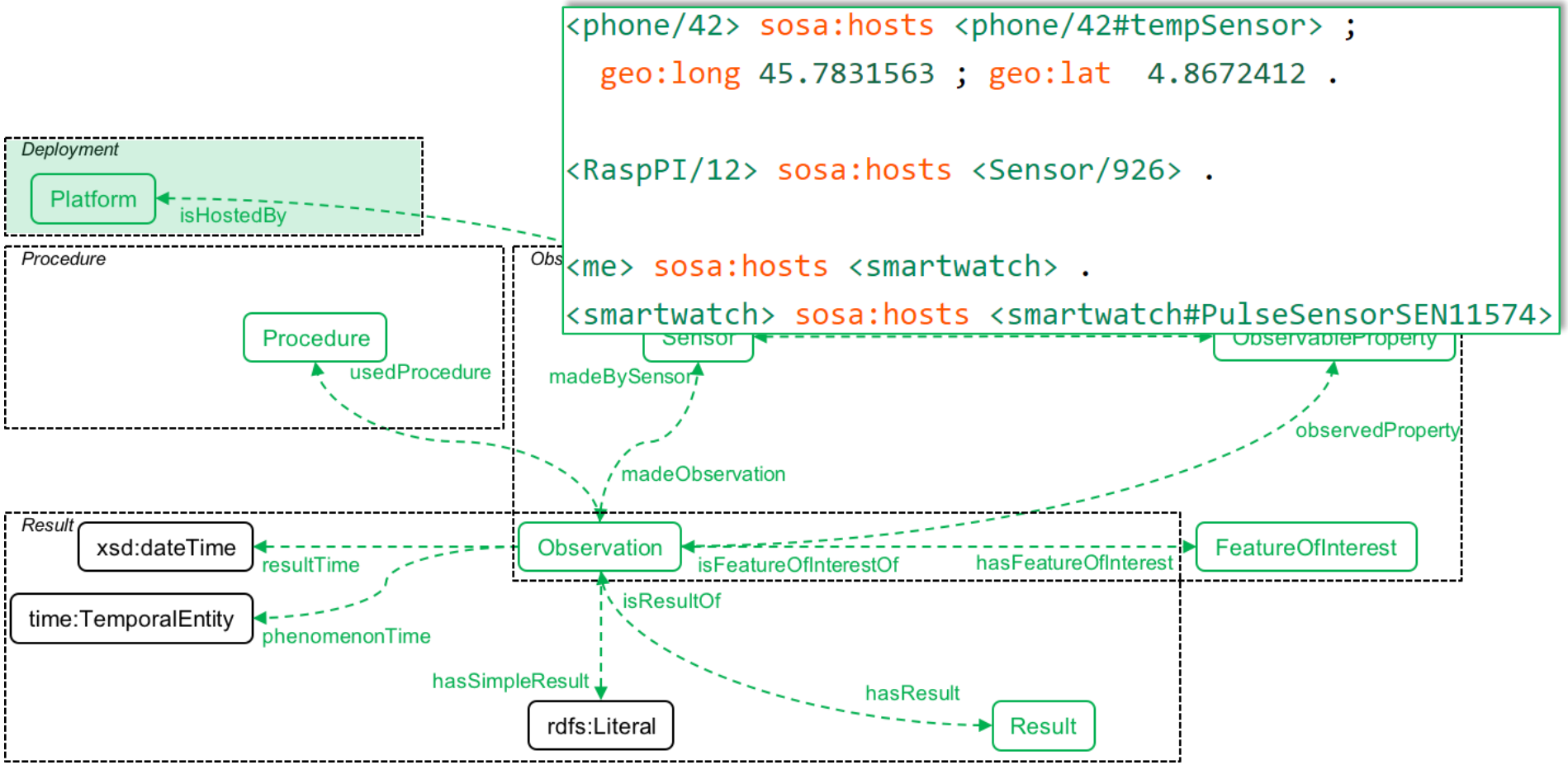
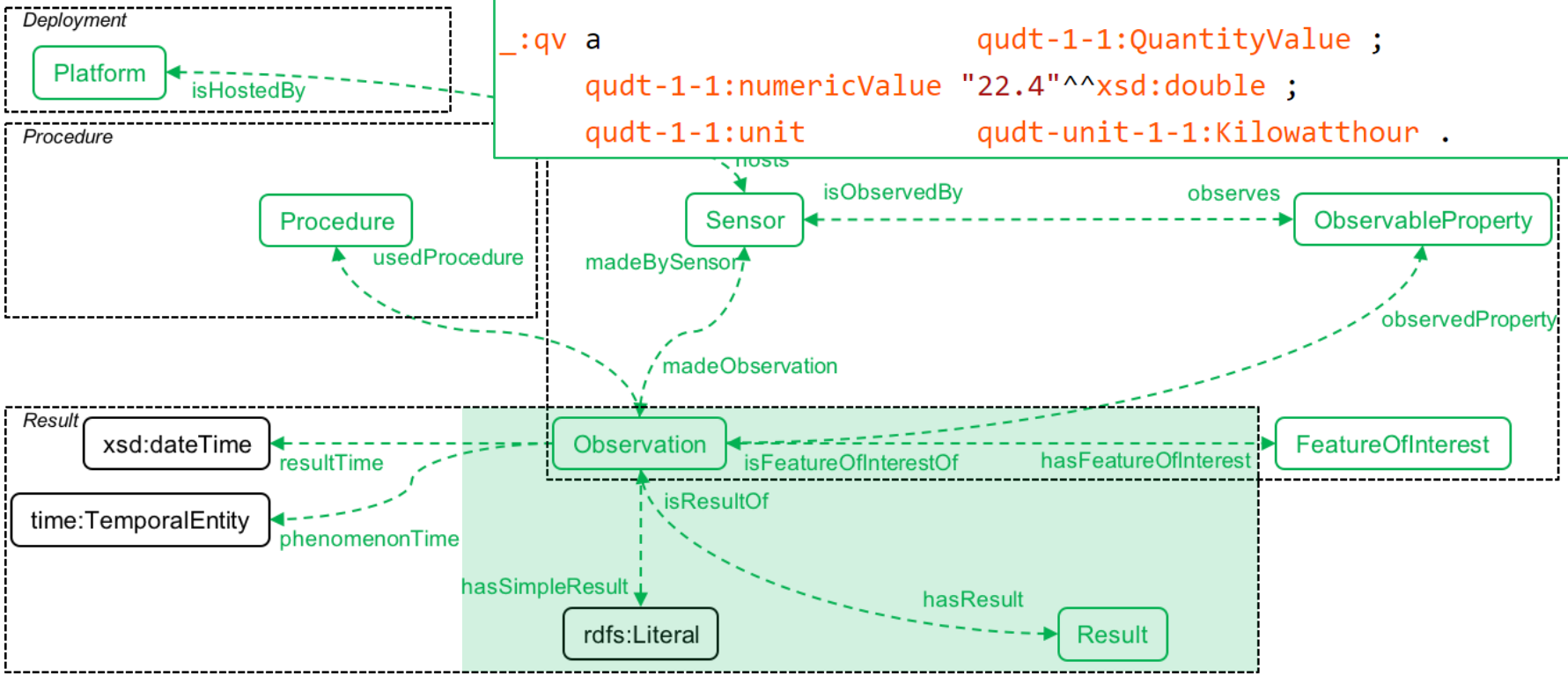


SOSA: simple core module

SOSA = Sensor, Observation, Sample, Actuator

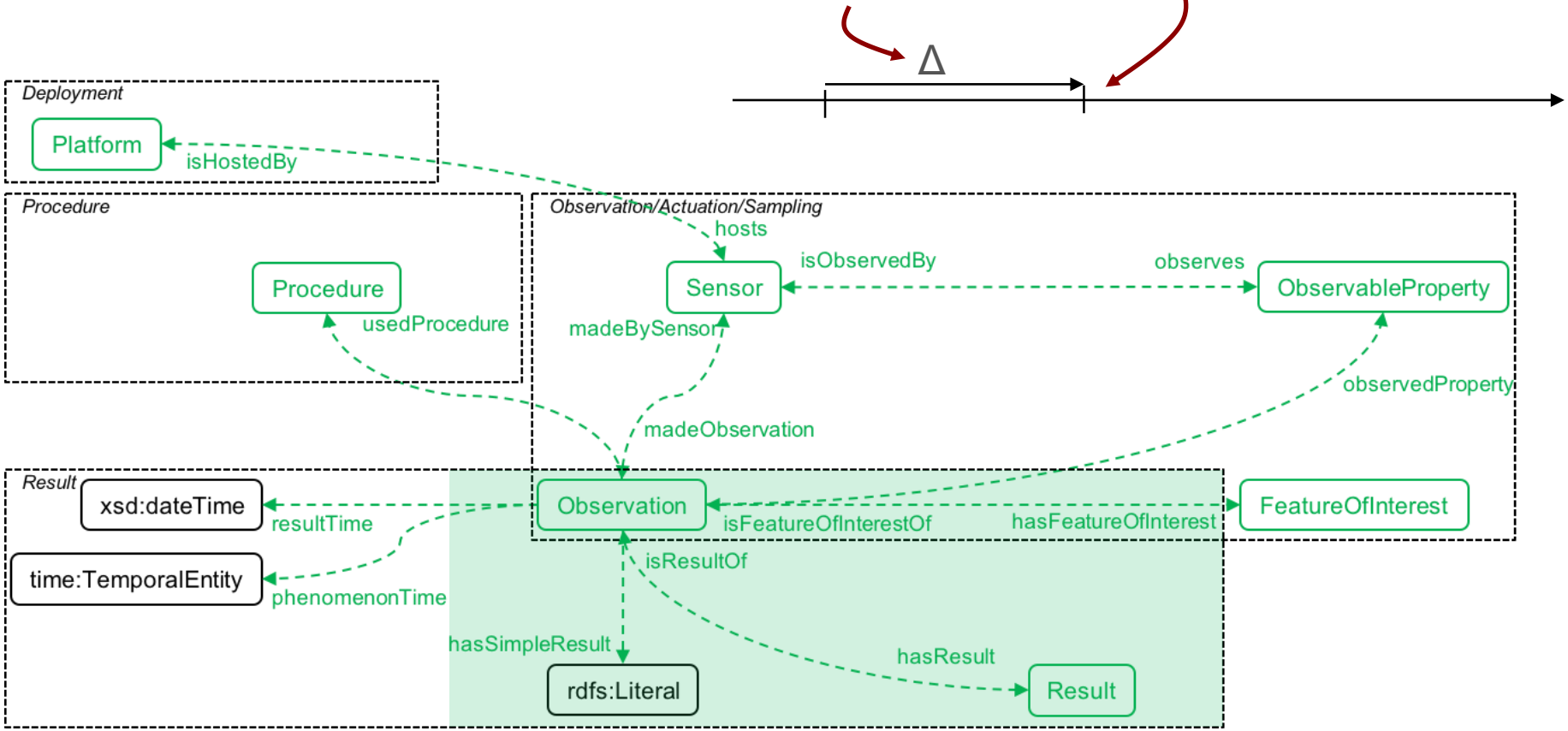
```
<Observation/235714> sosa:hasSimpleResult "22.4 kWh"^^cdt:ucum .

<Observation/235714> sosa:hasResult _:qv .

_:qv a                          qudt-1-1:QuantityValue ;
     qudt-1-1:numericValue "22.4"^^xsd:double ;
     qudt-1-1:unit              qudt-unit-1-1:Kilowatthour .
```



SOSA: simple core module

SOSA = Sensor, Observation, Sample, Actuator

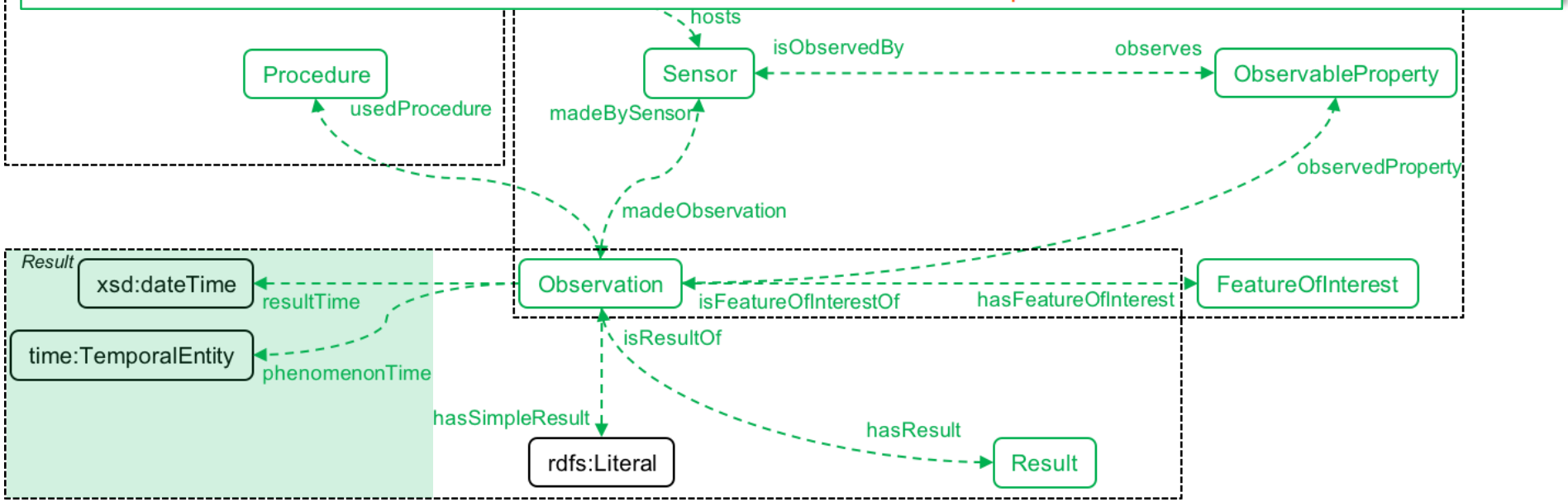
QUDT 1.1, a sosa:Result = qudt:QuantityValue.
OM 2, a sosa:Result = om:Measure or om:Point.



SOSA: simple core module

SOSA = Sensor, Observation, Sample, Actuator

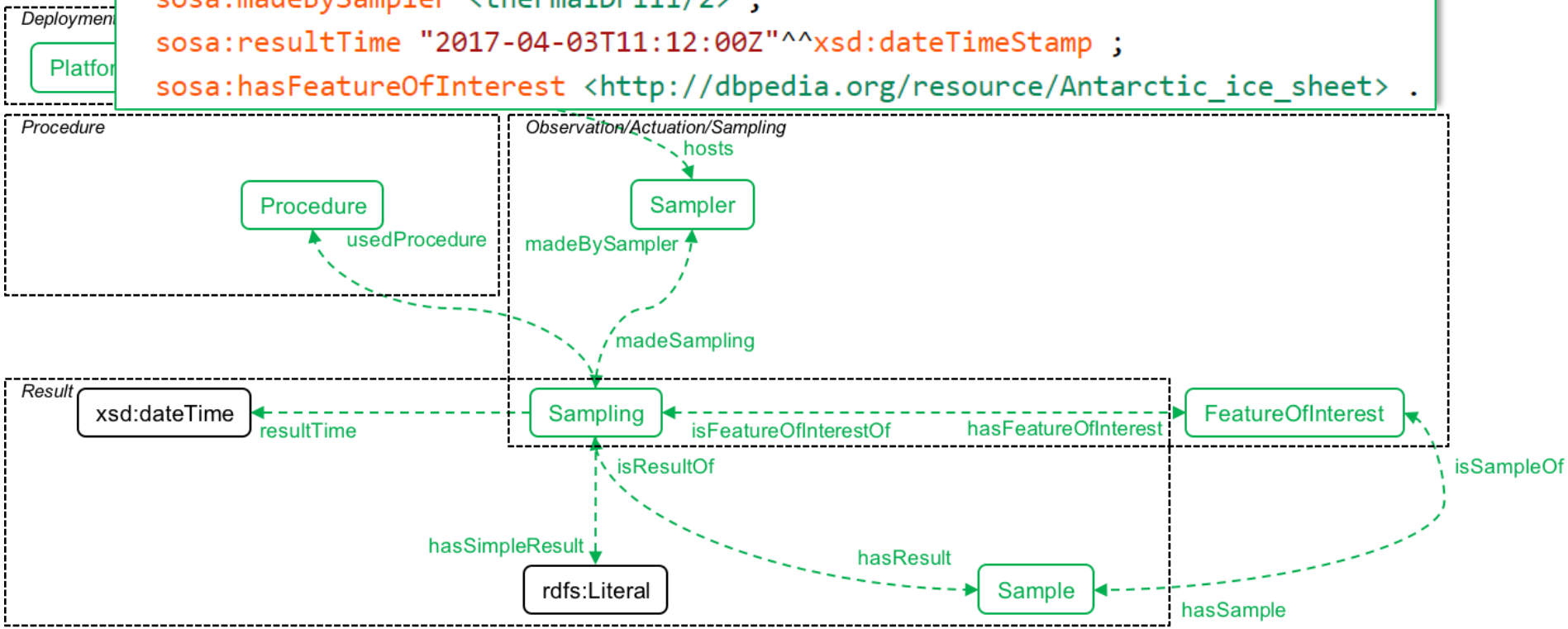
```
<Observation/235714> rdf:type sosa:Observation ;
  sosa:observedProperty  <apartment/134/electricConsumption> ;
  sosa:hasSimpleResult "22.4 kWh"^^cdt:ucum ;
  sosa:phenomenonTime [ a time:Interval ;
    time:hasBeginning [ time:inXSDDateTimeStamp "2017-04-15T00:00:00+00:00"^^xsd:dateTimeStamp ] ;
    time:hasEnd [ time:inXSDDateTimeStamp "2017-04-16T00:00:00+00:00"^^xsd:dateTimeStamp ]
  ] ;
  sosa:resultTime "2017-04-16T00:00:12+00:00"^^xsd:dateTimeStamp .
```



SOSA: simple core module

SOSA = Sensor, Observation, Sample, Actuator

```
<WellDrilling/4578> a sosa:Sampling ;
  geo:lat -73.35 ;
  geo:long 9.32 ;
  sosa:hasResult <iceCore/12> ;
  sosa:madeBySampler <thermalDrill/2> ;
  sosa:resultTime "2017-04-03T11:12:00Z"^^xsd:dateTimeStamp ;
  sosa:hasFeatureOfInterest <http://dbpedia.org/resource/Antarctic_ice_sheet> .
```

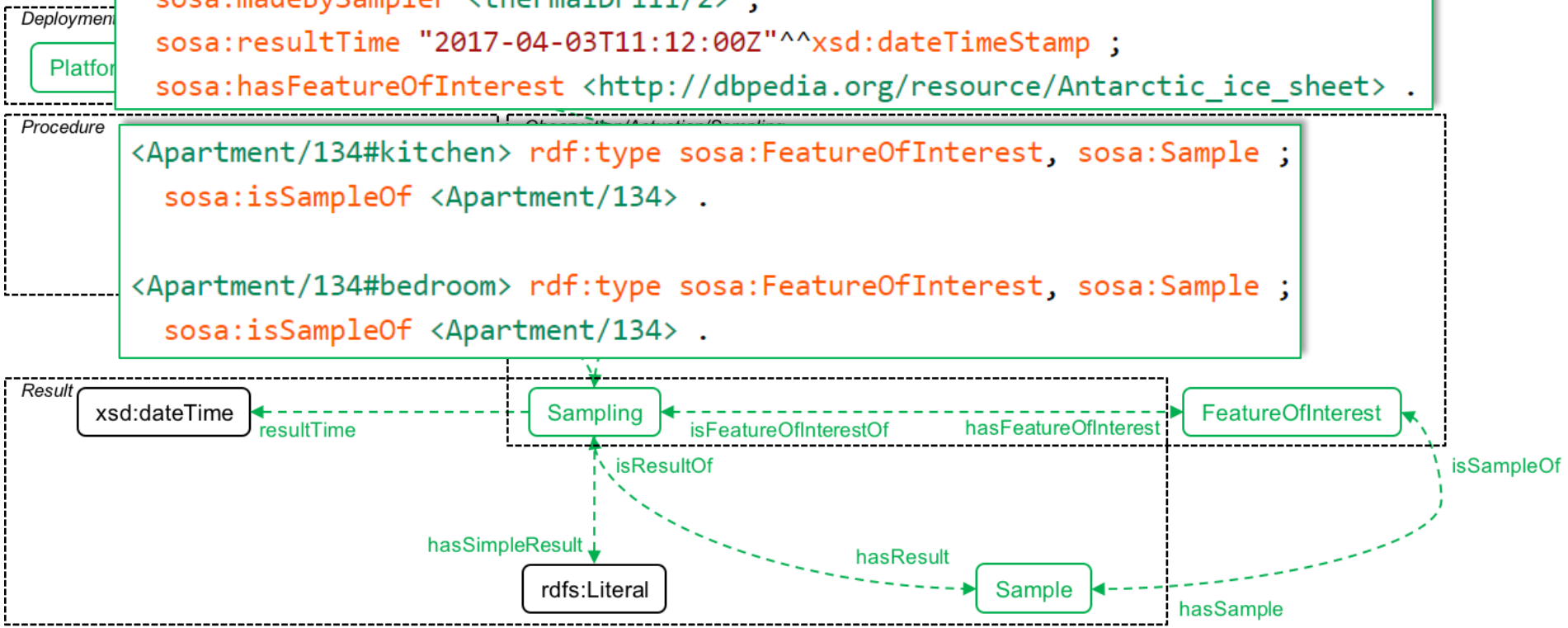


SOSA: simple core module

SOSA = Sensor, Observation, Sample, Actuator

```
<WellDrilling/4578> a sosa:Sampling ;
  geo:lat -73.35 ;
  geo:long 9.32 ;
  sosa:hasResult <iceCore/12> ;
  sosa:madeBySampler <thermalDrill/2> ;
  sosa:resultTime "2017-04-03T11:12:00Z"^^xsd:dateTimeStamp ;
  sosa:hasFeatureOfInterest <http://dbpedia.org/resource/Antarctic_ice_sheet> .
```

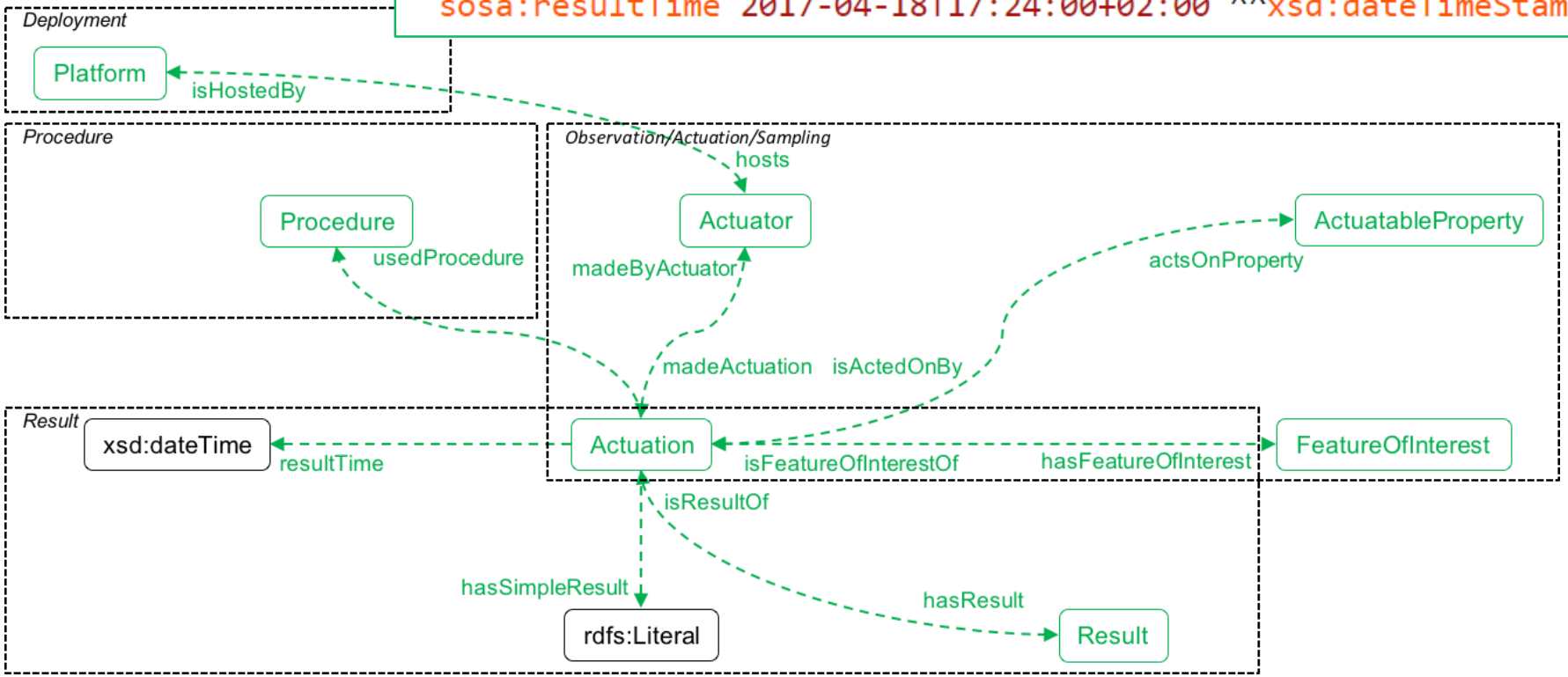
```
<Apartment/134#kitchen> rdf:type sosa:FeatureOfInterest, sosa:Sample ;
  sosa:isSampleOf <Apartment/134> .

<Apartment/134#bedroom> rdf:type sosa:FeatureOfInterest, sosa:Sample ;
  sosa:isSampleOf <Apartment/134> .
```



SOSA: simple core module

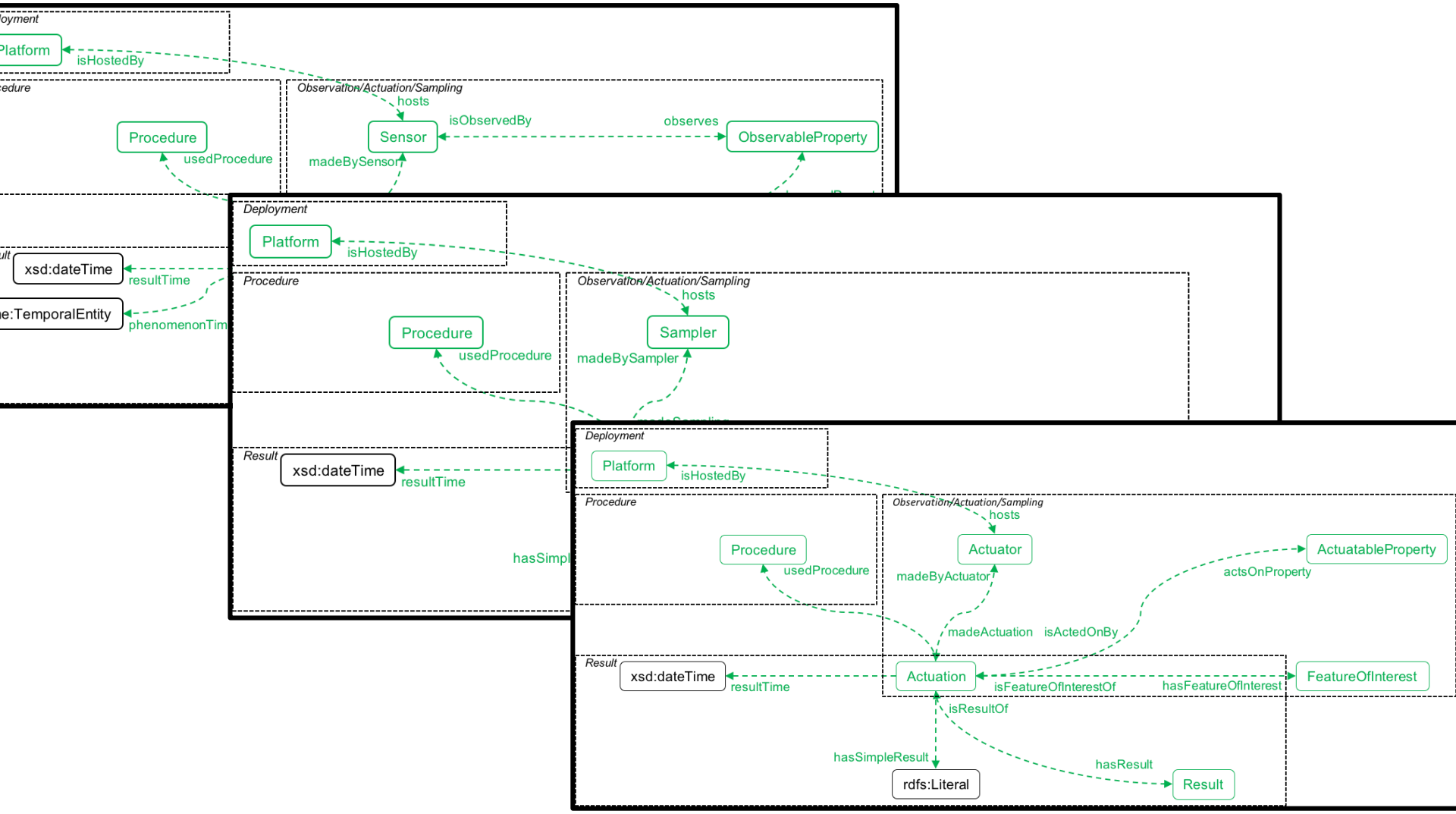
SOSA = Sensor, Observation, Sample, Actuator

```
<Actuation/188> rdf:type sosa:Actuation ;
  sosa:actsOnProperty <window/104#state> ;
  sosa:actuationMadeBy <windowCloser/987> ;
  sosa:hasSimpleResult true ;
  sosa:resultTime"2017-04-18T17:24:00+02:00"^^xsd:dateTimeStamp .
```

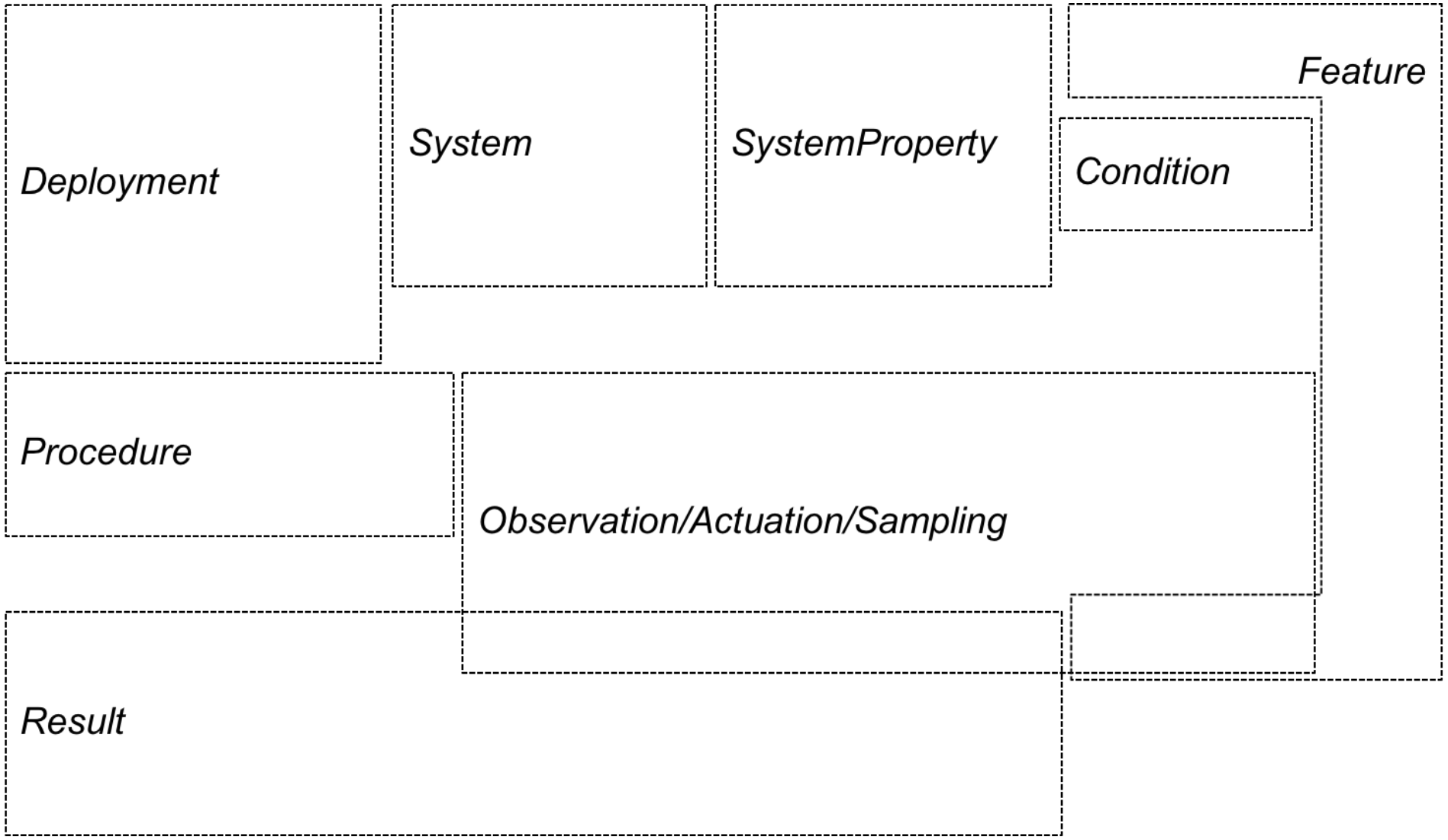


SOSA: simple core module

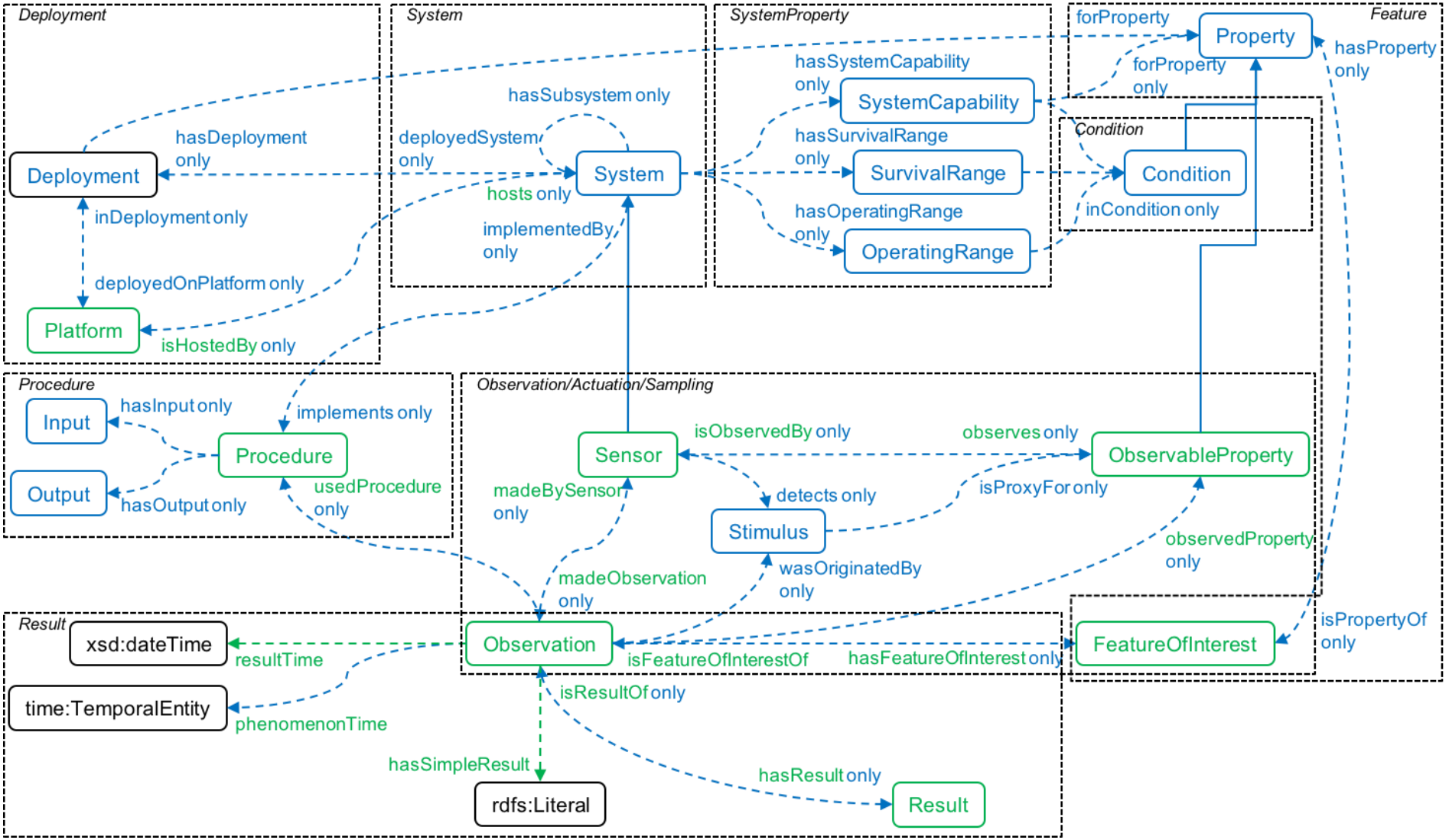
SOSA = Sensor, Observation, Sample, Actuator



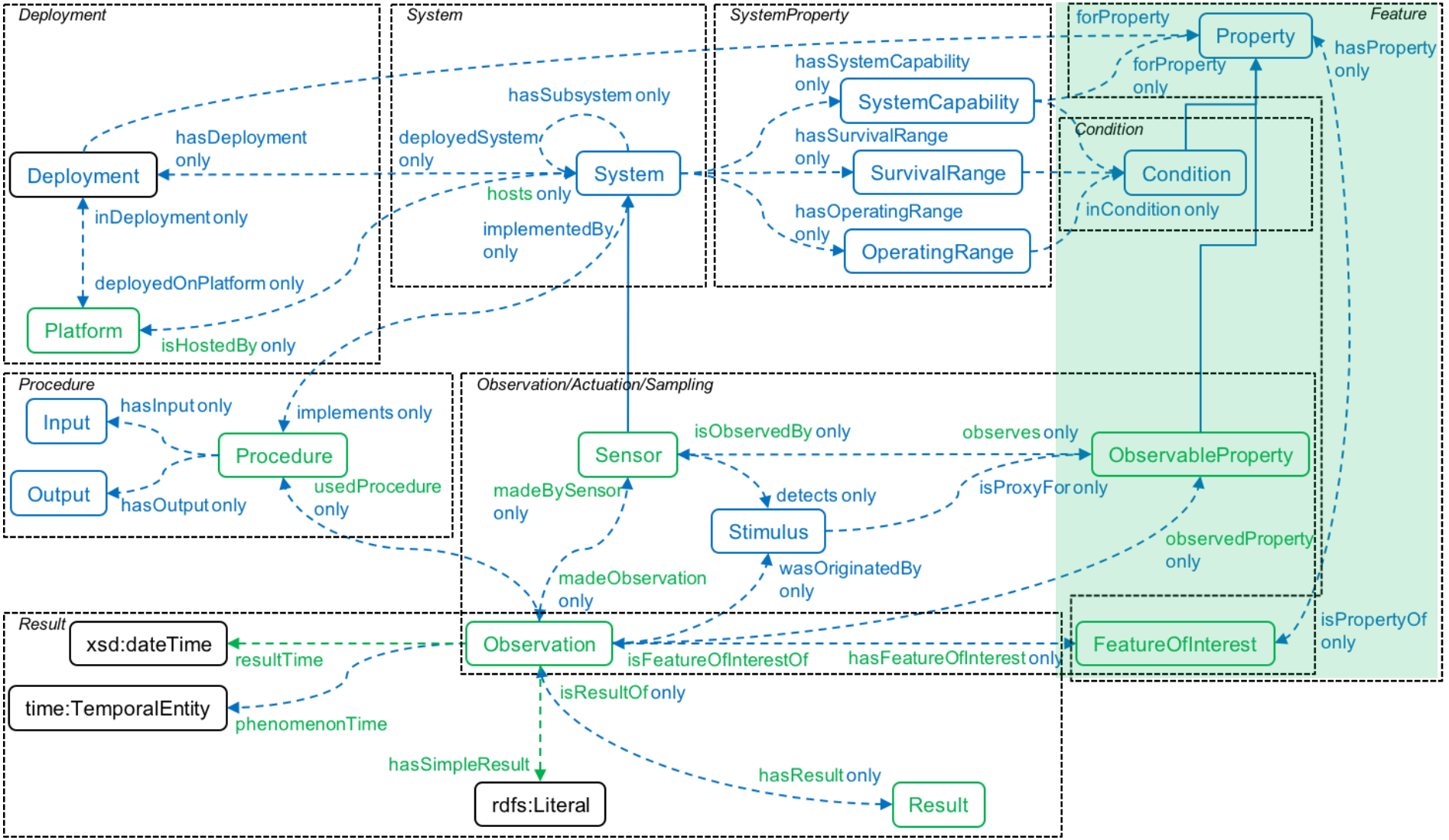
W3C Semantic Sensor Network



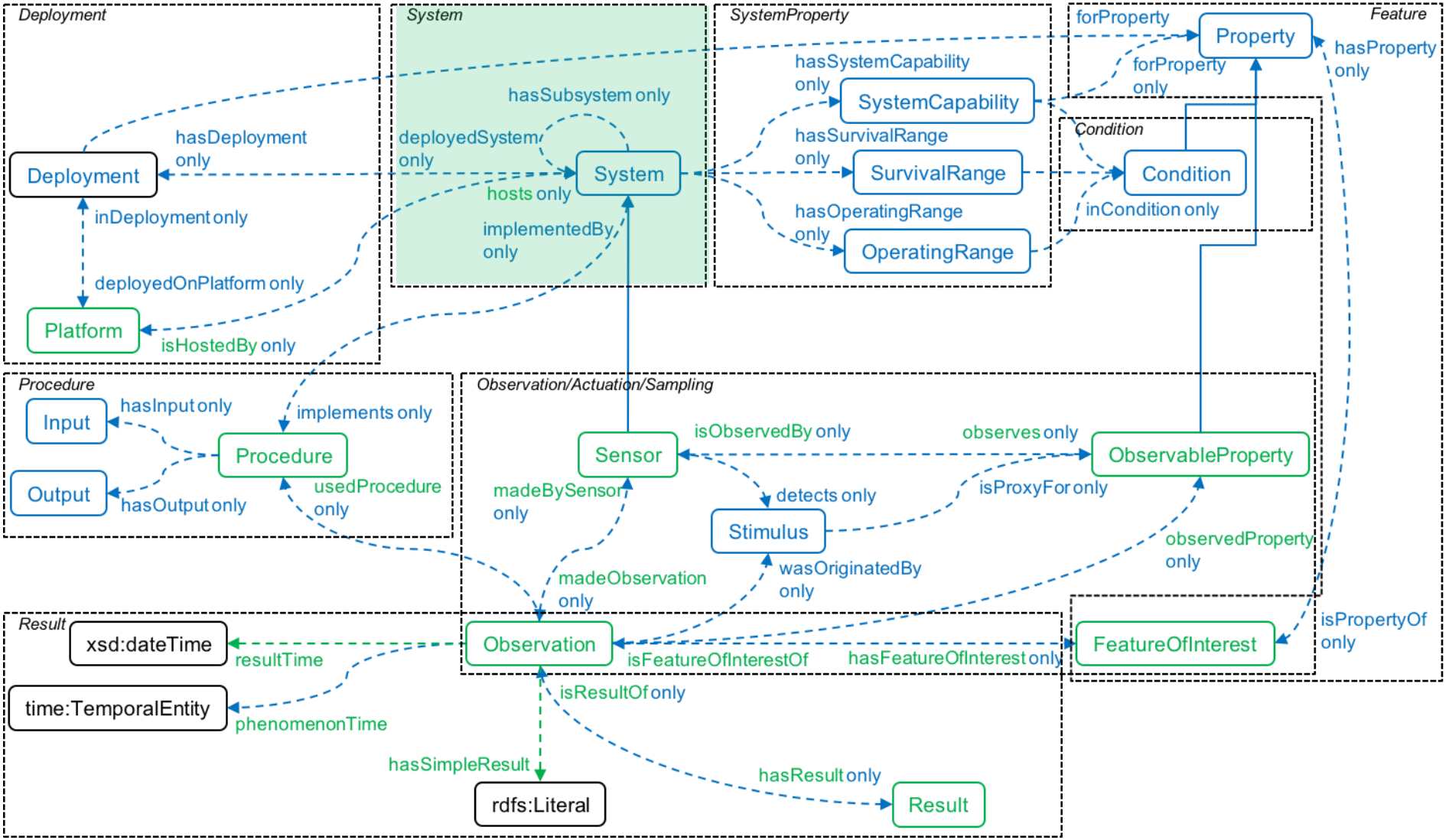
W3C Semantic Sensor Network



W3C Semantic Sensor Network

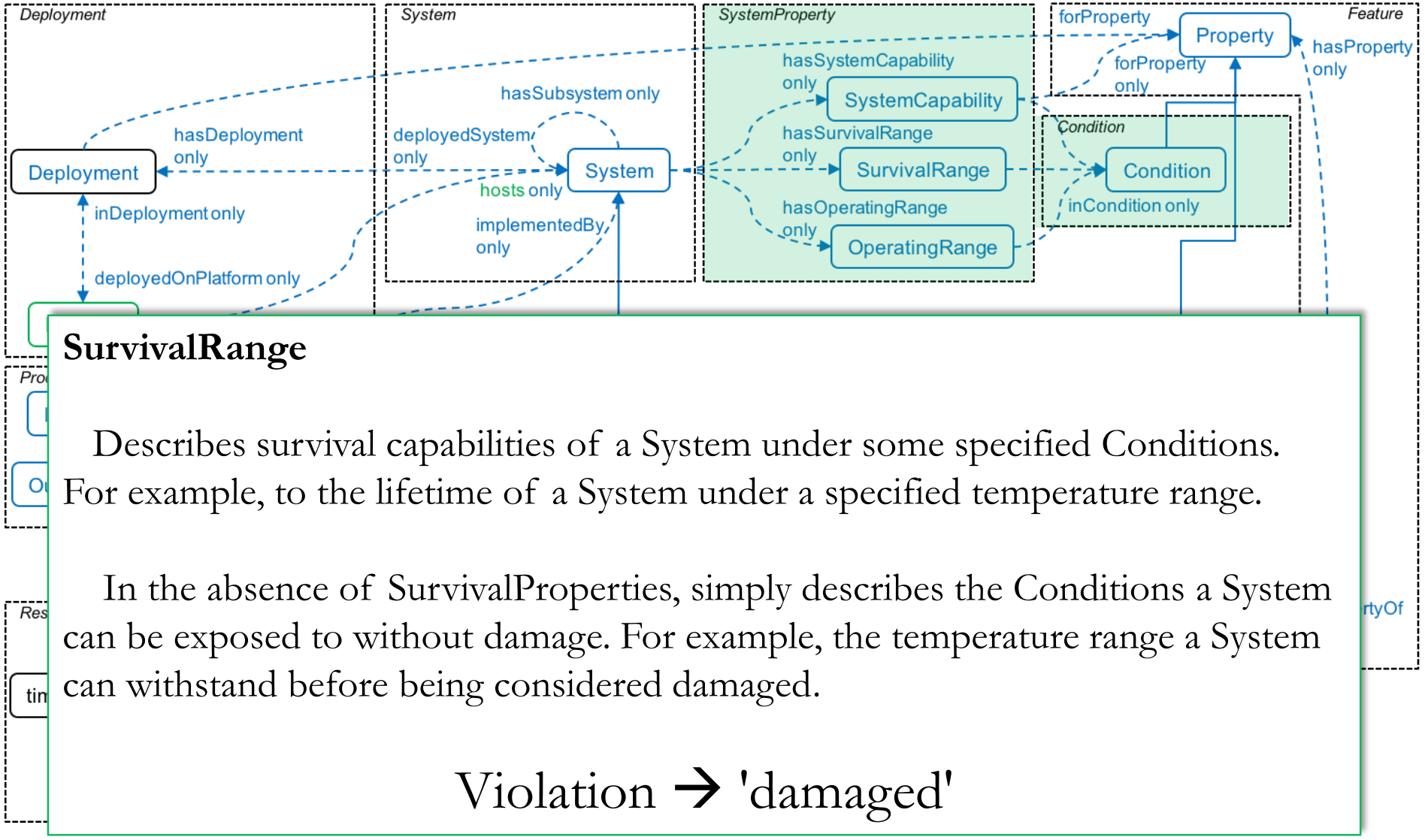


W3C Semantic Sensor Network



SSN-systems Separate Module

Non normative http://www.w3.org/ns/ssn/systems/



SurvivalRange

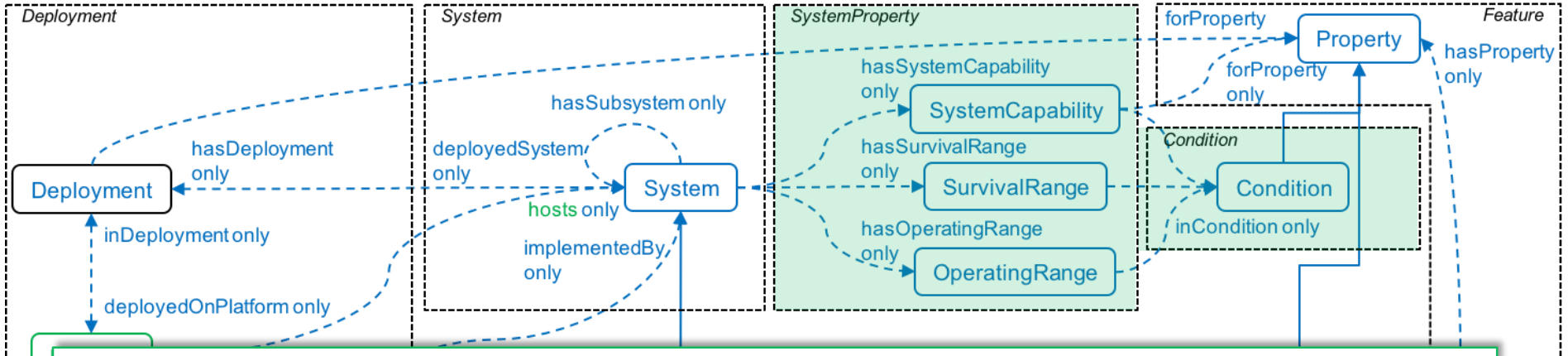
Describes survival capabilities of a System under some specified Conditions. For example, to the lifetime of a System under a specified temperature range.

In the absence of SurvivalProperties, simply describes the Conditions a System can be exposed to without damage. For example, the temperature range a System can withstand before being considered damaged.

Violation → 'damaged'

SSN-systems Separate Module

Non normative http://www.w3.org/ns/ssn/systems/



OperatingRange

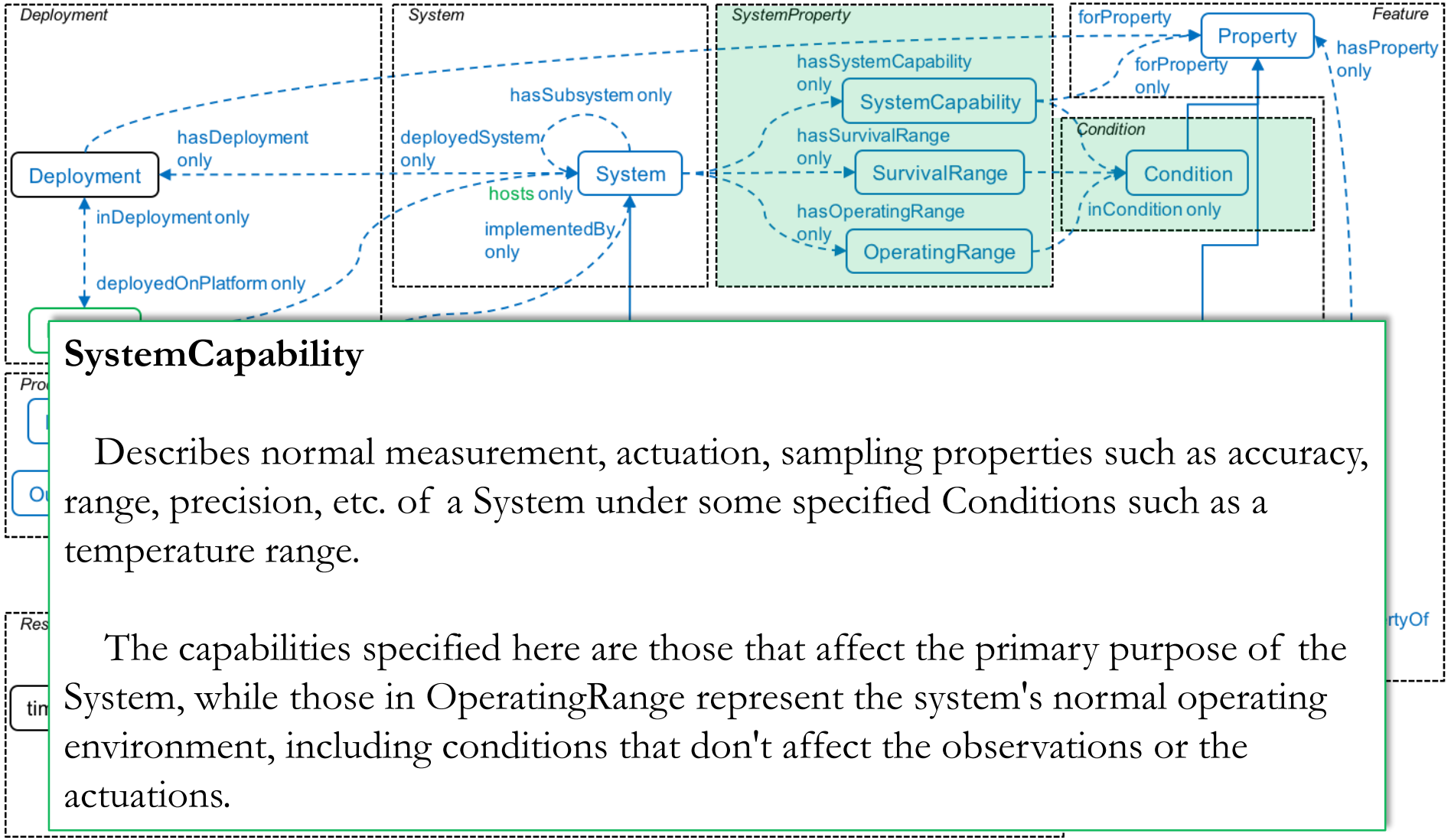
Describes normal OperatingProperties of a System under some specified Conditions. For example, to the power requirement or maintenance schedule of a System under a specified temperature range.

In the absence of OperatingProperties, it simply describes the Conditions in which a System is expected to operate.

Violation → 'out of operating range'

SSN-systems Separate Module

Non normative http://www.w3.org/ns/ssn/systems/



SystemCapability

Describes normal measurement, actuation, sampling properties such as accuracy, range, precision, etc. of a System under some specified Conditions such as a temperature range.

The capabilities specified here are those that affect the primary purpose of the System, while those in OperatingRange represent the system's normal operating environment, including conditions that don't affect the observations or the actuations.

First integration in schema.org

iotschema.org

Search

Google, Microsoft, Yahoo, Yandex, …

About Schemas Documentation

Actuator

Canonical URL: http://iotschema.org/Actuator

Device > Actuator

Actuator – A device that is used to change the state of the world.

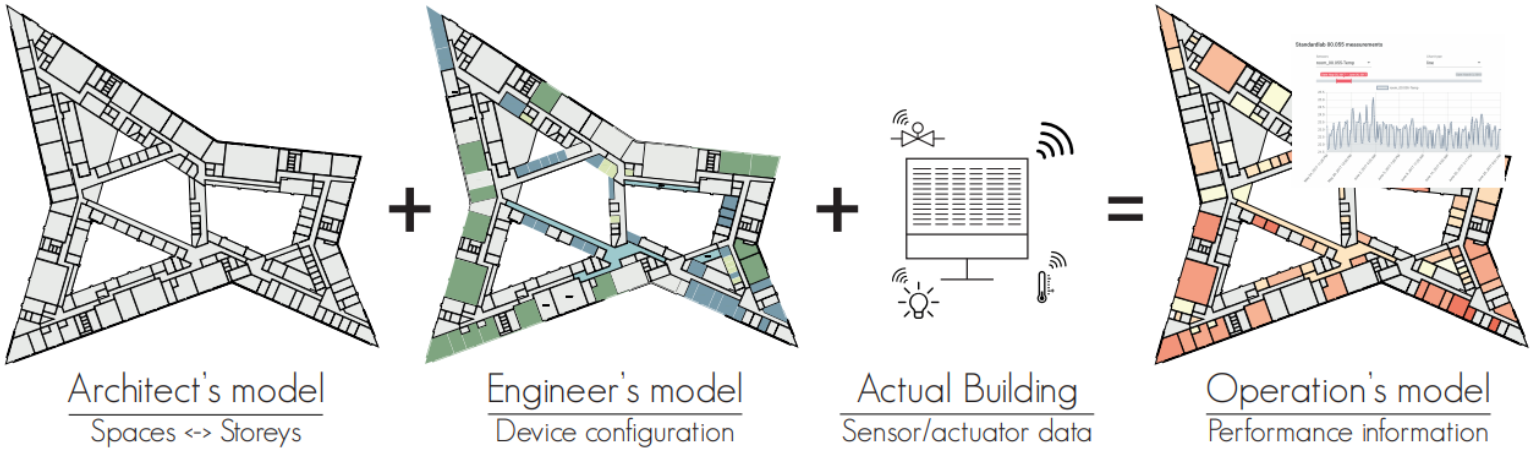
Property	Expected Type	Description
Properties from Actuator		
Made Actuation	PropertyValue	Relation linking a PropertyValue to the Actuator that made that Actuation.
For Property	Property or Action	Relation between an Actuator and either a Property or an Action that it is capable of actuation.

Instances of Actuator may appear as values for the following properties

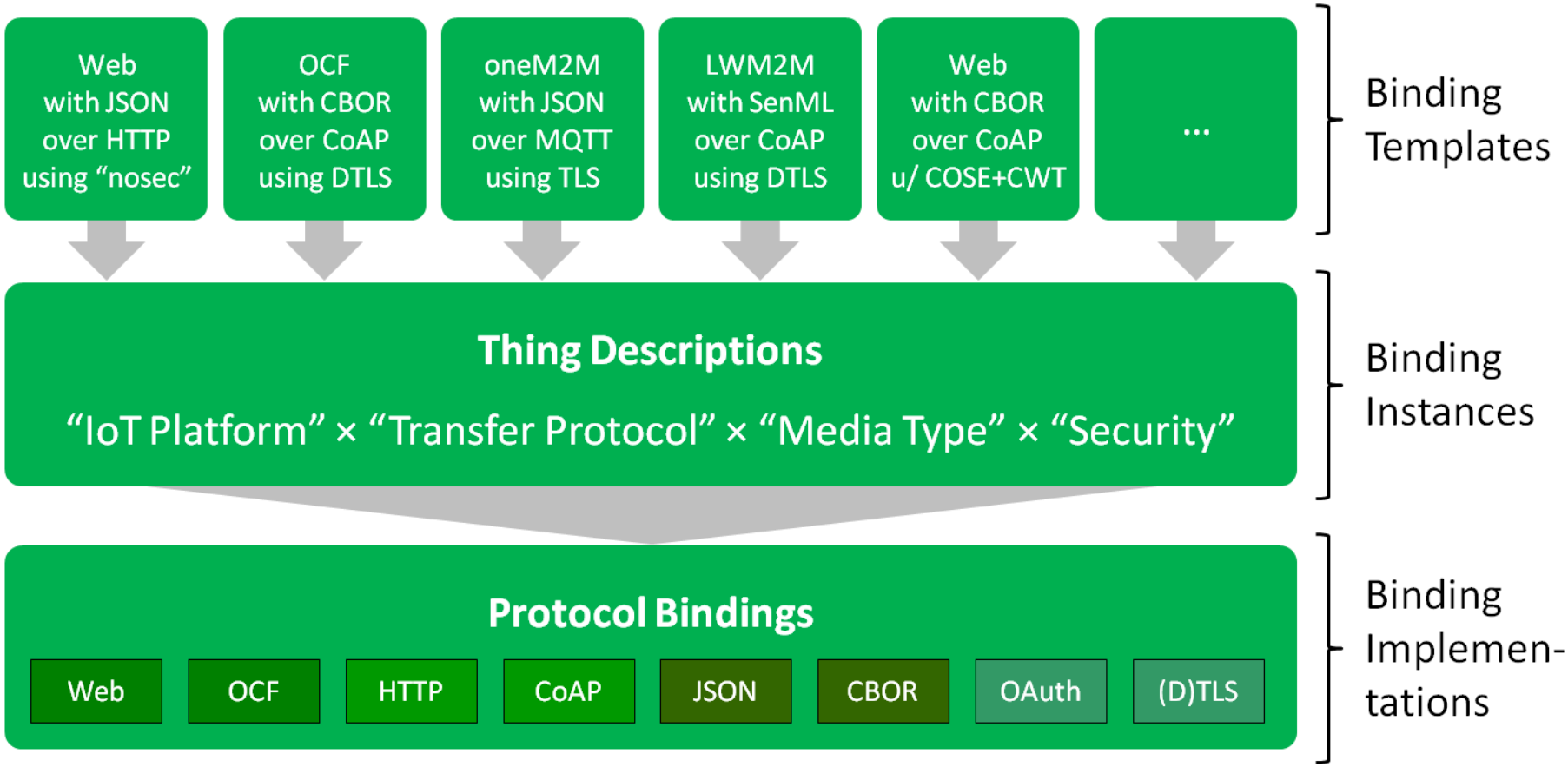
Property	On Types	Description
Is Acted On By	Property or Action	Relation between an Action or a Property of a FeatureOfInterest and an Actuator changing its state.

Early SSN adopters (as of 2018)

- Topics of papers published this year citing SSN
  - Smart agriculture (irrigation)
  - Smart transportation (sensors generating vehicule signals)
  - Smart building (figure below)
  - Smart health (Smart homes for seniors)
  - Brain-Computer interaction
  - GeoScience (earth, meteorology, oceans, events, flooding, ...)
  - Smart grids (electric vehicles charging stations)
  - Industry of the future



The W3C Web of Things working group



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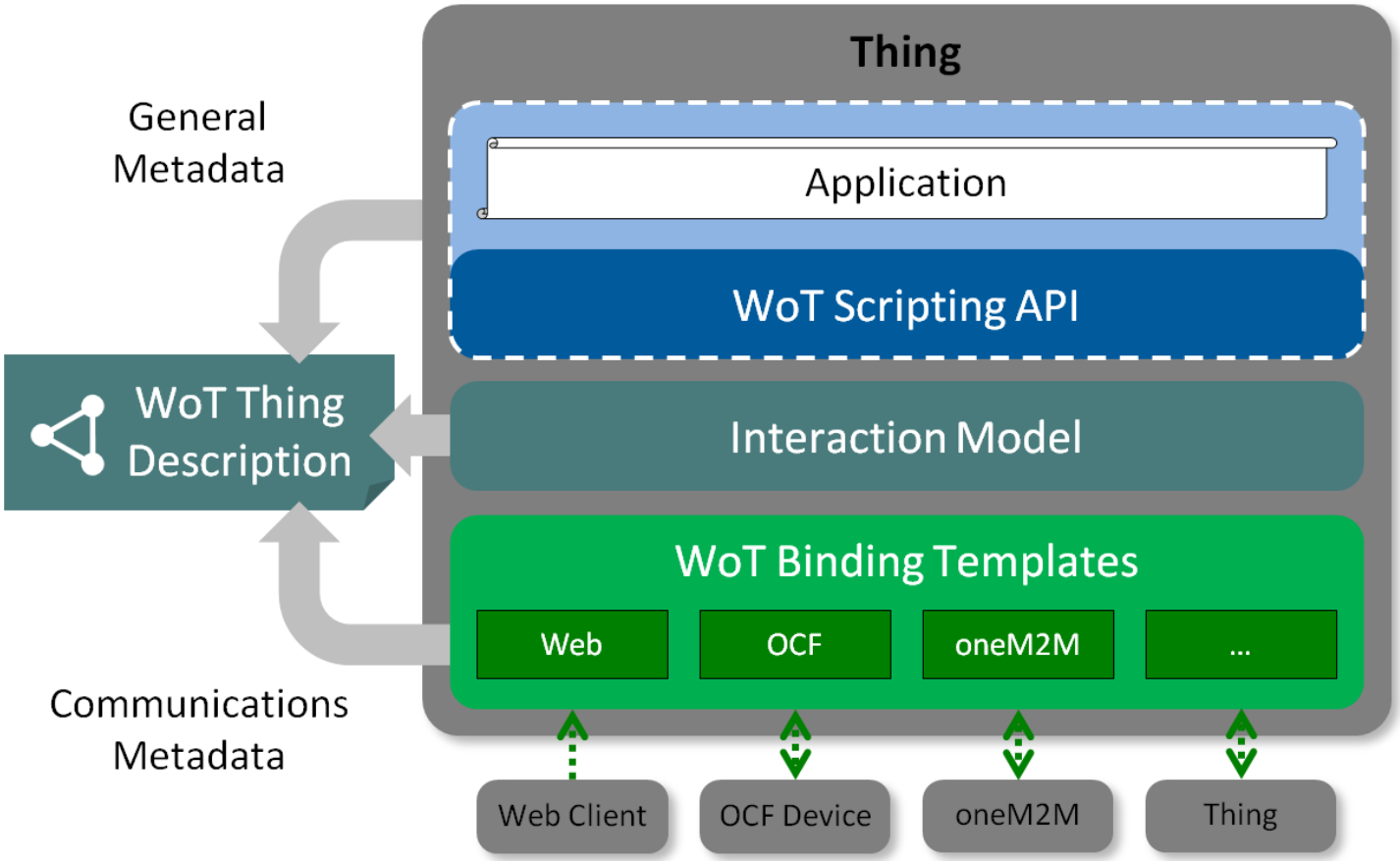


The W3C Web of Things working group

Thing Description representation (semantic ~ ?) of:

- the Thing,
- the interaction capabilities it exposes
  - Properties (observable ?, writable ?)
  - Action (an object is generated to monitor, cancel, …)
  - Event (type pub/sub)
- how to sollicitate it (URL, media type and in/out datamodel)

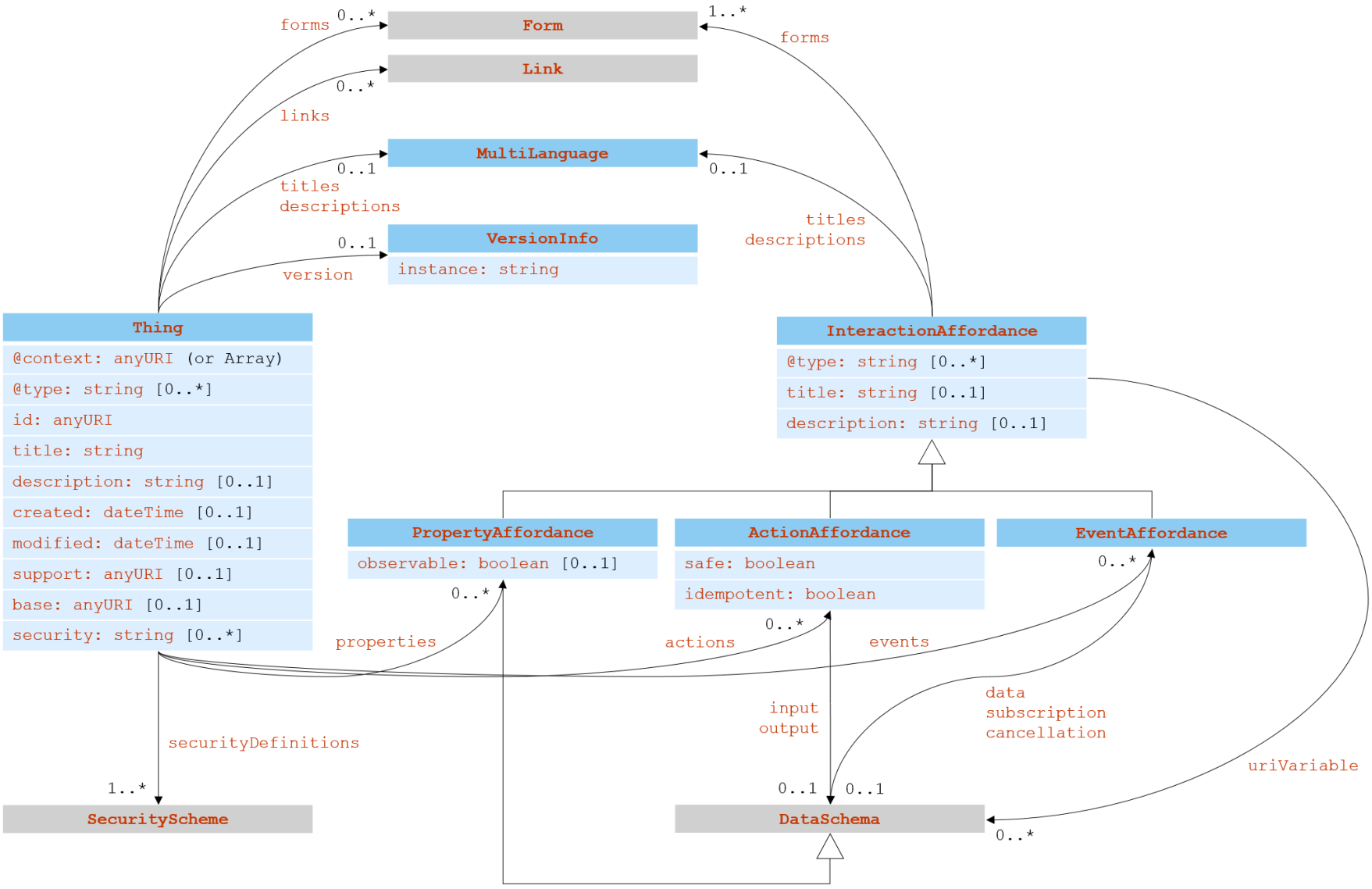
WoT Binding Templates

- every interaction type with every protocol or existing standard
  - ex. OCF light and motion sensor using CoAP on LAN
  - ex. LWM2M+IPSO environmental sensor from MQTT brokers, LAN and cloud
  - ex SmartThings Endpoint API using HTTP cloud-to-cloud

Scripting API

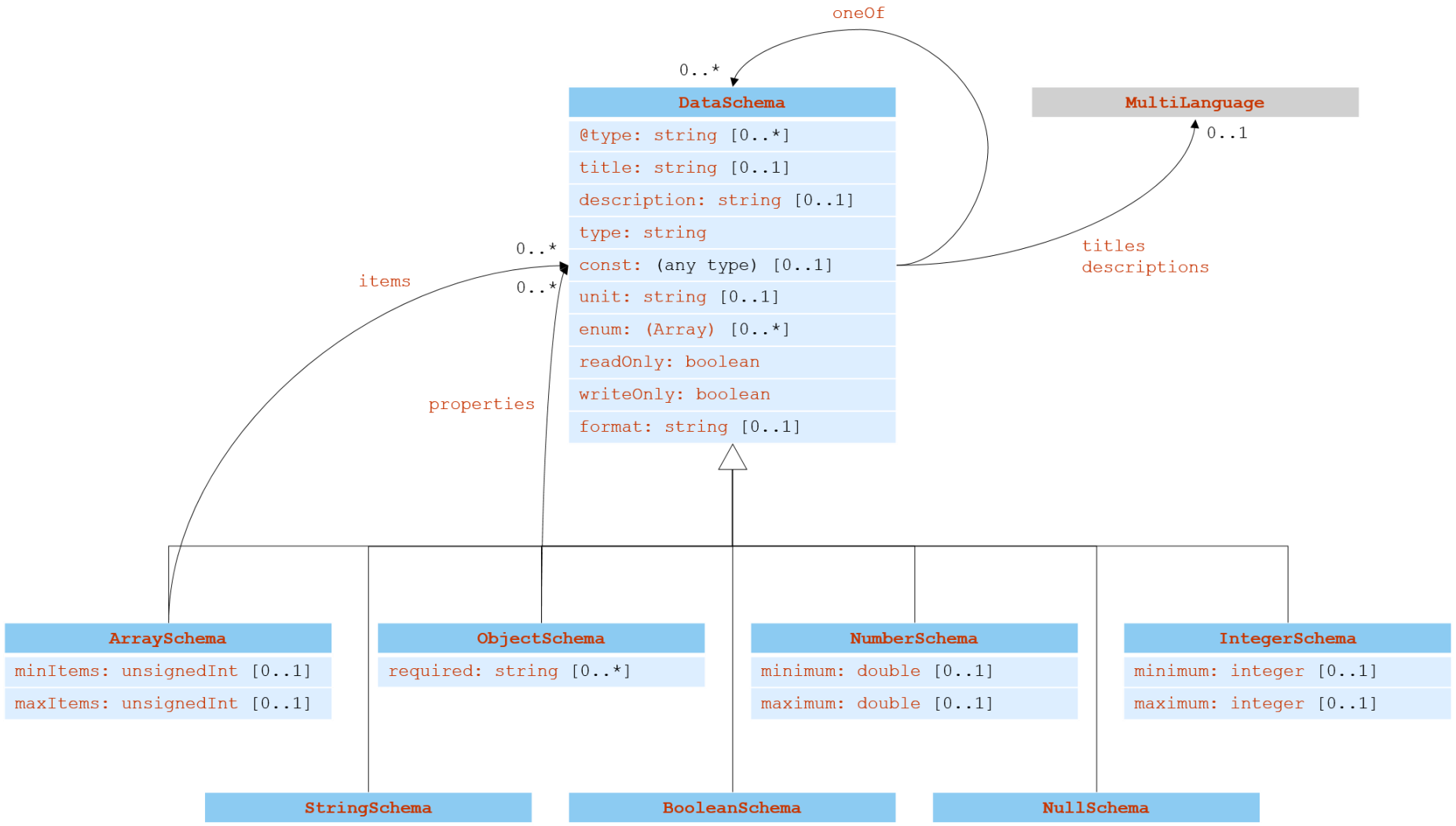
- javacript API to search / discover / sollicitate things

The W3C Web of Things working group



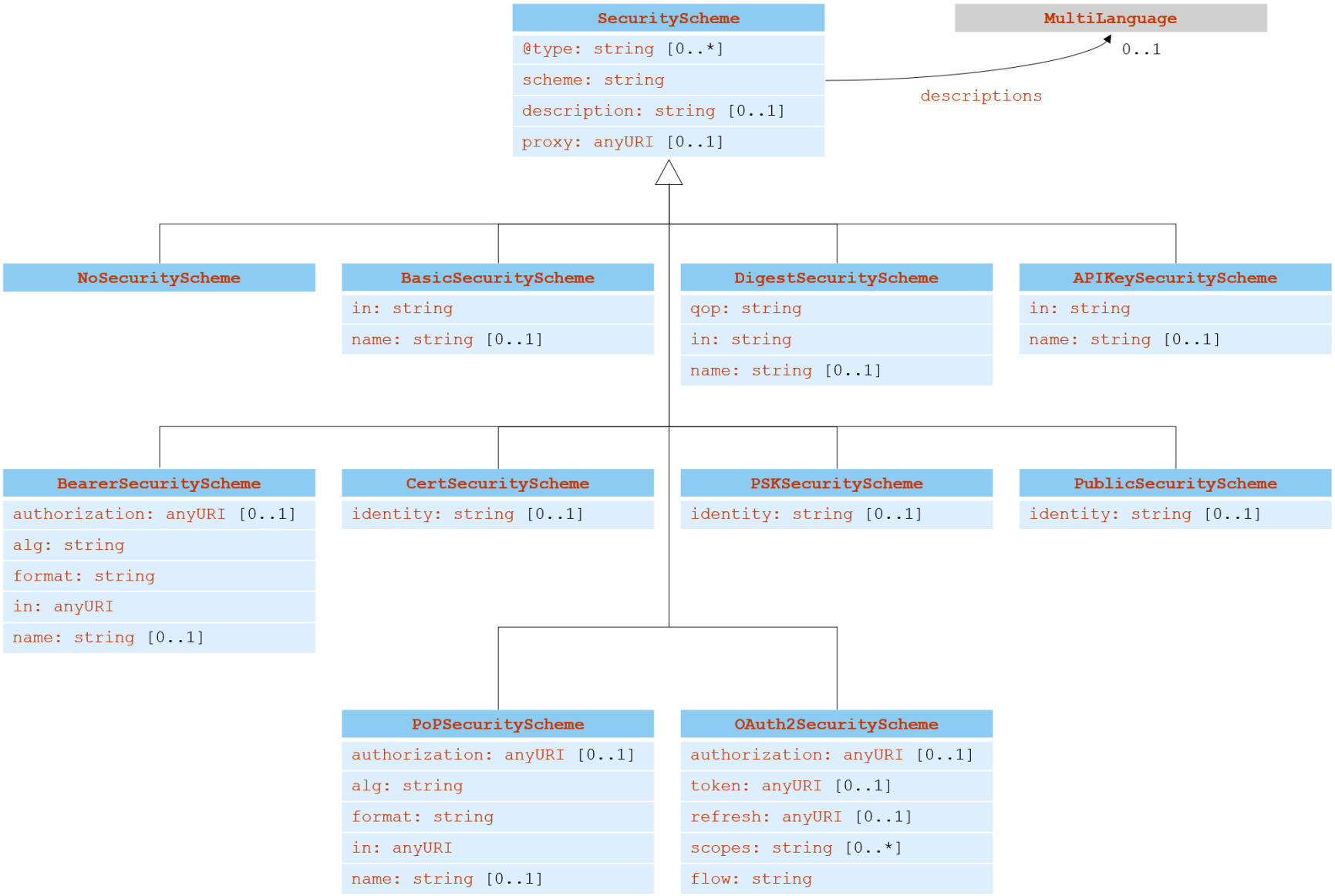
@prefix td: <http://www.w3.org/ns/td#>.

JSON Schema vocabulary



@prefix td: <http://www.w3.org/ns/td#>.

WoT Security vocabulary




```
@prefix td: <http://www.w3.org/ns/td#>.
```

W3C Linked Building Data community group

W3C Community Group Draft Report

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Building Topology Ontology

Draft Community Group Report 21 June 2018

ReSpec

Latest editor's draft:
https://w3c-lbd-cg.github.io/lbd/bot/

Implementation report:
https://w3c-lbd-cg.github.io/lbd/bot/

Editors:
Mads Holten Rasmussen (Niras | Technical University of Denmark)
Pieter Pauwels (Ghent University)
Maxime Lefrançois (École Nationale Supérieure des Mines de Saint-Étienne)

Contributors (ordered alphabetically):

Abstract

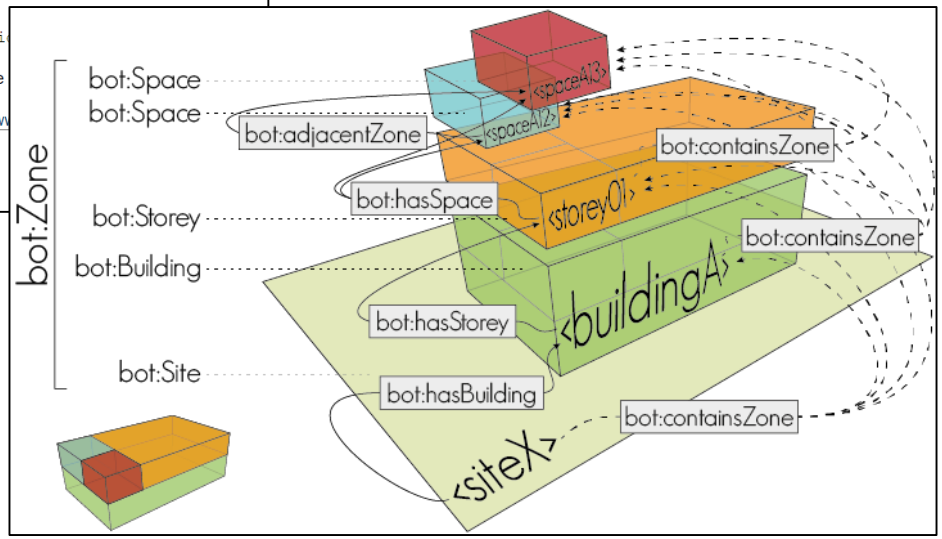
The Building Topology Ontology (BOT) is a minimal ontology for describing the core topological concepts of a building.

The namespace for BOT terms is `http://www.w3i`

The suggested prefix for the BOT namespace

The Turtle version of the BOT ontology is available at http://w

Status of This Document

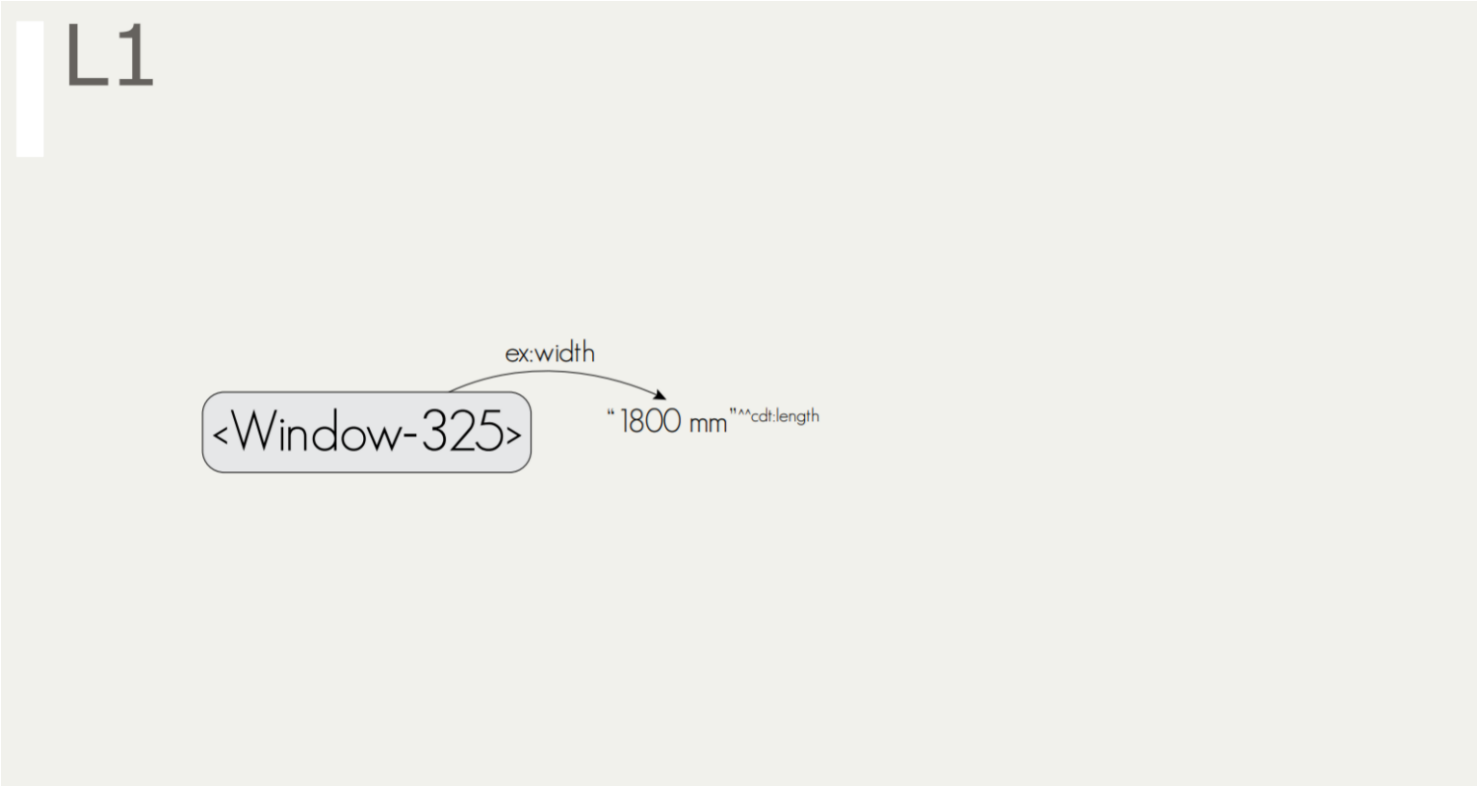


credit: Mads Holten Rasmussen, Alectia

@prefix bot: <https://w3id.org/bot#>.

W3C Linked Building Data community group

Features of Interest – Property – Value



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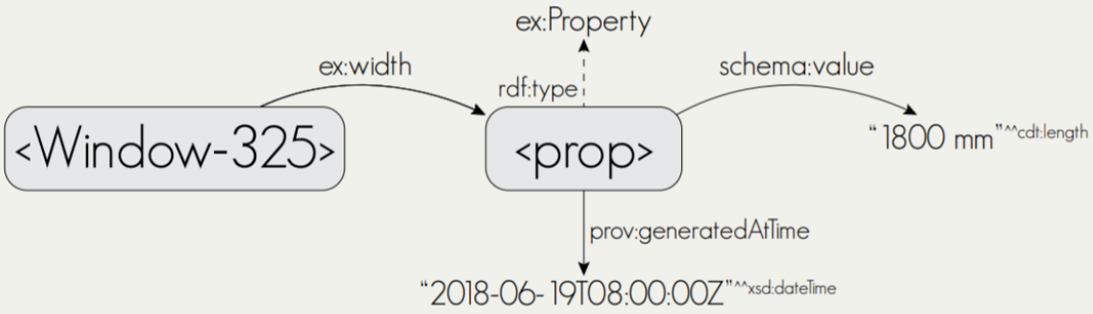
Features of Interest – Property – Value

L2



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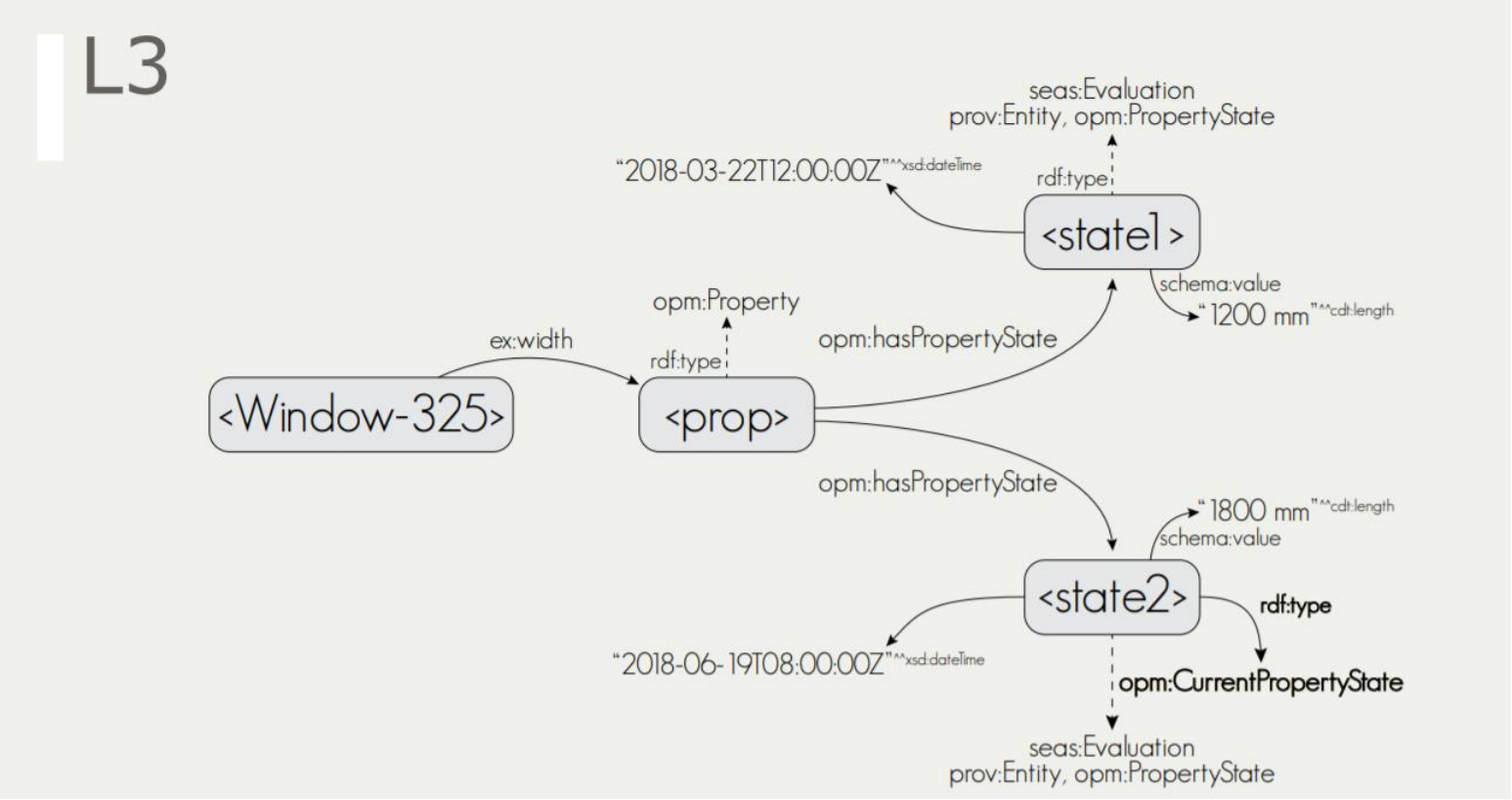
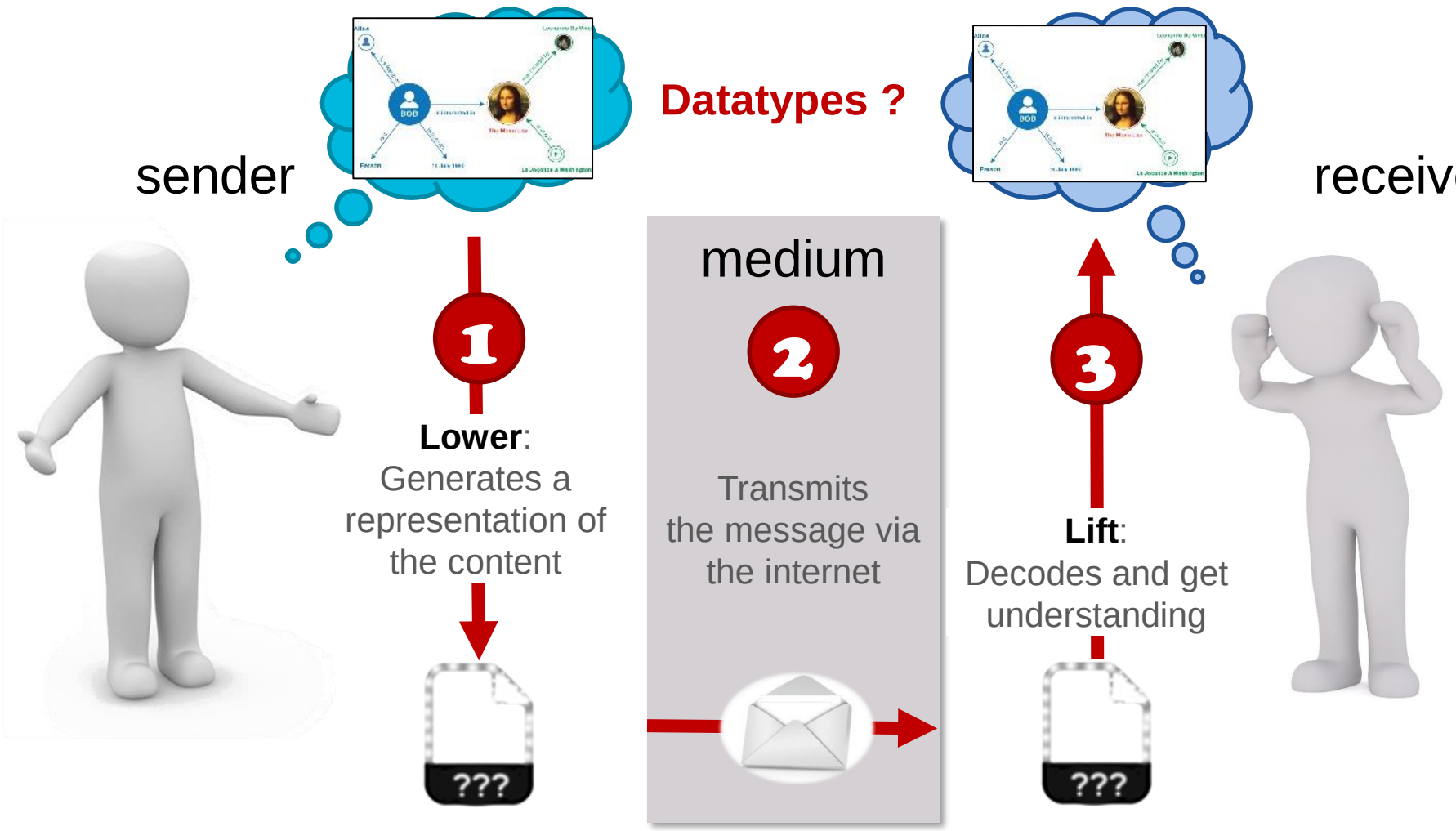


Communication between heterogeneous agents on the Web: conceptualization, scenarios, challenges



Datatypes for industrial applications
Physical quantities representation

- CDT: Custom Datatypes
  - Simplifies the representation and exchange of physical quantities

M. Lefrançois and A. Zimmermann, The Unified Code for Units of Measure in RDF: cdt:ucum and other UCUM Datatypes, In Proc. Extended Semantic Web Conference, 2018

Datatypes for industrial applications
Physical quantities representation

- CDT: Custom Datatypes
  - Simplifies the representation and exchange of physical quantities
  - Simpler requests, faster execution
  - Less complexity for the expert that writes them

CDT https://w3id.org/lindt/ **vs** **QUDT**

```
PREFIX cdt: <http://w3id.org/lindt/v1/custom_datatypes#>
SELECT ?x ?prop ?length WHERE {
  ?x ?prop ?length .
  FILTER(datatype(?length) = cdt:length )
  FILTER( ?length < "5m"^^cdt:length )
}
ORDER BY DESC (?length)
LIMIT 100
```

DEMO

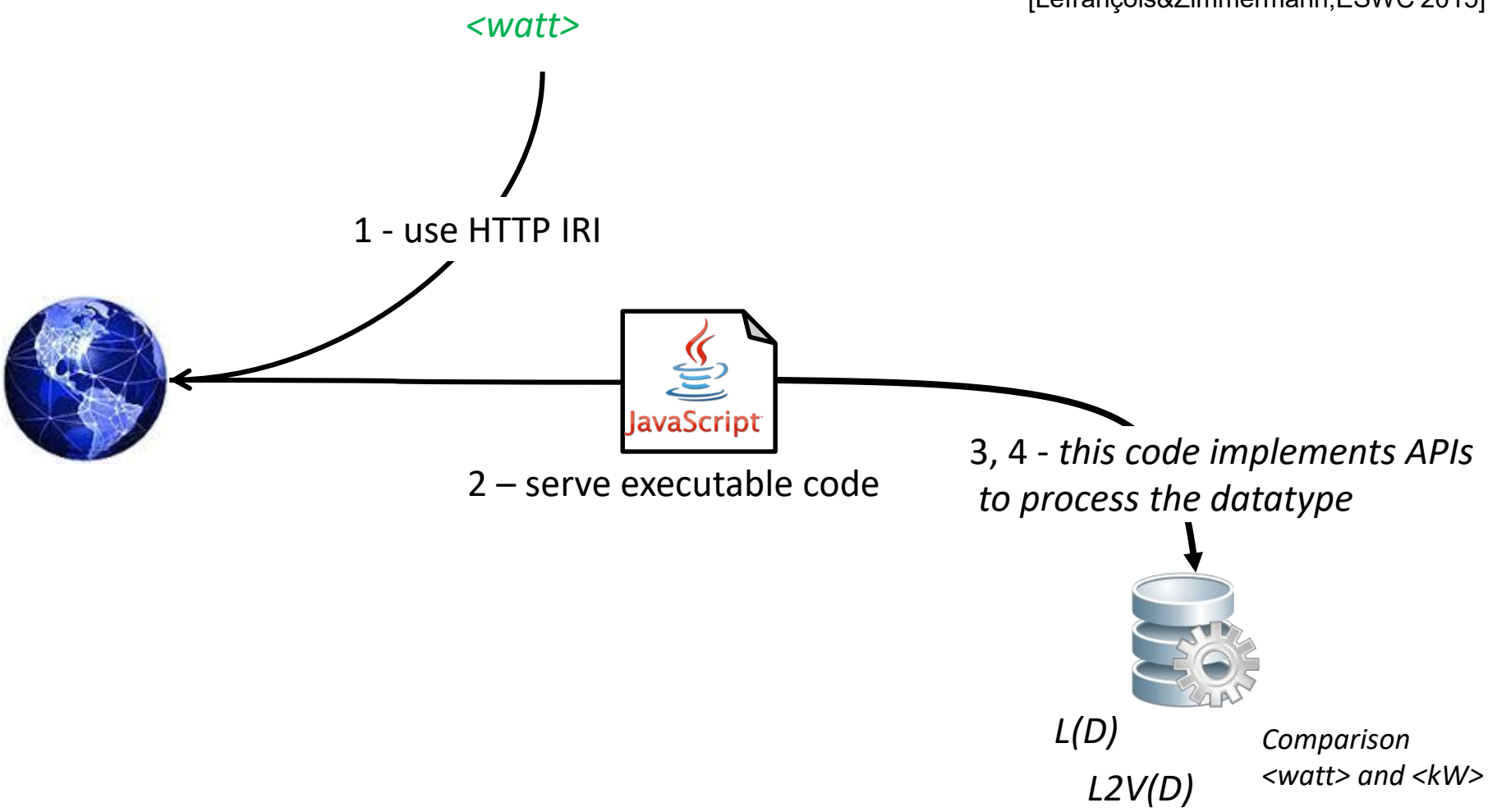
```
PREFIX qudt: <http://qudt.org/schema/qudt#>
PREFIX qudt-unit: <http://qudt.org/vocab/unit#>
SELECT ?x ?prop ?length (?factor*?length as ?metres) WHERE {
VALUES (?factor ?unit)
  { (0.001 qudt-unit:millimetre)
    (0.01 qudt-unit:centimetre)
    (1 qudt-unit:metre)
    (1000 qudt-unit:kilometre)
  }
  ?x ?prop [
    qudt:quantityValue [
      qudt:numericValue ?length ;
      qudt:unit ?unit ] ] .
  FILTER( ?factor*?length < 5 )
}
ORDER BY DESC (?metres)
LIMIT 100
```

M. Lefrançois and A. Zimmermann, The Unified Code for Units of Measure in RDF: cdt:ucum and other UCUM Datatypes, In Proc. Extended Semantic Web Conference, 2018

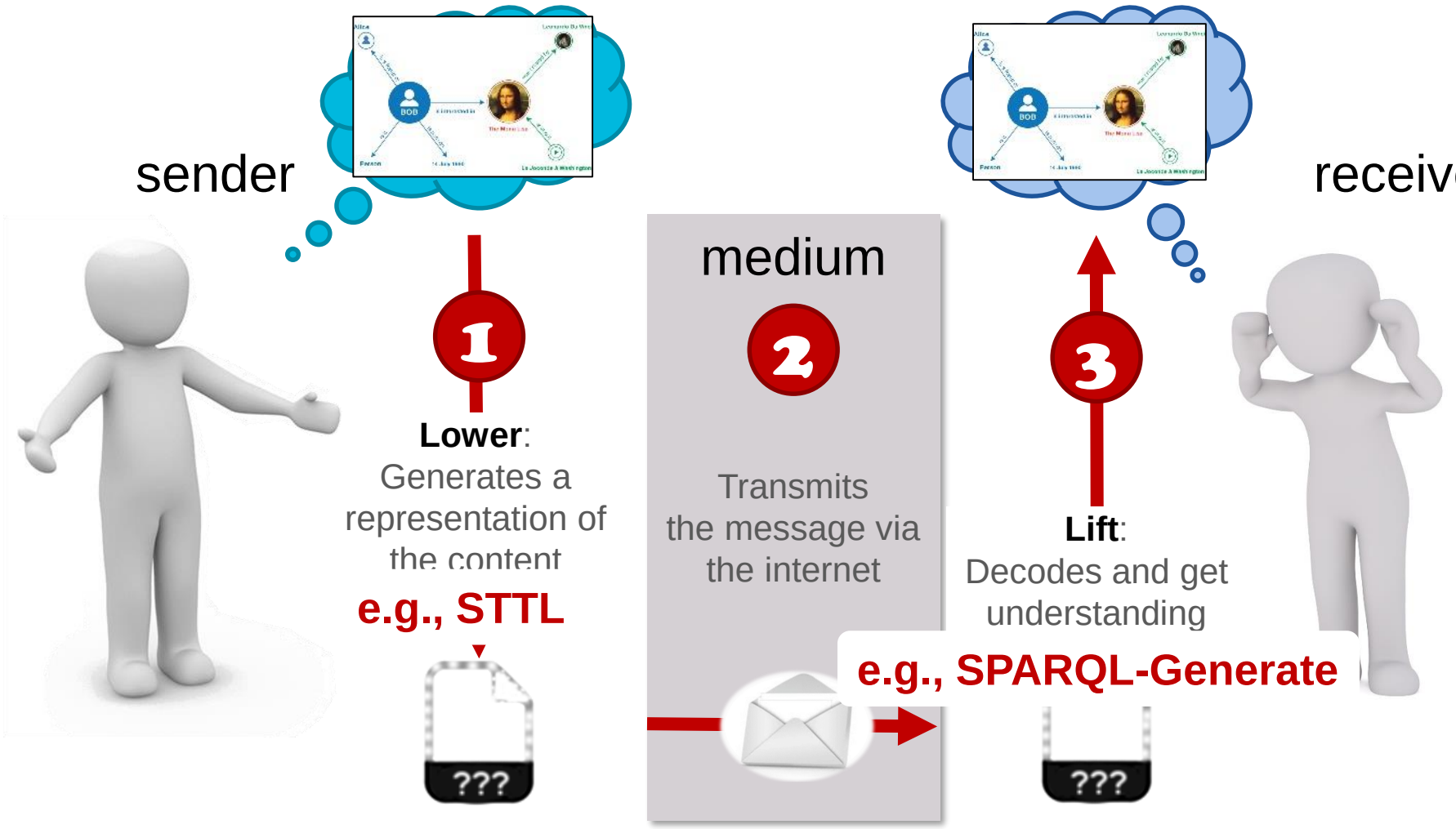
Script-based Support of Arbitrary Datatypes

https://ci.mines-stetienne.fr/lindt/spec.html

[Lefrançois&Zimmermann,ESWC'2015]

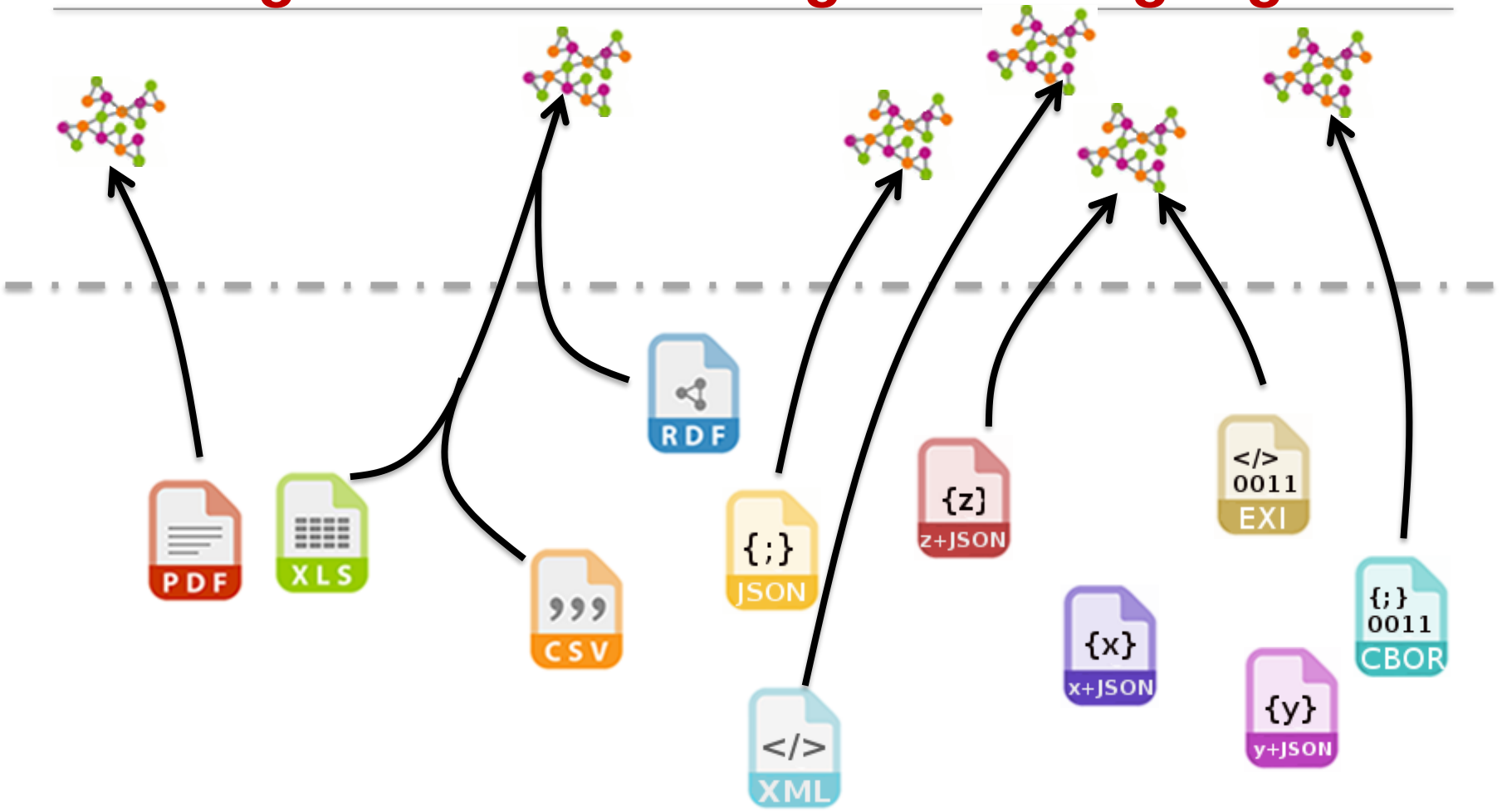


Communication between heterogeneous agents on the Web: conceptualization, scenarios, challenges



M. Lefrançois, RDF presentation and correct content conveyance for legacy services and the web of things. IOT 2018

SPARQL-Generate
Heterogeneous data integration language



M. Lefrançois, ,A. Zimmermann, N. Bakerally, A SPARQL extension for generating RDF from heterogeneous formats,
In Proc. Extended Semantic Web Conference, 2017
+ EKAW, Hackatons, Tutorial ESWC 2018

SPARQL-Generate
Heterogeneous data integration language

https://w3id.org/sparql-generate/

Requests and generates both RDF and documents with heterogeneous formats.

Generates RDF from documents
in XML, JSON, CSV, GeoJSON, HTML, CBOR, text, …

Generates RDF or text streams from streams of
big CSV documents, MQTT streams, WebSocket, …

Open-source implementation Licence Apache 2.0
Expressive, fast, extensible to other formats

M. Le
In Proc. Extended Semantic Web Conference, 2017
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SPARQL-Generate
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TUTORIAL

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