M3 Framework: User's guide & tutorial

Creator	Amelie Gyrard (Eurecom - Insight - NUIG/DERI) Designed and implemented by Amélie Gyrard, she was a PhD student at Eurecom under the supervision of Prof. Christian Bonnet and Dr. Karima Boudaoud. Currently, LOVIoT is maintained since she is a post-doc researcher at Insight within the IoT unit led by Dr. Martin Serrano and involved in the FIESTA-IoT (Federated Interoperable Semantic IoT/Cloud Testbeds and Applications) H2020 project.
Send Feedback	Do not hesitate to ask for help or give us feedback, advices to improve our tools or documentations, fix bugs and make them more user-friendly and convenient: amelie.gyrard@insight-centre.org
Google Group	https://groups.google.com/d/forum/m3-semantic-web-of-things
Last updated	June 2016 • Adding the end to end scenario • Update the documentation
Created	March 2015
Status	 Work in progress
Goal	This documentation enables a first approach with M3: • Understand what we can do with M3 • Understanding M3 and its components
URL	http://www.sensormeasurement.appspot.com/documentation/UserGuide.pdf

Table of contents

Table of figures

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
S-LOR	Sensor-based Linked Open Rules
SWoT	Semantic Web of Things
WoT	Web of Things
STAC	Security Toolbox: Attacks & Countermeasures

I. Citations

Please do not forget to cite our M3 framework:

- Cross-Domain Internet of Things Application Development: M3 Framework and Evaluation. 3rd International Conference on Future Internet of Things and Cloud (FiCloud 2015), 24-26 August 2015, Rome, Italy. Amelie Gyrard, Soumya Kanti Datta, Christian Bonnet, Karima Boudaoud
- Enrich Machine-to-Machine Data with Semantic Web Technologies for Cross-Domain Applications IEEE World Forum on Internet of Things (WF-IoT), Seoul, Korea, March 6-8, 2014. Amelie Gyrard, Christian Bonnet and Karima Boudaoud
- All publications:
    - http://localhost:57708/?p=publication

II. Introduction

The M3 framework enables assisting to (see Figure 1):

- Develop Semantic Web of Things (SWoT) applications with the SWoT generator.
- Interpret IoT data with S-LOR
- Find & reuse domain knowledge already designed by domain experts with LOV4IoT
- Find attacks & security mechanisms related to specific technologies employed in IoT with STAC

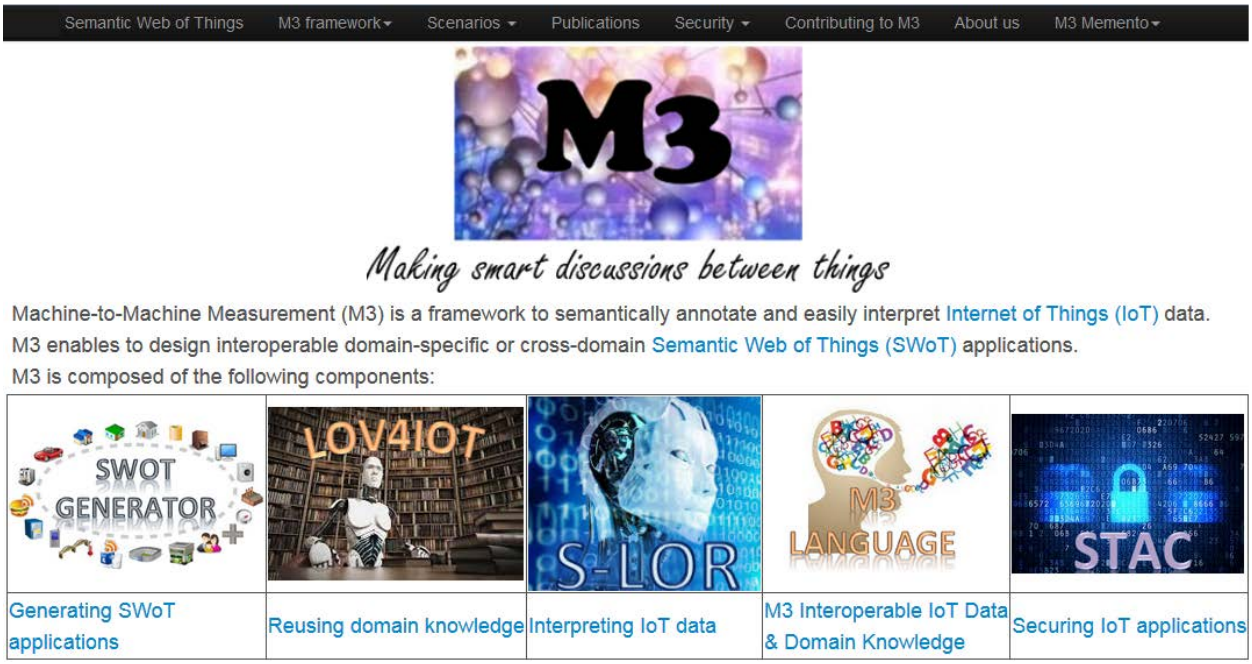

Figure 1. Home page

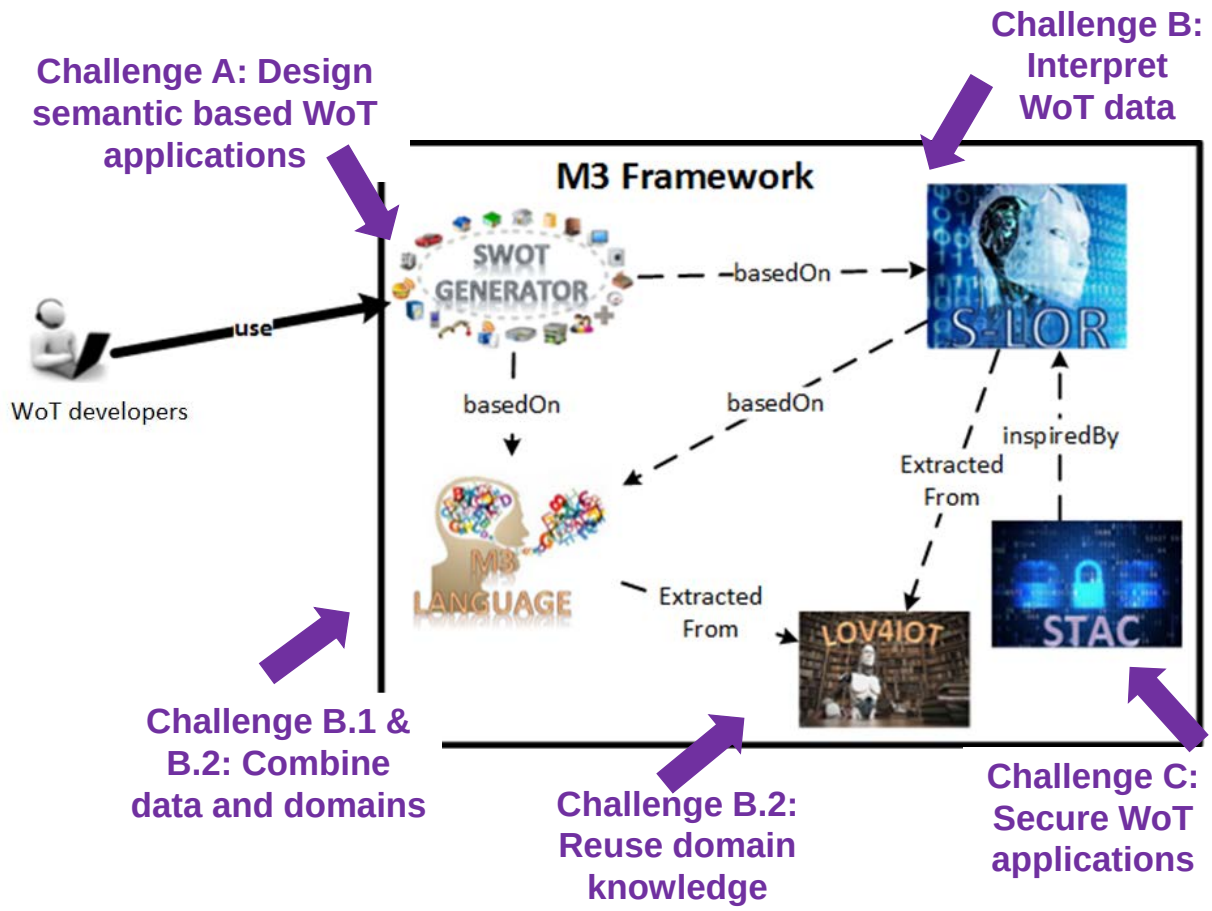

Figure 2. M3 framework and its components

III. Understanding what you can do with M3

- Go there: http://www.sensormeasurement.appspot.com/?p=end_to_end_scenario
- Follow the tutorial:
  - STEP 1 is using the SWoT generator
  - STEP 2 is using the M3 language and its semantic annotator
  - STEP 3 is the core based on the Jena framework to build semantic web of things applications
  - STEP 4 executes the reasoning engine
  - STEP 5 executes the query engine.
  - STEP 6 provides smarter data to visualize in a user-friendly interface.

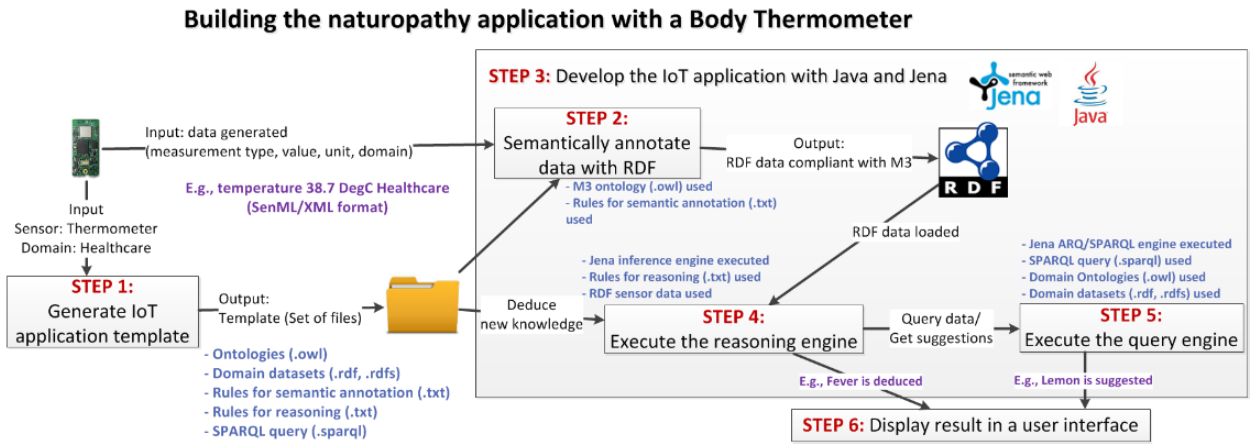

Figure 3. Building Deducing meaningful information with M3 and its components

IV. Generating Semantic Web of Things templates with the SWoT generator

The main purpose of the template generated is to interpret IoT data to provide suggestions.

- ➔ Go to this web page: http://www.sensormeasurement.appspot.com/?p=m3api (see Figure 2)
- ➔ Choose a sensor (e.g., Precipitation)
- ➔ Choose a domain (e.g., Weather)
- ➔ Click on the button “Search IoT application template”
- ➔ The drop-down list in STEP 2 is not empty anymore

➔ Choose a template (e.g., Precipitation, Transportation and Safety devices)
➔ Click on the button “Generate zip file”
➔ A zip file has been generated with interoperable M3 and domain ontologies, rules and datasets (Figure 3).

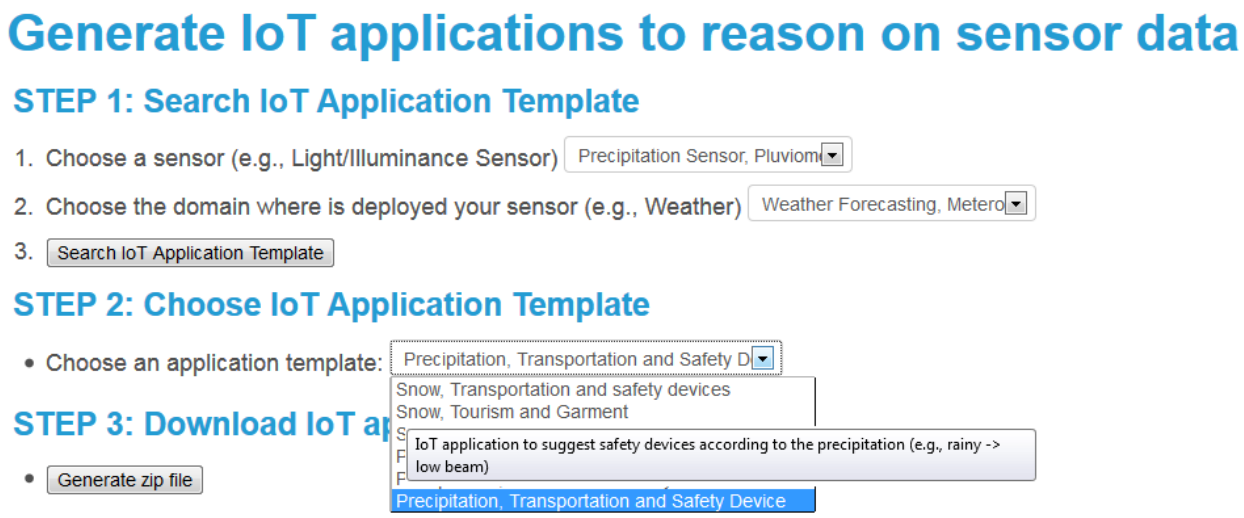

Figure 4. Generating Semantic Web of Things templates

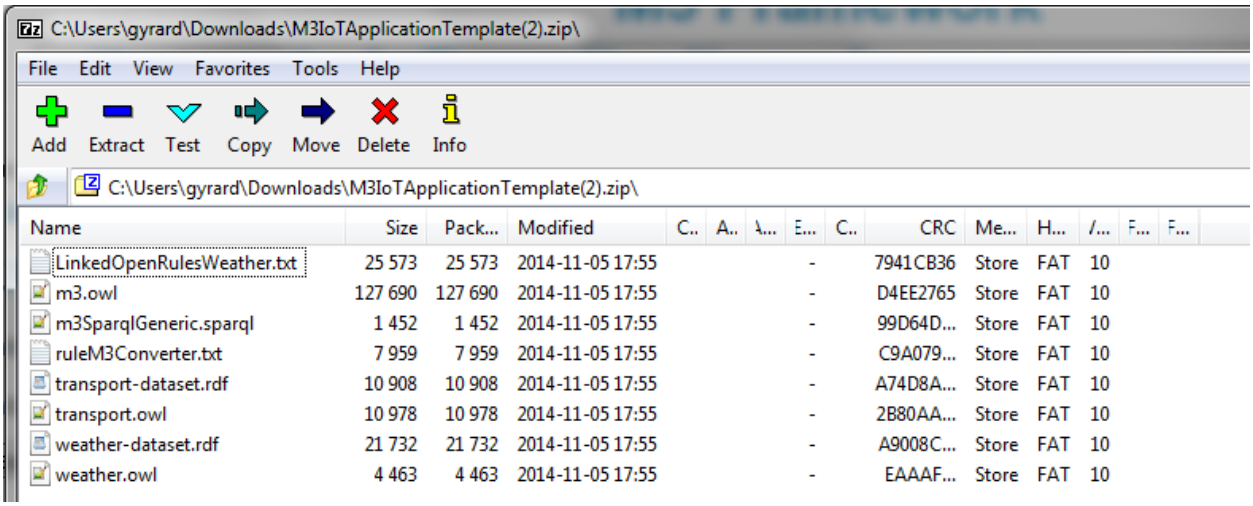

Figure 5. Zip file generated with domain knowledge for interpreting sensor data

V. Interpreting IoT data with SLOR

Go to this web page: http://www.sensormeasurement.appspot.com/?p=slor

- ➔ Select a sensor to find all rules interpreting sensor values as depicted in Figure 4 (e.g., Precipitation)
- ➔ The demonstration will show all rules related to the sensor chosen by the user to interpret sensor values.
  (e.g., if precipitation = 0 mm/h then NoPrecipitation)
- ➔ You have both the rule for humans and for machines (click on the LinkedOpenRules link)

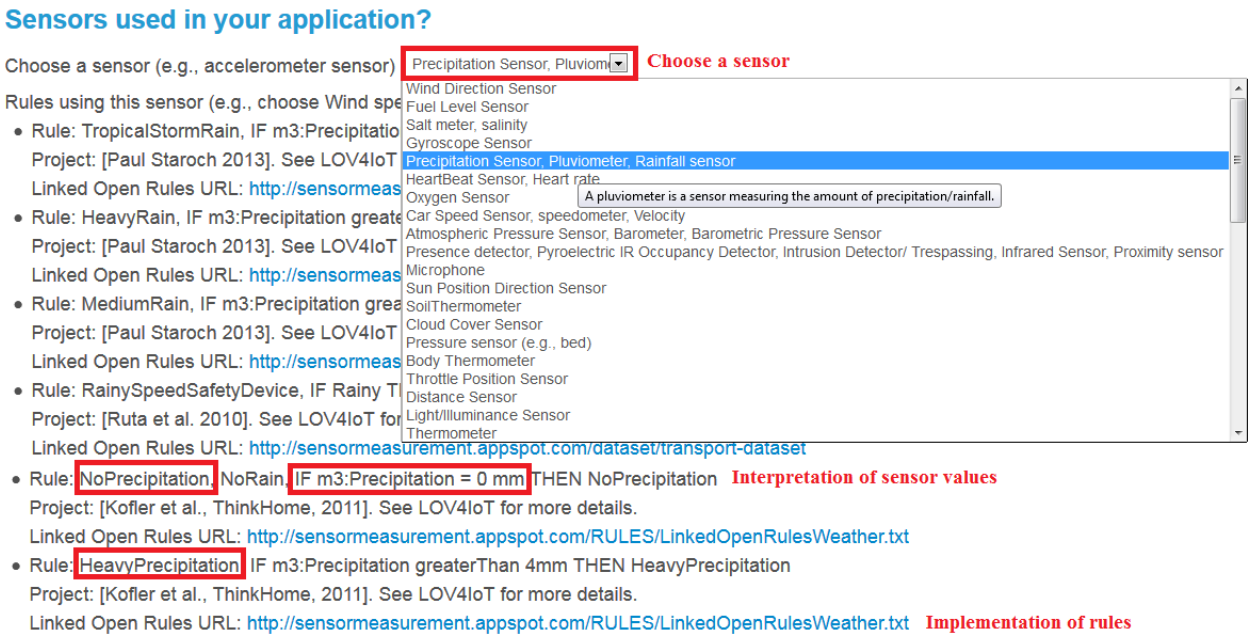

Figure 6. Finding rules to interpret sensor data with S-LOR

VI. Reusing domain knowledge with LOV4IoT

- ➔ Go to the Linked Open Vocabularies for Internet of Things (LOV4IoT) web page (see Figure 5): http://www.sensormeasurement.appspot.com/?p=ontologies
- ➔ Choose 1 domain by clicking on the image (e.g., transportation) as depicted in Figure 5.

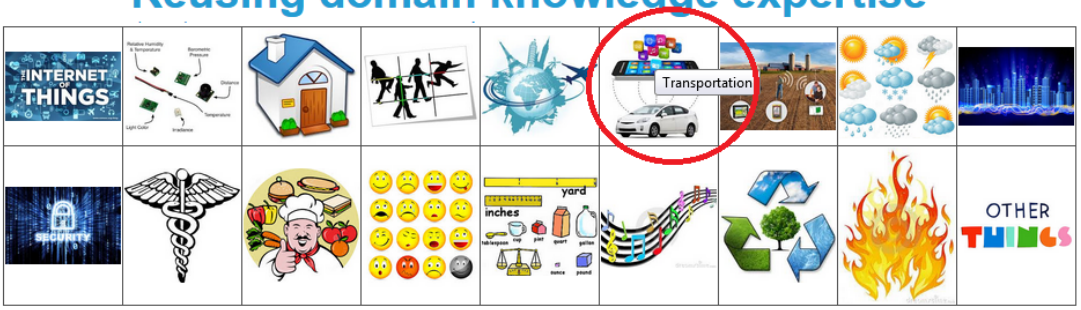

Figure 7. Ontologies classified in various domains

➔ You will find a table with the following information as depicted in Figure 7:

- Domain experts names (authors)
- Year of publication
- Research articles
- Ontology URL of available
- Technologies used in their project
- Sensors used in their project
- Rules designed

-Ontologies and projects have been classified according to different colors (see Figure 6):

- 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)[1] 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 8. Classification of projects according to the reusability

[1] 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 9. Screenshot of LOV4IoT

VII. Simulating SenML sensor measurements

The following interface enables to simulate sensor data:

http://emulator-box-services.appspot.com/senmladmin/zones

These data are compliant with the SenML[2] format.

You can simulate heterogeneous domains (healthcare, smart kitchen, smart home, etc.), as you can see in Figure 8. You can create a new domain (Add sub zone button).

[2] http://www.ietf.org/archive/id/draft-jennings-senml-10.txt

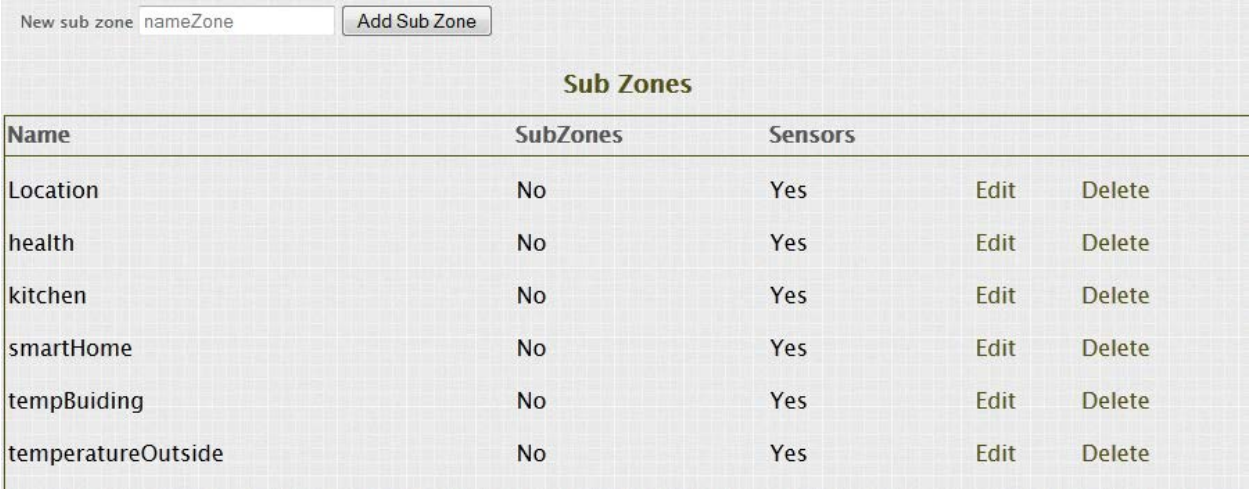

Figure 10. Simulate M2M area networks

Click on the button “Edit” associated to the kitchen zone.

You go to the following URL:

http://emulator-box-services.appspot.com/senmladmin/ahdzfmVtdWxhdG9yLWJveC1zZXJ2aWNlc3IWCxIJWm9uZUFkbWluIgdraXRjaGVuDA/edit.

You can simulate smart devices (sensors, actuators, transducer, controllers and RFID tags).

In this use case, we simulate RFID tags embedded on ingredients.

We simulate SenML measurements (in XML or JSON).

A measurement has a name, a value, a unit, and the date.

Example 1: Measure name: Temperature, Unit: Degree Celsius, Value: 35

Example 2: Measure name: banana, Unit: Gram, Value: 1000

Use the M3 nomenclature[3] to describe sensor measurements.

To be sure that the M3 converter will semantically annotate correctly the sensor measurements.

It will ease the process to build the application with the Semantic Web of Things template.

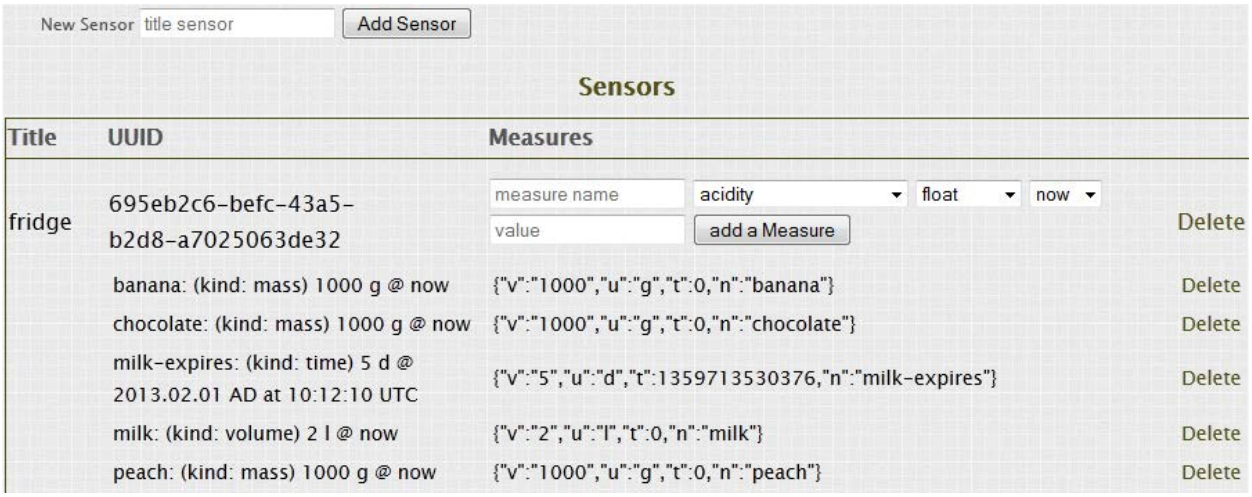

Figure 11. Simulating sensor measurements

VIII. Converting senML sensor data with the M3 language and the Semantic Annotator

Go to the M3 converter to semantically annotate SenML data with RDF according to the M3 ontology.

[3] www.sensormeasurement.appspot.com/documentation/NomenclatureSensorData.pdf

Web page: http://www.sensormeasurement.appspot.com/?p=senml_converter

Use Chrome to get the data in a text format, with Firefox you only have the JavaScript alert popup.

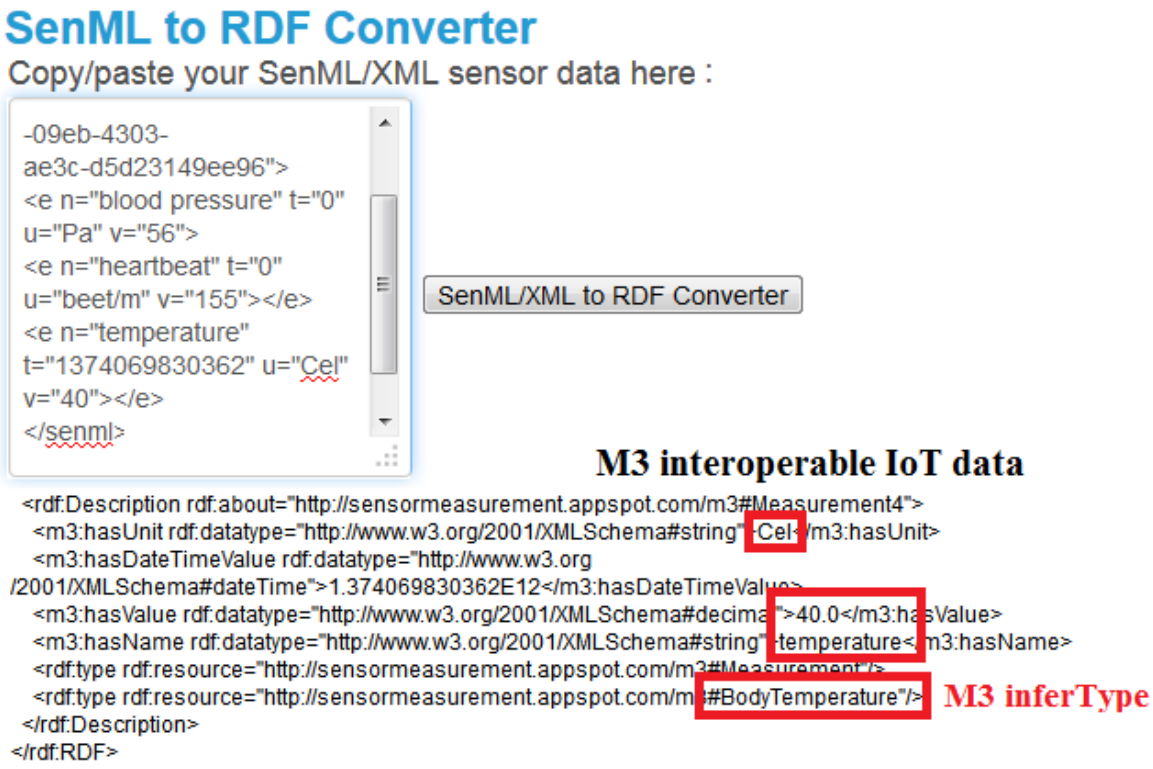

Figure 12. Semantically annotating IoT data with the M3 converter user interface

Figure 13. Semantically annotating sensor data

IX. Testing our scenarios

- ➔ Go to the menu bar
- ➔ Go to the tab called “Scenarios”.
- ➔ Choose a scenario (e.g. tourism)

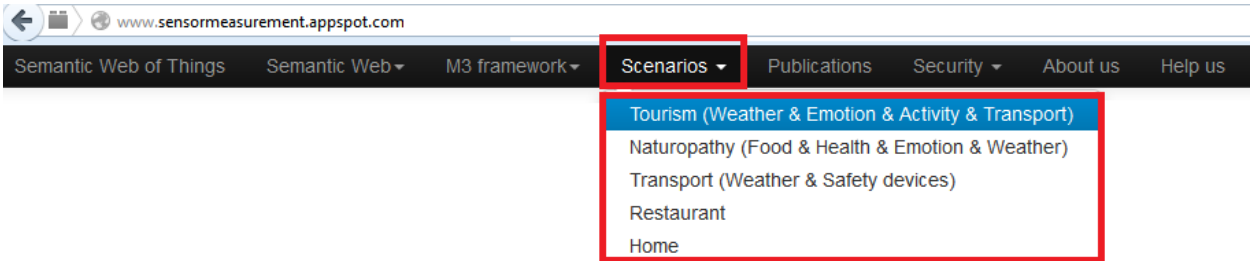

Figure 14. Testing our scenarios

If you choose the tourism scenario. You will have the following web page.

- ➔ Click on the “Activity & Precipitation” button.
- ➔ It will display the M3 results after the reasoning process

Tourism (Weather & Emotion & Activity & Transport)

Weather & Activity

1. This scenario is based on these M3 RDF sensor data
2. We deduce the weather outside.
3. We propose activities according to the weather.
4. M2M Application (Temperature => weather => Activity): Activity & Temperature
5. M2M Application (Luminosity => weather => Activity): Activity & Luminosity
6. M2M Application (Precipitation => weather => Activity): Activity & Precipitation
7. M2M Application (Wind speed => weather => Activity): Activity & Wind Speed

Click here to display m3 reasoning results

Input data	Inferred data after M3 process
• Name=precipitation, Value = 1.0, Unit=m	InferType = Precipitation, Deduce = LightRain, Suggest= Paintball
• Name=precipitation, Value = 1.0, Unit=m	InferType = Precipitation, Deduce = LightRain, Suggest= Squash
• Name=precipitation, Value = 1.0, Unit=m	InferType = Precipitation, Deduce = LightRain, Suggest= Concert
• Name=precipitation, Value = 1.0, Unit=m	InferType = Precipitation, Deduce = LightRain, Suggest= Opera
• Name=precipitation, Value = 1.0, Unit=m	InferType = Precipitation, Deduce = LightRain, Suggest= Bowling
• Name=precipitation, Value = 1.0, Unit=m	InferType = Precipitation, Deduce = LightRain, Suggest= Theater

Do not hesitate to try other scenarios.