Linked Open Vocabularies for Internet of Things (LOV4IoT)

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Google Group	https://groups.google.com/d/forum/m3-semantic-web-of-things (Not really active yet)
Last updated	September, June 2016 • Add section web services/APIs (already explained in the M3 documentation) • Restructuration of the document • Update LOV4IoT citations • Suggestion new web services – improvement idea April 2016 • Errors with LOV, LOV community Google + • Suggesting a vocab to LOVIoT March 2016 • Suggesting a vocab to LOV
Created	February 2016
Status	Work in progress
Goal	This documentation enables understanding the LOV4IoT tool: • Use the Graphical User interface (GUI) • Use the web services • Contribute to the LOV4IoT knowledge base Linked Open Vocabularies for Internet of Things (LOV4IoT) is an extension of Linked Open Vocabularies (LOV) for Internet of Things

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Terms and acronyms

IoT	Internet of Things (IoT)
LOV	Linked Open Vocabularies
LOV4IoT	Linked Open Vocabularies for Internet of Things
M3 framework	Machine-to-Machine Measurement (M3) framework

I. LOV4IoT Citations

Please do not forget to cite our LOV4IoT work:

- Reusing and Unifying Background Knowledge for Internet of Things with LOV4IoT. 4rd International Conference on Future Internet of Things and Cloud (FiCloud 2016), 22-24 August 2016, Vienna, Austria. Amelie Gyrard, Ghislain Atemezing, Christian Bonnet, Karima Boudaoud and Martin Serrano
- LOV4IoT: A second life for ontology-based domain knowledge to build Semantic Web of Things applications. 4rd International Conference on Future Internet of Things and Cloud (FiCloud 2016), 22-24 August 2016, Vienna, Austria. Amelie Gyrard, Christian Bonnet, Karima Boudaoud and Martin Serrano
- Semantic Web Methodologies, Best Practices and Ontology Engineering Applied to Internet of Things IEEE World Forum on Internet of Things (WF-IoT), Milan, Italy, December 14-16, 2015 Amelie Gyrard, Martin Serrano, Ghislain Atemezing
- Domain knowledge Interoperability to build the Semantic Web of Things W3C Web of Things, 25-26 June 2014, Berlin, Germany Amelie Gyrard, Christian Bonnet and Karima Boudaoud
- Semantic Web Guidelines for domain knowledge interoperability to build the Semantic Web of Things OneM2M International standard, Management, Abstraction and Semantics (MAS) Working Group 5, April 2014 Amelie Gyrard, Christian Bonnet

II. Introduction: From LOV to LOV4IoT

Linked Open Vocabularies (LOV) [10] is an ontology catalogue designed by semantic web experts.

New ontologies should follow some best practices to be referenced. In Internet of Things, we classified almost 300 ontologies that cannot be referenced on LOV because of the “bad practices”.

For those reasons, we designed Linked Open Vocabularies for Internet of Things (LOV4IoT).

Figure 1. Linked Open Vocabularies (LOV)

1. Suggesting a vocabulary to LOV

- Step 1: Go to the LOV web page: http://lov.okfn.org/dataset/lov/
- Step 2: Click on Suggest
- Step 3: Enter the URL of the ontology
- Step 4: Does your ontology contain ontology metadata as recommended by LOV? [11]

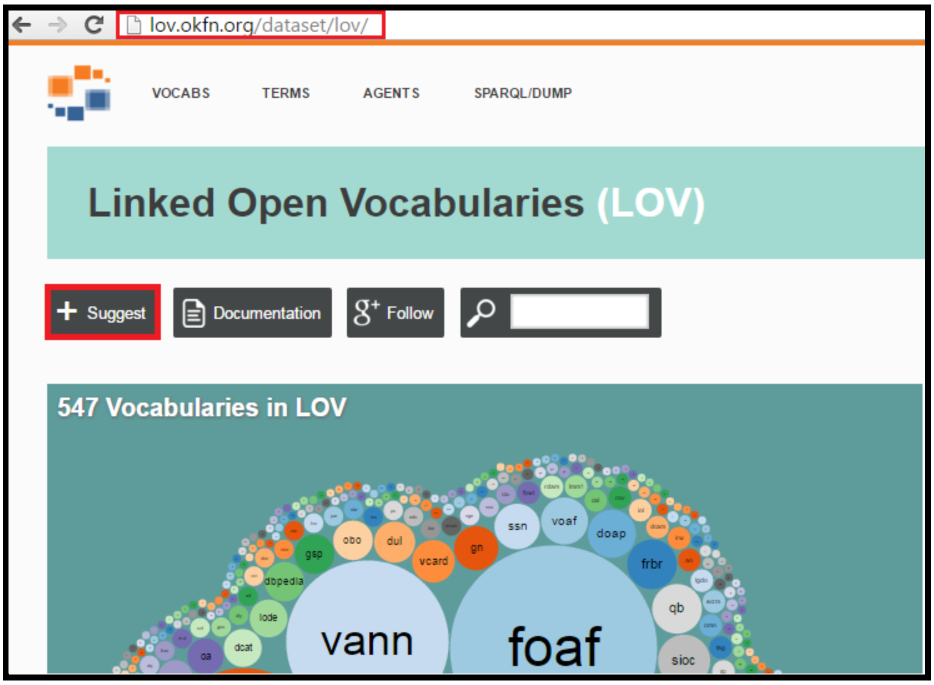


Figure 2. Suggest a vocabulary on LOV

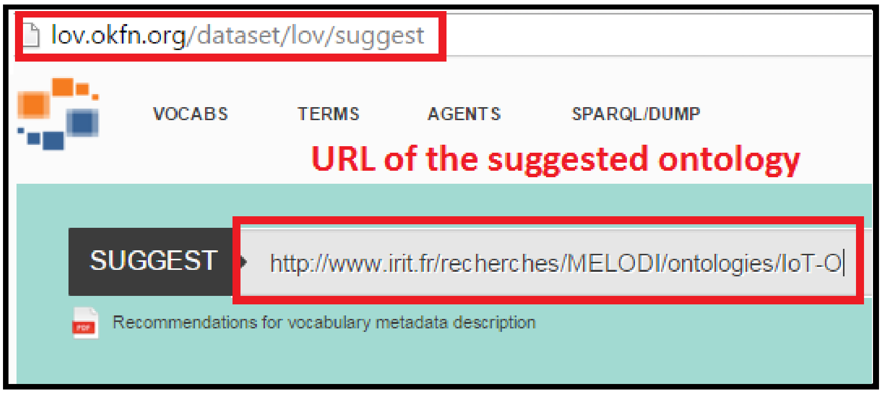


Figure 3. Suggest your ontology on LOV

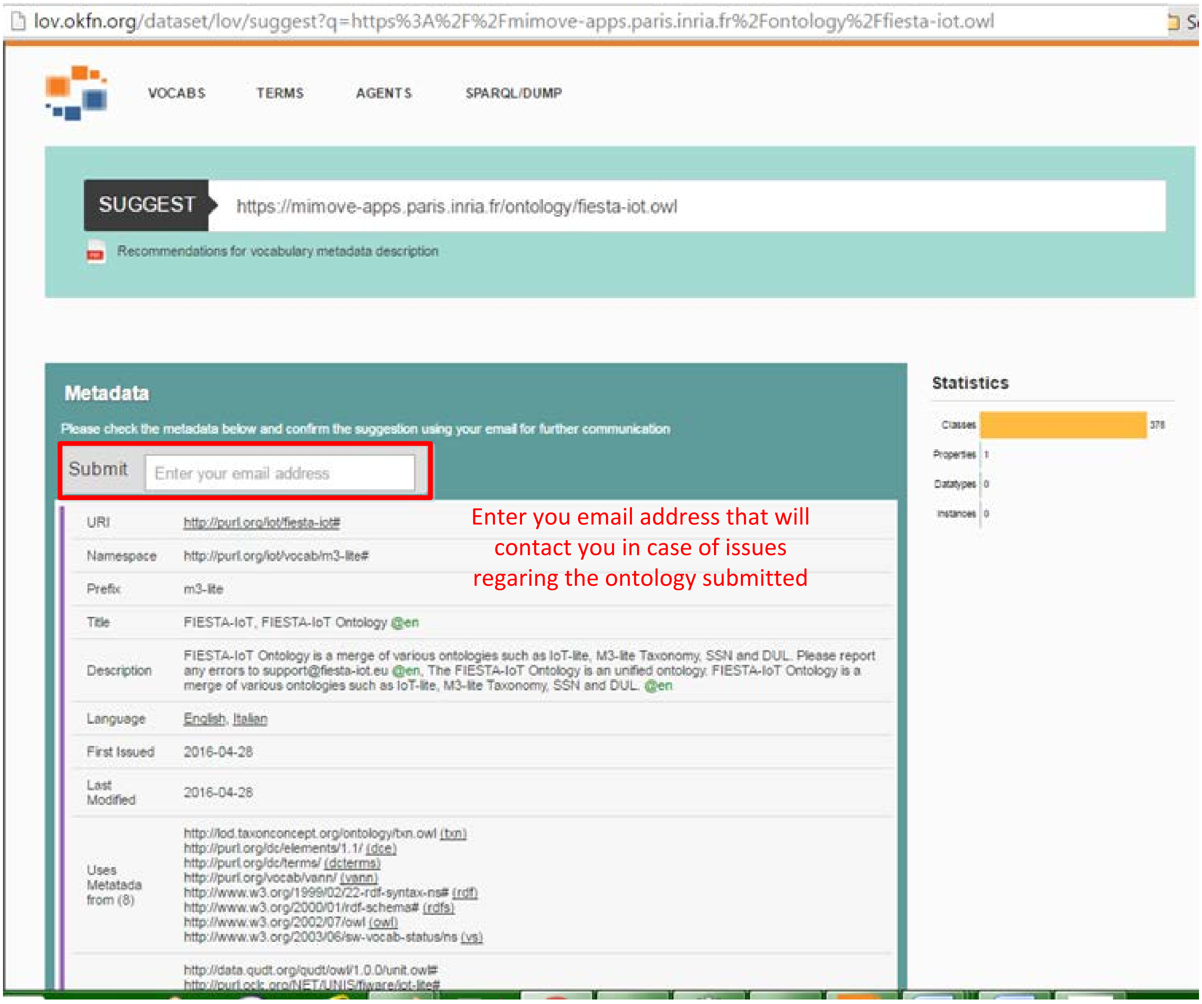
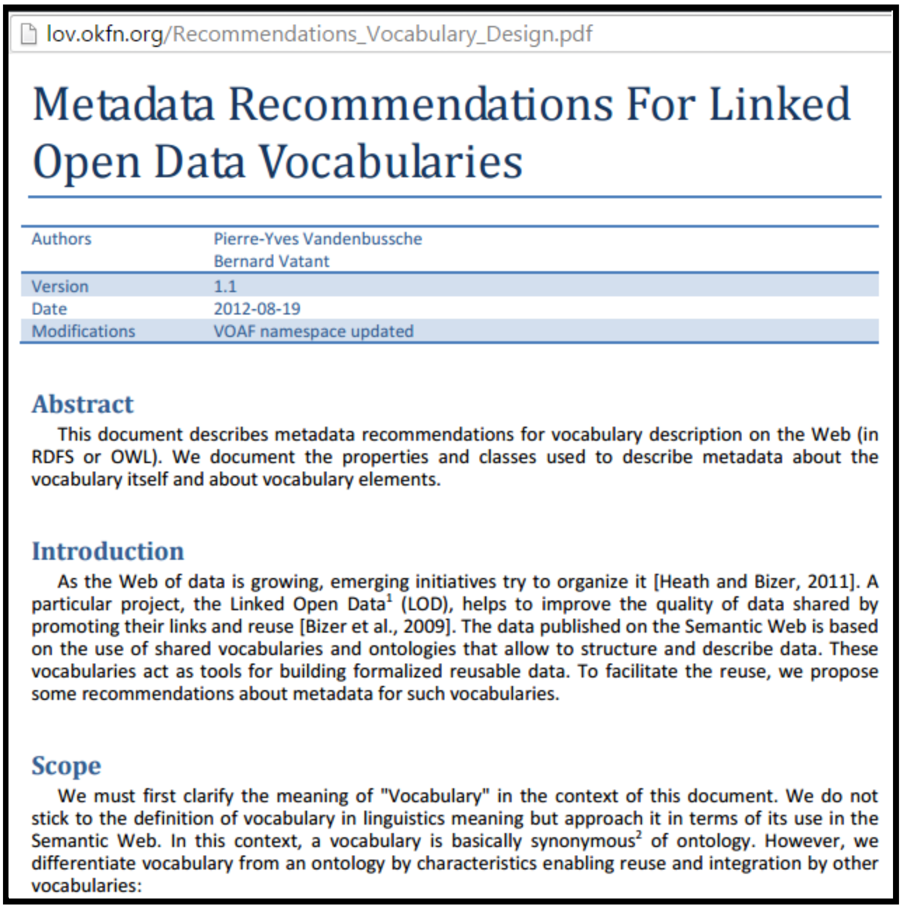


Figure 4. Suggest your ontology on LOV without errors


lov.okfn.org/Recommendations_Vocabulary_Design.pdf

Metadata Recommendations For Linked Open Data Vocabularies

Authors	Pierre-Yves Vandenbussche Bernard Vatant
Version	1.1
Date	2012-08-19
Modifications	VOAF namespace updated

Abstract

This document describes metadata recommendations for vocabulary description on the Web (in RDFS or OWL). We document the properties and classes used to describe metadata about the vocabulary itself and about vocabulary elements.

Introduction

As the Web of data is growing, emerging initiatives try to organize it [Heath and Bizer, 2011]. A particular project, the Linked Open Data[1] (LOD), helps to improve the quality of data shared by promoting their links and reuse [Bizer et al., 2009]. The data published on the Semantic Web is based on the use of shared vocabularies and ontologies that allow to structure and describe data. These vocabularies act as tools for building formalized reusable data. To facilitate the reuse, we propose some recommendations about metadata for such vocabularies.

Scope

We must first clarify the meaning of "Vocabulary" in the context of this document. We do not stick to the definition of vocabulary in linguistics meaning but approach it in terms of its use in the Semantic Web. In this context, a vocabulary is basically synonymous[2] of ontology. However, we differentiate vocabulary from an ontology by characteristics enabling reuse and integration by other vocabularies:

Figure 5. LOV recommendations

2. Errors encountered when suggesting a vocabulary on LOV

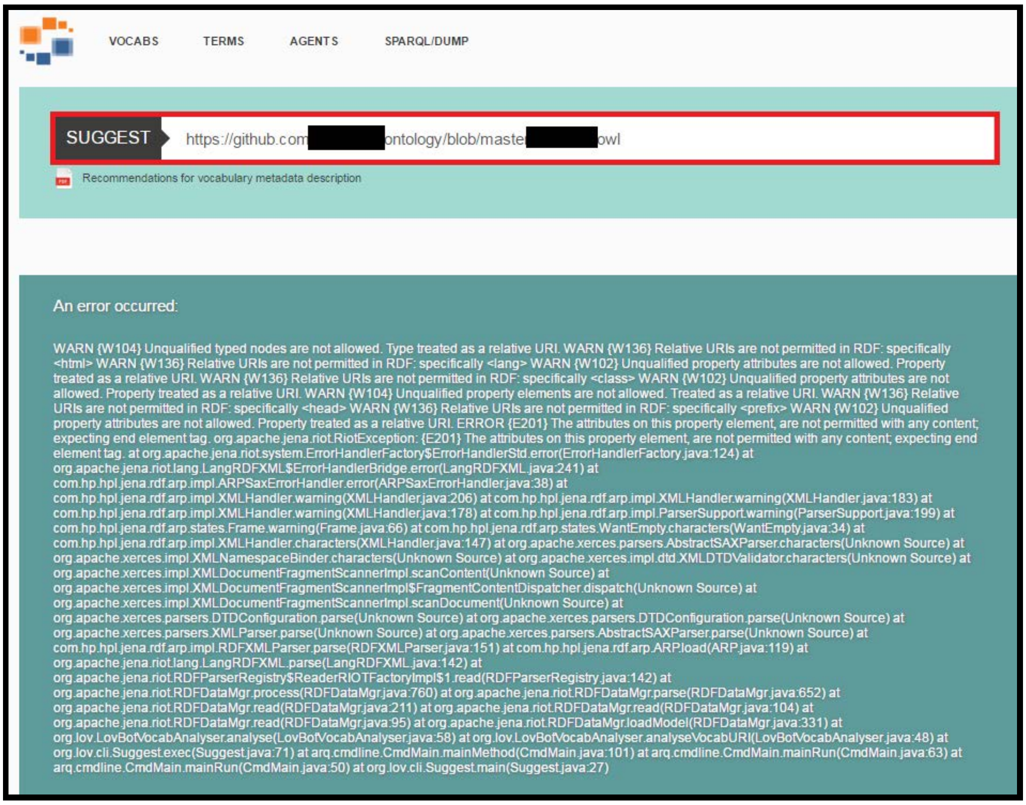


Figure 6. Errors encountering when suggesting ontologies on LOV

In case you cannot fixed the error, you can asked to the reactive LOV community on Google +[1]

[1] https://plus.google.com/u/1/communities/108509791366293651606

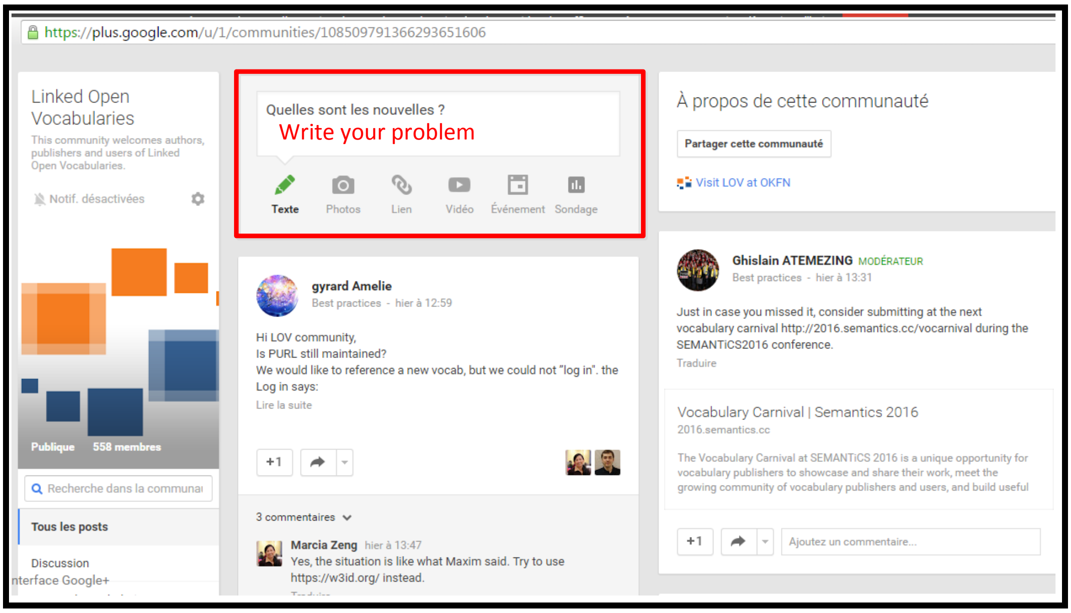


Figure 7. LOV community on Google +

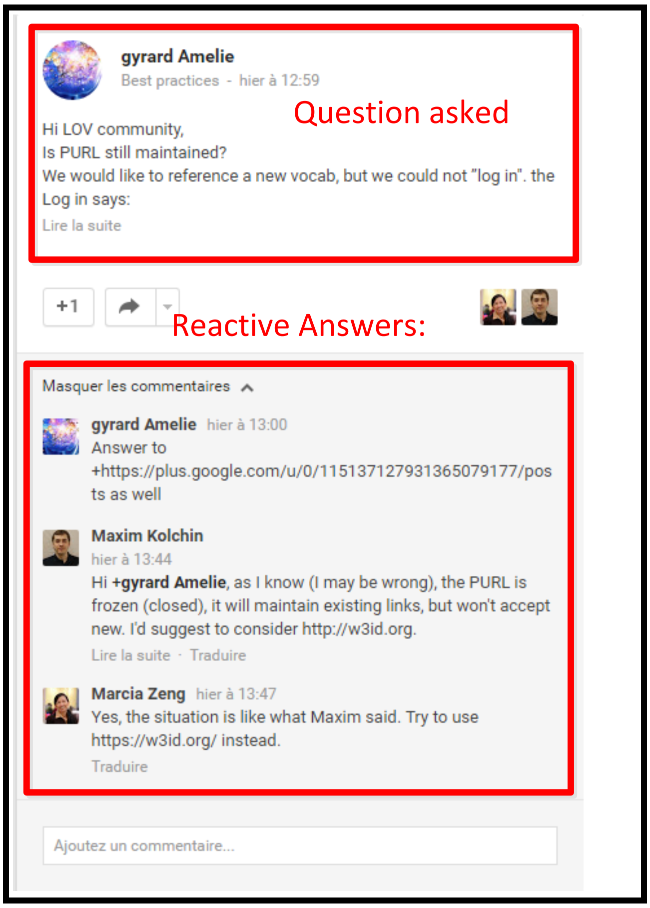


Figure 8. The reactive LOV community guides us to fix issues regarding ontologies

3. Suggesting a vocabulary to LOV4IoT

We are thinking about a web page to submit a new ontology.

The current solution is to send us a message and we will update the LOVIoT dataset.

amelie.gyrard@insight-centre.org

Thanks for your help for referencing more ontologies ☺ We have almost 300 ontology-based projects referenced in LOV4IoT.

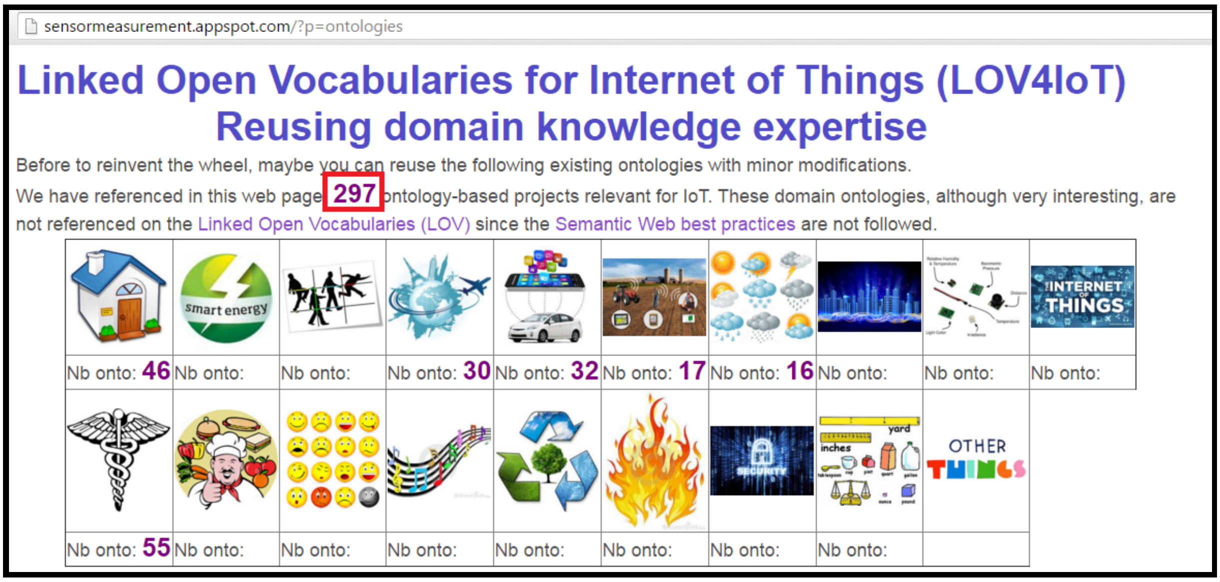


Figure 9. Almost 300 ontology-based projects referenced in LOV4IoT

III. Reusing domain knowledge with LOV4IoT

- ➔ Go to the Linked Open Vocabularies for Internet of Things (LOV4IoT) web page (see Figure 10): http://www.sensormeasurement.appspot.com/?p=ontologies
- ➔ Choose 1 domain by clicking on the image (e.g., transportation) as depicted in Figure 10.

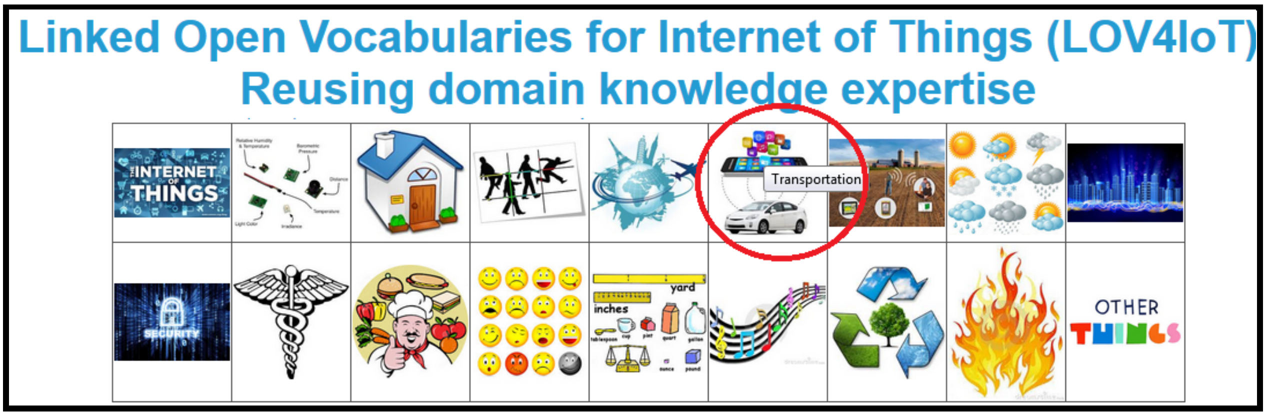


Figure 10. Ontologies classified in various domains

- ➔ You will find a table with the following information as depicted in Figure 12:
  - o Domain experts names (authors)
  - o Year of publication
  - o Research articles
  - o Ontology URL of available
  - o Technologies used in their project
  - o Sensors used in their project
  - o Rules designed

-Ontologies and projects have been classified according to different colors (see Figure 11):

- Red: the ontology is not available
- White: we do not have any links to get the ontology
- Orange: we contacted authors to get their ontologies. They answered us they will share ontologies and rules soon.
- Yellow: we retrieve the ontology URL or get a copy
- Green: Ontologies published online, cannot be referenced on the Linked Open Vocabularies (LOV)[2] project due to a lack of best practices.
- Dark green: The ontology is referenced on the Linked Open Vocabularies project. It checks best practices.

The ontology will never be available (lost, confidential, etc.) :-(	We are waiting the response of the authors to publish the ontology online	Authors are publishing online the ontology (ongoing work)	Ontology published online but the Semantic Web best practices are not complied with.	Ontology published online and referenced by LOV since Semantic Web best practices are adopted! :-)))	Already on LOV - No email sent

Figure 11. Classification of projects according to the reusability

[2] http://lov.okfn.org/dataset/lov/

Intelligent Transport Systems

Authors	Year	Paper	Url onto	Technologies	Sensors	Rules	LOV status	Security
Bermejo, Astrain Escola Mail: 14/02/14, Response: 18/02/14	2014	Paper: Ontology based road traffic management	No server (response), but sent us the OWL ontology copy URL Application ? Concepts: 24 classes, 12 properties, 77 rules. Vehicle	SWRL (DLSafeRule), Jess reasoner, extension of A3ME ontology, OWL API 3.4.2	LastBeforeGap, FirstAfterGap, NotOvertaker, Overtaker), distance sensor -> Space (Lateral, Ahead, Behind, NoSpace), Acceleration sensor (BigSpeedDifference, SpeedWith,	77 rules/actions (swrl dlsafe rule in the ontology) change line, decelerate, accelerate, maintain distance with car in front, maintain speed	Priority 1, responsive, ongoing, lov metadata, uri deferencable 26/03/14, ask for label and comment	
Morignot, Pollard et al.	2013	Paper: An ontology-based Model to determine the automation level of an automated vehicle for co-driving Paper: An ontology-based approach to relax traffic regulation for autonomous vehicle assistance	Ontology URL Ontology URL Concepts: emotion driver, Weather Conditions (foggy, cloudy, snowy, sunny, rainy), lighting conditions (day, night, setting sun), road (highway, campaing, urban, mountain), obstacles	Pellet, SWRL (DLSafeRule), Protege, SWOOPS (ontology editor)	Position, velocity, acceleration/braking and steering actuators	foggy -> mode manual, search for parking place, stopped, hasNextMotion	content negociation, uri def error, vapour rdf/xml	

Figure 12. Screenshot of LOV4IoT

IV. LOV4IoT web services/APIs

1. LOV4IoTWS Java class

This Java class contains all web services related to LOV4IoT.

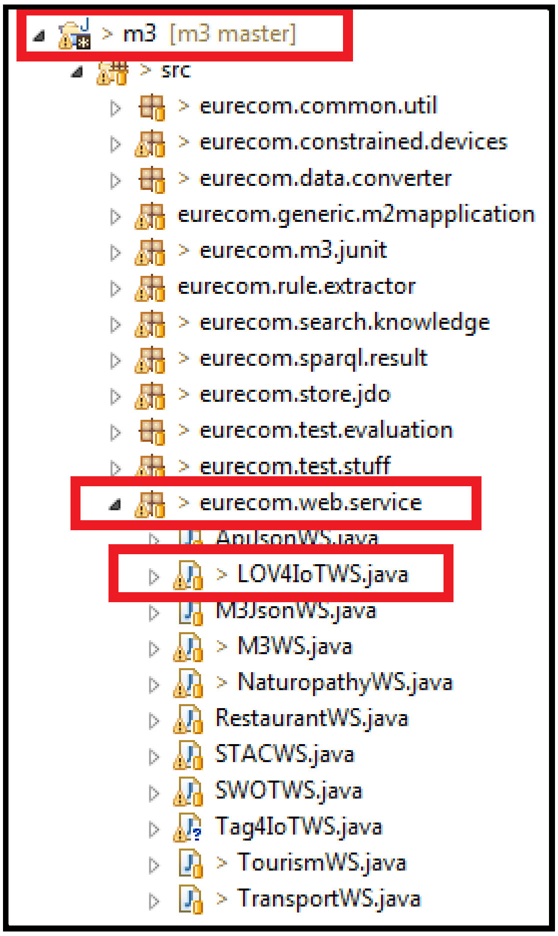


Figure 13. LOV4IoTWS Java Class location

All web services related to the Linked Open Vocabularies for Internet of Things (LOV4IoT) dataset[3] to automatically count the number of ontologies in this dataset (e.g., by domains, by ontology status, etc.):

- lov4iot/totalOnto/ which executes a SPARQL query to count the total number of ontology-based project referenced in the LOV4IoT RDF dataset.
  E.g., **http://sensormeasurement.appspot.com/lov4iot/totalOnto/**
- /lov4iot/ontoStatus/{status} which executes a SPARQL query to count the different status of ontologies
  - Status can be: Online, Confidential, OngoingProcessOnline, WaitForAnswer, Online, OnlineLOV, AlreadyLOV

  E.g., **http://sensormeasurement.appspot.com/lov4iot/ontoStatus/?status=Online**

[3] http://www.sensormeasurement.appspot.com/?p=ontologies

- /lov4iot/nbOntoDomain/{domain} which executes a SPARQL query to count the different ontologies in all domains
  - Domain can be: BuildingAutomation, Weather, Emotion, Agriculture, Health, Tourism, Transportation, City, EnergyFOI, Environment, TrackingFood, Activity, Fire, TrackingCD, TrackingDVD, SensorNetworks, IoT, Security

E.g.,

http://sensormeasurement.appspot.com/lov4iot/nbOntoDomain/?domain=BuildingAutomation

- /lov4iot/sendEmail/{recipient,paper} which sends email to encourage people to share their domain knowledge (ontologies, datasets, and rules)

```
@GET
@Path("/totalOnto/")
@Produces(MediaType.APPLICATION_XML)
public Response getTotalNumberOntology() {
    //load the LOV4IoT dataset into the model
    Model model = ModelFactory.createDefaultModel();
    ReadFile.enrichJenaModelOntologyDataset(model, Var.LOV4IOT_DATASET_PATH);
    M2MAppGeneric m2mappli = new M2MAppGeneric(model);

    //SPARQL query
    ExecuteSparql sparqlQuery = new ExecuteSparql(model, Var.ROOT_SPARQL_LOV4IoT + "countTotalOntology.sparql");

    //no variable to replace in the SPARQL query
    ArrayList<VariableSparql> var = new ArrayList<VariableSparql>();
    String resultSparqlsenml = sparqlQuery.getSelectResultAsXML(var);

    return Response.status(200).entity(resultSparqlsenml).build();
}
```

Figure 14. Example of the lov4iot/totalOnto: web service

Yan can download the LOV4IoT RDF dataset[4] and write your own SPARQL queries.

Otherwise, we designed some web services:

2. Web service: Get the total number of ontologies

Query:

http://www.sensormeasurement.appspot.com/lov4iot/totalOnto/

[4] http://www.sensormeasurement.appspot.com/dataset/lov4iot-dataset

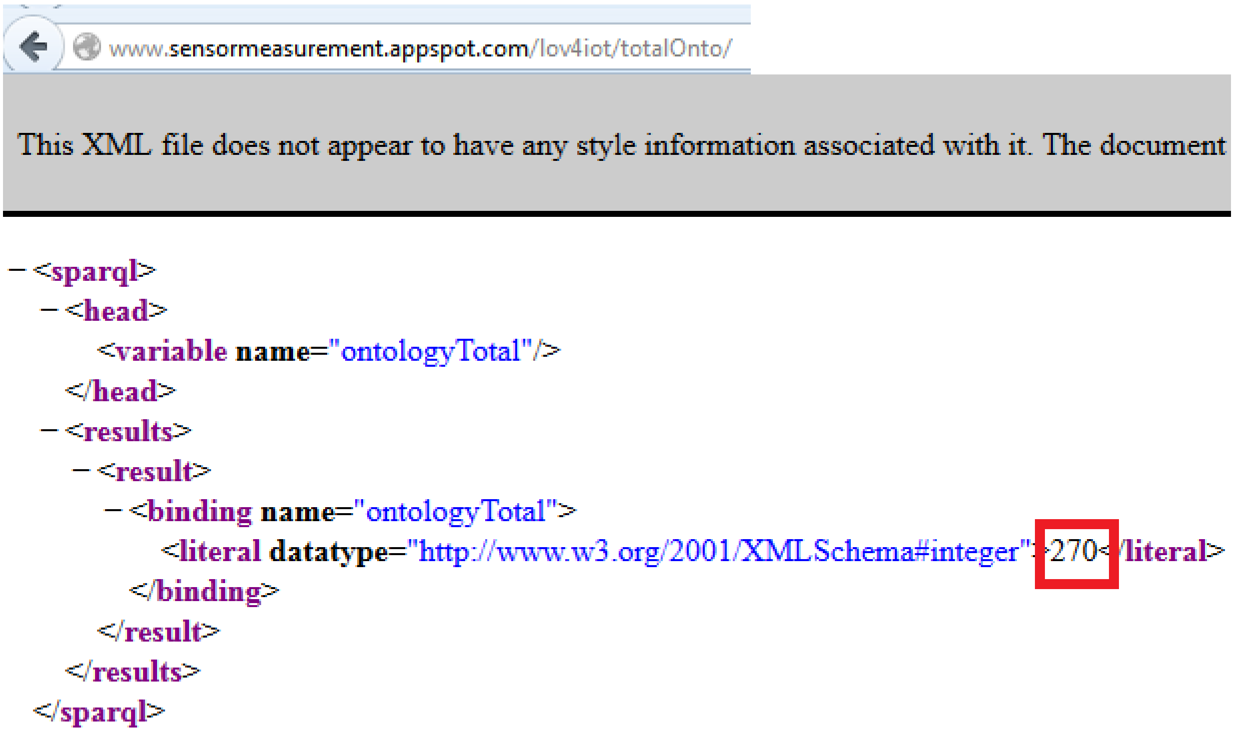


Figure 15. LOV4IoT Web service to count the total number of ontologies

In the picture, 270 is the total number of ontologies referenced in the LOV4IoT RDF dataset.

3. Web service: Get the number of ontologies by domains

Query:
http://www.sensormeasurement.appspot.com/lov4iot/nbOntoDomain/?domain=BuildingAutomation

For instance domain is: BuildingAutomation, Weather, Emotion, Agriculture, Health, Tourism, Transportation, City, Energy, Environment, TrackingFood, Activity, Fire, TrackingCD, TrackingDVD, SensorNetworks, Security.

The domain is referenced in the M3 nomenclature which is implemented in the M3 ontology (subclassOf FeatureOfInterest).

www.sensormeasurement.appspot.com/lov4iot/nbOntoDomain/?domain=BuildingAutomation

This XML file does not appear to have any style information associated with it. The documen

```
- <sparql>
  - <head>
      <variable name="nbOntoDomain"/>
    </head>
  - <results>
    - <result>
      - <binding name="nbOntoDomain">
          <literal datatype="http://www.w3.org/2001/XMLSchema#integer">45</literal>
        </binding>
      </result>
    </results>
  </sparql>
```

Figure 16. LOV4IoT Web service to count the number of ontologies by domain

4. Web service: Get the number of ontology by ontology status

Query:

http://www.sensormeasurement.appspot.com/lov4iot/ontoStatus/?status=Online

For instance, status is: Confidential, OngoingProcessOnline, WaitForAnswer, Online, OnelinLOV, AlreadyLOV.

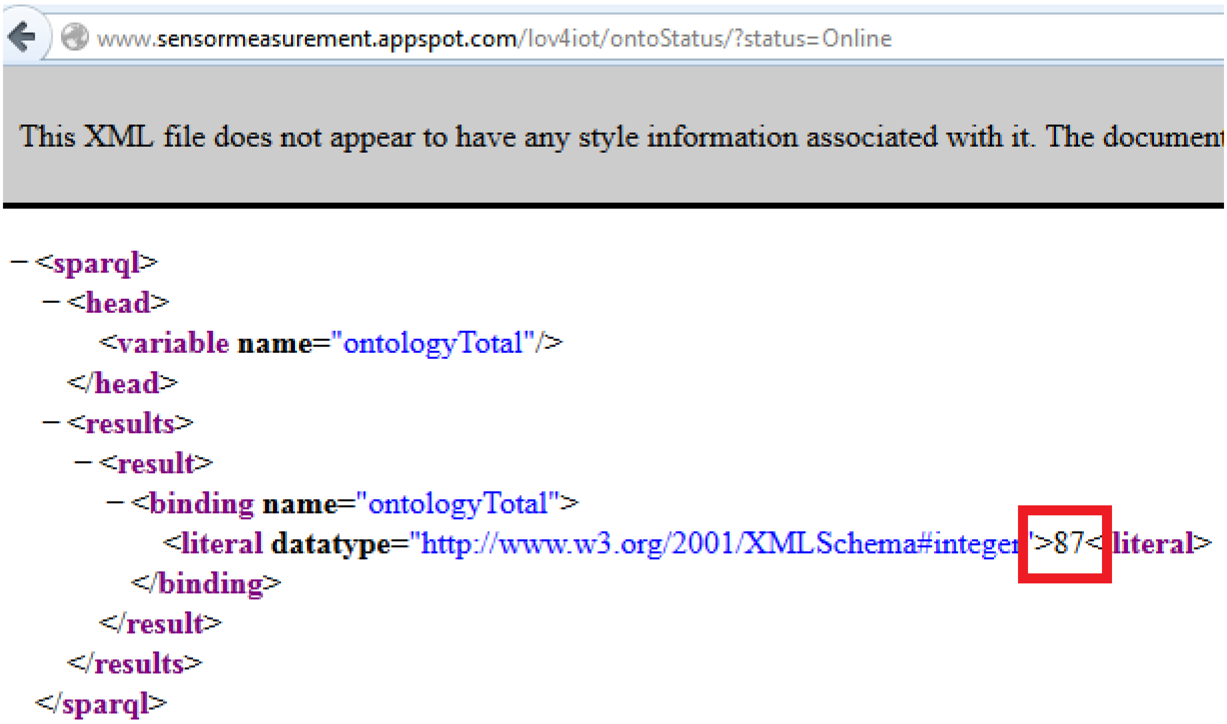


Figure 17. LOV4IoT Web service to count the number of ontologies by ontology status

The web service returns that 87 ontologies referenced in the LOV4IoT RDF dataset are online.

5. Use Case: LO4IoT HTML user interface using web services

All of these web services have been used in the HTML LOV4IoT web page[5] to automatically count the number of ontologies in the dataset (e.g., by domains, by ontology status, etc.)

[5] http://www.sensormeasurement.appspot.com/?p=ontologies

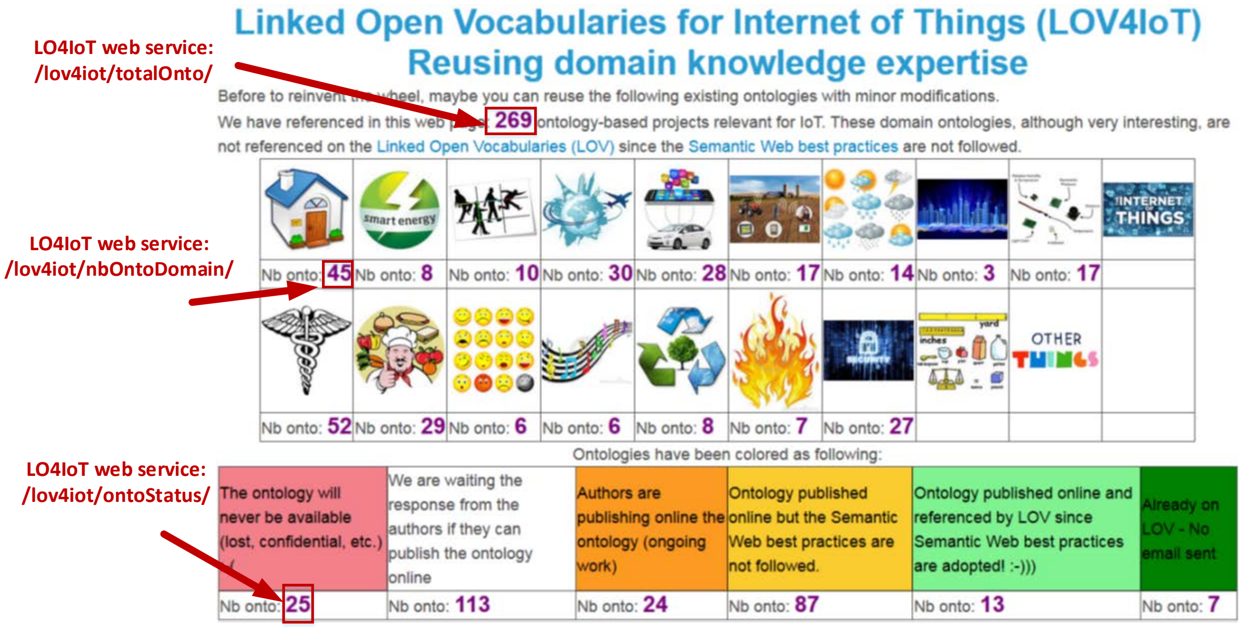


Figure 18. LOV4IoT web services

V. HTML web page

In the future, we will automatically build the HTML web page according to the LOV4IoT RDF dataset. This work is ongoing. Currently, we have to update the HTML web page and the RDF dataset when we want to reference a new onology-based project.

1. Adding a new ontology in LOV4IoT HTML web page

Go to m3/WAR/html/lov4iot.hml

Look for the table related to the domain, add a new line with all columns required.

http://sensormeasurement.appspot.com/?p=ontologies

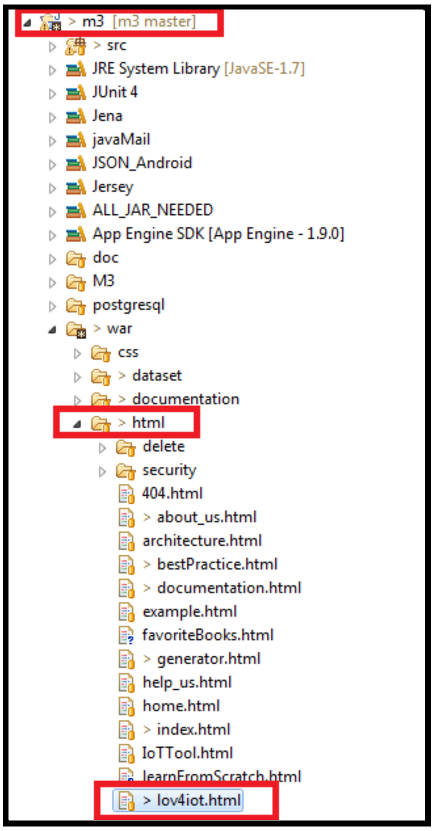


Figure 19. LOV4IoT HTML file location

VI. LOV4IoT ontology

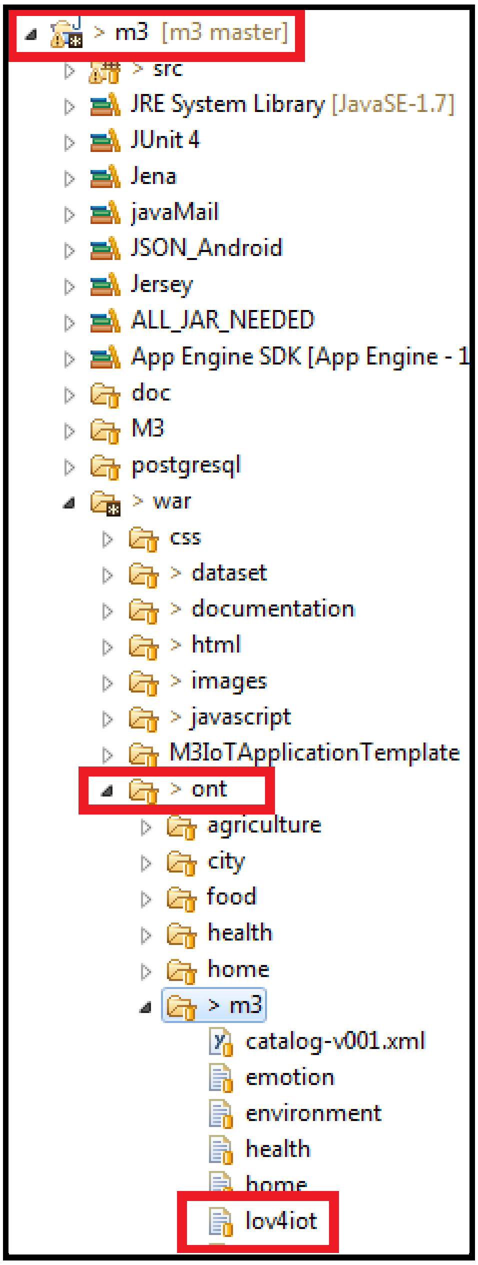


Figure 20. LOV4IoT ontology file location

1. Visualizing LOV4IoT with WEBVOWL

http://vowl.visualdataweb.org/webvowl/#iri=http://sensormeasurement.appspot.com/ont/m3/lov4iot#

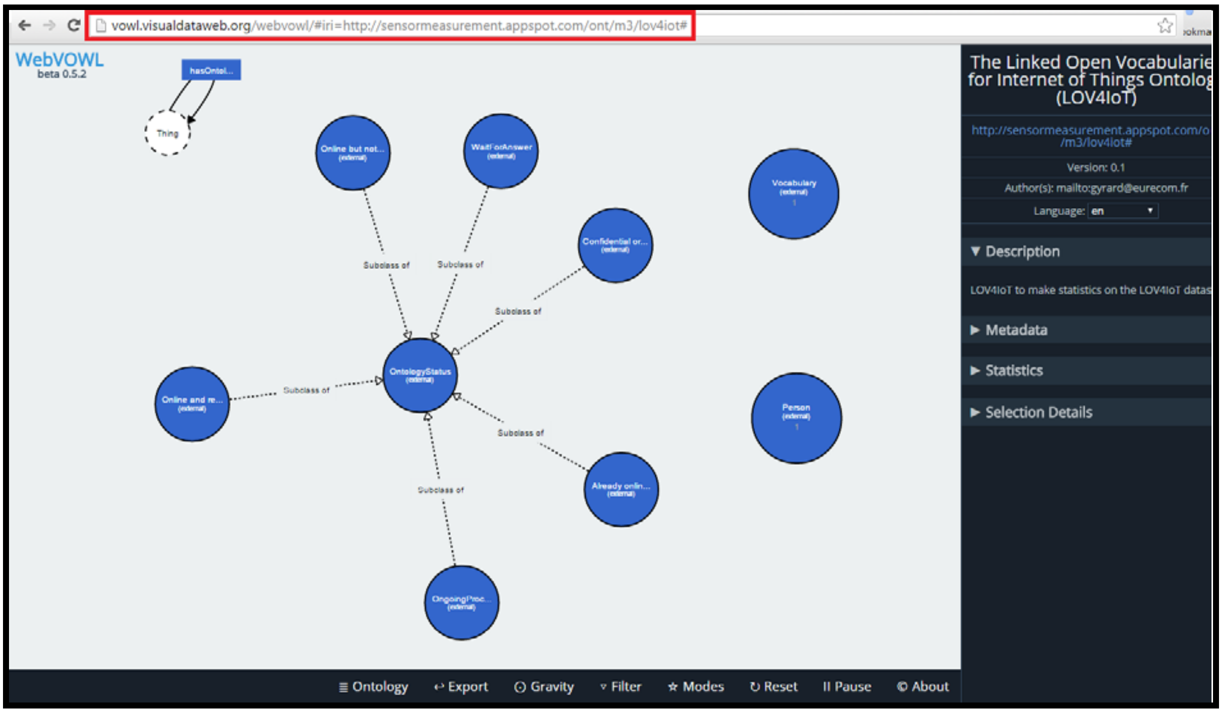


Figure 21. Visualizing LOV4IoT ontology with WEBVOWL

VII. LOV4IoT RDF dataset

You can download the LOV4IoT RDF dataset[6] and write your own SPARQL queries.

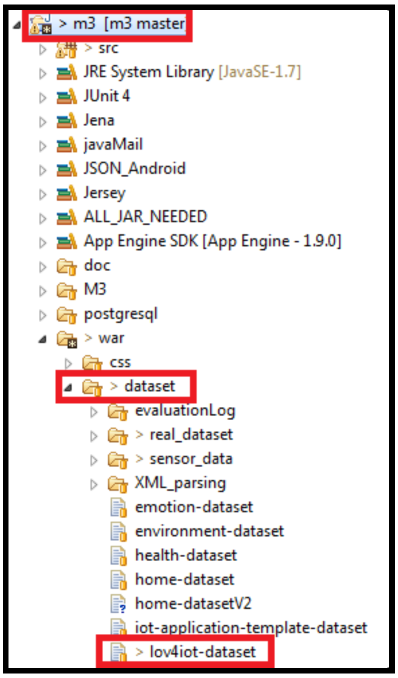


Figure 22. LOV4IoT RDF file location

[6] http://www.sensormeasurement.appspot.com/dataset/lov4iot-dataset

In the LOV4IoT RDF dataset[7], add a new ontology-based project.

1. Adding a new instance in the LOV4IoT RDF dataset

Figure below shows an instance of the LOV4IoT dataset. An instance is based on the LOV4IoT and M2 ontologies.

```
<m3:M2MApplication rdf:about="PaulStaroch">
    <m3:hasContext rdf:resource="&m3;Weather"/>
    <m3:hasContext rdf:resource="&m3;BuildingAutomation"/>
    <rdfs:label xml:lang="en">[Paul Staroch 2013]. See LOV4IoT for more details.</rdfs:label>
    <rdfs:comment xml:lang="en">Master's Thesis: A weather ontology for predictive control
    <m3:hasM2MDevice rdf:resource="&m3;Thermometer"/>      in smart homes. 2013</rdfs:comment>
    <m3:hasM2MDevice rdf:resource="&m3;PrecipitationSensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;HumiditySensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;AtmosphericPressureSensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;SolarRadiationSensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;WindDirectionSensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;WindSpeedSensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;SunPositionDirectionSensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;SunPositionElevationSensor"/>
    <m3:hasM2MDevice rdf:resource="&m3;CloudCoverSensor"/>
    <m3:hasUrlOntology rdf:resource="http://paul.staroch.name/thesis/SmartHomeWeather.owl"/>
    <m3:hasUrlRule rdf:resource="http://paul.staroch.name/thesis/SmartHomeWeather.owl"/>
    <lov4iot:hasOntologyStatus rdf:resource="&lov4iot;OnlineLOV"/>
    <dcterms:creator>
        <foaf:Person rdf:about="mailto:paul@staroch.name">
        <foaf:name>Paul Staroch</foaf:name>
        </foaf:Person>
    </dcterms:creator>
</m3:M2MApplication>
```

Figure 23. An ontology-based IoT project referenced in the LOV4IoT RDF dataset

VIII. LOV4IoT Bot

1. LOV Bot user interface

To encourage people to share their ontologies you can use the LOV4IoT bot[8].

[7] http://www.sensormeasurement.appspot.com/dataset/lov4iot-dataset

[8] http://sensormeasurement.appspot.com/?p=lov4iot

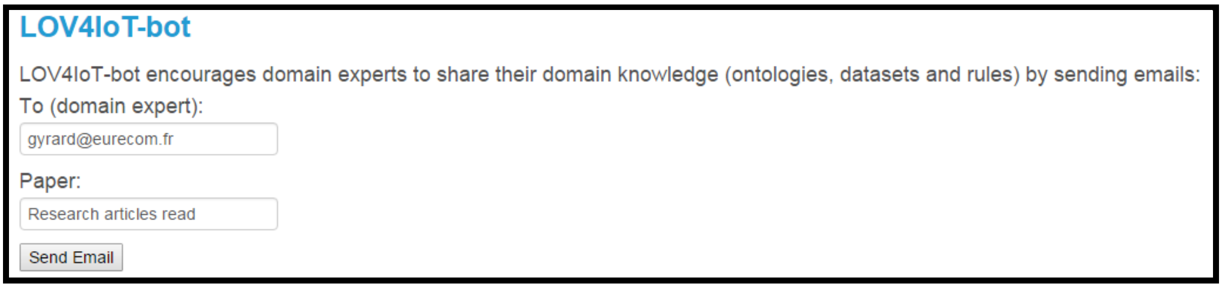


Figure 24. LOV4IoT bot user interface

2. LOV Bot explanations

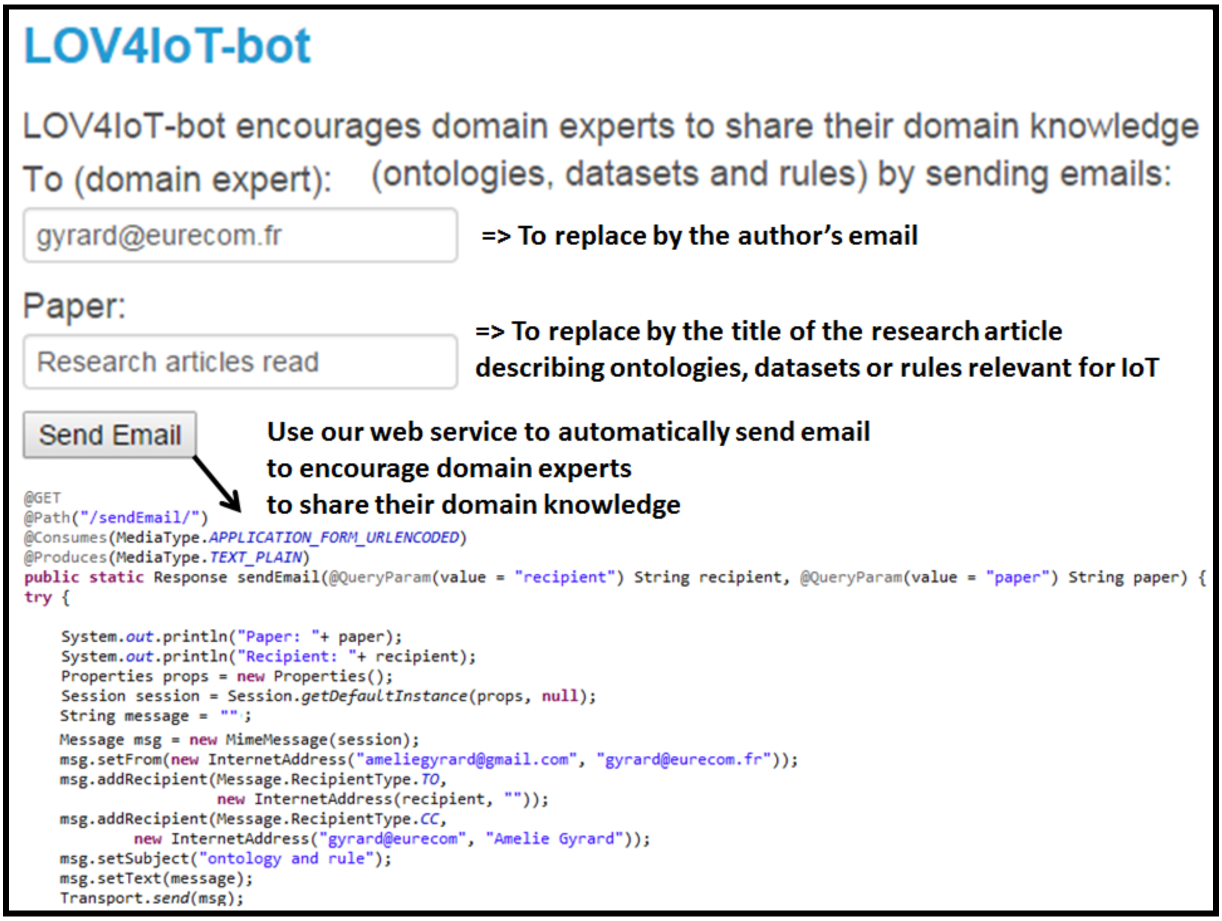


Figure 25. Code to send emails to convince authors to share their ontologies with LOV4IoT bot

IX. LOV4IoT Architecture

TO DO: Take inspiration from LOV paper?

X. LOV4IoT sequence diagram

TO DO

XI. Repository purl with Ghis

Some ontologies very relevant for IoT are kept in silos by the owners and do not follow some best practices in their design. LOV4IOT platform references almost 300 ontologies that fall into that category. To overcome the issue, we propose to use a collaborative approach using Github for modeling the ontologies and publish them using PURL system under the URI http://purl.org/iot/vocab/{name_ ontology}. For instance, name ontology is m3-lite with the following namespace http://purl.org/iot/vocab/m3-lite#. PURL enables keeping always the same namespace whatever where the ontology is hosted. The work has already started at https://github.com/ LOV4IoT/vocabs. The goal is to republish all the legacy ontologies under the PURL.org namespace using redirection to the Github location.

XII. LOV4IoT Use Cases

In this section, we demonstrate that the LOV4IoT dataset has been used in two uses cases: the Machine-to-Machine Measurement (M3) framework to build interoperable Semantic Web of Things applications and the LOV4IoT analyzer to detect the most popular terms used in ontologies. Moreover, we explain that different stakeholders can benefit from or exploit the LOV4IoT dataset such as domain experts, ontology matching tool experts, knowledge extraction experts, Semantic Web of Things developers and projects as depicted in Figure :

1. Machine-to-Machine Measurement (M3) framework

Machine-to-Machine Measurement (M3) framework employs the LOV4IoT dataset to redesign interoperable domain ontologies, rules and datasets to assist IoT developers in designing semantic-based IoT applications without having to learn semantic web technologies thanks to the Machine-to-Machine Measurement (M3) framework \cite{gyrard2015m3}.

LOV4IoT analyser exploits the LOV4IoT dataset to load all ontologies in the same domain and extract the most popular concepts and properties. An essential step to later automatically build interoperable background knowledge.

This functionality will be exploited within the EU FIESTA-IoT project\footnote{http://www.fiesta-iot.eu/}.

2. Domain experts

Domain experts can use this dataset for their state of the art and to reuse existing ontologies or before designing their own ontologies, etc. For instance, a security expert used the LOV4IoT user interface to analyze existing ontologies in the security domain.

3. Knowledge extraction experts

Knowledge extraction experts can benefit from the LOV4IoT dataset since the domain knowledge expertise is referenced and classified. There is a need of innovative tools to extract rules, etc. and redesign ontologies, datasets and rules in an unified way and having the same structure to facilitate interoperability in future architectures and systems.

4. Ontology matching tool experts

Ontology matching tool experts can reuse this dataset to later standardized the most popular and well-designed ontologies. They benefit from LOV4IoT by analyzing interoperability issues explained in [5] [4], exiting tools need to be improved to ease interoperability. Ontology editor tools such as Protege could preconize the re-use of existing ontologies based on the LOV and LOV4IoT dataset. When the user designd a new concept or property, some recommendations could be provided to reuse existing ontologies. This task is under development within ProtegeLOV[9]. Such extensions could be improved to recommend to integrate labels, comments, ontology metadata, etc. as preconized by LOV.

5. IoT/SWoT developers and projects

IoT/SWoT developers and projects can surf on the LOV4IoT web page to search domain ontologies according to a specific domain. For instance, the developer is looking for smart home ontologies, he goes on this section and finds more than 45 projects describing sensors and rules employed to build smart homes applications. Some scenarios such as air pollution or real-time traffic monitoring among the 101 scenarios proposed by CityPulse can reuse the ontologies referenced in LOV4IoT by searching these keywords or the related sections.

A table is available on the web[10] to match the scenarios proposed by CityPulse and how the LOV4IoT tool can assist in building the applications by reusing domain knowledge. A concrete example if the chronic disease scenario proposed by CityPulse, they want to build an application to monitor food consumption according to user's diseases deduced from physiological data. We have referenced the naturopathy ontology and dataset which can be reused to build this application.

[9] **http://boris.villazon.terrazas.name/projects/prolov/index.html**

[10] **http://www.sensormeasurement.appspot.com/?p=m3_scenario**

6. Ontology matching tool experts

Usually, ontology matching tools are evaluated with the Ontology Alignment Evaluation Initiative (OAEI)[11] benchmark. Current ontology matching tools are not adapted to ontologies referenced in the LOV4IoT dataset. A main challenge would be to have ontology matching tools adapted to both datasets (OAEI and LOV4IoT) meeting these main requirements: (1) heterogeneous languages, (2) syntactic heterogeneity, (3) conceptual heterogeneity, (4) terminological heterogeneity, and (5) semiotic heterogeneity. For instance, concepts or properties do not have labels or comments whereas ontology matching tool algorithms are based on labels to compare them. The ontologies from the OAEO benchmark differ in their structure compared to the domain ontologies from the ones found in LOV4IOT. Regarding ontologies relevant for IoT, concepts are linked with each other through owl:Restriction, and properties associated to concepts are not frequently used. For instance, snow is linked to temperature and precipitation through owl:Restriction. In the OAEI benchmark, concepts have properties which are mostly used by ontology matching tools. For instance, a person or a patient have both properties such as family name and birth date.

As explained above, the LOV4IoT dataset is relevant for various communities.

XIII. Lessons Learnt: Best Practices

We have learnt a set of best practices. More explanations can be found in [6] [4].

Reminder List of tools:

- Vapour [1]
- See this web page[12] for more tools
- ProtegeLOV[13] [3]
- LOV ontology metadata [11]

1. Ontology Documentation

Tools:

- WebVOWL [7]
    - Easy to use
- LODE [8]
    - Nice documentation
- Parrot [9]
    - Easy to use
    - Connot integrate picture

[11] http://oaei.ontologymatching.org/

[12] http://localhost:50101/?p=bestPractice

[13] http://data.semanticweb.org/conference/eswc/2015/paper/demo/2

- OWL DOC protege plugin[14]
- Neologism [2]

XIV. Improvement ideas

We have in mind the following improvements:

- Improving the user interface
- Automatically updating the LOV4IoT database
- Creation of an automatic workflow to check the best practices
- Interconnecting LOV4IoT with LOV
- Encouraging best practices with some tools (e.g., ProtegeLOV extension)
- Integrating LOV4IoT with semantic search engines, ontology and dataset catalogues.

Feel free to join the LOV4IoT community to help us! You are more than welcome ☺

1. Improving the user interface

- TO DO: Take inspiration from LOV user interface[15] and adapt it to IoT domain:
- Technology used: D3.js javaScript library for visualizations.

[14] http://protegewiki.stanford.edu/wiki/OWLDoc

[15] http://lov.okfn.org/dataset/lov/

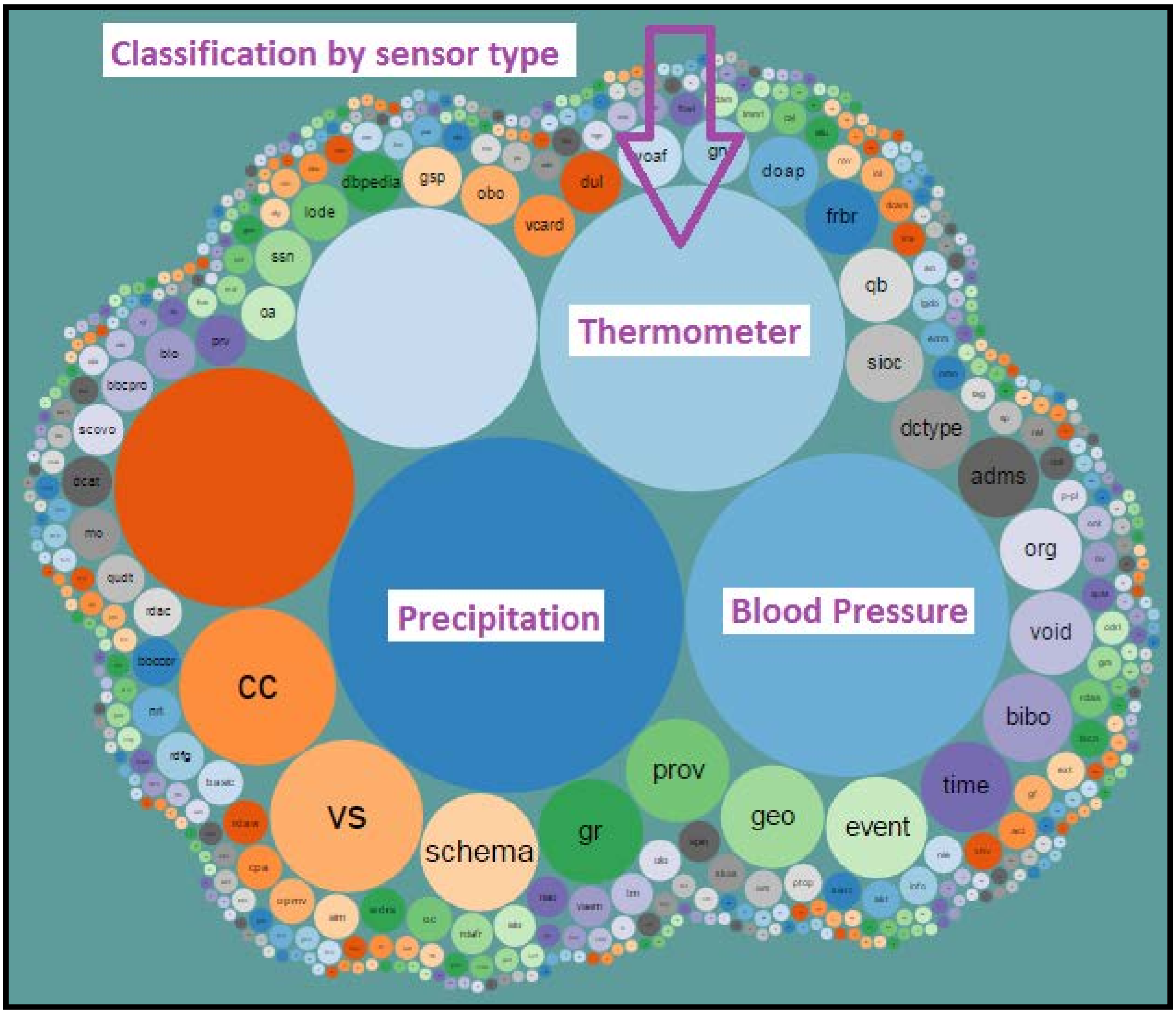


Figure 26. Bubble view to classify ontologies according to the sensor type

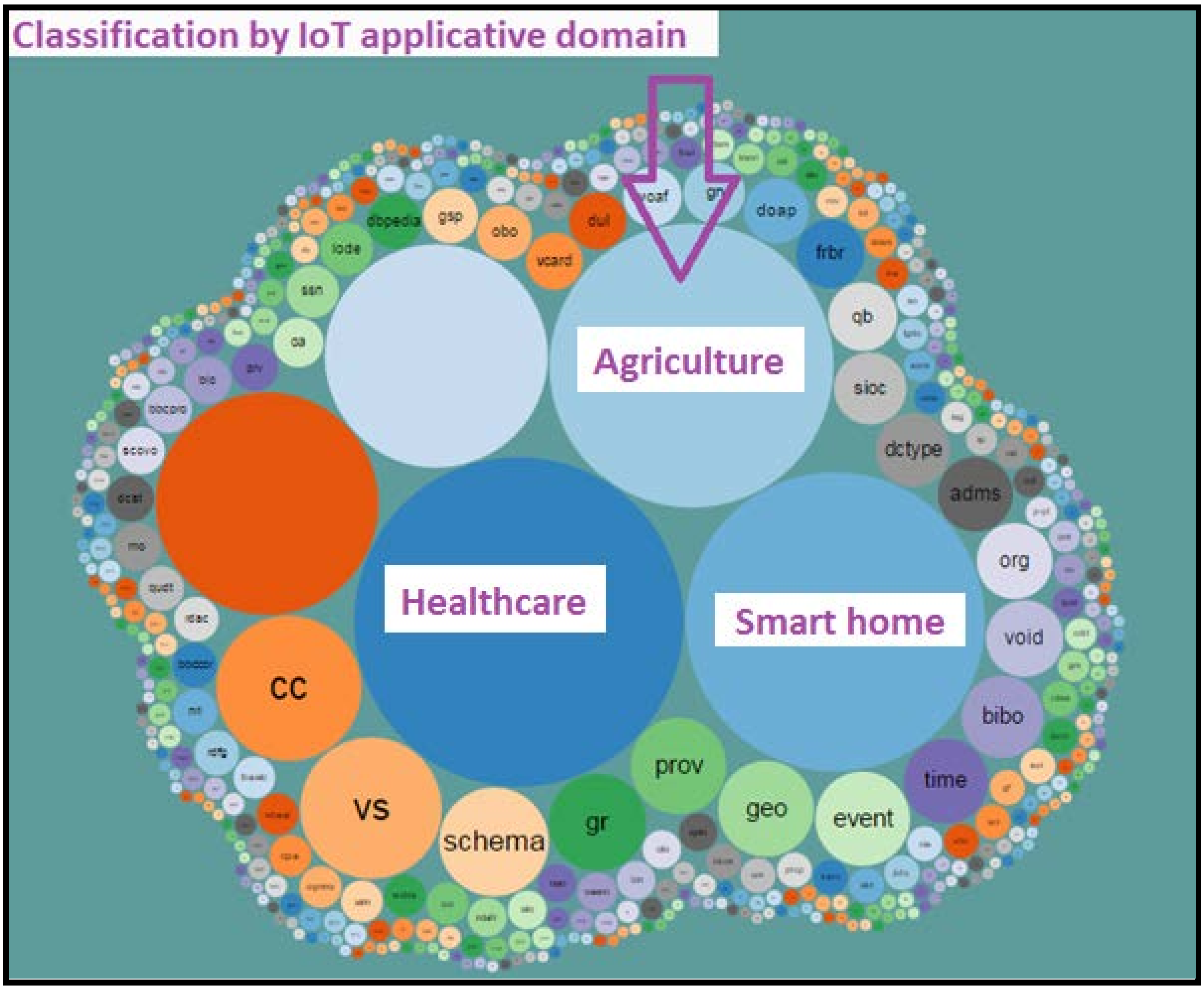


Figure 27. Bubble view to classify ontologies according to the IoT applicative domain

2. *Checking best practices*

LOV provides an interface for each ontology to use some tools such as:

- **WebVOWL** to visualize the ontology
- **Oops** to detect common ontology pitfalls
- **Parrot** to see the documentation of the ontology
- **Vapour** to check that the ONTOLOGY URL is deferencable (content negociation)
- RDF Triple-Checker to check some typos or syntax issues.

TO DO:

- Something similar with LOV4IoT
- Integration with more tools referenced in [6].
- Creating the entire workflow of validation.

Figure 28. Best practices tools integrated with LOV

3. Automatically updating LOV4IoT

Updating the LOV4IoT dataset is simple, it is adding a new row in the HTML web page or a new instance in the RDF LOV4IoT dataset. If required, we could find additional background knowledge by connecting LOV4IoT to semantic search engines and ontology or dataset catalogue as depicted in Figure 26.

At the beginning of this work, we started to use ontology catalogues such as Linked Open Vocabulary (LOV) since it provides web services. Unfortunately, when we were experimenting this, we realized that most of the ontologies designed for IoT were not referenced on such tools yet.

As a long-term vision, LOV4IoT should be interconnecting with existing ontology/dataset catalogues and semantic search engines.

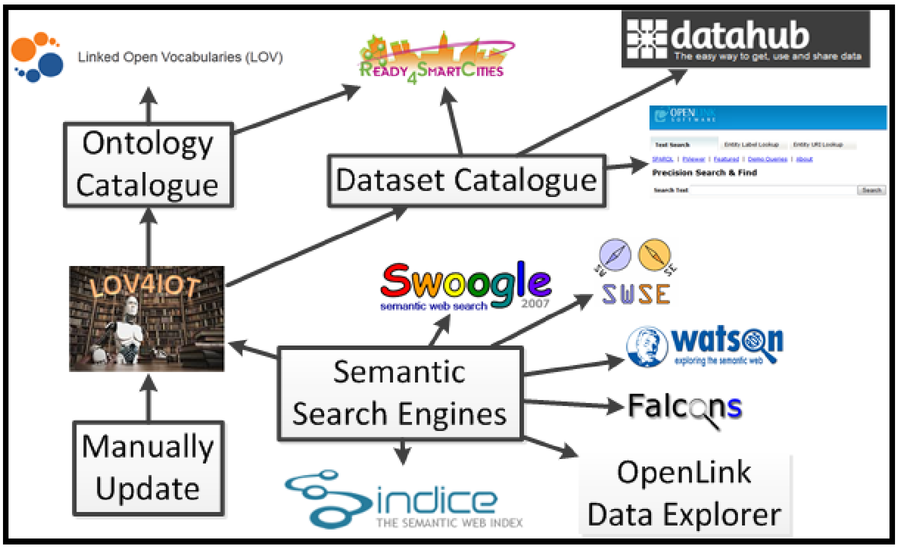


Figure 29. Integrating LOV4IoT with semantic search engines and catalogues

4. New web service

TO DO: Create web services (Suggested by Ali June 2016):

- Get all ontologies URL and research papers in IoT
- Get all ontologies URL and research papers in Sensor Networks
- Get all ontologies URL and research papers in IoT and in Sensor Networks

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