Semantic Annotator to unify sensor data by designing a nomenclature/dictionnary/language

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Contributors	Thanks to Pankesh Patel for fruitful questions and numerous questions ☺
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 (Not really active yet)
Last updated	July 2016 • Why M3 ontology, Why SSN is not sufficient (Pankesh's question) June 2016 • Add semantic annotator • Add M3 ontology March 2016 • Check actuators and RFID with M3 ontology
Created	2015
Status	Work in progress
Goal	We propose to use common terms to describe sensors, measurements, actuators and domains. Of course, we should improve it all together. This work synthetizes all concepts found in existing ontologies or projects related to Internet of Things (IoT) and are implemented in the M3 ontology to unify sensor measures/ IoT data. This step is essential to define interoperable/unified rules to interpret sensor measures. The M3 nomenclature defines a unified data model for the Internet of Things and is an extension of the W3C SSN ontology. The M3 taxonomy describes sensor names, measurement names, units and IoT applicative domains. This is a kind of dictionary for IoT to easily deal with synonyms,

	etc. This M3 taxonomy is implemented as an ontology extending W3C SSN ontology. The M3 ontology is a cornerstone component to semantically annotate data and extract meaningful information from IoT/sensor data. This documentation also enables understanding the Semantic Annotator: • A nomenclature/language/dictionary to unify terms to describe sensor data • A semantic annotator to unify databased on semantic web technologies (RDF) • Web services to query the M3 ontology
Caption	Rows in green, compliant with: • M3 ontology • Linked Open Rules • IoT application template Rows in white or red (to finish)
Definitions	• **Correctness** means that are no incompatibility with other rules. • **Completeness** means that all sensor values are covered by an high level information.
Links	• M3 Web site: **http://www.sensormeasurement.appspot.com/** • NS_M3 = **http://sensormeasurement.appspot.com/m3#** • SenML language: **http://www.ietf.org/archive/id/draft-jennings-senml-10.txt** • LOV4IoT: • **http://www.sensormeasurement.appspot.com/?p=ontologies**
This work has been extended for **FIESTA-IoT** EU project	This M3 taxonomy has been reused and refactor for the FIESTA-IoT EU project • Refactored • Aligned with other ontologies such as IoT-lite, QU-rec-20, etc. • Extended with more Quantity Kinds, units to cover the one required by different testbeds (e.g., KETI, University of Surrey, Smart Santander, Com4Innov) • M3-lite taxonomy: **http://purl.org/iot/vocab/m3-lite#**

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Table of figures

Terms and acronyms

IoT	Internet of Things (IoT)
M3 framework	Machine-to-Machine Measurement (M3) framework

I. Citations

- 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
- Standardizing Generic Cross-Domain Applications in Internet of Things. Third Workshop on Telecommunications Standards, Part of IEEE Globecom 2014, Austin, TX, USA, 8-12 December 2014. Amelie Gyrard, Soumya Kanti Datta, Christian Bonnet and Karima Boudaoud
- A unified language to describe M2M/IoT data. OneM2M, MAS Working Group 5, 22-27 March 2015, Sophia Antipolis, France. Amelie Gyrard, Christian Bonnet
- An Ontology to Semantically Annotate the Machine-to-Machine (M2M) Device Measurements. ETSI M2M Workshop 2013, 5-7 November 3013, Mandelieu, France. Amelie Gyrard, Christian Bonnet and Karima Boudaoud

II. M3 nomenclature/language dictionary

1. Sensor and measurement interpretation

E.g., precipitation and rainfall sensor have the same meaning and represents the same sensor, we should explicitly describe this information in machine to machine communications to ensure interoperability in each layer of the OneM2M architecture.

a) Healthcare

Table 1. Healthcare domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules
Health	BodyThermometer/ BodyTemperature	Body thermometer	DegreeCelcius	Completeness OK (3 rules [Obaid 2013] + 3 rules [Jara 2009]), Correctness OK
Health	HeartBeatSensor/ HeartBeat	Pulse sensor, pulse oxymeter, pulse-ox, heart beat, heart rate, pulse rate, cardiac frequency, breath rate	BeatPerMinute	Correctness ok (2 rules [5 rules Tanatong 2011] & [Hristoskova 2014]) + **Completeness No (>300 nothing)**
Health	PulseOxymeter/	Pulse oxymeter, spO2,	Percent	Correctness OK (1

	SPO2	blood oxygen saturation sensor, pulse and oxygen in blood sensor		rule [Hristoskova 2014]) + **Completeness NO**
Health	CholesterolSensor/ Cholesterol	cholesterol	MmolPerLiter	Correctness OK (1 rule [Bravo 2009-2013]) + **Completeness NO**
Health	Glucometer/ BloodGlucose	Glucometer, glucose sensor, blood glucose meter, blood sugar level	GramPerLiter	Completeness OK (3 rules [Guermah 2014]), Correctness OK
Health	BloodPressureSensor/ BloodPressure	blood pressure meter, sphygmomamometer, MAP (Mean arterial pressure), CVP (central venous pressure)	mmHg	0 rule
Health	SkinConductanceSensor/ SkinConductance	skin conductance, galvanic skin response sensor, GSR, sweating	?	0 rule
Health	WeightSensor/ Weight	Weight sensor, body weight, weight scale	Kilo, Pound	0 rule
Health	Pedometer/ NumberStep			

b) Weather

Table 2. Weather domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules
Weather	HumiditySensor/ Humidity	Hygrometer, humidity sensor, moisture sensor, soil moisture probes	Percent	Correctness OK (Conflict resolved with [Kofler 2011] and [Rodriguez 2014]) + Completeness OK (5 rules [Staroch 2013])
Weather	WindDirectionSensor/ WindDirection	Wind direction	DegreeAngle	Completeness OK (5 rules [Staroch 2013]) + Correctness OK
Weather	SunPositionDirectionSensor/ SunPosition	sun position direction to detect east, west, south, north	DegreeAngle	Completeness OK (5 rules [Staroch 2013]) + Correctness OK
Weather	AtmosphericPressureSensor/ AtmosphericPressure	Atmospheric pressure sensor, Barometer, barometric pressure sensor	Pascal	Completeness OK (5 rules [Staroch 2013]) + Correctness OK (even with [Kofler 2011])
Weather	CloudCoverSensor/ CloudCover	Cloud cover sensor	Okta	Completeness OK (5 rules [Staroch 2013]) + Correctness OK (even with [Kofler 2011])
Weather	SunPositionElevationSensor/ SunElevation	sun position elevation to detect (twilight, day, night, etc.)	DegreeAngle	8 rules [Staroch 2013] **Completeness NO + Correctness NO**
Weather	SolarRadiationSensor/ SolarRadiation	Solar radiation sensor, par (photo synthetically active radiation) sensor, sun light, solar sensors, sun's radiation intensity	WattPerMeter Square	Completeness OK (5 rules [Staroch 2013]) + Correctness OK (even with [Kofler 2011])
Weather	VisibilitySensor/ Visibility	Visibility sensor to detect fog	Miles, Meter	
Weather	Thermometer, AirThermometer/ Temperature	Thermometer, temperature sensor, thermistor	DegreeCelsius	Integrate [Kofler 2011] 15 rules See LOV4IoT [Staroch 2013] (6 home temperature rules)

Weather	LightSensor/ Luminosity	Light, luminosity, illuminance, lighting	Lux	
Weather	PrecipitationSensor/ Precipitation	Precipitation sensor, rainfall sensor, rain fall, pluviometer, rain, rainfall gauge	MilimeterPer Hour	
Weather	WindSpeedSensor/ WindSpeed	Wind speed sensor, wind velocity sensor, anemometer	MeterPerSeco nd	[Kofler 2011] 16 rules See LOV4IoT [Staroch 2013] 5 overlapping
Weather	WindChillSensor/ WindChill	Wind chill		

c) Smart home

Table 3. Smart home domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules
BuildingAutomation	SoundSensor/ Sound	Noise, sound, microphone, audio sensor	dB	Correctness OK (3 rules [Rodriguez 2014]) + **Completeness NO** (Between 30 and 110, overlapping with Vasileios]
Weather	Thermometer/ Temperature	Thermometer, temperature sensor, thermistor	DegreeCelsius	[Kofler 2011] 15 rules (only 9 implemented) See LOV4IoT [Staroch 2013] (6 home temperature rules) Rodriguez 3 rules Overlapping overlapping with Vasileios Yus
BuildingAutomation	LightSensor/ Luminosity	Light, luminosity, illuminance, lighting, illumination	lux	Pb with Vasileios
BuildingAutomation	Presence	Presence sensor, motion sensor, occupancy detector, pyroelectric IR occupancy, intrusion detector/ trespassing,	?	2 rules combined with light See LOV4IoT [Jacquet 2013]

		infrared sensor, motion sensor, motion detector, motion sensor, proximity, passive infrared (PIR)		
BuildingAutomation	PowerConsumption		Watts	
Weather	HumiditySensor/ Humidity	Hygrometer, humidity sensor, moisture sensor, soil moisture probes	Percent	5 rules See LOV4IoT [Staroch 2013] Completeness ok Correctness : Overlapping with kofler, Rodriguez More rules staroch
BuildingAutomation	gyroscope	Gyroscope attached to objects (e.g., mop) to detect if they are used	rad/s	No too complicated need machine learning to detect activities
BuildingAutomation	pressure	Pressure for beds, sofa, couch to detect (lying, sitting), bed occupancy		
BuildingAutomation	Accelerometer/ Motion	Accelerometer	m/s^2	
BuildingAutomation	magnetic field	Magnetometer, magnetic sensor attached to cupboards to detect if they are opened or closed		
BuildingAutomation	Camera	Video sensor		
BuildingAutomation	SmokeDetector			Percent
BuildingAutomation	GasDetector			

d) Transportation

Table 4. Transportation domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names	M3 or SenML Unit
Transportation	battery	Battery charge level	
Transportation	motorTemperature		

Transportation	RoadSurfaceThermometer/ RoadTemperature		
Transportation	SpeedSensor/ Speed	Speed sensor, speedometer, velocity sensor (car)	
Transportation	NumberVehicleSensor/ NumberVehicle		
Transportation	tire pressure		
Transportation	fuel	Fuel level	
Transportation	DistanceSensor/ Distance	Distance sensor, safety distance	
Transportation	rpm	Position and/or rotational speed	
Transportation	maf	mass air flow sensor	maf
Transportation	SoundSensor/ Sound		dB
Transportation	AlcoholLevelSensor/ AlcoholLevel		

e) Agriculture

Table 5. Agriculture domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ name	Description, other names (synonyms)	M3 or SenML Unit
Agriculture	SoilHumiditySensor/ SoilHumidity		Percent
Agriculture	LeafWetnessSensor/ LeafWetness		Percent
Agriculture	AirThermometer/ AirTemperature	Thermometer, temperature sensor, thermistor	°C, K, F
Agriculture	SoilThermometer/ SoilTemperature	Thermometer, temperature sensor, thermistor	
Agriculture	Luminosity	LightIntensity	
Agriculture	PHSensor/ PH		

f) Emotion

Table 6. Emotion domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor name	M3 or SenML measurement name	Description, other names (synonyms)	M3 or SenML Unit
Emotion	SkinConductanceSensor	SkinConductanceSensor	skin conductance, galvanic skin response sensor, GSR, sweating	

g) Energy

Table 6. Emotion domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor name	M3 or SenML measurement name	Description, other names (synonyms)	M3 or SenML Unit
Energy	EnergyMeter/ Energy	Energy	Electricity meter, electric meter, energy meter	KiloWattHour

h) Environment

Table 7. Air quality domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules
Environment	AirPollutantSensor/ AirPollution	Air pollutant sensor	EAQI	5 rules Completeness + Correctness Kofler + See LOV4IoT [Staroch 2013]
Environment	SaltMeter / Salinity		ppt	
Environment	oxygen	oxygen sensor		
Environment	no	Nitrogen oxide sensor		
Environment	CO	Carbon monoxide CO sensor		
Environment	SO2	Sulfure dioxide sensor		
Environment	CO2	Carbon Dioxyde Sensor	Ppm (parts per million)	
Environment	pH	pH		

i) Generic

Table 8. Generic domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor name	M3 or SenML measurement name	Description, other names (synonyms)	M3 or SenML Unit
Generic	HumiditySensor	Humidity	Hygrometer, humidity sensor, moisture sensor, soil moisture probes	Percent
Generic	Thermometer	Temperature	Thermometer, temperature sensor, thermistor	°C
Generic	LightSensor	Luminosity	Light, luminosity, illuminance, lighting	lux
Generic		gps	Global positioning system, gps, location sensor	lon, lat, alt

Generic		frequency		Hz
Generic		shake	Shake sensor, vibration	

2. IoT Applicative Domains

E.g., Aix means Air en Provence which is a city.
E.g., you use the temperature in the health domain enable the computer to understand that the measurement corresponds to a body temperature.

For instance, Fire is a subclass of Environment.

FOI when duplication with measurement type,
FOI for feature of Interest

Table 9. Domain names

M3 or SenML Domain name	Description, other names (synonyms)
BuildingAutomation (subclass: Activity)	Smart home, building automation, or building or room (kitchen, bathroom, living room, dining room)
Health	healthcare
Weather	Weather forecasting, meteorology
Agriculture	Agriculture, smart farm, garden
Environment (subclass: Fire)	Environment (earthquake, flooding, forest fire, air pollution)
Emotion	Affective science, emotion, mood, emotional state; brain wave
Transport	Intelligent transportation systems (ITS), smart car/vehicle, transportation
EnergyFOI	Smart grid, smart energy
Tourism	Tourism
Location	Location, place, GPS coordinates
City	Smart city, city automation, public lighting
TrackingGood (subclasses: TrackingFood, TrackingCD)	Tracking RIFD goods
Generic	Others

3. Actuators

If SenML value = 0 it means the actuator is not used
If SenML value = 1 it means the actuator is used

Table 10. Actuator names

M3 or SenML domain	M3 or SenML Actuator name	Description, other names (synonyms)
Transport	FogLamp	Fog lamp
Transport	Brake	
Transport	ABS	Abs, anti-lock braking system
Transport	ESP	Electronic stability program
Transport	SeatBeltTensionSensor	Seat belt tension sensor
BuildingAutomation	WaterFlow	water flow attached to sinks, showers, flushing

BuildingAutomation, Transportation	AirConditioner	Air conditioner, ac
BuildingAutomation, Transportation	AlarmSystem	
BuildingAutomation	Heating	
BuildingAutomation	Blind	
BuildingAutomation	Ventilation	
BuildingAutomation	Curtain	
BuildingAutomation	Window	
BuildingAutomation	Cupboard	
BuildingAutomation	DishWasher	
BuildingAutomation	WashingMachine	
BuildingAutomation	Drawer	
BuildingAutomation	Door	
BuildingAutomation	Boiler	
BuildingAutomation	CoffeeMachine	Coffee machine, coffee maker
BuildingAutomation	Computer	Computer, pc
BuildingAutomation	Shower	Water actuator
BuildingAutomation	TV	tv, television
BuildingAutomation	Lavatory	
BuildingAutomation	Fridge	Refrigerator, fridge
BuildingAutomation	Freezer	Chiller
BuildingAutomation	Microwave	
BuildingAutomation	Lamp	Dimmable light, lamp

Table 11. RFID tags common terms

RFID tags name	Description, other names (synonyms)
RFID_Food	food
RFID_Book	book (isbn)
RFID_CD	cd, music
RFID_DVD	dvd, movie
RFID_Garment	clothes, garments
RFID_BrushTeeth	
RFID_Broom	
RFID_TeaBag	
RFID_Cup	
RFID_Mop	
RFID_Bed	
RFID_Sofa	
RFID_Pan	
pill box	
passport	
luggage	
parking space	
toll	
animal	
payment card	

transit pass	

4. Others Measurement names

E.g., t temp and temperature have the same meaning and represents the temperature measurement.
The same as the one referenced for sensors

Table 12. measurement names

M3 or SenML measurement name	**Description, other names (synonyms)**
lon	longitude
lat	latitude
Others measurements are the same than those referenced for sensors	

III. M3 language

1. Why W3C SSN ontology is not enough?

As explained by W3C SSN (final report):

- The W3C SSN ontology does not describe domain concepts, time, locations, etc. these are intended to be included from other ontologies via OWL imports.
- Future work: Standardise the SSN ontology to bridge the Internet of Things
- Future work: Standardise the SSN ontology to use it in a Linked Sensor Data context

To sum up, W3C SSN is insufficient to unify sensor metadata such as describing units, sensor measurement types, applicative domains, and sensor types.

They suggest to reuse domain ontologies, but a deep analysis from the Linked Open Vocabularies for Internet of Things (LOV4IoT)[1] dataset [1] [2] shows that we can find several ontologies describing units, or the same sensor types.

2. Why do we need the M3 ontology?

To add reasoning on sensor data, we identified the need to design a common taxonomy to unify sensor metadata.

For this reason, we build this taxonomy that we called M3 nomenclature/language [3] as presented in the previous section.

The M3 nomenclature has been implemented in our M3 ontology. The M3 Ontology references more than 30 sensors, measurements, units and about 10 domains. The M3 ontology is focused on the ssn:ObservationValue concept from the W3C SSN ontology which describes sensors and observations, and related concepts.

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

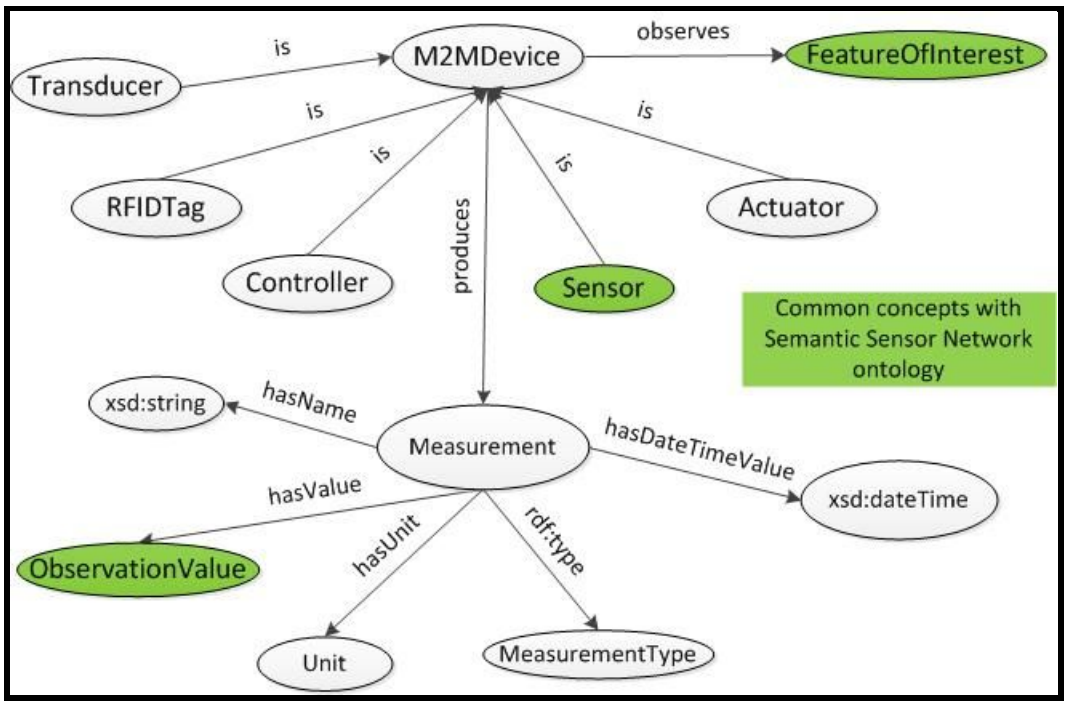

Figure 1. M3 ontology: extension of W3C SSN

3. M3-lite taxonomy (M3 ontology V2)

M3-lite taxonomy is a refinement of the M3 ontology (refactored, cleaned and aligned with the vision of the EU H2020 FIESTA-IoT project).

4. M3 interoperable domain knowledge

The key aspect of the M3 ontology is enabling linking domain ontologies and rules to deduce meaningful knowledge from sensor data.

5. M3 hub to combine cross-domain ontologies

The Machine-to-Machine Measurement (M3) hub interlinked cross-domain knowledge (ontologies, datasets and rules) as follows:

- Link ontologies in the same domain
- Link cross-domain ontologies

- Link rules thanks to the Sensor-based Linked Open Rules (S-LOR) to interpret IoT data.

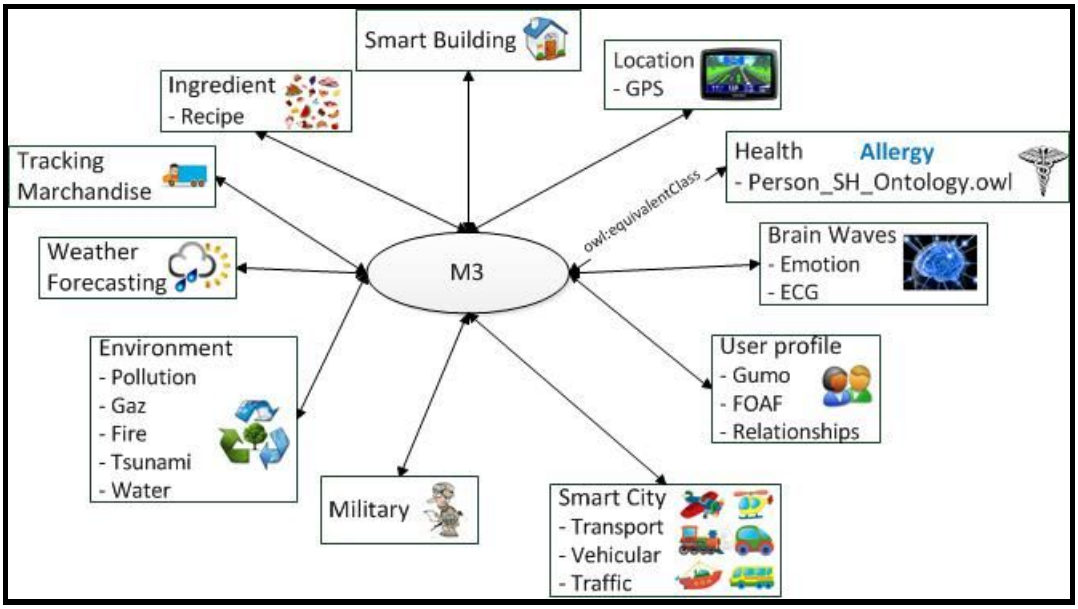

Figure 2. M3 to build cross-domain knowledge

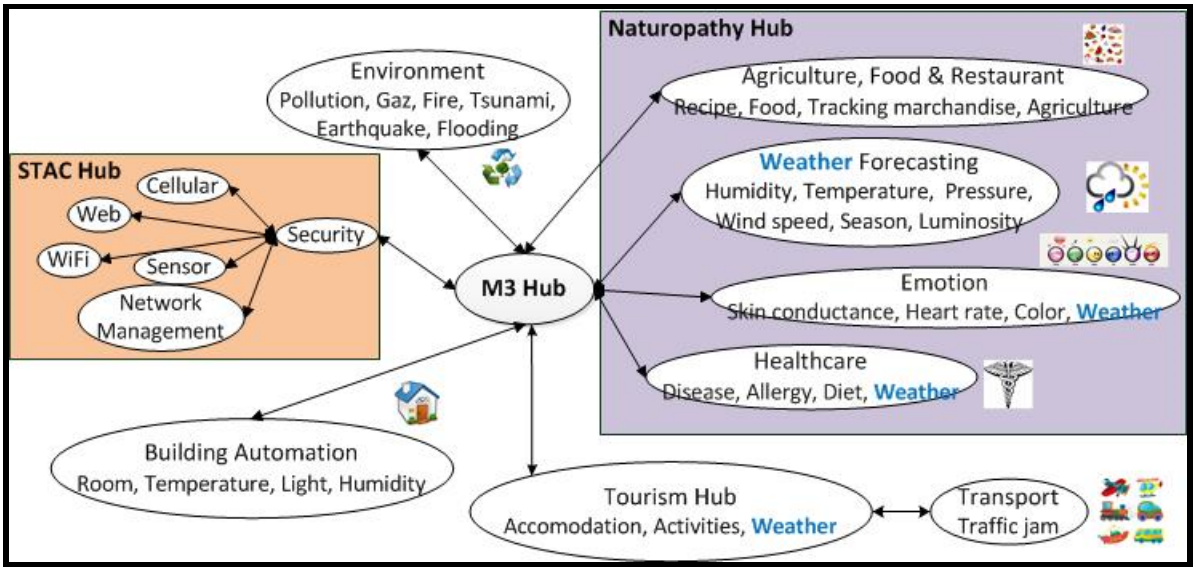

Figure 3. M3 to build cross-domain knowledge: Naturopathy and security example

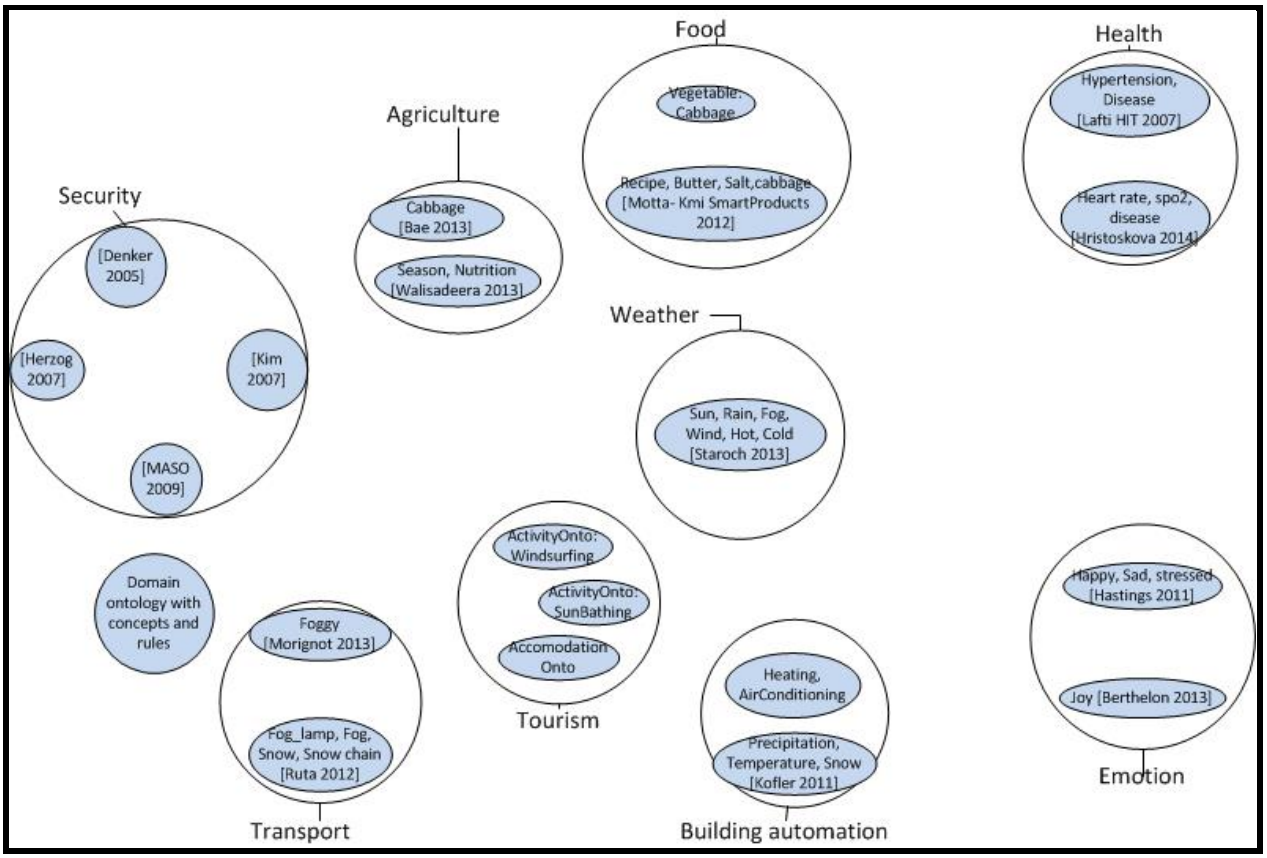

Figure 4. Without M3, the knowledge is not connected

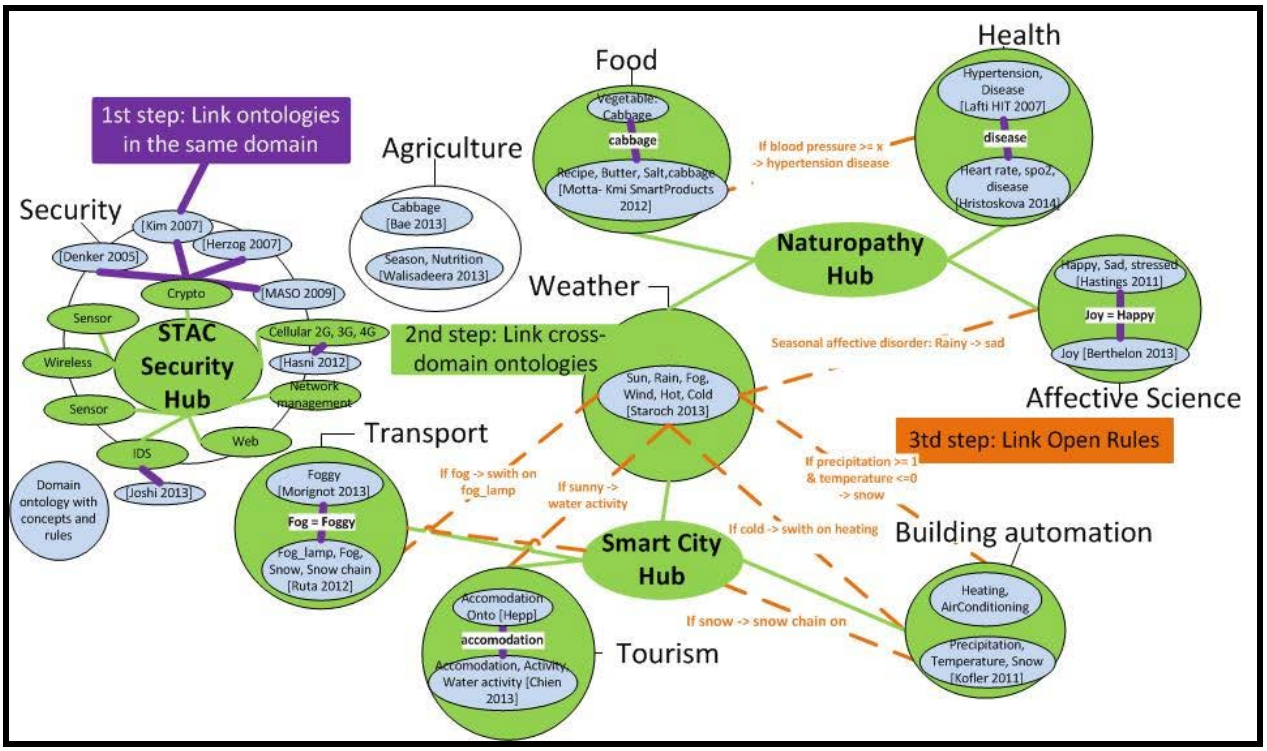

Figure 5. M3 used to build cross-domain knowledge: ontologies, datasets and reasoning

IV. Semantic Annotator: M3 Converter

6. M3 converter user interface

The developer can use the M3 converter user interface:
http://www.sensormeasurement.appspot.com/?p=senml_converter

See user guide: www.sensormeasurement.appspot.com/documentation/UserGuide.pdf

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

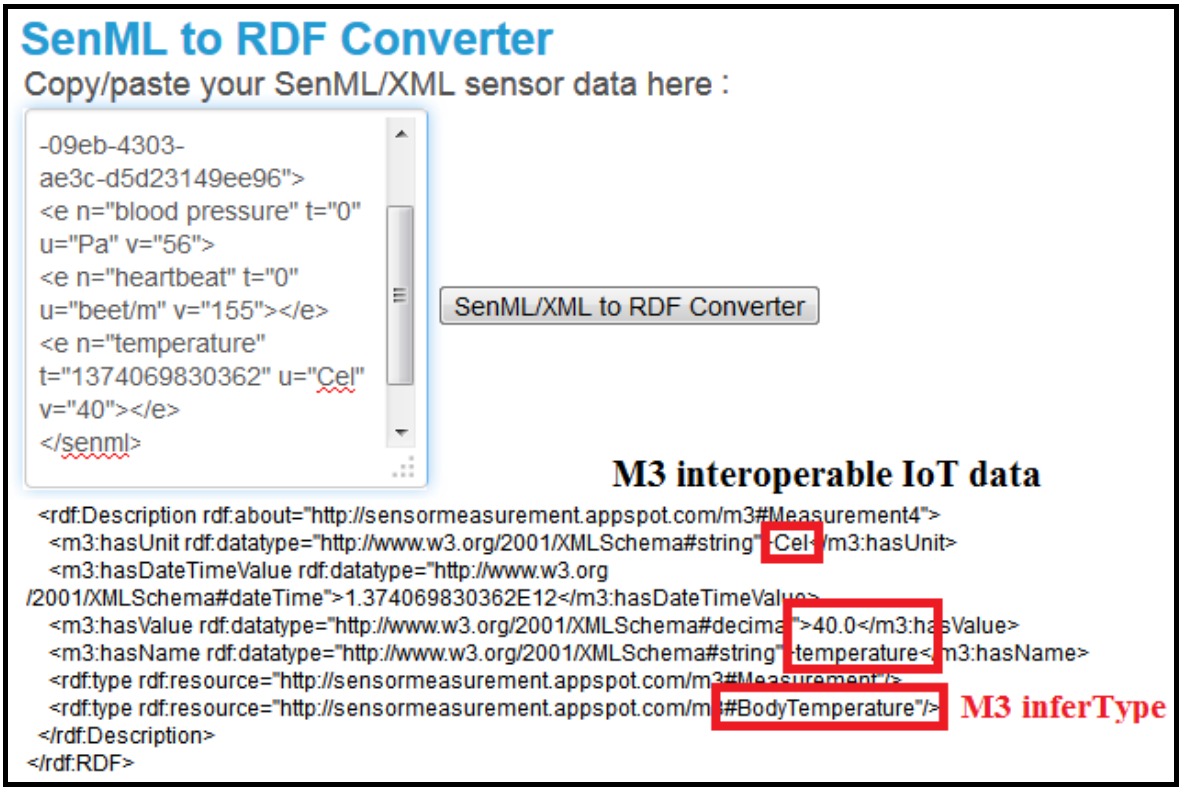

Figure 6. Semantically annotating IoT data with the M3 converter user interface

7. Code example to semantically annotate IoT data with M3

```
// Converting your IoT data using SenML to RDF converter

// String URL_M3_CONVERTER = "http://www.sensormeasurement.appspot.com/swot/";
String format = "xml"; // or json
String iot_data = getSenMLData();

String m3_data = queryWebService(URL_M3_CONVERTER + "convert_senml_to_rdf/?data=" + iot_data +
                                 "&format="+ format);

store(m3_data);
```

Figure 7. Semantically annotating IoT data with the M3 converter web service

8. Enrich the M3 converter and adapt it to your data

When you download a template with the SWoT generator[2] you also get the rules to semantically annotate data, the file is called 'ruleM3Converter.txt'.

We did not have time to implement all the M3 nomenclature. Further, we frequently update the M3 nomenclature[3].

But you can still improve and add more rules to semantically annotate your sensor data.

[2] http://www.sensormeasurement.appspot.com/?p=m3api
[3] http://www.sensormeasurement.appspot.com/documentation/NomenclatureSensorData.pdf

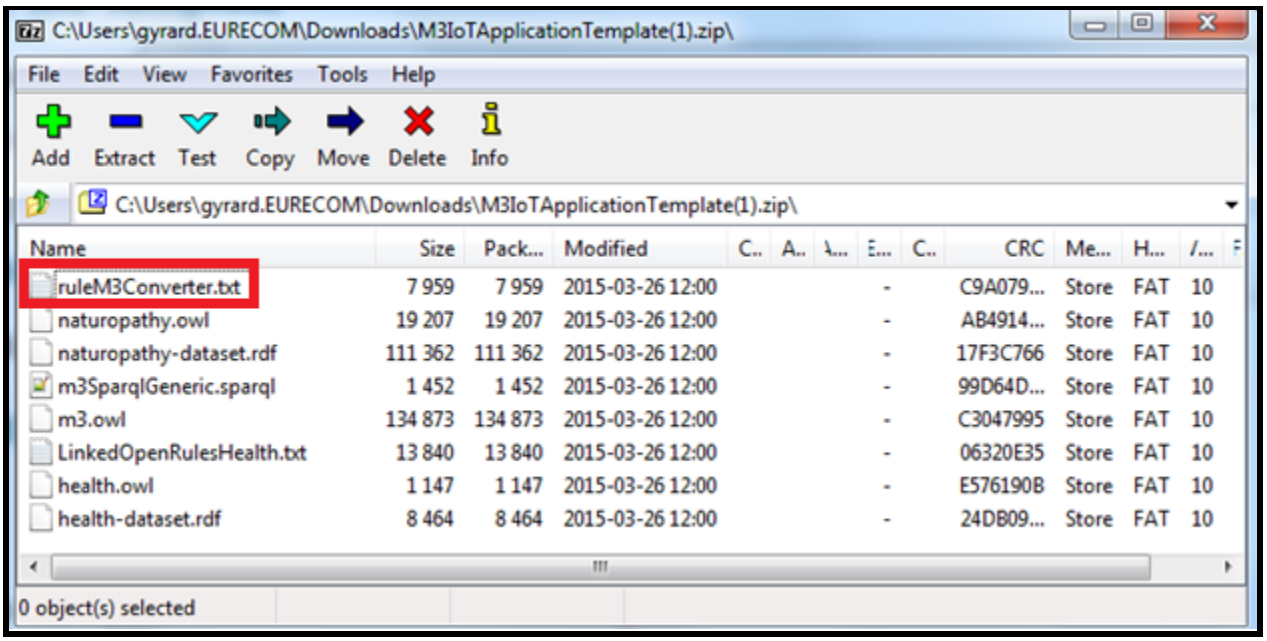

Figure 8. Rules provided in the template to semantically annotate sensor data

The following rule means that we explicitly add the context:

If you get a temperature from health domain (subclassOf m3:FeatureOfInterest), we will explicitly add that it corresponds to a body temperature.

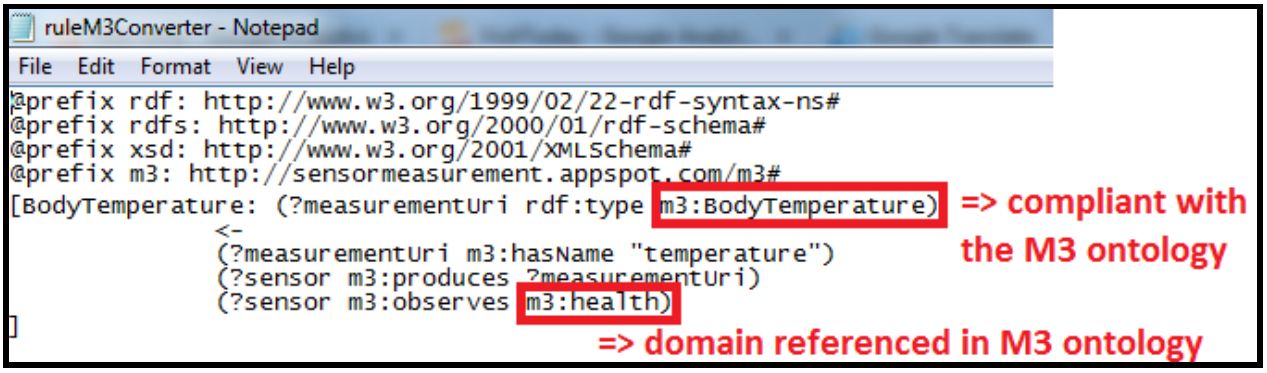

Figure 9. Add new rules to semantically annotate sensor data according to the M3 ontology.

This is important because after, you have the rules adapted to this kind of measurement.

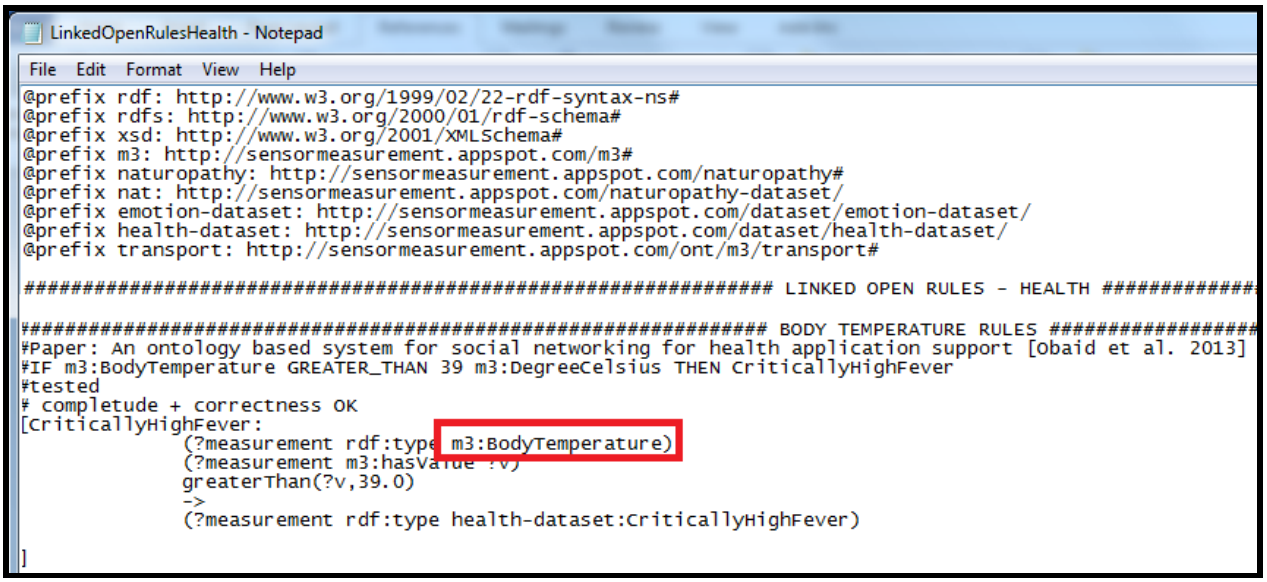

Figure 10. Explicit M3 measurement type is reused in the reasoning process

V. 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[4] 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).

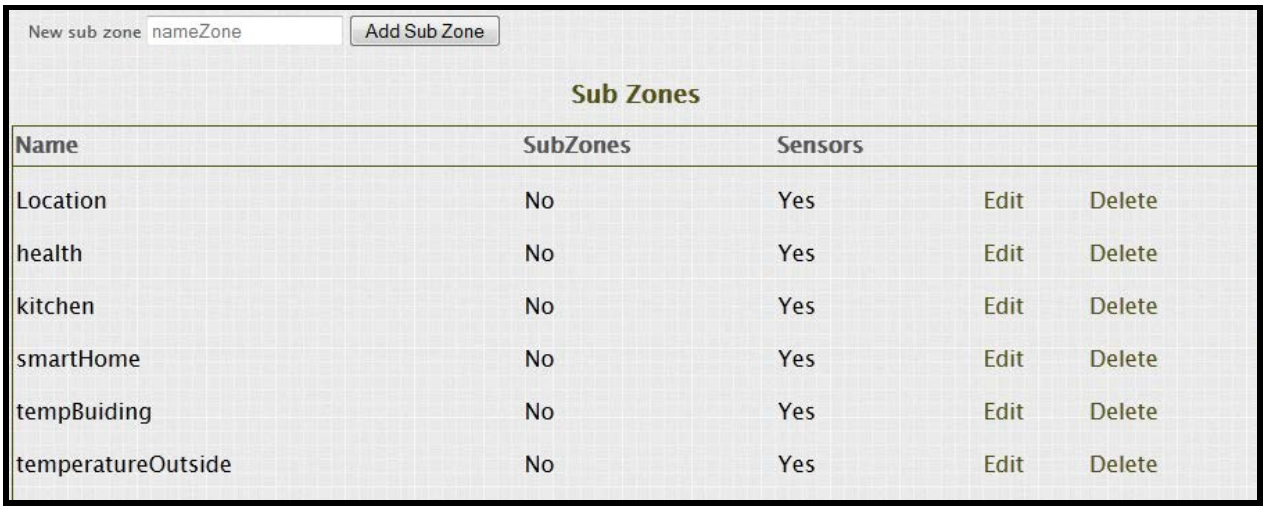

Figure 11. Simulate M2M area networks

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).

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

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[5] 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.

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

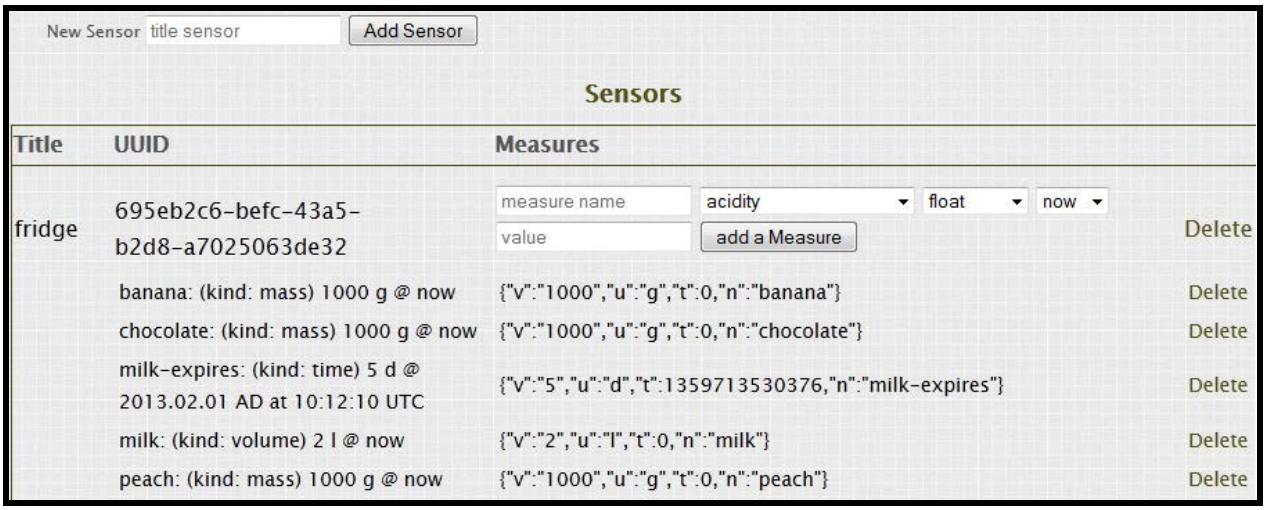

Figure 12. Simulating sensor measurements

VI. Converting senML sensor data

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

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.

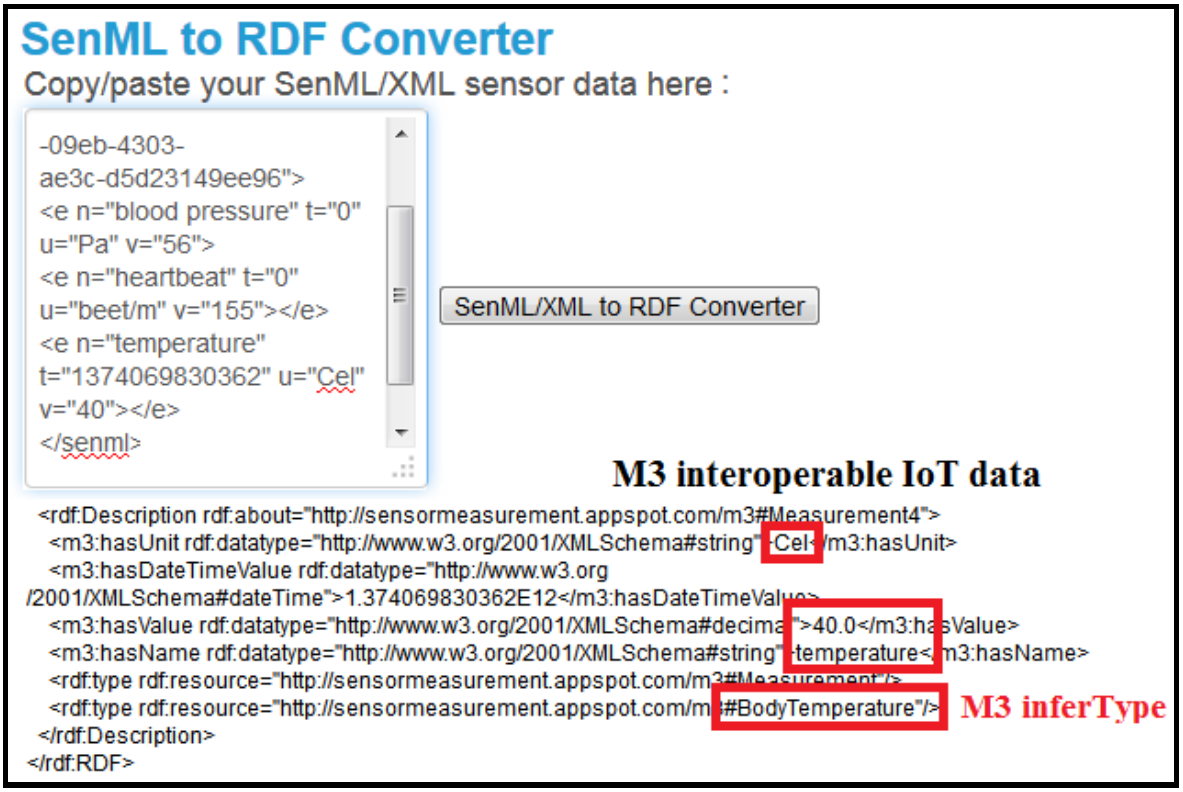

Figure 13. Semantically annotating IoT data with the M3 converter user interface

Figure 14. Semantically annotating sensor data

VII. Querying the M3 nomenlature/ontology

1. Web service: querying sensors

Search for all M3 sensors:

http://www.sensormeasurement.appspot.com/m3/subclassOf/?nameClass=Sensor&format=json

Results:

2. Web service: querying actuators

Search for all M3 actuators:

http://www.sensormeasurement.appspot.com/m3/subclassOf/?nameClass=Actuator&format=json

3. Web service: querying domains

Search for all M3 domains (=FeatureOfInterest):

http://www.sensormeasurement.appspot.com/m3/subclassOf/?nameClass=FeatureOfInterest&format=json

4. Web service: querying health devices

Search for all M3 health devices:
http://www.sensormeasurement.appspot.com/m3/subclassOf/?nameClass=HealthM2MDevice&format=json

5. Web service: querying transport devices

Search for all M3 transport devices:
http://www.sensormeasurement.appspot.com/m3/subclassOf/?nameClass=TransportM2MDevice&format=json

6. Web service: querying home devices

Search for all M3 home devices:
http://www.sensormeasurement.appspot.com/m3/subclassOf/?nameClass=HomeM2MDevice&format=json

VIII. Code

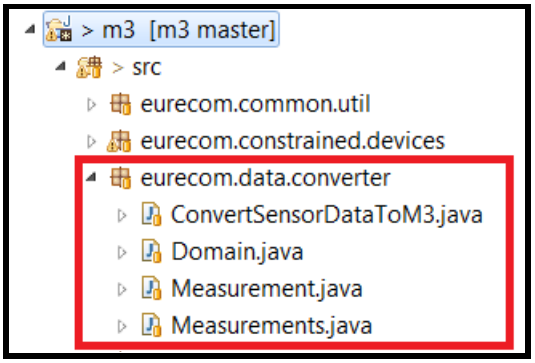

Figure 15. The converter package

1. eurecom.data.converter

- Domain.java: Class which transforms XML data to RDF data. Have a public ArrayList containing the measurements, getter and setter of the nameZone.
- ConvertSensorDataToM3.java: Behaviour of the conversion of java object (Measurements) into RDF data and of the other way. Can create also some instance object into RDF (type of object: Measurement, FeatureOfInterest, and Sensor).
- Measurement.java && Measurements.java: Objects measurements, describe the object that is used to transform Xml data into RDF data. Mostly composed by variables and their getter/setter.
- *Note*: A Domain has an ArrayList of Measurements (with an S) and Measurements has an ArrayList of Measurement. Where Measurement is just a data (30 °C for instance), Measurements is a bunch of data (all the data from one sensors) and FeatureOfInterest could be the domain (Temperature).

IX. Semantic annotator: Tutorial

TO DO

1. Use case: M3 framework

TO DO

Semantically annotate XML data following the SenML format.

It employs the M3 ontology.

2. Use Case: M3 embedded in Android-powered devices

TO DO

Semantically annotate JSON data following the SenML format provided by Raspberry Pi.

It employs the M3 ontology.

3. Use Case: FIESTA-IoT project

TO DO

It employs the M3-lite taxonomy.

4. Use Case: Insight testbed

TO DO

Data sent by netatmo devices.

It employs the M3-lite taxonomy.

X. References

[1] A. Gyrard, G. Atemezing, C. Bonnet, K. Boudaoud, and M.Serrano. Reusing and unifying background knowledge for internet of things with lov4iot. In *Future Internet of Things and Cloud (FiCloud), 2016 4th International Conference on*, Aug 2016.

[2] A. Gyrard, C. Bonnet, K. Boudaoud, and M.Serrano. Lov4iot: A second life for ontology-based domain knowledge to build semantic web of things applications. In *Future Internet of Things and Cloud (FiCloud), 2016 4th International Conference on*, Aug 2016.

[3] Amélie Gyrard, Soumya Kanti Datta, Christian Bonnet, and Karima Boudaoud. Standardizing generic cross-domain applications in Internet of Things. In *GLOBECOM 2014, 3rd IEEE Workshop on Telecommunication Standards: From Research to Standards, December 8, 2014, Austin, Texas, USA*, Austin, UNITED STATES, 12 2014.