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Semantic Web

Introduction to semantic data

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UT2J - IRIT, MELODI Team

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Agenda

Why the Semantic Web ?

Semantic data on the Linked Open Data

One step further : the Semantic Web

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Agenda

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Artificial Intelligence

A definition, proposed by J. Pitrat

"Artificial Intelligence is the science which aims is to make machines do what humans are capable of doing."

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Levels of "understanding"

- **Data** : Result of a measure
- **Information** : Data and its context
- **Knowledge** : Possible deductions from information with background rules (reasoning)

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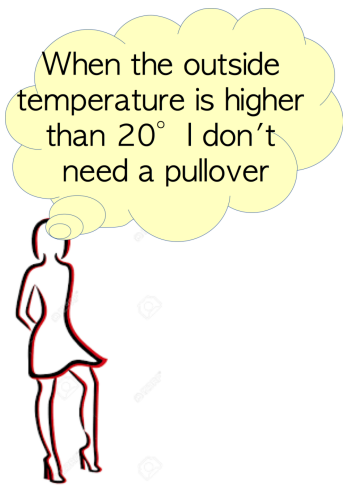

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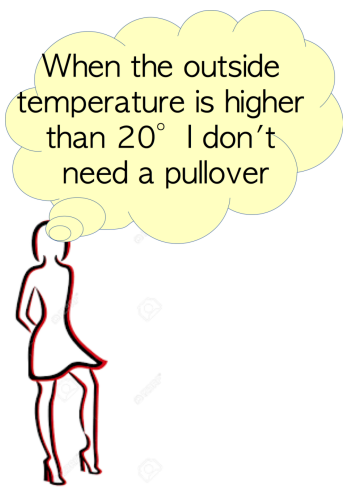

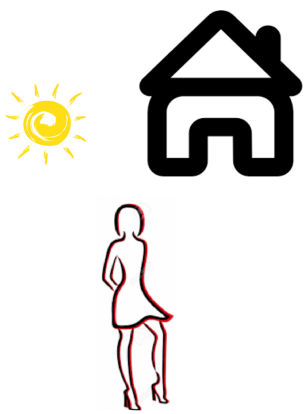

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Logic

Logic models formalize common sense and reasoning mechanisms in order to study and automatize them.

KNOW YOUR LOGICAL PROOFS:

DIRECT PROOF:	
·IF P THEN Q ·P THEREFORE Q	P→Q P ∴ Q
PROOF BY CONTRAPOSITION	
·IF P THEN Q ·NOT Q THEREFORE NOT P	P→Q ¬Q ∴ ¬P
PROOF BY CONTRADICTION	
·IF NOT P THEN CONTRADICTION THEREFORE P	¬P→F ∴ P
PROOF BY TRADITION	
·MY DAD Q ·AND HIS DAD Q ·AND HIS DAD Q ·AND I'LL BE DAMNED IF MY SON R.! THEREFORE Q	Q←Q←Q→¬R ∴Q
PROOF BY INTIMIDATION	
·IF P THEN Q ·FIRST PERSON TO SAY "NOT P" GETS MY FOOT UP HIS ASS THEREFORE Q	P→Q S(x,¬P)→↯ ∴Q

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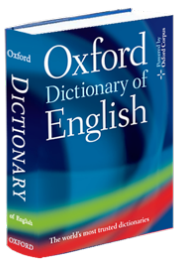
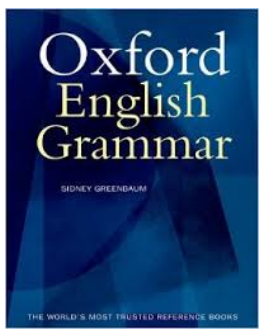
What is a logic ?

Constituents of a logic

- A **syntax** (grammar + vocabulary)
- A **semantic**
- A mechanism for **deduction**





Their roles (respectively)

- Describe data
- Associate meaning to the data
- Deduce new knowledge

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Internet and the Web

Internet

Network of computers offering countless services

The Web

The World Wide Web is an information system supported by Internet based on :

- a system addressing the resources (page, image, video) via their URL
- HTML pages related thanks to hyperlinks

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The W3C

A organism standardizing the web

Founded in 1993 by Tim Berners Lee

What does the W3C standardize?

- Web Application (HTML, CSS, Ajax...)
- Web Architectures (URL, HTTP...)
- XML & consorts (XPath, ...)
- Web Services (SOAP, WSDL)
- Semantic Web languages (RDF, OWL, ..)

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What you can do with the Web...

- Search for plane tickets to go to Venice
- Adapt the dates according to forecast
  - Avoid rainy days until I receive the boots that I've ordered
  - Take into consideration my medical constraints
- Book a room in the Hotel where G. Clooney stayed
- Command a pizza without gluten and a Torus bottle to cheer me up as no room is available at the suitable dates...

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... if you know where to look ...

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What you do not want to do...

:(

- Use complicated tools
- Search in several sources
- Go further than the first google page of results ...

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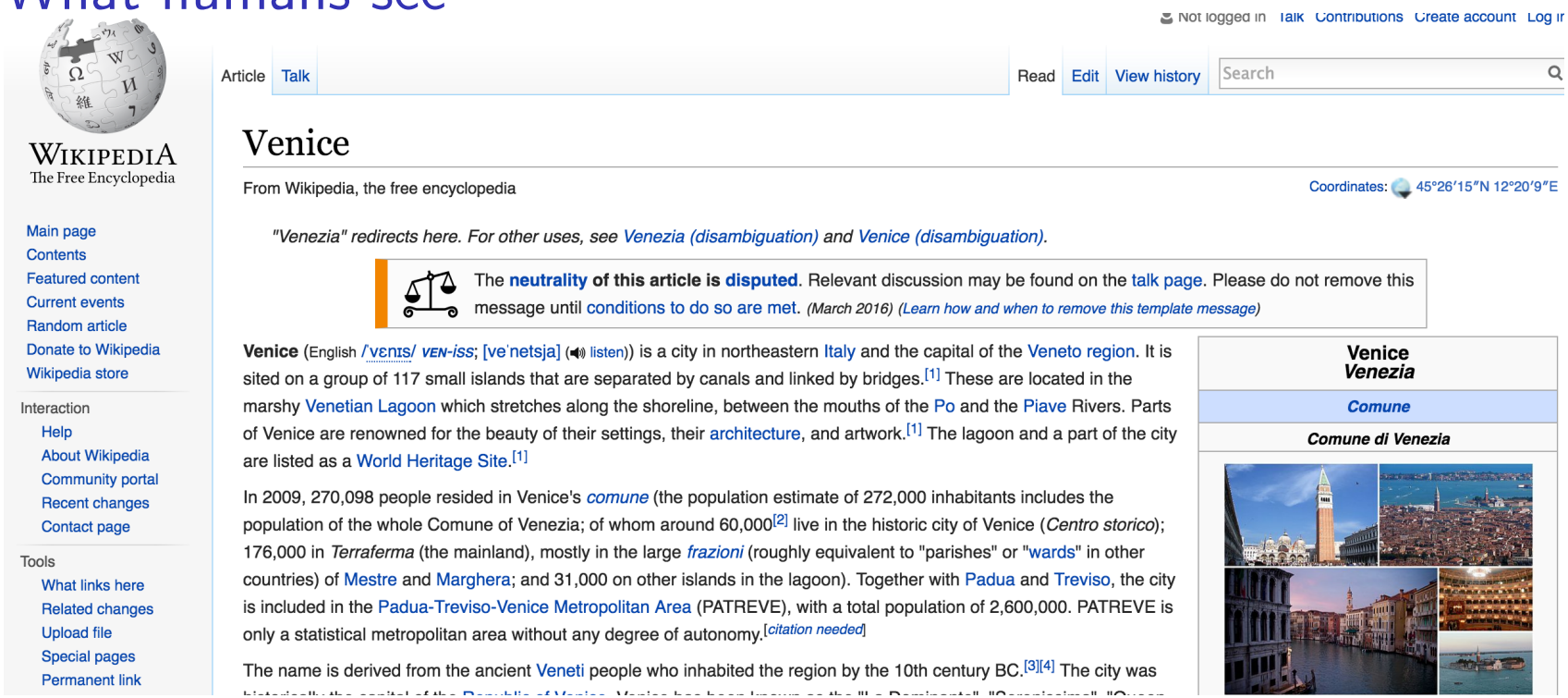
Any semantics in this Web to help?

What humans see



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Contact page

Tools
What links here
Related changes
Upload file
Special pages
Permanent link

Venice

From Wikipedia, the free encyclopedia

Coordinates: 45°26′15″N 12°20′9″E

"Venezia" redirects here. For other uses, see Venezia (disambiguation) and Venice (disambiguation).

The **neutrality of this article is disputed**. Relevant discussion may be found on the talk page. Please do not remove this message until conditions to do so are met. *(March 2016) (Learn how and when to remove this template message)*

Venice (English /ˈvɛnɪs/ *VEN-iss*; [veˈnetsja] (listen)) is a city in northeastern Italy and the capital of the Veneto region. It is sited on a group of 117 small islands that are separated by canals and linked by bridges.[1] These are located in the marshy Venetian Lagoon which stretches along the shoreline, between the mouths of the Po and the Piave Rivers. Parts of Venice are renowned for the beauty of their settings, their architecture, and artwork.[1] The lagoon and a part of the city are listed as a World Heritage Site.[1]

In 2009, 270,098 people resided in Venice's *comune* (the population estimate of 272,000 inhabitants includes the population of the whole Comune of Venezia; of whom around 60,000[2] live in the historic city of Venice (*Centro storico*); 176,000 in *Terraferma* (the mainland), mostly in the large *frazioni* (roughly equivalent to "parishes" or "wards" in other countries) of Mestre and Marghera; and 31,000 on other islands in the lagoon). Together with Padua and Treviso, the city is included in the Padua-Treviso-Venice Metropolitan Area (PATREVE), with a total population of 2,600,000. PATREVE is only a statistical metropolitan area without any degree of autonomy.[*citation needed*]

The name is derived from the ancient Veneti people who inhabited the region by the 10th century BC.[3][4] The city was

Venice
Venezia

Comune

Comune di Venezia

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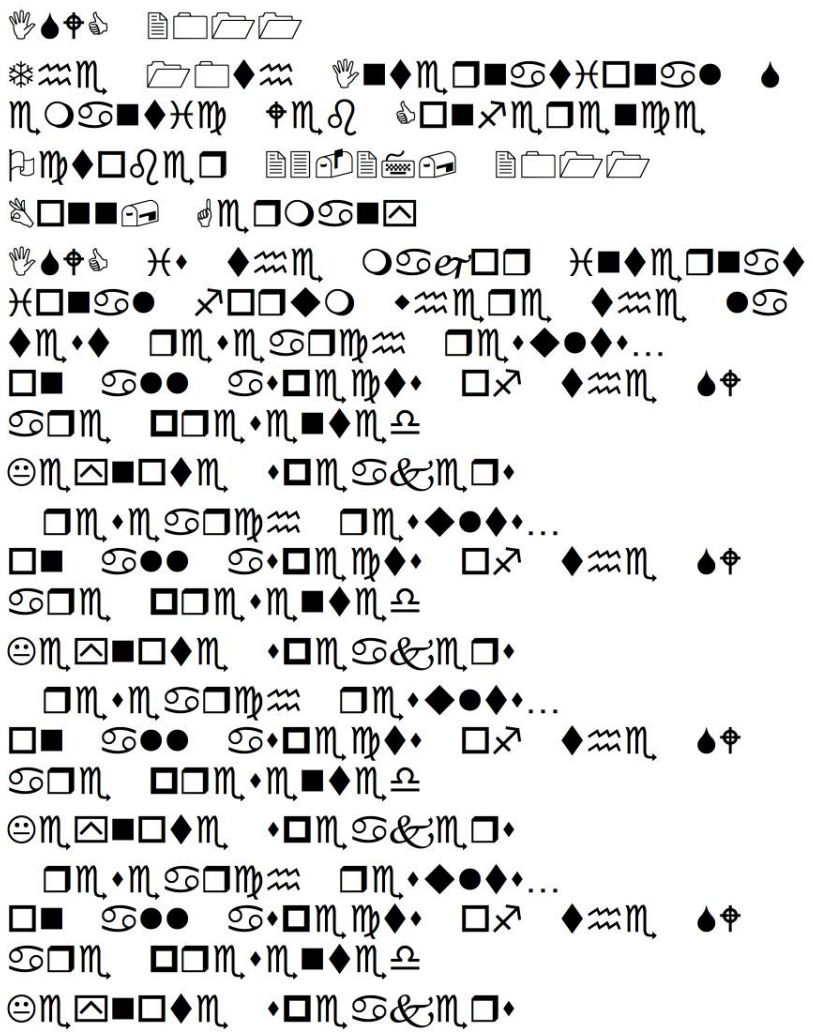
Any semantics in this Web to help?

What computers see ...



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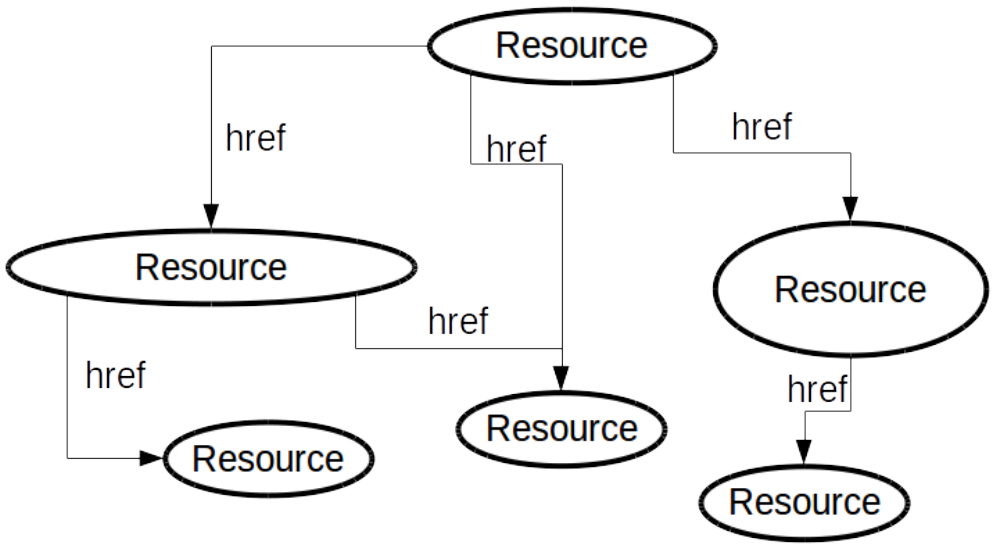
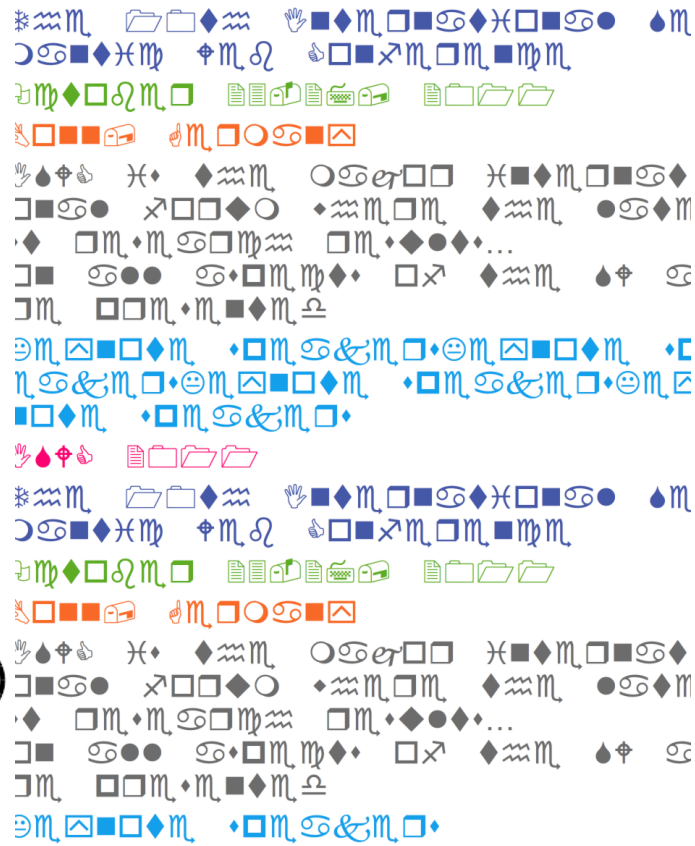
Any semantics in this Web to help?

What computers see?

More syntax than dogs thanks to HTML !





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Any semantics in this Web to help?

Limitations of HTML markups

- HTML markups are defined by web page authors and not people looking for information
- Markups indicate information "zones" and links between resources
- No formal semantic or common sense associated to these zones or links

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Any semantics in this Web to help?

The data used in Geosciences

- data distributed in several sources
- data in different formats
- a considerable effort to use (extract, combine, ...) them for specific applications

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Semantics please HELP US!

The founder article of the Semantic Web

- Tim Berners Lee, at the conference WWW in 1994
  `http://www.w3.org/Talks/WWW94Tim/`
- **The Semantic Web** is **a new form** of the syntactic Web in which content is **meaningful to computers and humans** thus unleashing a revolution of new possibilities
- **The Semantic Web** relies on **standards** allowing to represent **knowledge usable by computers**.
- Today's reality : the Linked Open Data (LOD)

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Agenda

Why the Semantic Web ?

Semantic data on the Linked Open Data
- Data semantization
- Linked Open Data cloud

One step further : the Semantic Web

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Sacré Tim !

From 1 To 5 stars data !

Tim Berners Lee (him again!!!) has proposed a hierarchisation of data which reflects their quality in the perspective of making them open and reusable.

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One star data

data characteristics

- Data **accessible** on the Web, with an **open license**.
  For example, the following pdf document :

Feuille1

06/04/2015 00:00:00	N0.VENT.MES.TT_FOR_CHAUD	18	192
06/04/2015 00:00:00	N0.PAC1.MES.TT_EXT	11.8	192
06/04/2015 00:00:00	N0.PAC1.MES.TT_BALON_SEC	46.7	192
06/04/2015 00:00:00	N0.PROD.MES.V3VPACEC	51.5	192
06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_S_3M5	16.3	192
06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_S_1M5	15.7	192
06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_N_6M5	16.7	192
06/04/2015 00:00:00	N0.UTA_1.MES.V_EC	0	192
06/04/2015 00:00:00	N0.PROD.MES.PRESSGALZ1Z2	1	192
06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_N_1M5	16.1	192
06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_S_6M5	15.3	192
06/04/2015 00:00:00	N2.UTA_1.MES.V_EG	99.6	192
06/04/2015 00:00:00	N0.VENT.MES.TT_MOY_650	16.0352	192
06/04/2015 00:00:00	N0.PAC3.MES.TT_RET_PRIM	12.6	192
06/04/2015 00:00:00	N2.VC206.MES.V_EG	38.3	192
06/04/2015 00:00:00	NVDS.ADIABOX4.MES.TSOUF	13.9	192
06/04/2015 00:00:00	N0.PAC2.MES.TT_DEP_PRIM	13.6	192
06/04/2015 00:00:00	N0.PAC2.MES.TT_RET_PRIM	15.8	192
06/04/2015 00:00:00	N0.VENT.MES.QAIRCTA	474	192

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Two star data

★★ data characteristics

- ★ data in a **structured** format.

  For example, the same table but in the xls format.

	A	B	C	D
1	06/04/2015 00:00:00	N0.VENT.MES.TT_FOR_CHAUD	18	192
2	06/04/2015 00:00:00	N0.PAC1.MES.TT_EXT	11.8	192
3	06/04/2015 00:00:00	N0.PAC1.MES.TT_BALON_SEC	46.7	192
4	06/04/2015 00:00:00	N0.PROD.MES.V3VPACEC	51.5	192
5	06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_S_3M5	16.3	192
6	06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_S_1M5	15.7	192
7	06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_N_6M5	16.7	192
8	06/04/2015 00:00:00	N0.UTA_1.MES.V_EC	0	192
9	06/04/2015 00:00:00	N0.PROD.MES.PRESSGALZ1Z2	1	192
10	06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_N_1M5	16.1	192
11	06/04/2015 00:00:00	N0.VENT.MES.TT_GAL_PV_S_6M5	15.3	192
12	06/04/2015 00:00:00	N2.UTA_1.MES.V_EG	99.6	192
13	06/04/2015 00:00:00	N0.VENT.MES.TT_MOY_650	16.0352	192
14	06/04/2015 00:00:00	N0.PAC3.MES.TT_RET_PRIM	12.6	192
15	06/04/2015 00:00:00	N2.VC206.MES.V_EG	38.3	192
16	06/04/2015 00:00:00	NVDS.ADIABOX4.MES.TSOUF	13.9	192

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Three star data

★★★ data characteristics

- ★★ data in an **open** format.

  For example, the same table in csv.

```
"06/04/2015 00:00:00",N0.VENT.MES.TT_FOR_CHAUD,18,192,
"06/04/2015 00:00:00",N0.PAC1.MES.TT_EXT,11.8,192,
"06/04/2015 00:00:00",N0.PAC1.MES.TT_BALON_SEC,46.7,192,
"06/04/2015 00:00:00",N0.PROD.MES.V3VPACEC,51.5,192,
"06/04/2015 00:00:00",N0.VENT.MES.TT_GAL_PV_S_3M5,16.3,192,
"06/04/2015 00:00:00",N0.VENT.MES.TT_GAL_PV_S_1M5,15.7,192,
"06/04/2015 00:00:00",N0.VENT.MES.TT_GAL_PV_N_6M5,16.7,192,
"06/04/2015 00:00:00",N0.UTA_1.MES.V_EC,0,192,
"06/04/2015 00:00:00",N0.PROD.MES.PRESSGALZ1Z2,1,192,
"06/04/2015 00:00:00",N0.VENT.MES.TT_GAL_PV_N_1M5,16.1,192,
"06/04/2015 00:00:00",N0.VENT.MES.TT_GAL_PV_S_6M5,15.3,192,
"06/04/2015 00:00:00",N2.UTA_1.MES.V_EG,99.6,192,
"06/04/2015 00:00:00",N0.VENT.MES.TT_MOY_650,16.0352,192,
"06/04/2015 00:00:00",N0.PAC3.MES.TT_RET_PRIM,12.6,192,
"06/04/2015 00:00:00",N2.VC206.MES.V_EG,38.3,192,
"06/04/2015 00:00:00",NVDS.ADIABOX4.MES.TSOUF,13.9,192,
"06/04/2015 00:00:00",N0.PAC2.MES.TT_DEP_PRIM,13.6,192,
"06/04/2015 00:00:00",N0.PAC2.MES.TT_RET_PRIM,15.8,192,
"06/04/2015 00:00:00",N0.VENT.MES.QAIRCTA,474,192,
"06/04/2015 00:00:00",NVDS.ADIABOX3.MES.TSOUF,13.3,192,
"06/04/2015 00:00:00",NVDS.ADIABOX2.MES.TSOUF,12.2,192,
"06/04/2015 00:00:00",NVDS.ADIABOX1.MES.TSOUF,13.3,192,
"06/04/2015 00:00:00",N0.VENT.MES.QAIREXT2P,157,192,
"06/04/2015 00:01:00",N0.PAC1.MES.TT_DEP_PRIM,13.8,192,
"06/04/2015 00:01:00",N0.PAC1.MES.TT_RET_PRIM,14.8,192,
"06/04/2015 00:01:00",N0.PAC2.MES.TT_BALON_SEC,47.5,192,
"06/04/2015 00:01:00",N0.PAC2.MES.TT_EXT,12.7,192,
"06/04/2015 00:01:00",N0.PAC1.MES.TT_BALON_SEC,46.6,192,
```

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Four star data

★★★★ data characteristics

- ★★★ data described with RDF (a W3C formalism!)
- First step towards semantic description of data !!!
  For example, the same table in RDF.

```
@prefix rdf:  <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix adream:  <http://pelican/adreamdata#> .

<http://pelican/adreamdata#CNRS.RDC.EXT.LUX.mesure_01/03/2015%2000:00:00>
        adream:hasId         "CNRS.RDC.EXT.LUX.mesure" ;
        adream:hasTimeStamp  "01/03/2015 00:00:00" ;
        adream:hasValue      "8" ;
        adream:hasQuality    "192" ;
        adream:comment       "RDC_Exterieur_lux" .

<http://pelican/adreamdata#CNRS.RDC.R2.H020.D13.puissance_01/03/2015%2000:01:00>
        adream:hasId         "CNRS.RDC.R2.H020.D13.puissance" ;
        adream:hasTimeStamp  "01/03/2015 00:01:00" ;
        adream:hasValue      "3" ;
        adream:hasQuality    "192" ;
        adream:comment       "Rez_de_chaussee_Salle_experimentation_D13" .

<http://pelican/adreamdata#CNRS.RDC.R2.H020.D12.puissance_01/03/2015%2000:01:00>
        adream:hasId         "CNRS.RDC.R2.H020.D12.puissance" ;
        adream:hasTimeStamp  "01/03/2015 00:01:00" ;
        adream:hasValue      "3" ;
        adream:hasQuality    "192" ;
        adream:comment       "Rez_de_chaussee_Salle_experimentation_D12" .
```

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The RDF, graph language

Bases of RDF : the triplet

- A triplet is composed of 3 resources :
  - The subject : the resource the representation is talking about
  - The predicate : the property of the subject
  - The object : who/what the property links the subject to

What RDF adds

- Resources can be physical documents (web pages, video...), "moral" resources (person, institution, color,...) or data value
- The predicate makes explicit the nature of the link between resources

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(car, color, grey)


(Clooney, married_in, Venice)


(Dominique, love, Torus)

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The IRI

- Unique identification of resources on the Web
- Evolution of the notion of URL for internationalization
- Examples :
  - IRI of an observation :
    http://pelican/adreamdataCNRS.RDC.EXT.LUX.mesure_01/03/2015%2000

"Now! ... *That* should clear up
a few things around here!"

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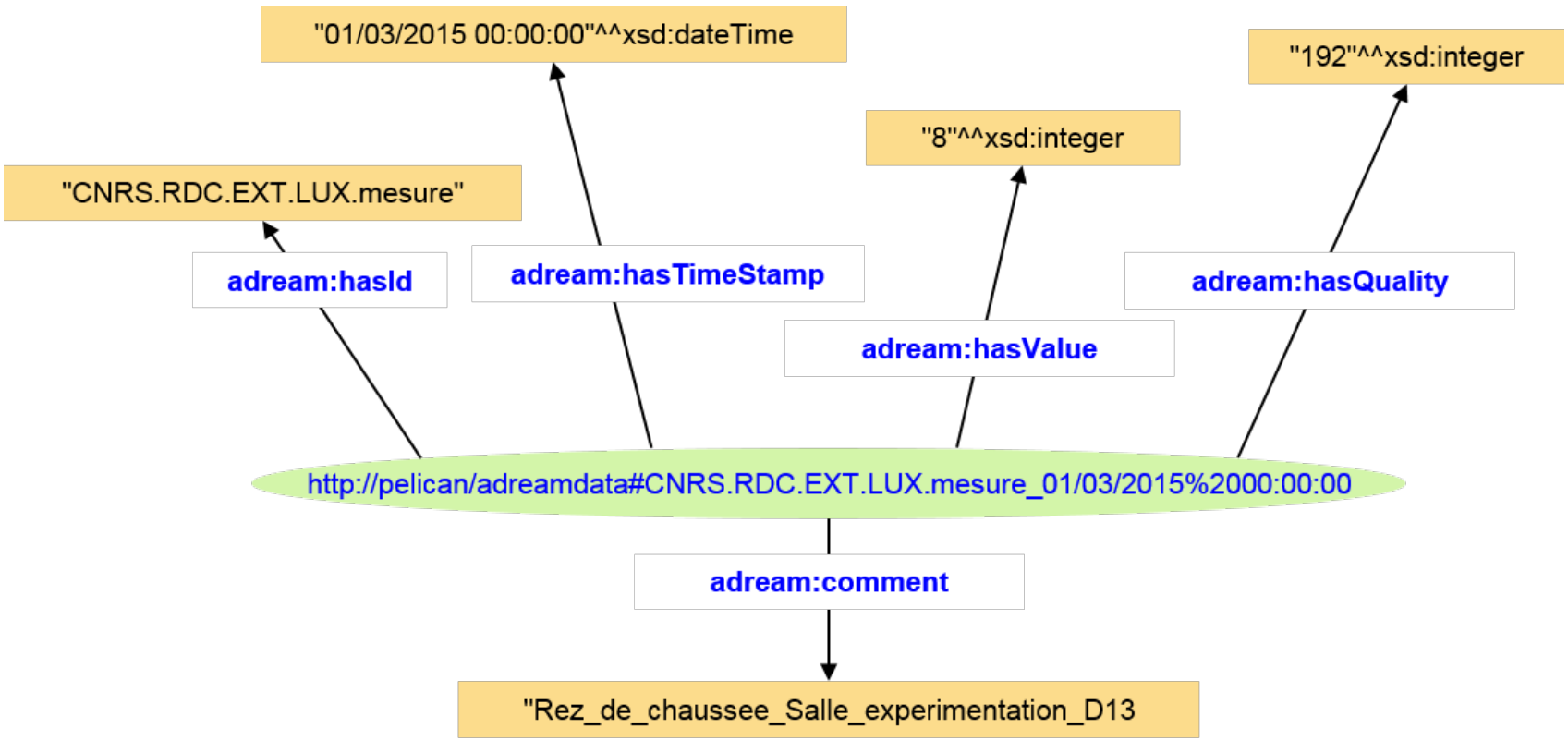
Examples of RDF triplets



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Five star data

★★★★★ data characteristics

- ★★★★ data linked to data from other data sets

```
@prefix rdf:  <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix qudt_q:  <http://qudt.org/vocab/quantity#> .
@prefix qudt_u:  <http://qudt.org/vocab/unit#> .
@prefix rdfs:  <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dul:  <http://ontologydesignpatterns.org/ont/dul/DUL.owl> .
@prefix adream:  <http://pelican/adreamdata#> .
@prefix ssn:  <http://purl.oclc.org/NET/ssnx/ssn#> .

<http://pelican/adreamdata#CNRS.RDC.EXT.LUX.mesure_01/03/2015%2000:00:00>
        rdf:type            ssn:ObservationValue ;
        adream:hasId        "CNRS.RDC.EXT.LUX.mesure" ;
        adream:hasQuality   "192" ;
        dul:hasDataValue    "8" ;
        rdfs:comment        "RDC_Exterieur_lux" .

<http://pelican/adreamdata#CNRS.RDC.R2.H020.D13.puissance_01/03/2015%2000:01:00>
        rdf:type            ssn:ObservationValue ;
        adream:hasId        "CNRS.RDC.R2.H020.D13.puissance" ;
        adream:hasQuality   "192" ;
        dul:hasDataValue    "3" ;
        rdfs:comment        "Rez_de_chaussee_Salle_experimentation_D13" .

<http://pelican/adreamdata#CNRS.RDC.R2.H020.D12.puissance_01/03/2015%2000:01:00>
        rdf:type            ssn:ObservationValue ;
        adream:hasId        "CNRS.RDC.R2.H020.D12.puissance" ;
        adream:hasQuality   "192" ;
        dul:hasDataValue    "3" ;
        rdfs:comment        "Rez de chaussee Salle experimentation D12" .
```

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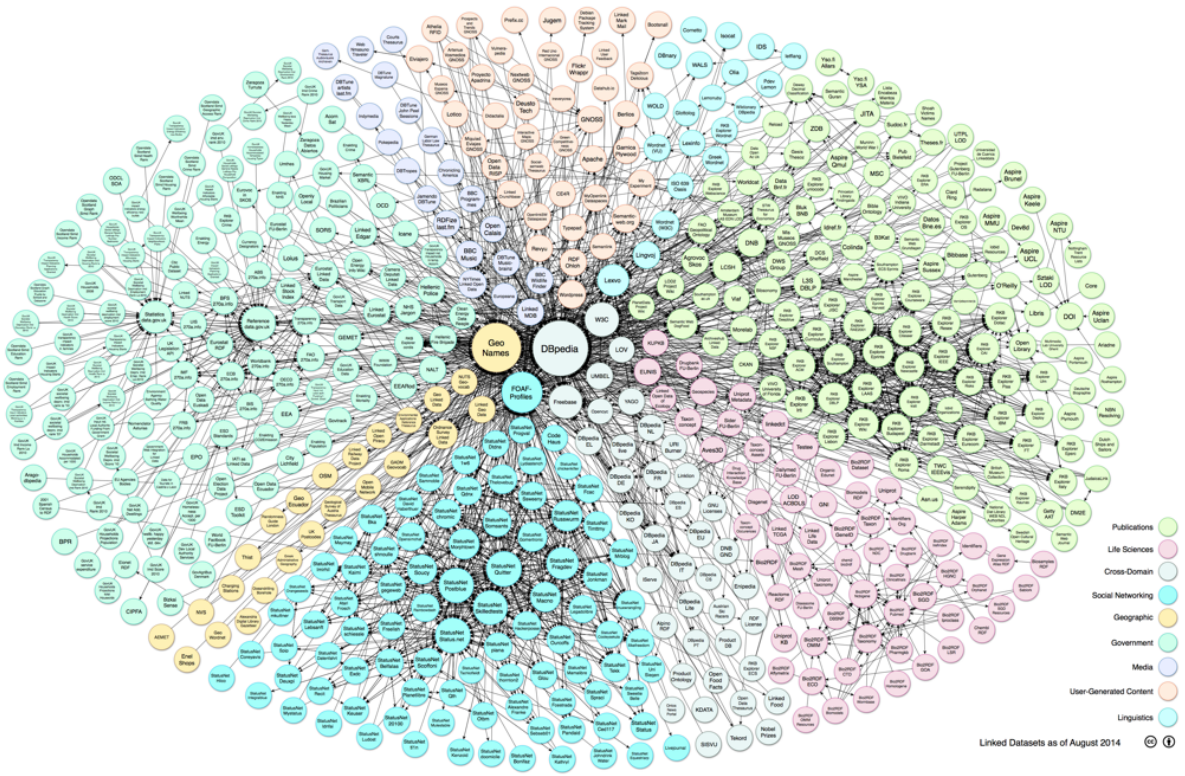
The Linked Open Data cloud

Where are we now ?

- **Who?** A lot of people on the LOD : BBC, MusicBrainz, Wikipedia, IBM, IEEE, flickr, etc...
- **What?** Everything : 5 star data dealing with music, science, geography, government, ...



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Agenda

Why the Semantic Web ?

Semantic data on the Linked Open Data

One step further : the Semantic Web

- Interrogation de données liées : SPARQL
- Ontology
- Reasoning

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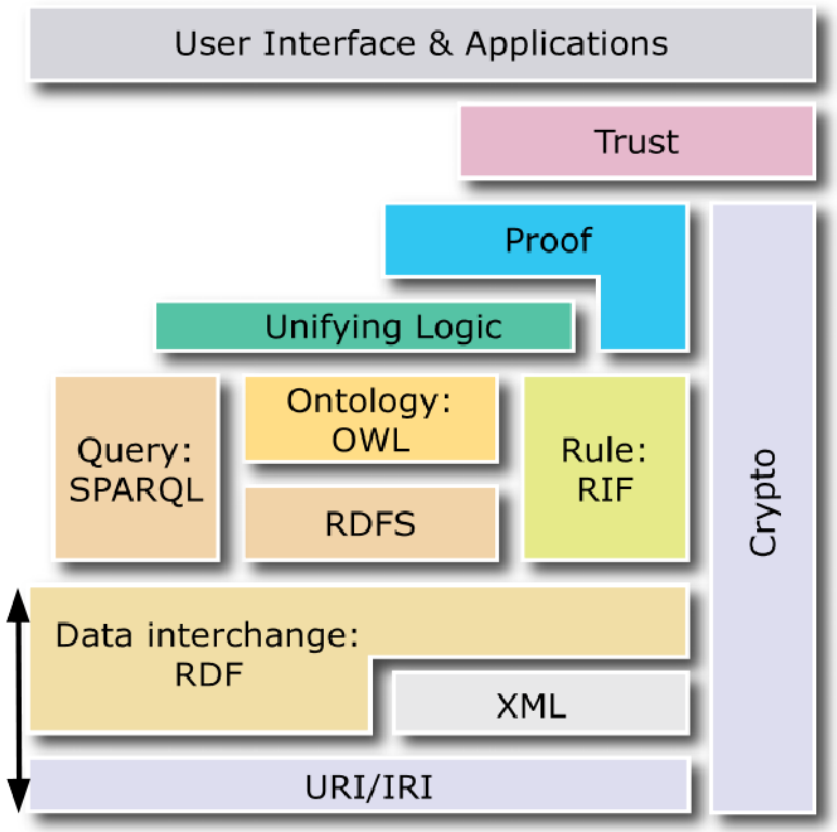
More semantics thanks to W3C standards !



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Querying RDF data with SPARQL

What is SPARQL ?

- Retrieves, deletes, updates RDF graphs
- Works by indicating **graph patterns**
- Syntax similar to SQL
- Not suited for end-users...

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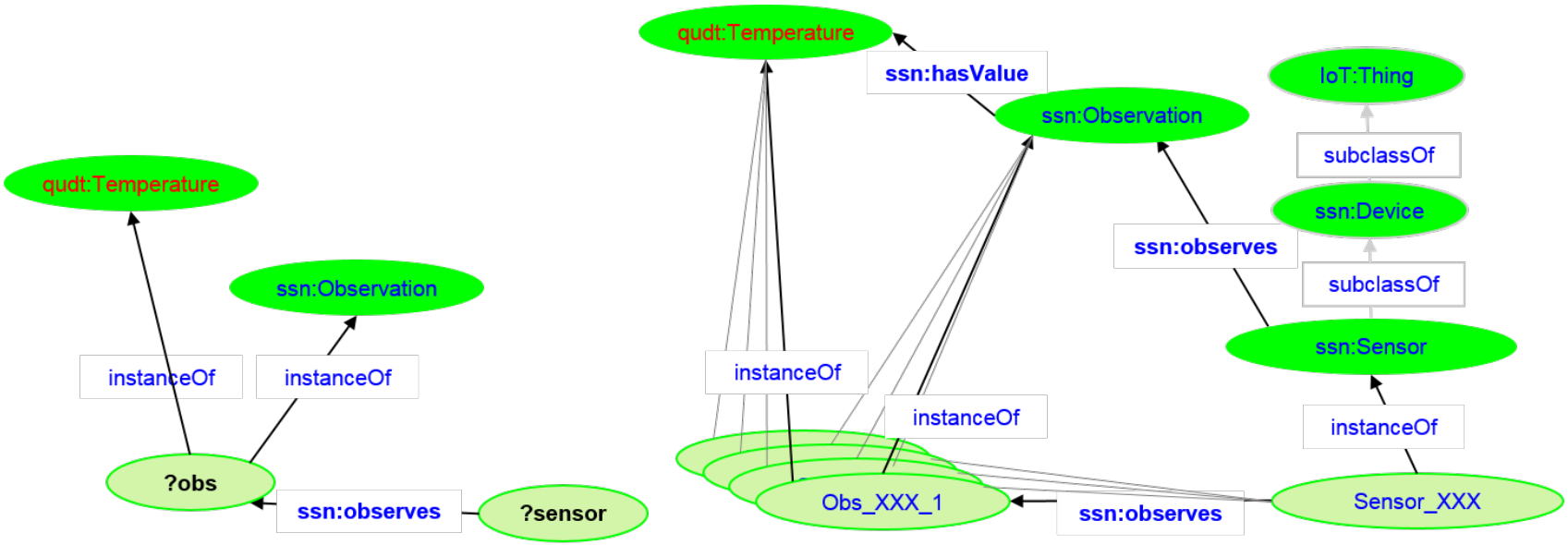
Example of SPARQL query



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What is an ontology ?

An academic definition

An ontology is a **formal**, and **explicit specification** of a **shared conceptualisation** [Studer, 1998]

More concretely

An ontology is a shared and formalized vocabulary used to describe data or information to

- enable interoperability
- infer new knowledge

An ontology is a knowledge representation used by agents (computers).

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What is an ontology ?

What do we have in an ontology?

- Labels (lexicon or symbols) : fog, nieba
- Classes (notions, set of objects, event, state,...): Sensor, Location, City, Observation...
- Relations between classes
  - Hierarchy of classes: City is a Location
  - Properties: Sensor observes parameter, Observation occurs in Location, ...
- More axioms : A sensor that observes a Temperature is a TemperatureSensor

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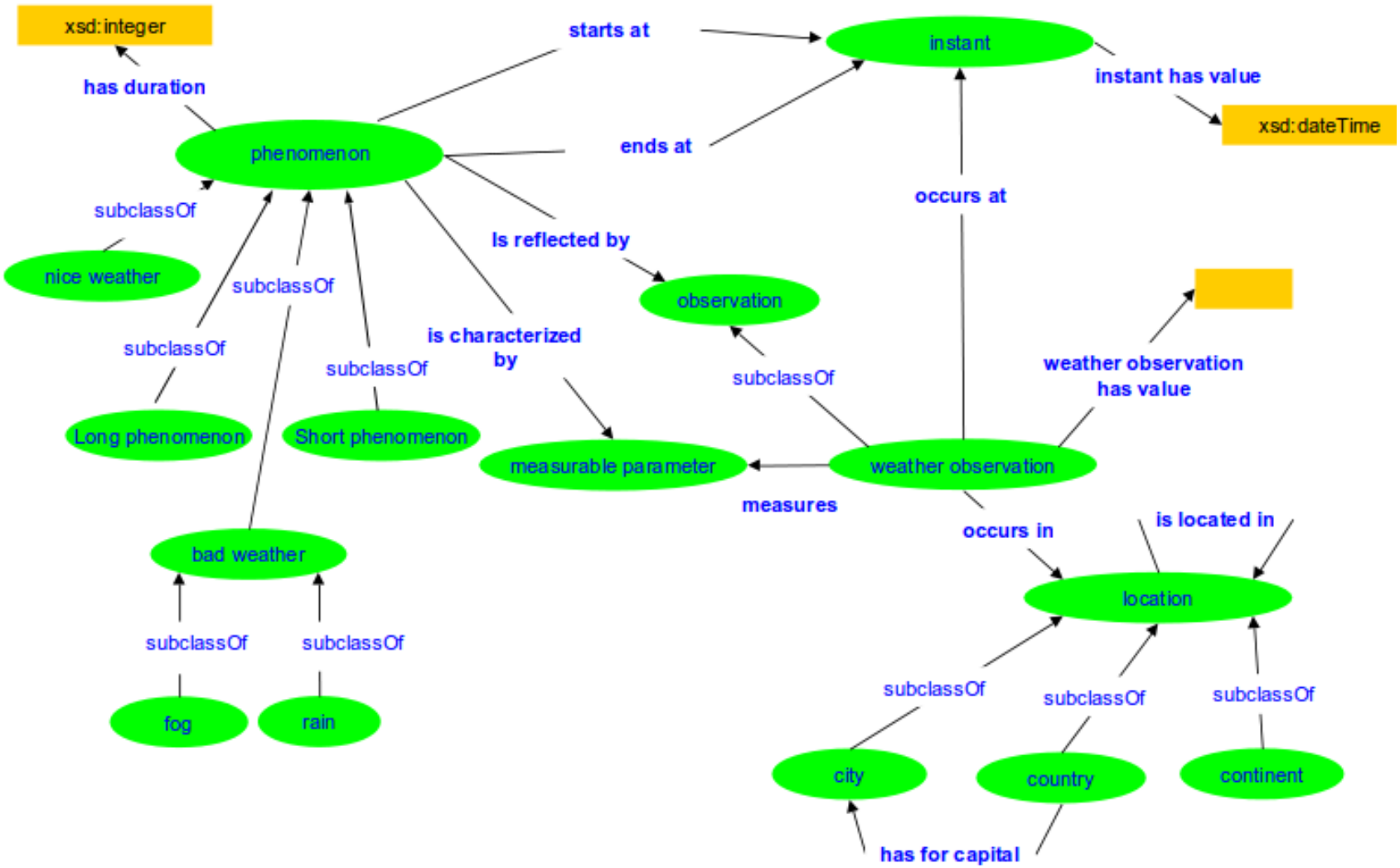
What is an ontology ?



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Description logic

The OWL language for representing ontologies

- a W3C formalism
- relies on Description Logics (DL)

Two types of axioms in DL

- Terminological (T-box) : defining the vocabulary
  - $ssn : Sensor \sqsubseteq ssn : Device$
  - $ssn : Sensor \sqcap ssn : Actuator \sqsubseteq \bot$
  - $ssn : LightSensor \equiv ssn : Sensor \sqcap \exists ssn : observes.qudt : Light$
- Assertional (A-box) : asserting facts on data with the vocabulary (or data semantic description)
  - $XXX \in ssn : Sensor$

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How is the formalization exploited ?

The reasoner

- is a program which uses the vocabulary, the logic in which it is represented and the assertions made on data to infer new facts.
- can detect inconsistencies when logical rules are violated.

An inference

- corresponds to a new fact deduced by the reasoner
- relies on different characterics of the used logic

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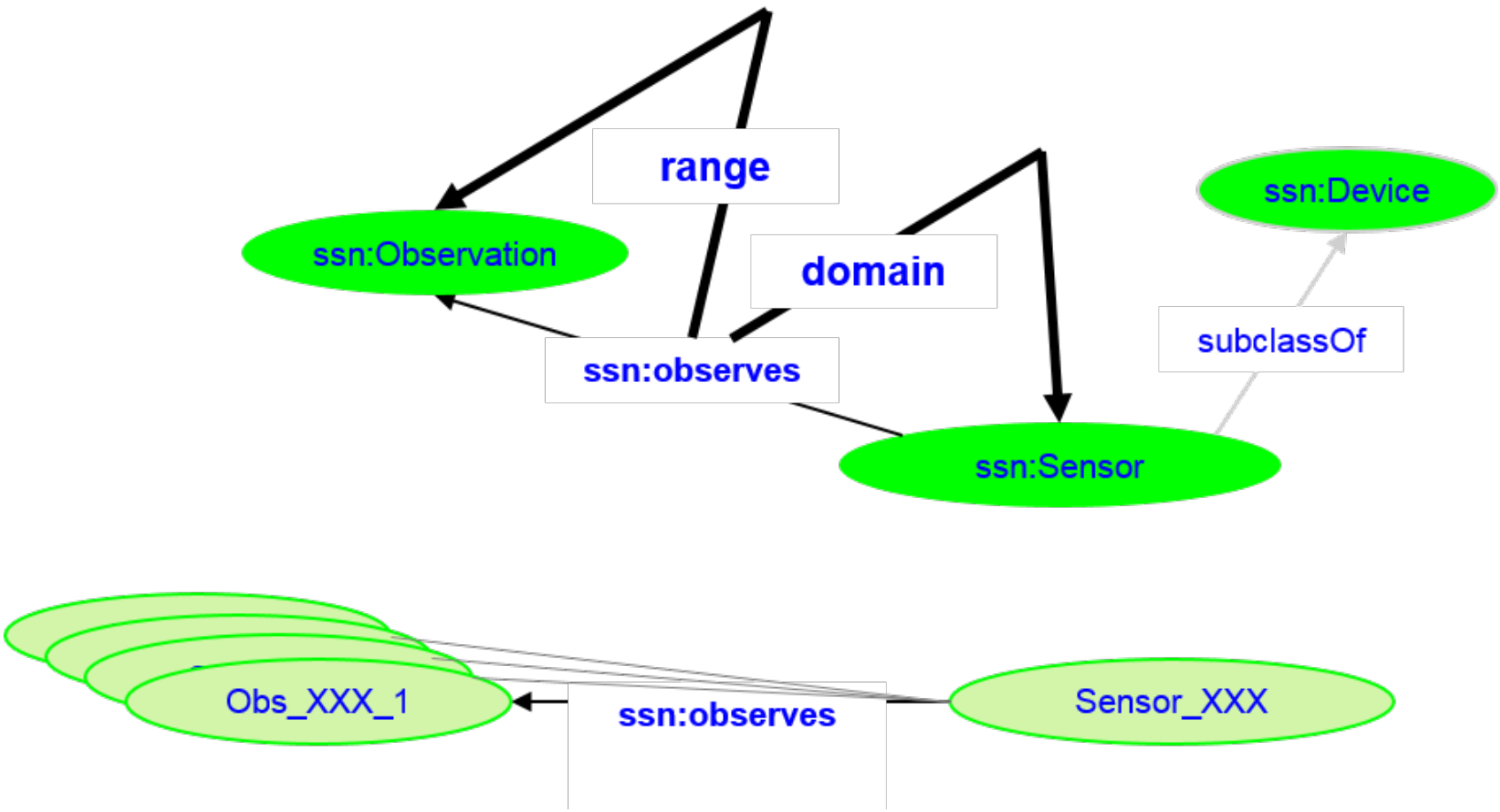
Inference based on properties



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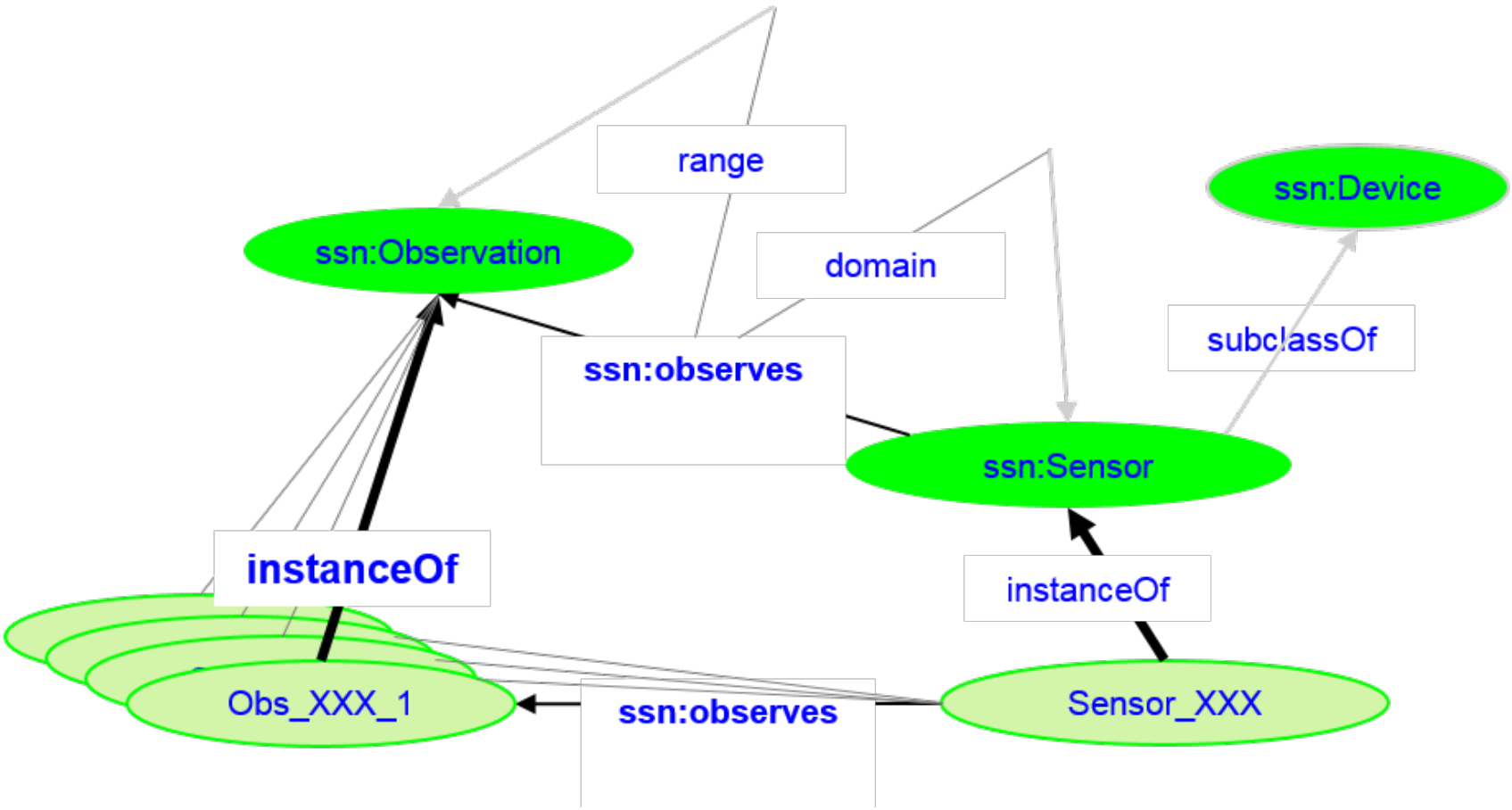
Inference based on properties



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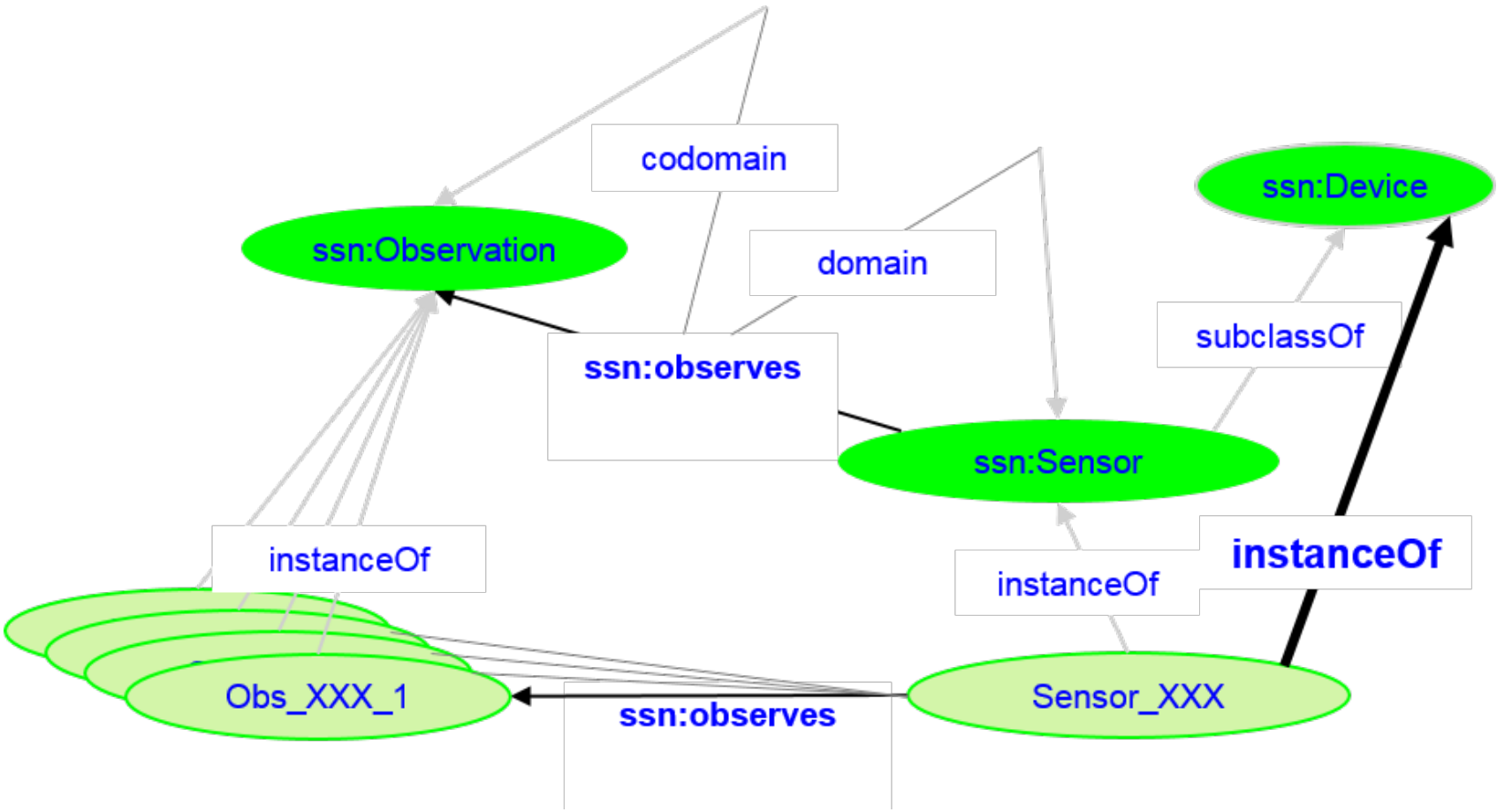
Inference based on the hierarchy of classes



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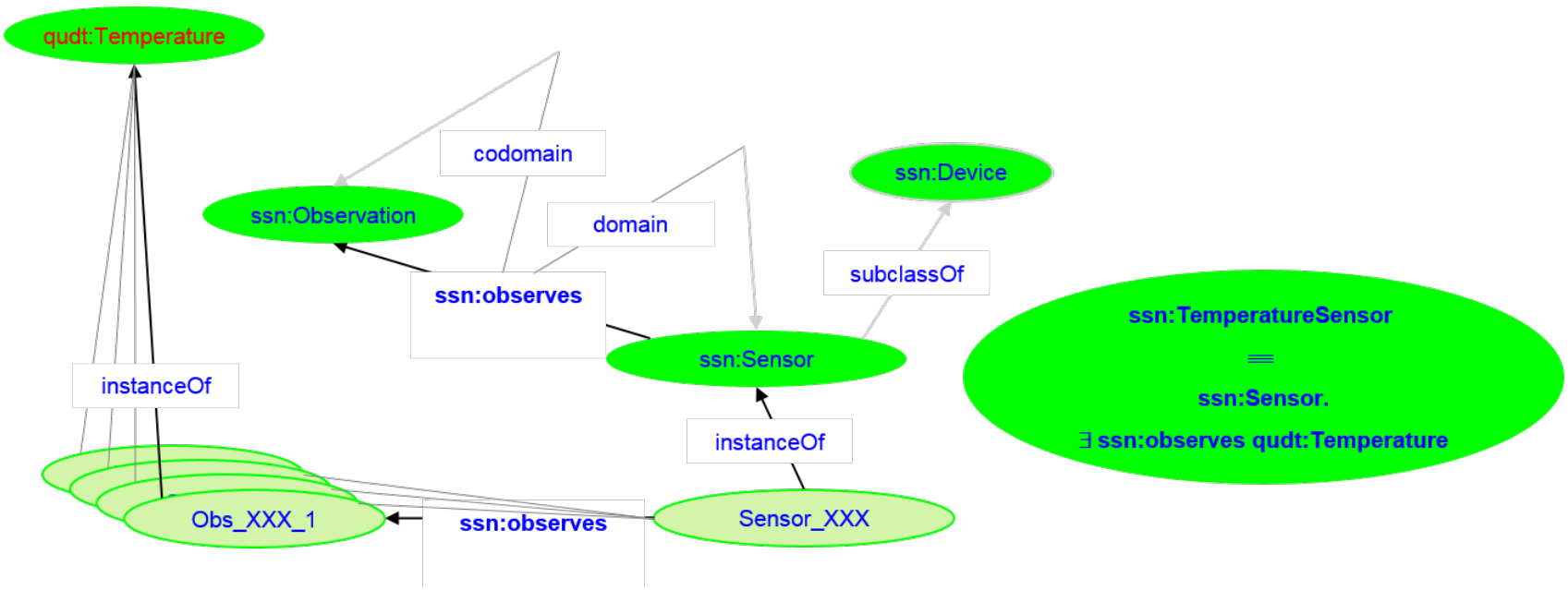
Inference based on class definition



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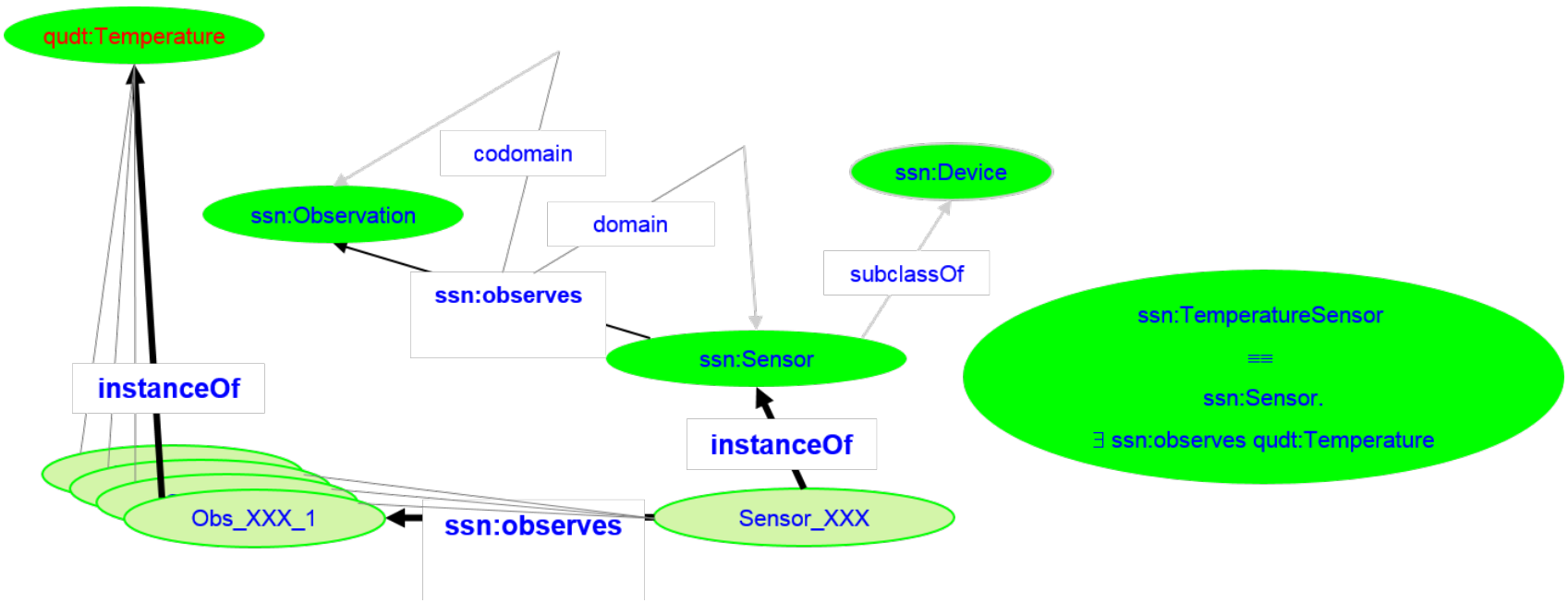
Inference based on class definition



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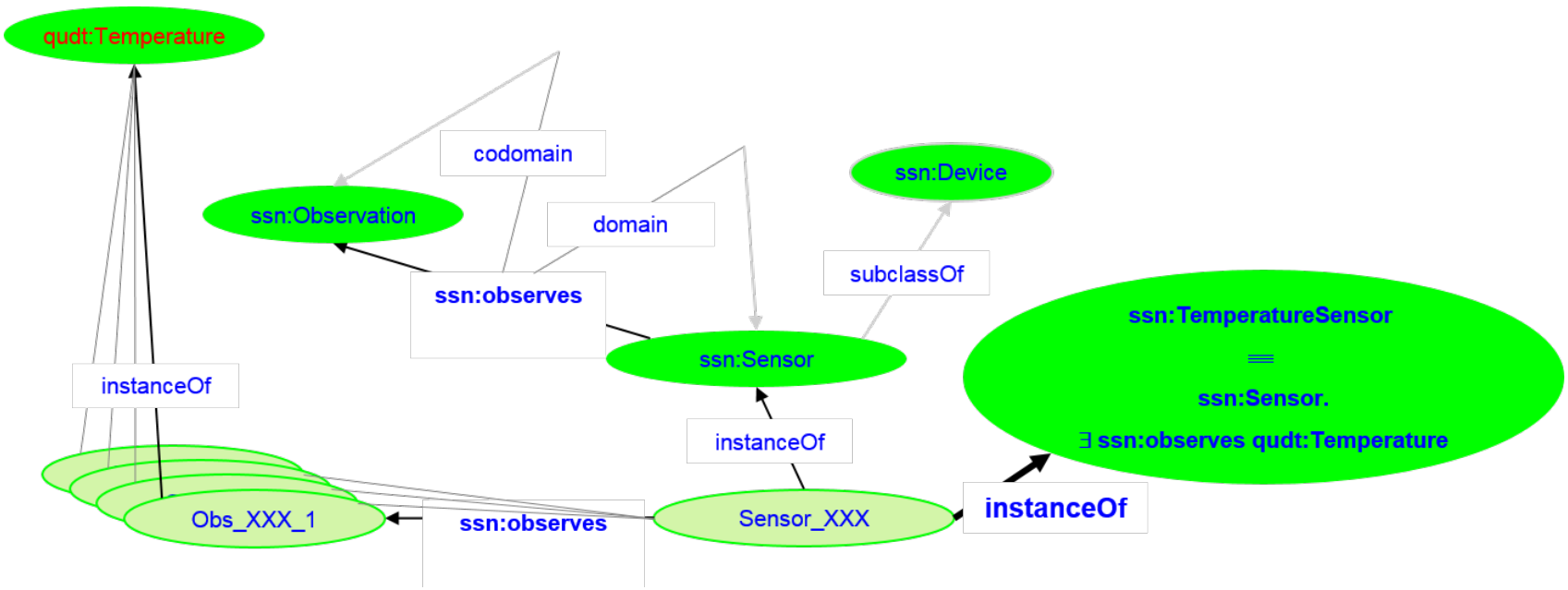
Inference based on class definition



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Different levels of formalization

Type	Content	Language
Lightweight ontology	Class hierarchy and properties	RDFS
Heavyweight ontology	Lightweight ontology - More axioms	OWL

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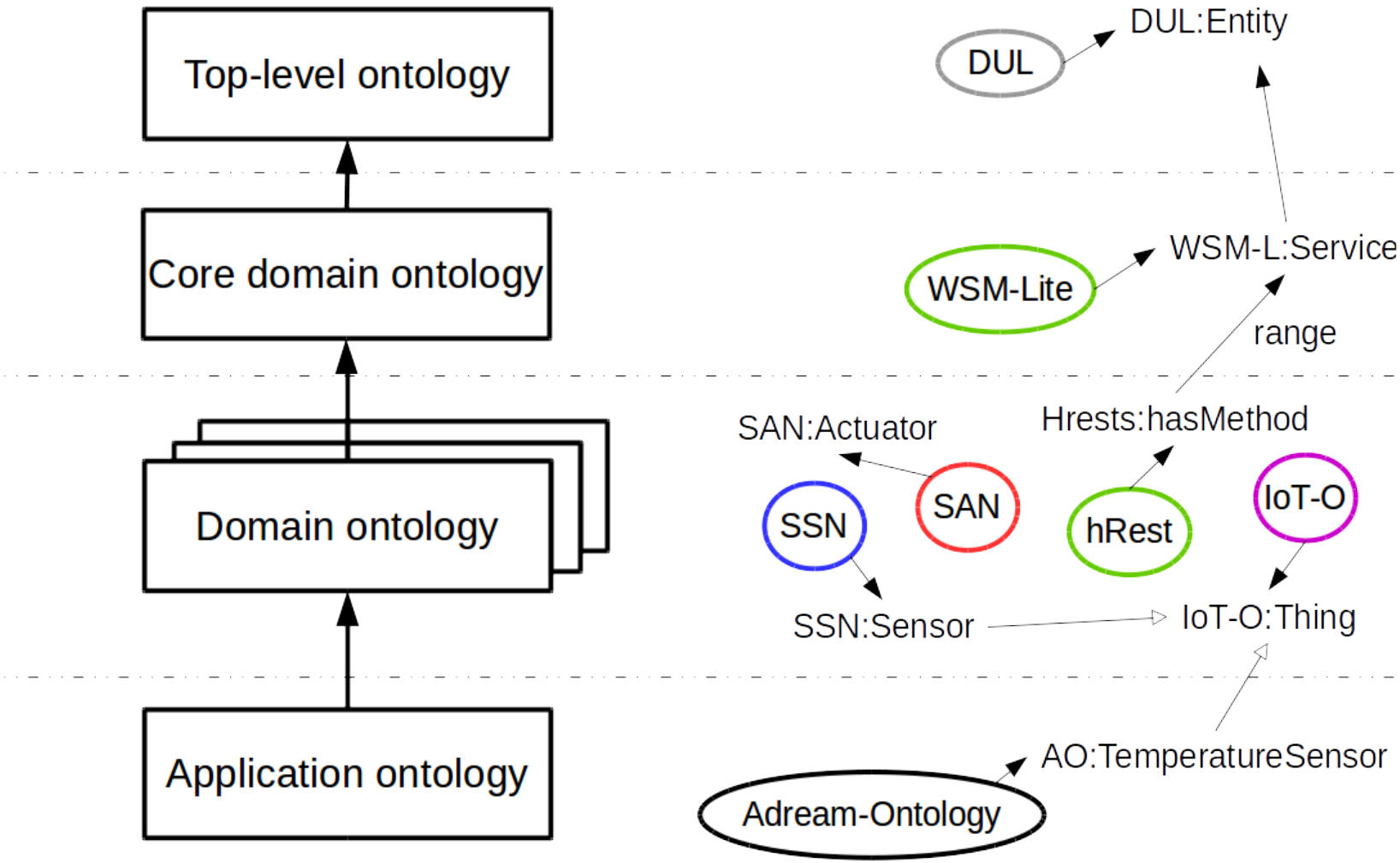
Different "roles" for ontologies



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Ontology Alignment

Alignment

- Finding corresponding entities between ontologies or knowledge bases
- The possible links :
  - Equivalence/Disjointedness
  - Specialization/Generalization/Composition
- A branch of Semantic Web is dedicated to the study of automated ways for generating alignments

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Example of Alignment

SSN and SAREF : T-box Alignments

- saref:Device $\equiv$ ssn:Device
- ssn:startTime $\subset$ saref:Time
- saref:UnitOfMeasure $\subset$ ssn:MeasuringCapability

A-box Alignment

- Toulouse : http://sws.geonames.org/2972315 $\equiv$ http://fr.dbpedia.org/resource/Toulouse

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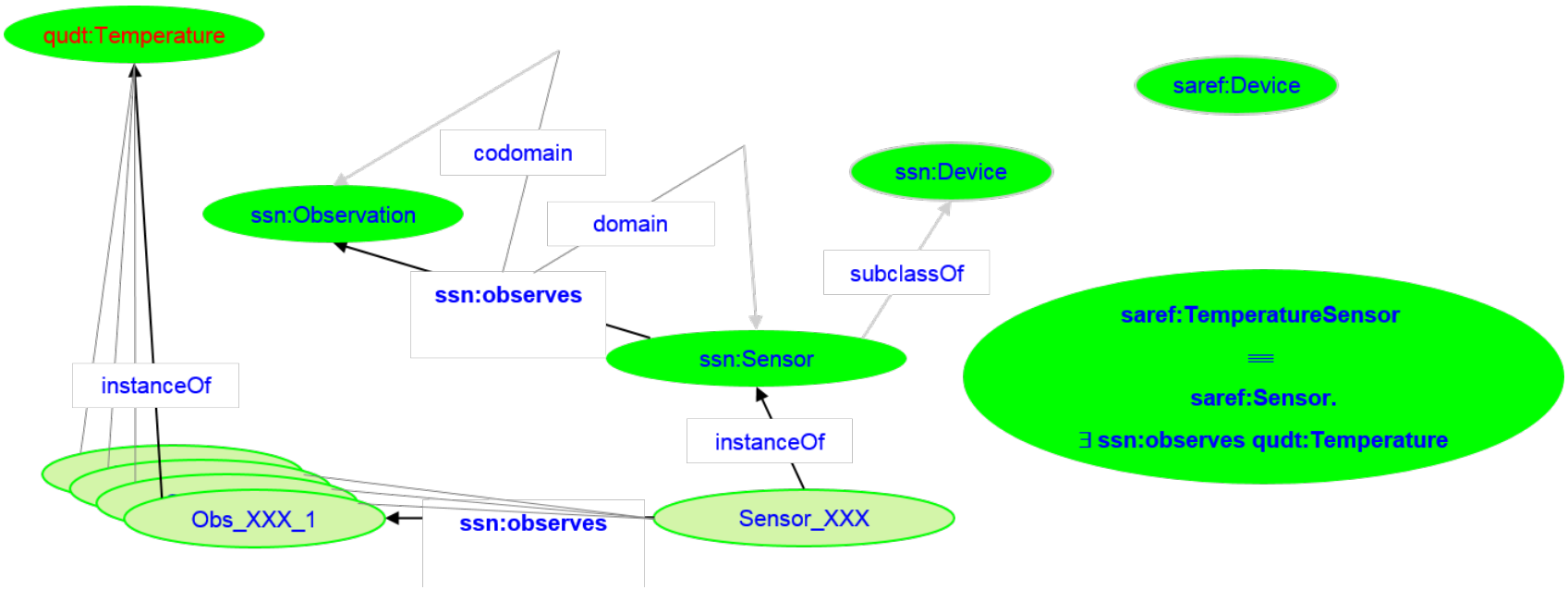
Alignment and reasoning



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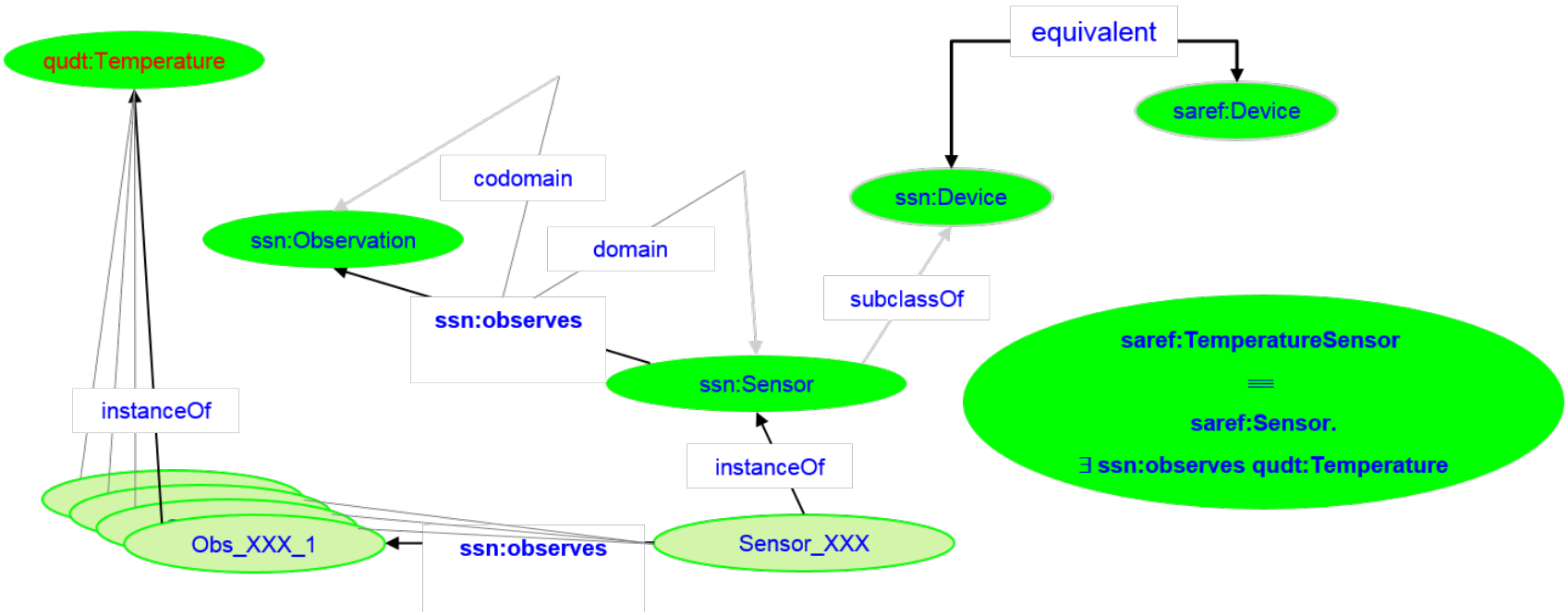
Alignment and reasoning



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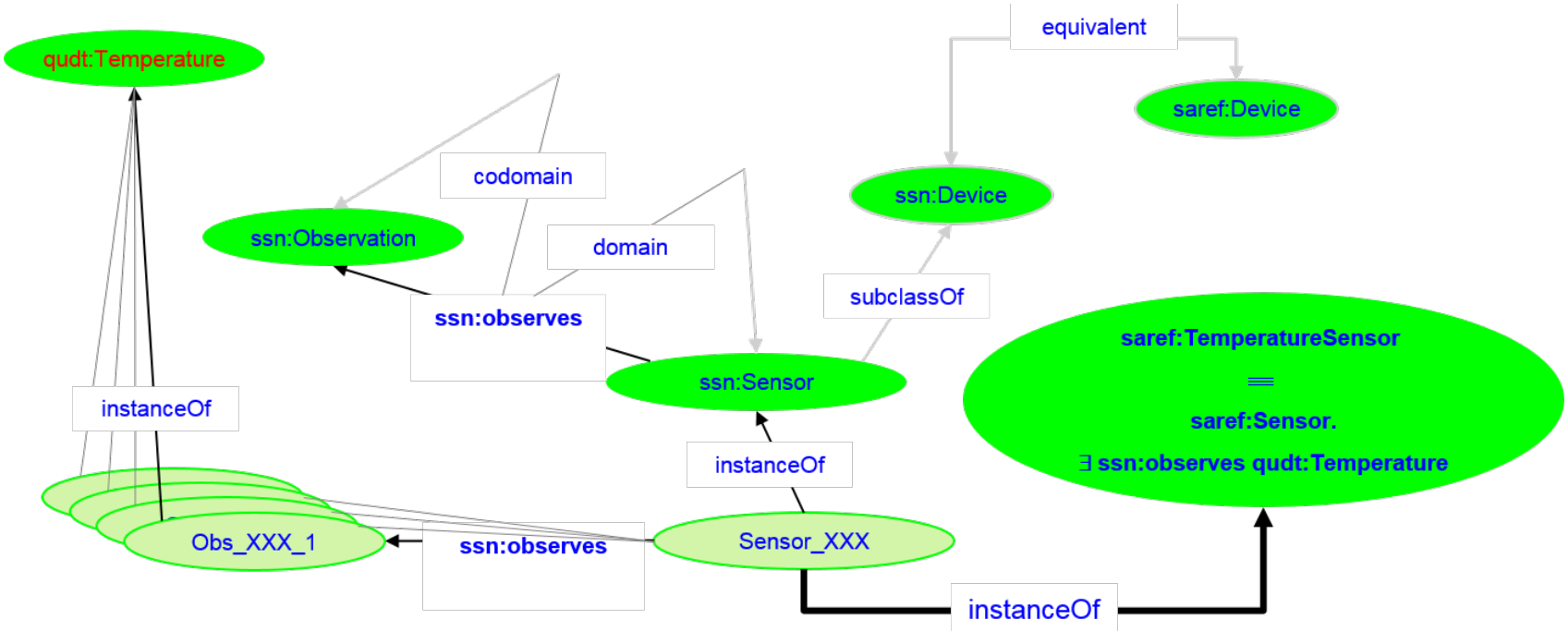
Alignment and reasoning



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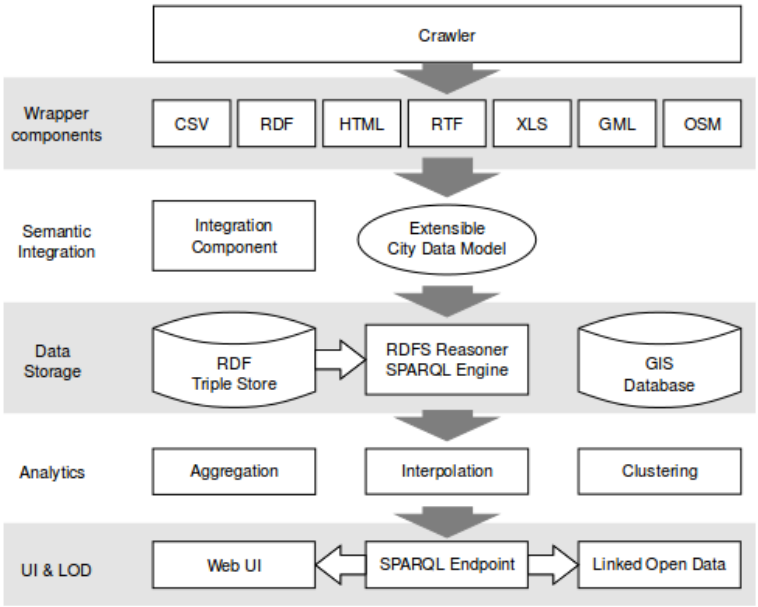
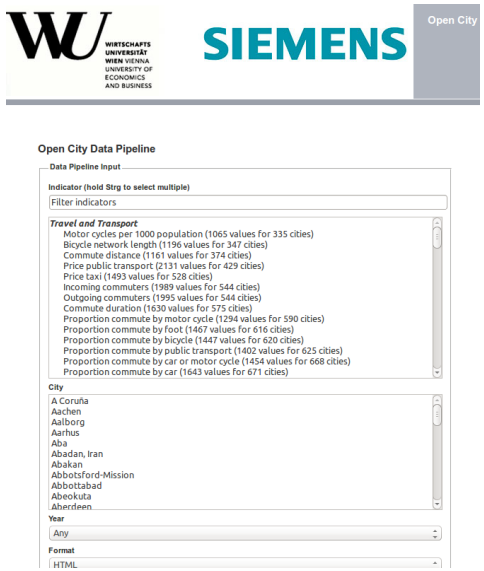
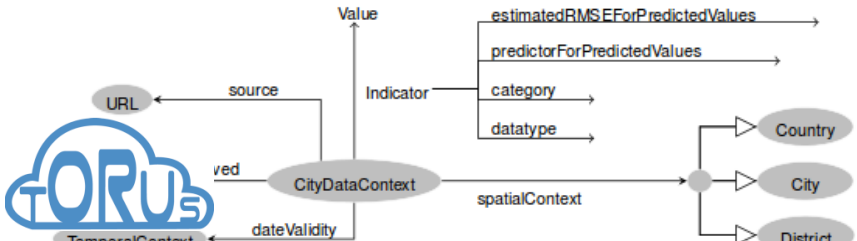
The semantic Web for GeoScience

A project using ontologies for both interoperability and reasoning







http://citydata.ai.wu.ac.at/KPIDataPipeline/