### M3 Framework:
**User’s guide & tutorial**

<table>
<thead>
<tr>
<th>Creator</th>
<th>Amelie Gyrard (Eurecom - Insight - NUIG/DERI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>Send Feedback</td>
<td>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: <a href="mailto:amelie.gyrard@insight-centre.org">amelie.gyrard@insight-centre.org</a></td>
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<tr>
<td>Google Group</td>
<td><a href="https://groups.google.com/d/forum/m3-semantic-web-of-things">https://groups.google.com/d/forum/m3-semantic-web-of-things</a></td>
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<tr>
<td>Last updated</td>
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<td>• Adding the end to end scenario</td>
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<td>• Update the documentation</td>
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<tr>
<td>Status</td>
<td><img src="https://www.w3.org/2008/visibletext/icon-status.png" alt="Work in progress" /></td>
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<tr>
<td>Goal</td>
<td>This documentation enables a first approach with M3:</td>
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<tr>
<td></td>
<td>• Understand what we can do with M3</td>
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<td>• Understanding M3 and its components</td>
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## Terms and acronyms

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<th>Term</th>
<th>Description</th>
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<tr>
<td>IoT</td>
<td>Internet of Things (IoT)</td>
</tr>
<tr>
<td>LOV</td>
<td>Linked Open Vocabularies</td>
</tr>
<tr>
<td>LOV4IoT</td>
<td>Linked Open Vocabularies for Internet of Things</td>
</tr>
<tr>
<td>M3 framework</td>
<td>Machine-to-Machine Measurement (M3) framework</td>
</tr>
<tr>
<td>S-LOR</td>
<td>Sensor-based Linked Open Rules</td>
</tr>
<tr>
<td>SWoT</td>
<td>Semantic Web of Things</td>
</tr>
<tr>
<td>WoT</td>
<td>Web of Things</td>
</tr>
<tr>
<td>STAC</td>
<td>Security Toolbox: Attacks &amp; Countermeasures</td>
</tr>
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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
- All publications:
  - [http://localhost:57708/?p=publication](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
Challenge A: Design semantic based WoT applications

Challenge B.1 & B.2: Combine data and domains

Challenge B.2: Reuse domain knowledge

Challenge B: Interpret WoT data

Challenge C: Secure WoT applications

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).

Generate IoT applications to reason on sensor data

**STEP 1: Search IoT Application Template**
1. Choose a sensor (e.g., Light/Illuminance Sensor)
2. Choose the domain where is deployed your sensor (e.g., Weather)
3. Search IoT Application Template

**STEP 2: Choose IoT Application**
- Choose an application template:

**STEP 3: Download IoT application**
- Generate zip file

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](image)

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.
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) project due to a lack of best practices.
- Dark green: The ontology is referenced on the Linked Open Vocabularies project. It checks best practices.

1 http://lov.okfn.org/dataset/lov/
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
Click on the button “Edit” associated to the kitchen zone.

You go to the following URL:

http://emulator-box-services.appspot.com/senmladmin/ahdzfmVtdWxhdG9yLWJveC1zZXJ2aWNlc3IWCxIJWm9uZUFkbWluaXRjaGVuDA/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**

<table>
<thead>
<tr>
<th>Title</th>
<th>UUID</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>fridge</td>
<td>695eb2c6-befc-43a5-b2d8-a7025063de32</td>
<td>acidity: {&quot;1000&quot;,&quot;x&quot;:&quot;g&quot;,&quot;t&quot;:0,&quot;n&quot;:&quot;banana&quot;}</td>
</tr>
<tr>
<td>banana</td>
<td>(kind: mass) 1000 g @ now</td>
<td>Delete</td>
</tr>
<tr>
<td>chocolate</td>
<td>(kind: mass) 1000 g @ now</td>
<td>Delete</td>
</tr>
<tr>
<td>milk</td>
<td>(kind: volume) 2 l @ now</td>
<td>Delete</td>
</tr>
<tr>
<td>milk-expires</td>
<td>(kind: time) 5 d @ 2013-02-01 AD @ 10:12:10 UTC</td>
<td>Delete</td>
</tr>
<tr>
<td>milk-expires</td>
<td>(kind: volume) 2 l @ now</td>
<td>Delete</td>
</tr>
<tr>
<td>peach</td>
<td>(kind: mass) 1000 g @ now</td>
<td>Delete</td>
</tr>
<tr>
<td>peach</td>
<td>(kind: mass) 1000 g @ now</td>
<td>Delete</td>
</tr>
</tbody>
</table>

**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](http://www.sensormeasurement.appspot.com/documentation/NomenclatureSensorData.pdf)
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
SenML to RDF Converter

**SenML to RDF Converter (Use chrome)**

1. Simulate your data
2. Get SenML/XML data
3. Enter an url (see previous link):
   ```
   http://emulator-box-services.appspot.com/senml/zones/ahdz2fml/tdbWxidG9lyLWxveC1zZXJ2aWNlc3MVClUWm9uZUFkWluty2oZWsdSglM
   ```

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](image)

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]

- 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.