M3 Framework Developer Documentation

To set up, run, understand the M3 project and exploit M3 web services

Making smart discussions between things

Creator	The M3 framework has been designed and implemented by Amélie Gyrard, she was a PhD student at Eurecom, Sophia Antipolis, France under the supervision of Prof. Christian Bonnet and Dr. Karima Boudaoud. Currently, Amélie Gyrard is a post-doc researcher at Insight/NUIG, Galway, Ireland.
Contact	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**
Code	https://github.com/gyrard/M3Framework
Documentation URL	http://www.sensormeasurement.appspot.com/documentation/M3DeveloperDocumentation.pdf

Last updated	October 2017
	• Issue localhost/online version, check compiler 1.7
	• Error Over Quota. This application is temporarily over its serving quota. Please try again later.
	
	June 2016
	• Step up with Pankesh
	• Update the documentation according to the errors encountered
	  ○ Use Java 1.7 compiler within Eclipse
	  ○ Issues to import JAR files (Jena, JAX-RS, Geonames, etc.)
	  ○ Import the M3 project within Eclipse
	
	February 2016
	• Update technology used in the project section + picture archi
	• Deploy M3 on the web – optional – section updated
	
	November 2015
	• Technologies used in the project
	• Get the M3 framework code on Github
	• Get the M3 required libraries and tools on Google Shared directory

	• Understanding the M3 converter
	**After 5 years and half of research and development, this project really needs a refactoring (even if I have done it frequently), and even maybe to be re-think from scratch. Anyway, this is the documentation to reuse, set up and understand the M3 project.**
Goal	• This documentation guides developers to set up and run the M3 project. • Understanding the M3 project code (description of packages) • Understanding the technologies used in the project • Understanding M3 web services • It also help understand the web services (to use it or add new ones if you have the code) • Understanding the M3 converter • Add a new Semantic Web of Things (SWoT) template • Reference a new ontology-based project in LOV4IoT (HTML web page & RDF dataset) • Documentation to extend the STAC ontology and dataset
Requirements	Java 1.7, Eclipse Kepler, App Engine SDK 1.9, Jena framework 2.11.
Technologies used	• Java 1.7 is required to use Google App Engine • We used Eclipse Kepler to develop the M3 framework • Jena: a framework to build semantic web applications • Google App engine (App Engine SDK 1.9) to host the web site online (we do not need to have our own server and domain name) • Java Data Objects (JDO) to store data (e.g., semantic sensor data) on the google app engine datastore • RESTful Java, Jersey (JAX-RS) to develop Java web services • User interface: HTML, CSS, Bootstrap, JavaScript, AJAX
System	Windows 7, 64 bits
Status	Work in progress
Time estimated	1 day to set up the project

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Part I : Technologies used in M3

We employed the following technologies as displayed in Figure 1:

- **Jena** 2.11 framework [**Erreur ! Source du renvoi introuvable.**] is used to build semantic web applications. Jena includes the Jena reasoning engine to interpret IoT data and Jena/ARQ to execute SPARQL queries on the knowledge base. Jena was the easier Semantic Web framework to learn, it was well-documented and had tutorials. Integrating Jena to our application was simple thanks to the JAR file. A light version of Jena is available for constrained devices too.
- **RDF, RDFS and OWL** are used to design ontologies and datasets.
- **SPARQL** is used to query knowledge base designed with RDF, RDFS and OWL [**Erreur ! Source du renvoi introuvable.**] .
- **Java** 1.7 is used to implement the entire framework
- **Jersey** (JAX-RS) is used to design JAVA RESTful web services.
- **Google Web Toolkit (GWT)** and **Google App Engine (GAE)** are used to develop the framework and host the entire web site online. We do not have to maintain a server or taking care of security issues, it is easy to deploy and maintain applications online.
- **Java Data Object (JDO)** is used to store data in a database.
- **HTML5, CSS3, JavaScript** are used to design the Graphical User Interface (GUI)
- **AJAX** technologies are used query web services. Then, the result returned by web serviced is parsed with JavaScript.

Finally, the designing phase has been achieved by using extreme programming [**Erreur ! Source du renvoi introuvable.**] and Scrum-like methodologies.

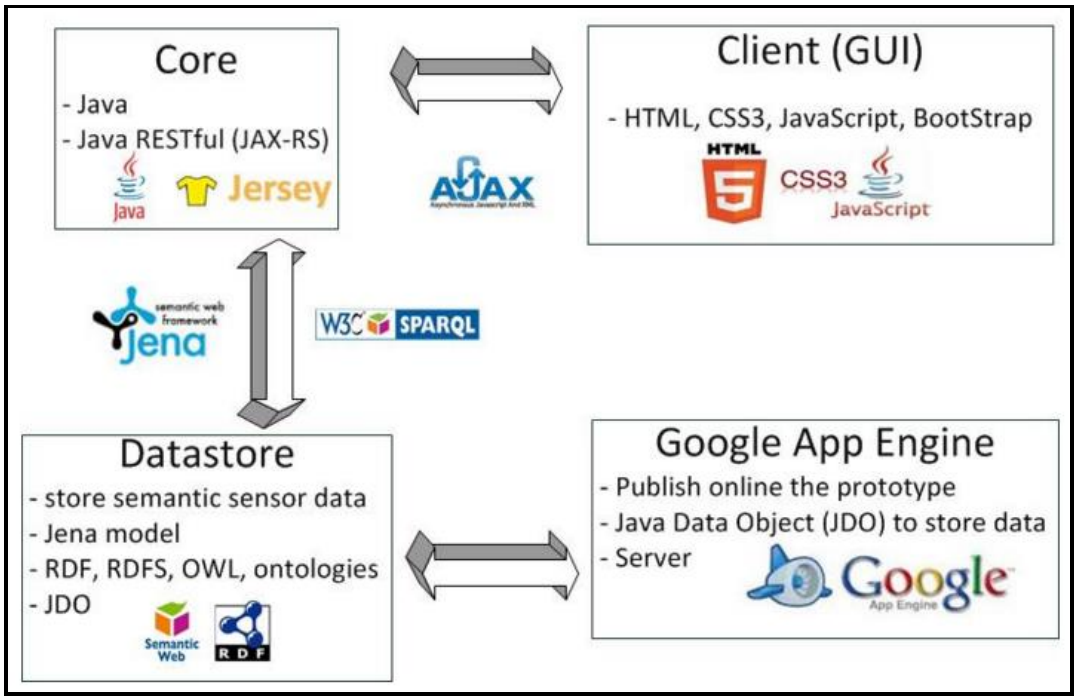


Figure 1. Technologies used is M3

I. Jena

We used Jena[1], a framework to build semantic web applications.

II. Google App Engine

To host the M3 web site on the web, we used Google App Engine. It provides a server and the domain name (http://sensormeasurement.appspot.com/). ".appspot.com" means that the web site is hosted on Google, we do not need to pay for a domain name. Further, Google App Engine provides us a server, so we do not need to maintain it, and take care of security issues.

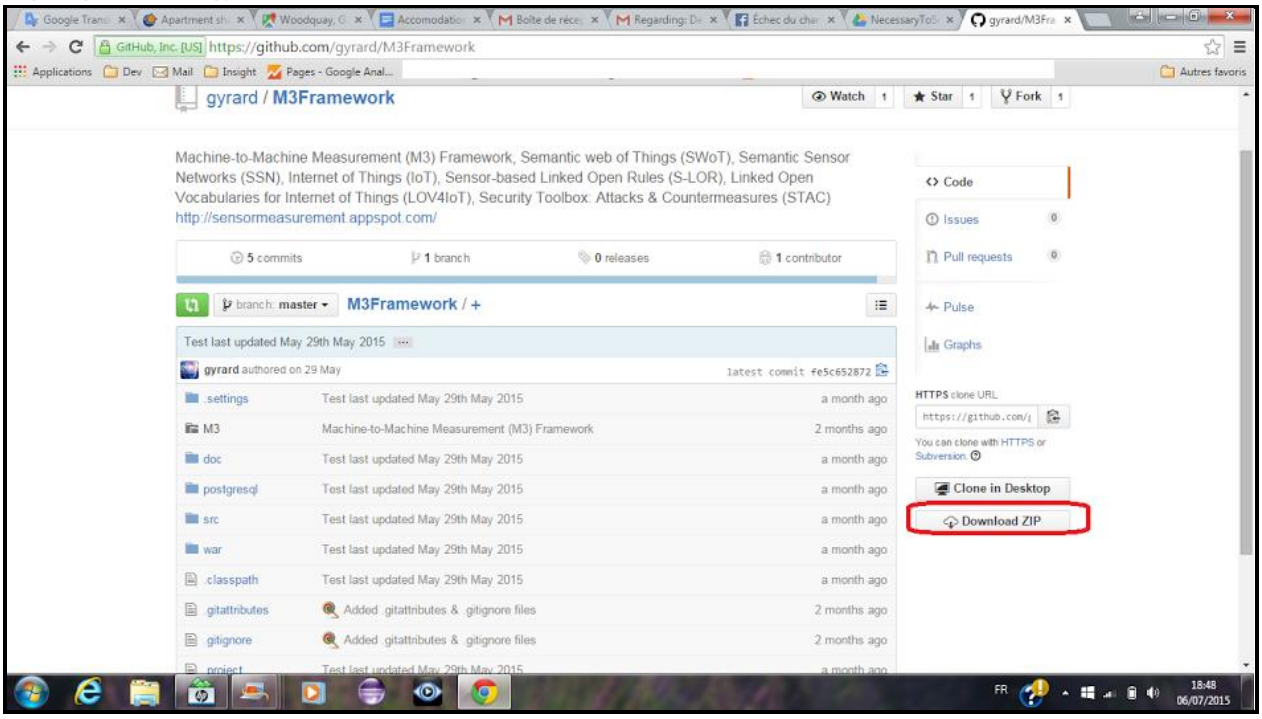
III. RESTful implementation for JAVA: JAX-RS

To build RESTful web services in Java, we use the Jersey Java library[2].

Part II : Setting up the M3 project

IV. Get the M3 framework code on Github

The M3 framework code is on Github: you can download the ZIP file (see Figure 2).
https://github.com/gyrard/M3Framework



[1] https://jena.apache.org/
[2] https://jersey.java.net/

Figure 2. The M3 framework code on Github

1. Download required libraries or tools (Eurecom users)

On BSCW (For Eurecom users)

You have access to the directory SetUpM3 which is comprised of:

- ➔ NecessaryToSetUpM3 with eclipse Kepler, all JAR required and the JDK and JRE 1.7 (e.g., NecessaryToSetUpM3.zip)
- ➔ workspace with the M3 project (e.g., m3_save2Avril2015.zip), see last version on Github
- ➔ Download and unzip both!

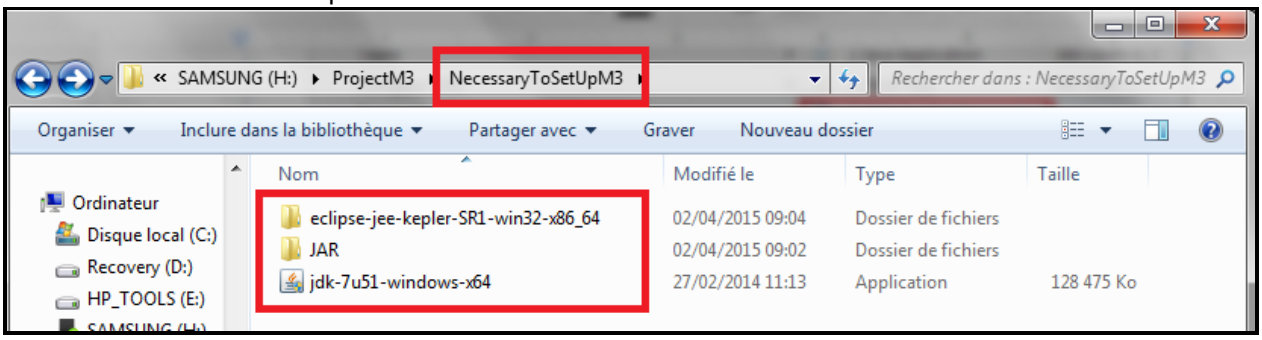


Figure 3. NecessaryToSetUpM3 directory

2. Download required libraries or tools (External users)

The M3 framework code is on Github: you can download the ZIP file (see Figure 2).

https://github.com/gyrard/M3Framework

For external users, ask us to share this directory:

https://drive.google.com/drive/u/0/folders/0B5D7PRXO3e6afm1jUElvb0Z5S0dFVzJSU0VGWk01d3VtOTdiamMtUmpZOG1XM3RnRlBJSk0

You will have access to this directory:

- ➔ NecessaryToSetUpM3 with eclipse Kepler, all JAR required and the JDK and JRE 1.7 (e.g., NecessaryToSetUpM3.zip)

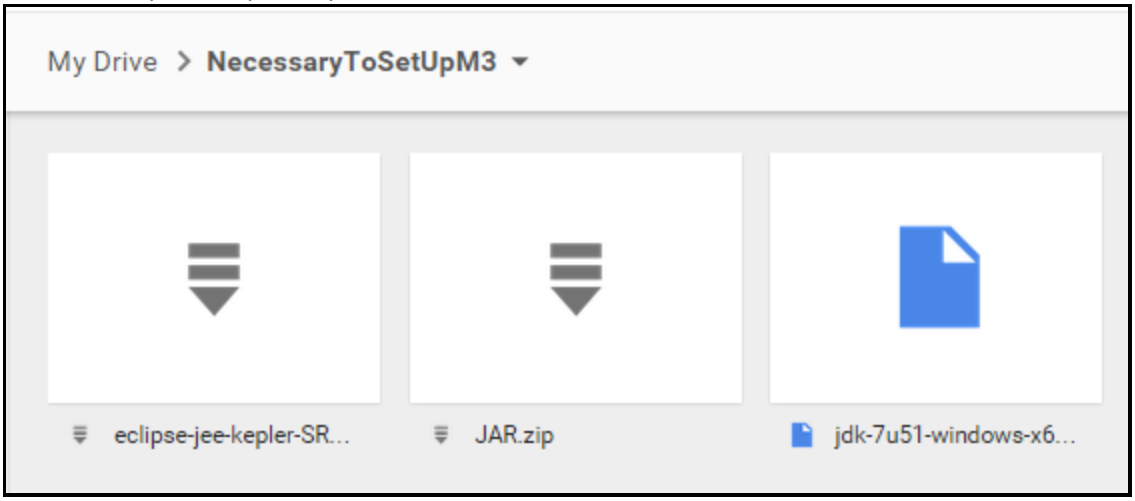


Figure 4. Download the NecessaryToSetUpM3 on Google Drive

V. The NecessaryToSetUpM3 directory

Requirements

- Java 1.7
- Eclipse Kepler
- Plugin Google App Engine SDK App engine 1.9
- Jena
- Jars required

To avoid any incompatibility issues, we provide all tools with the good version:
The NecessaryToSetUpM3 directory is comprised of:

- ➔ Eclipse Kepler
- ➔ All jar required to run the M3 project
- ➔ JDK Java 1.7

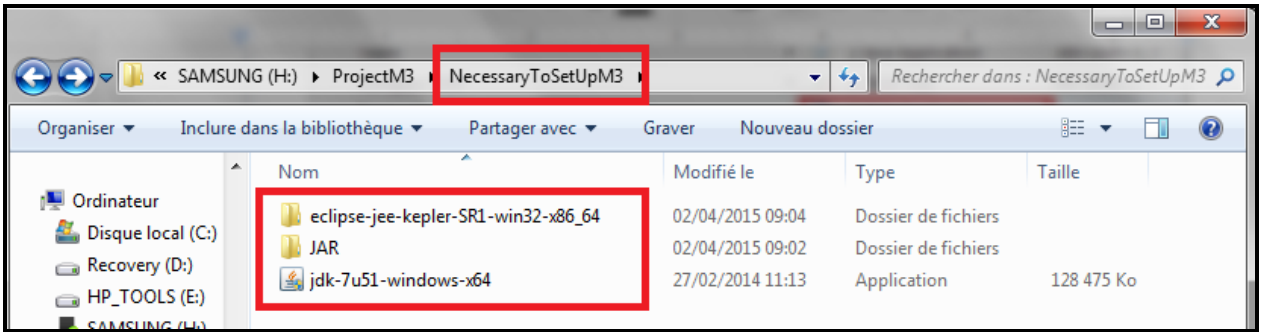


Figure 5. NecessaryToSetUpM3 directory

In the Eclipse directory you already have the plugin for App Engine SDK 1.9:

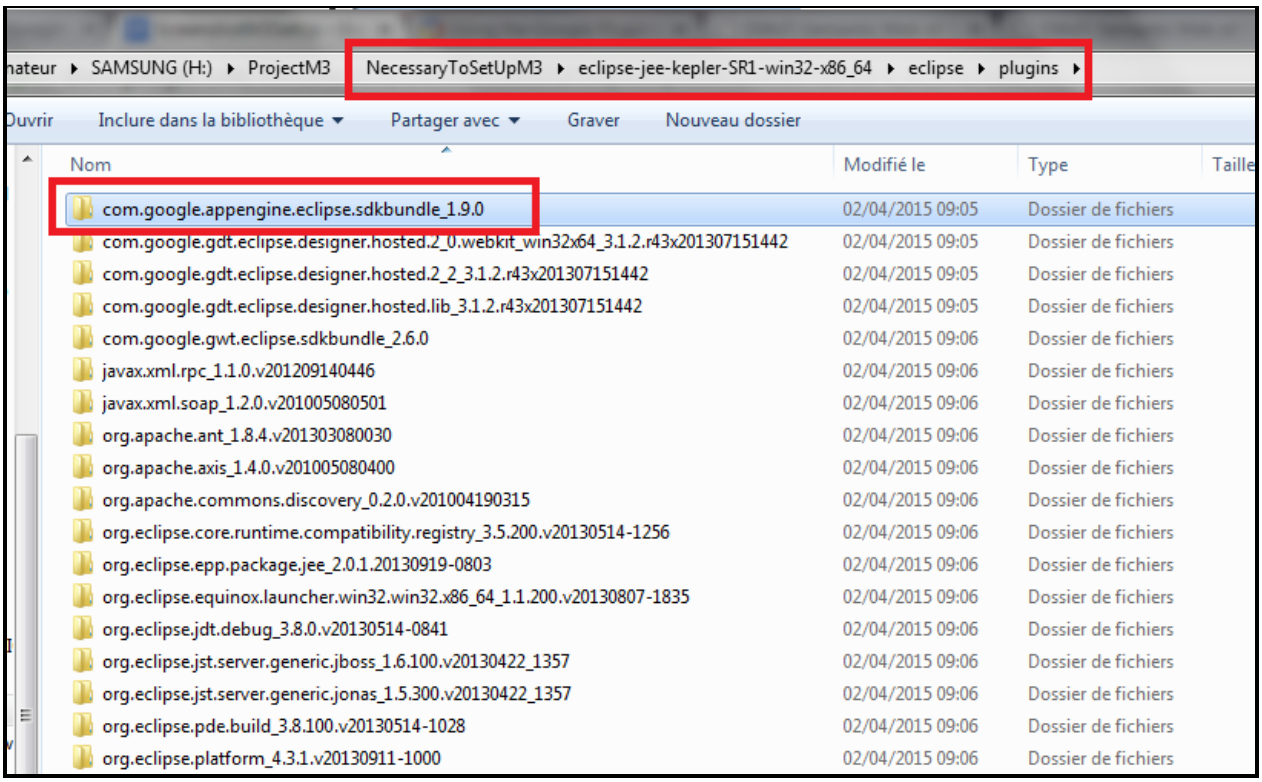


Figure 6. App Engine SDK 1.9 already in the Eclipse that we provided

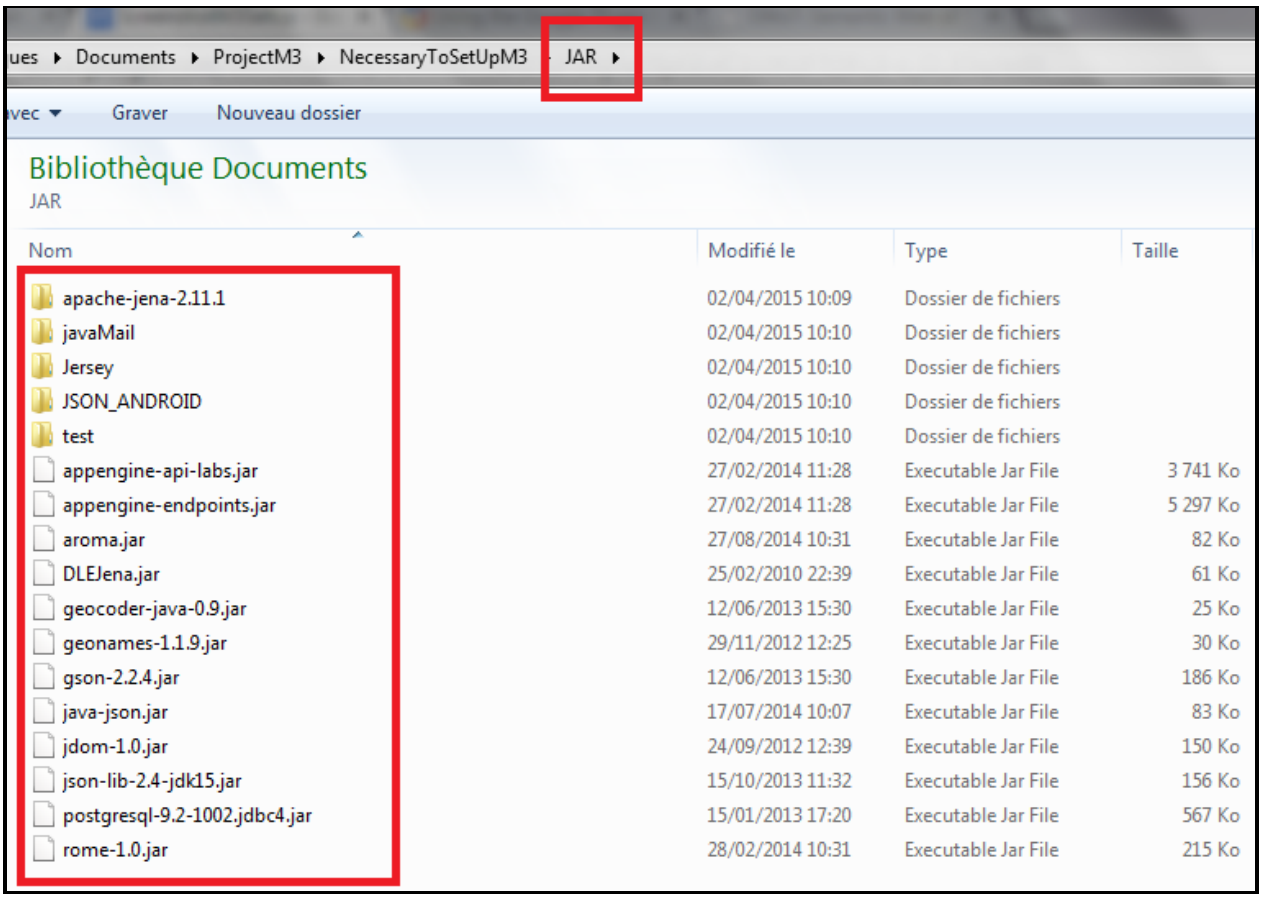


Figure 7. JARs required in the M3 project are provided in the JAR directory

VI. Install Java and JRE 1.7

In our case: jdk-7u51-windows-x64

Because of Google App Engine, we cannot use anymore Java 1.6.

If you have Java 1.6, you should uninstall it, restart the machines, to avoid issues.
(if it does not compromise the other projects running on your machine).

Double click on the JDK and install it.

VII. Install Eclipse Kepler

In our case: eclipse-jee-kepler-SR1-win32-x86_64

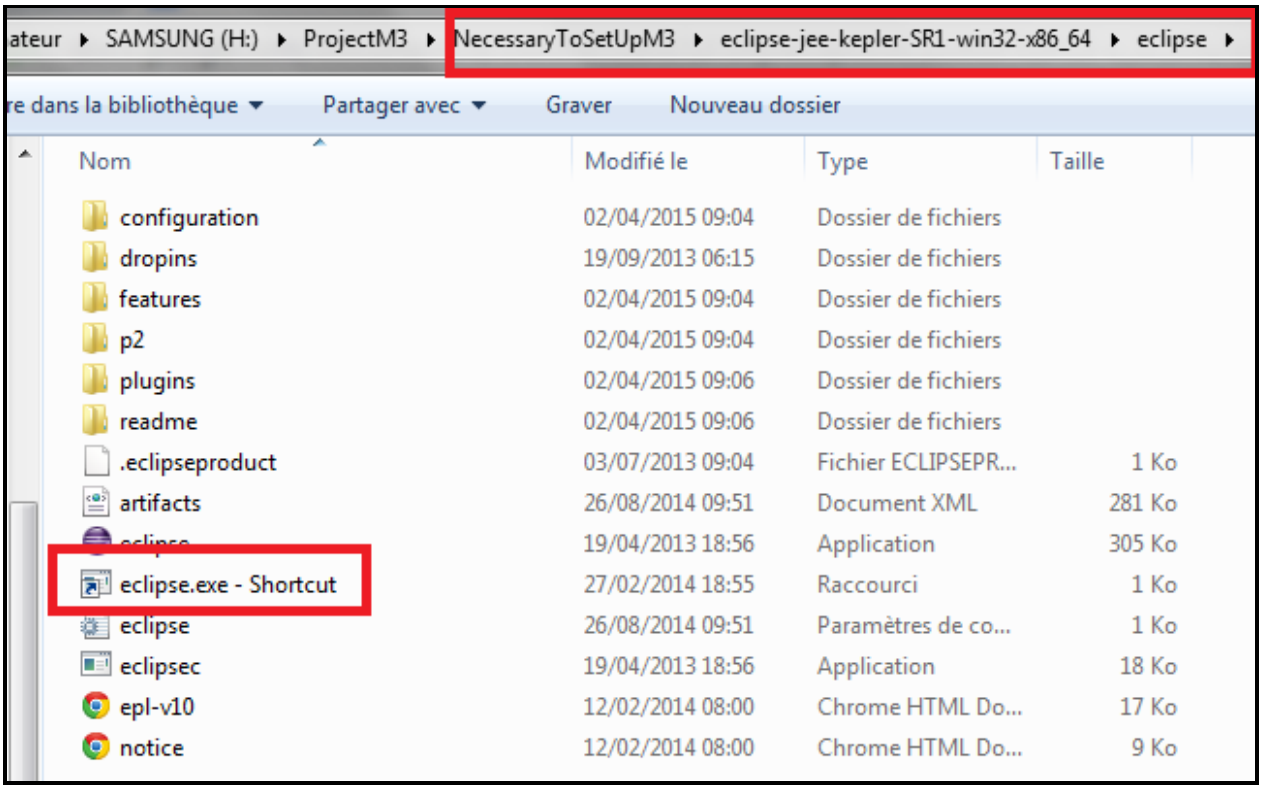


Figure 8. Install Eclipse Kepler that we provided

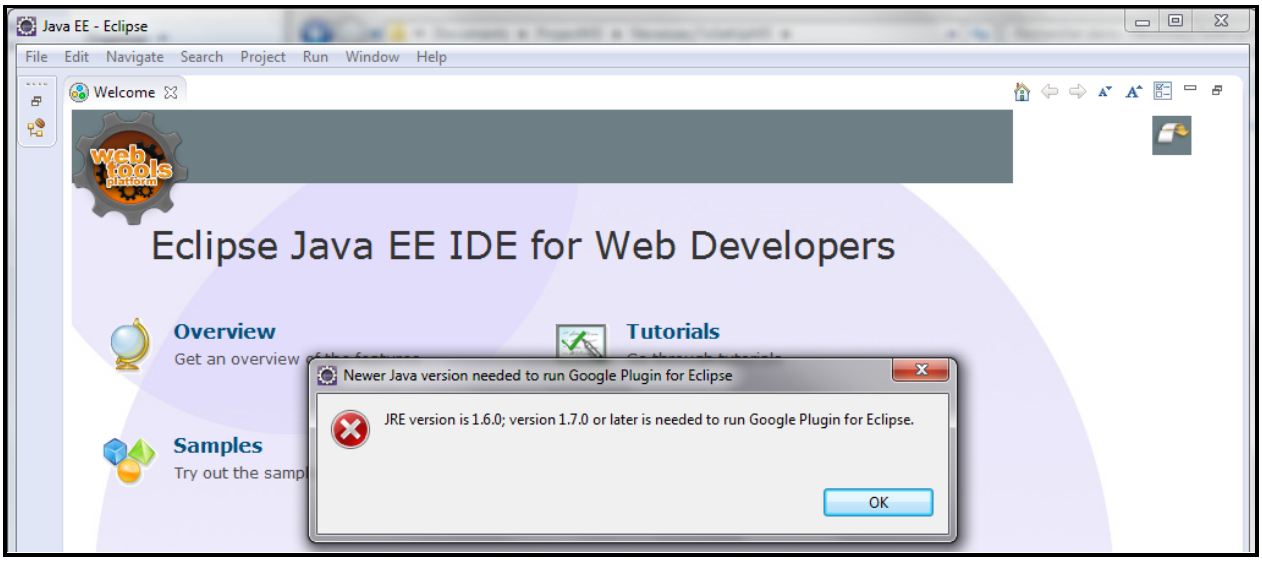


Figure 9. Java 1.7 is required with the Google Plugin for Eclipse

➔ Click ok (This is why we set up Java 1.7)

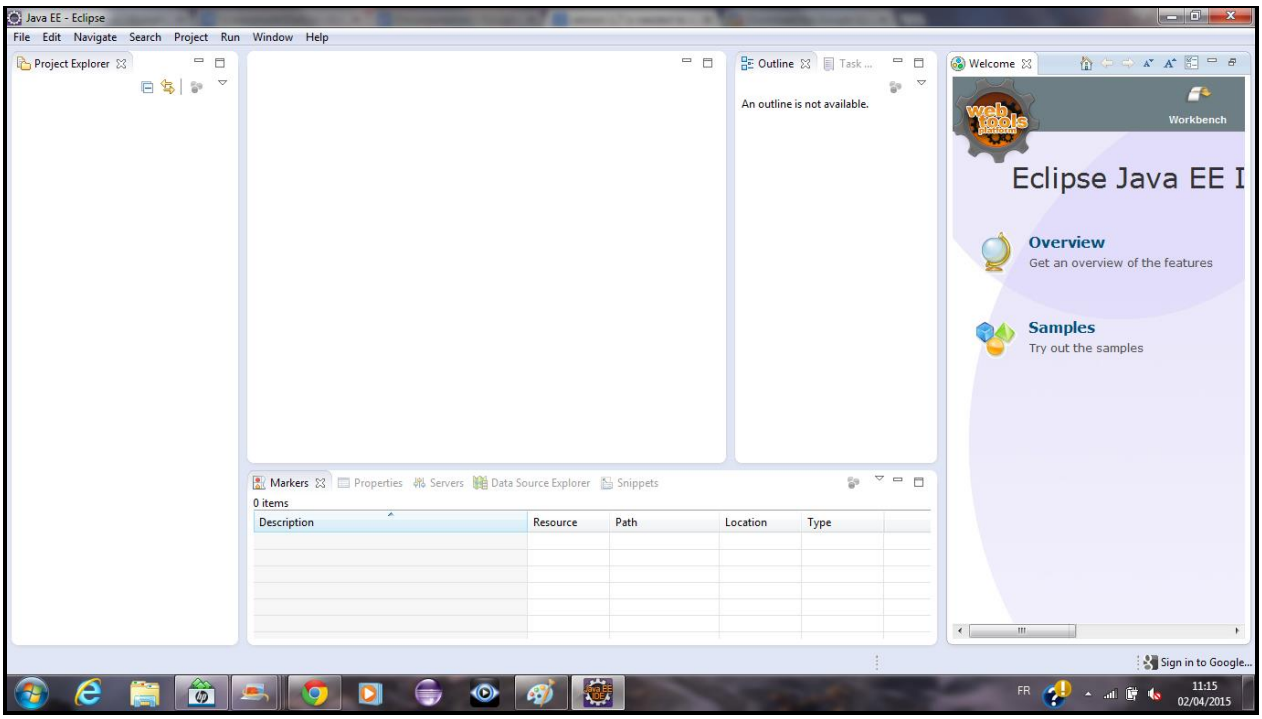


Figure 10. The eclipse workspace is empty

3. Use the default Eclipse workspace

Eclipse installed by default a workspace: E:\Workspace.

In this case, close Eclipse, copy the workspace with the m3 project and replace the default workspace with this workspace.

Result expected:

4. Optional: Reference your own workspace

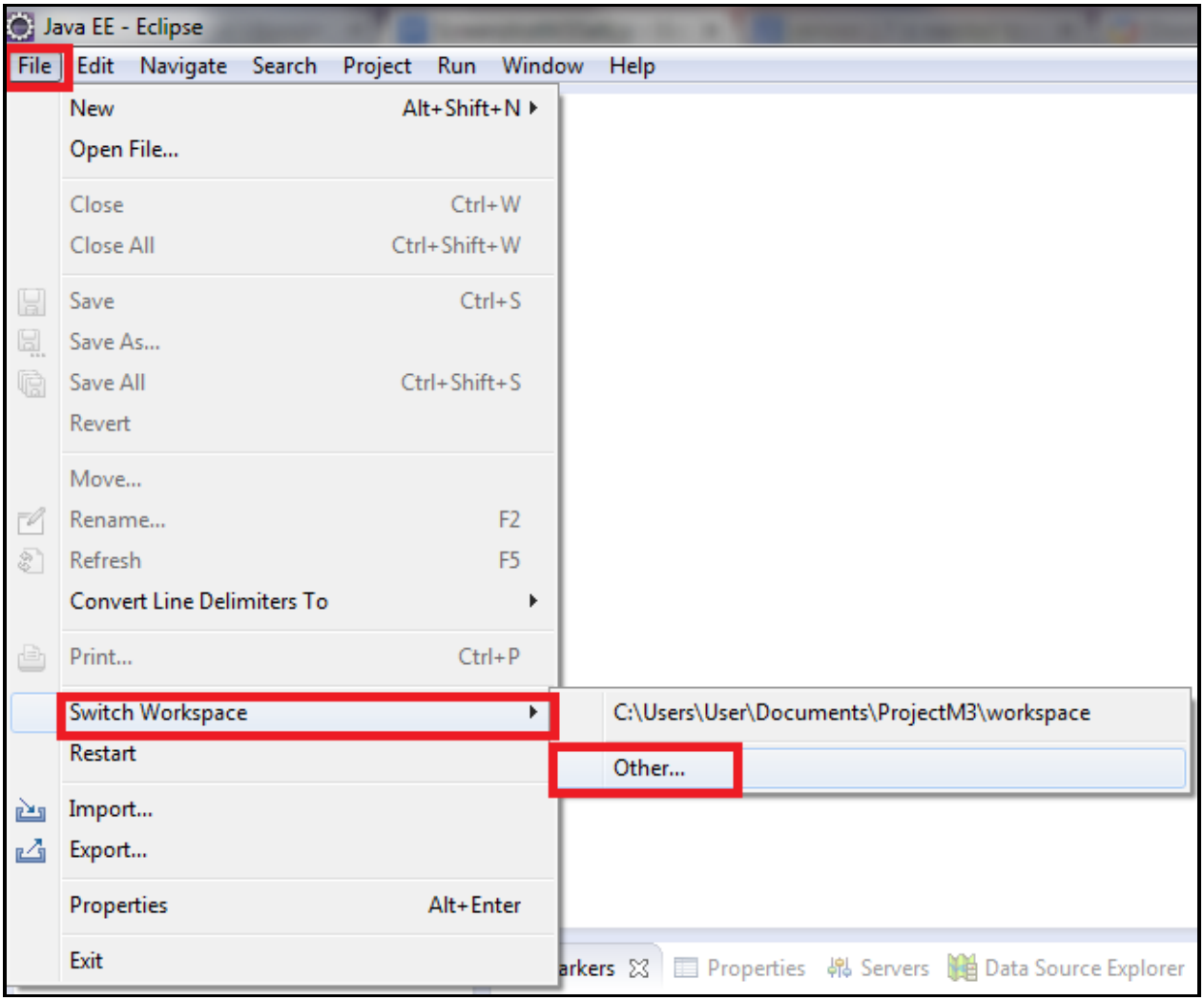


Figure 11. Switch workspace to reference the M3 project

We referenced the existing M3 workspace and not the one by default:

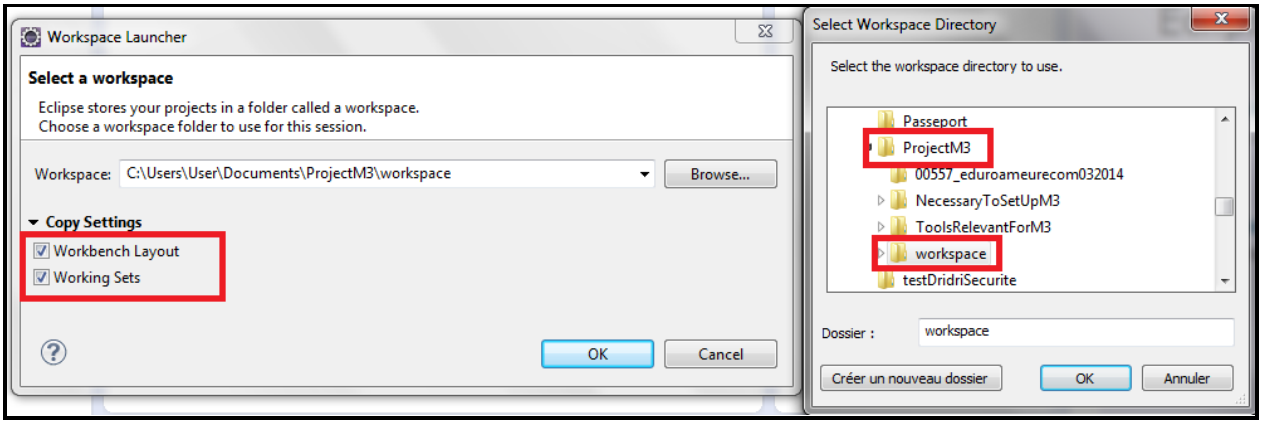


Figure 12. Reference the M3 project

5. Result expected: Check that you can see the M3 project

You should have the following screenshot:

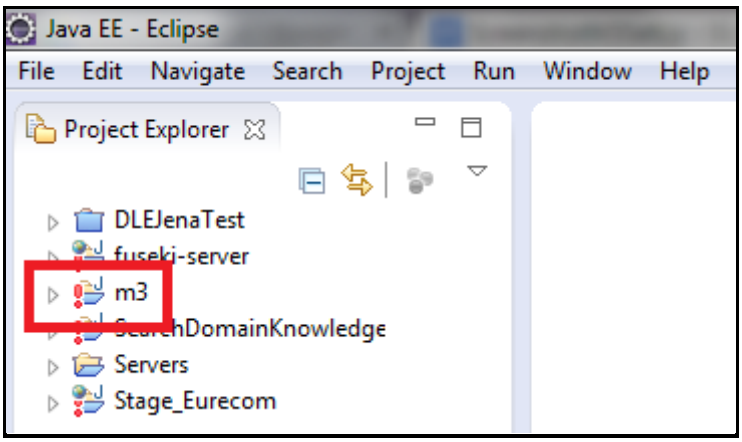


Figure 13. The M3 project in the Eclipse workspace

VIII. (Optional) Install the Google Plugin for Eclipse

In case you encounter some issues, you can follow this tutorial:
https://cloud.google.com/appengine/docs/java/tools/eclipse

We do not remember why, but we have to change the default setting of Google:
M3 project -> Right Click -> Google -> App Engine Settings
➔ Choose DataNucleus JPO/JPA version v1

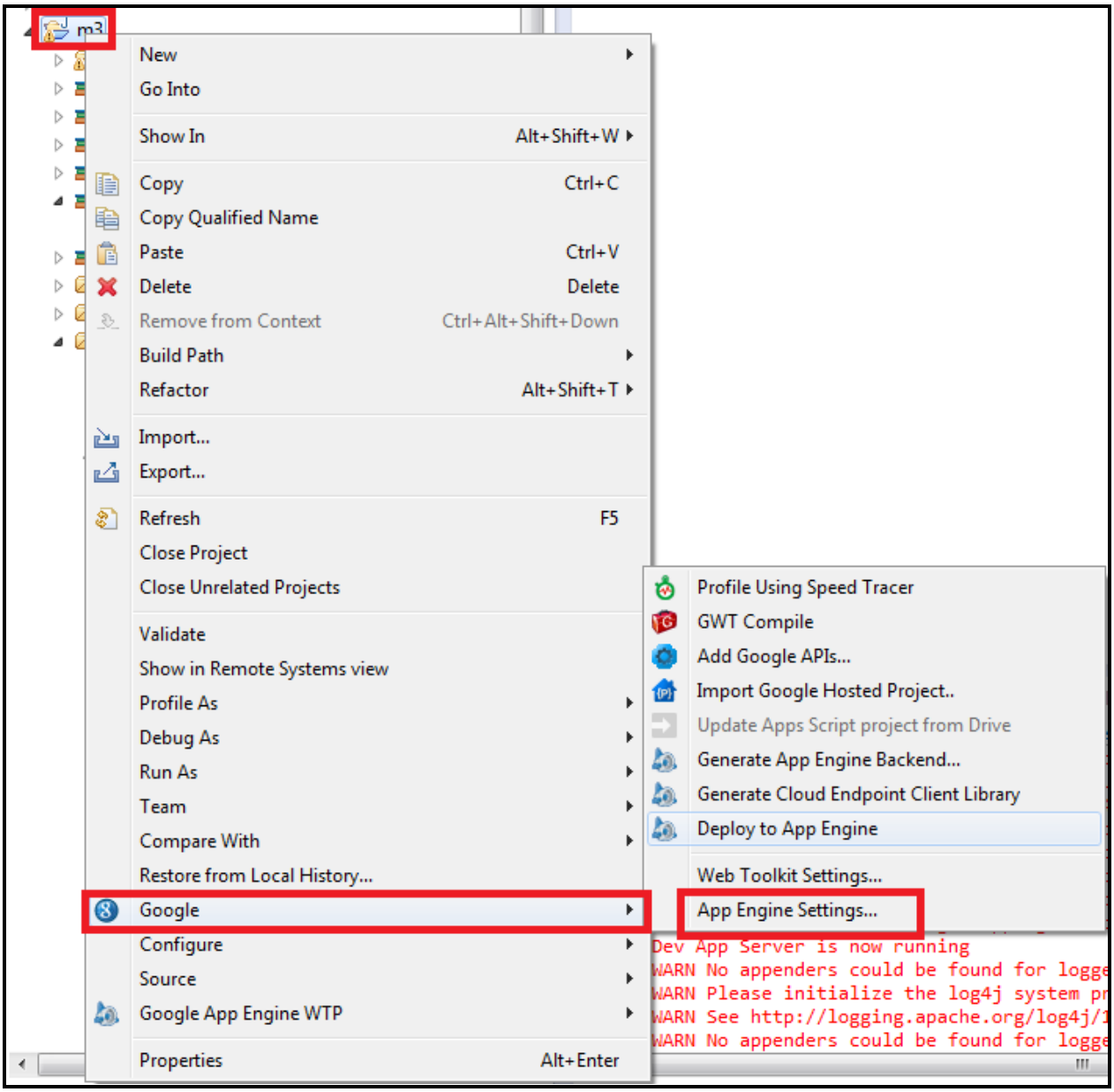


Figure 14. Google App Engine settings

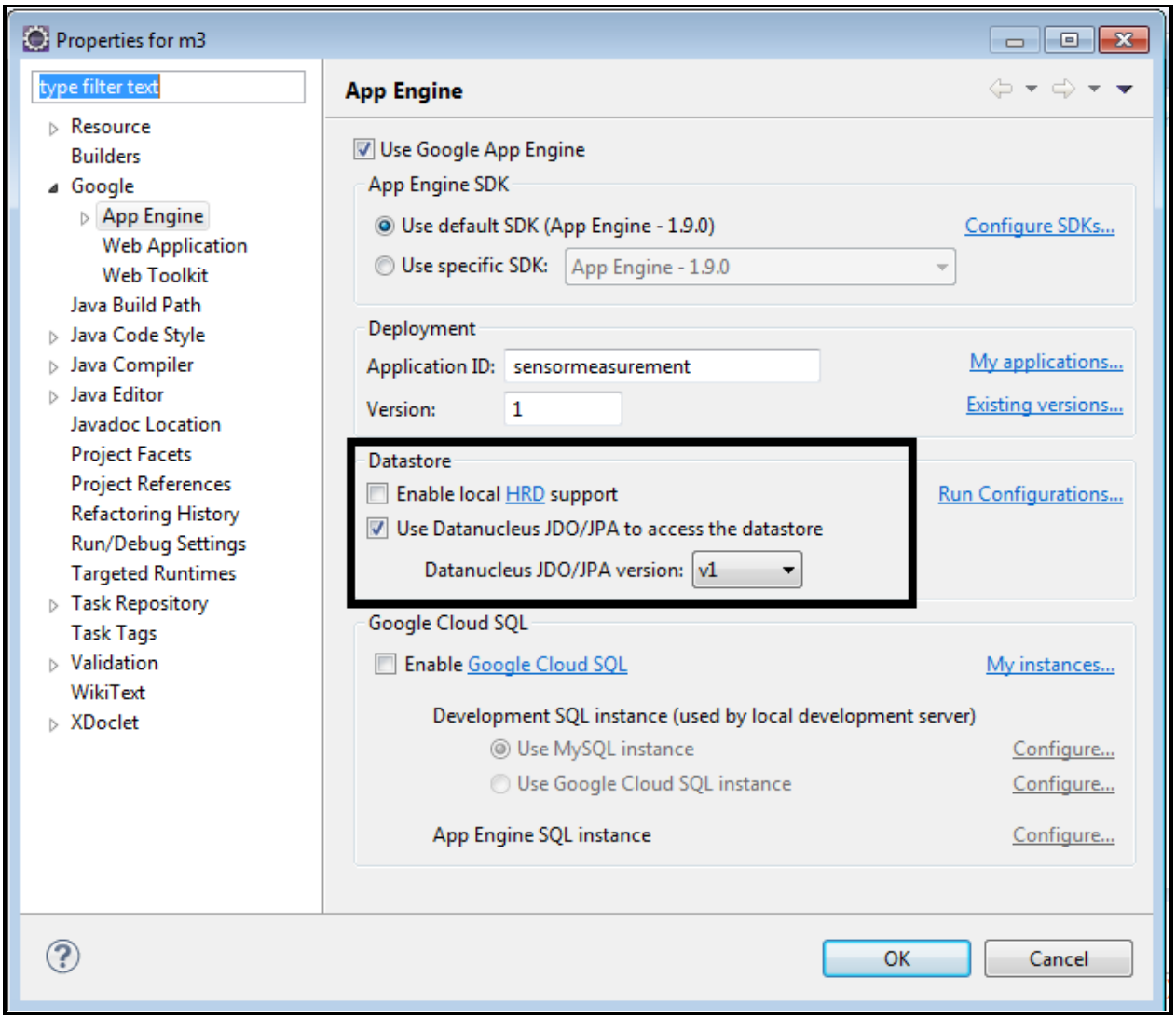


Figure 15. Check that the Datanucleus JPP/JPA is V1

Part III : Running the M3 project on localhost

I. Discover the M3 project and run it

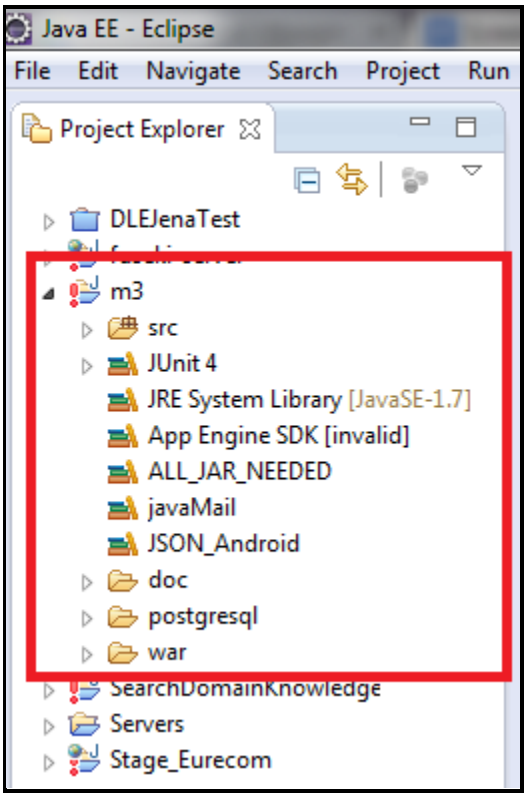


Figure 16. Open the M3 project

In case, it does not appear:

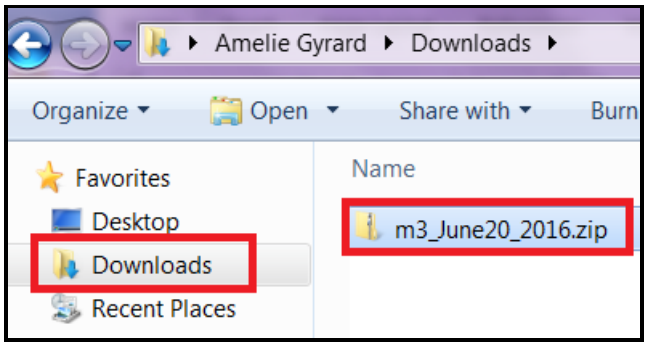


Figure 17. Download the M3 code zip file.

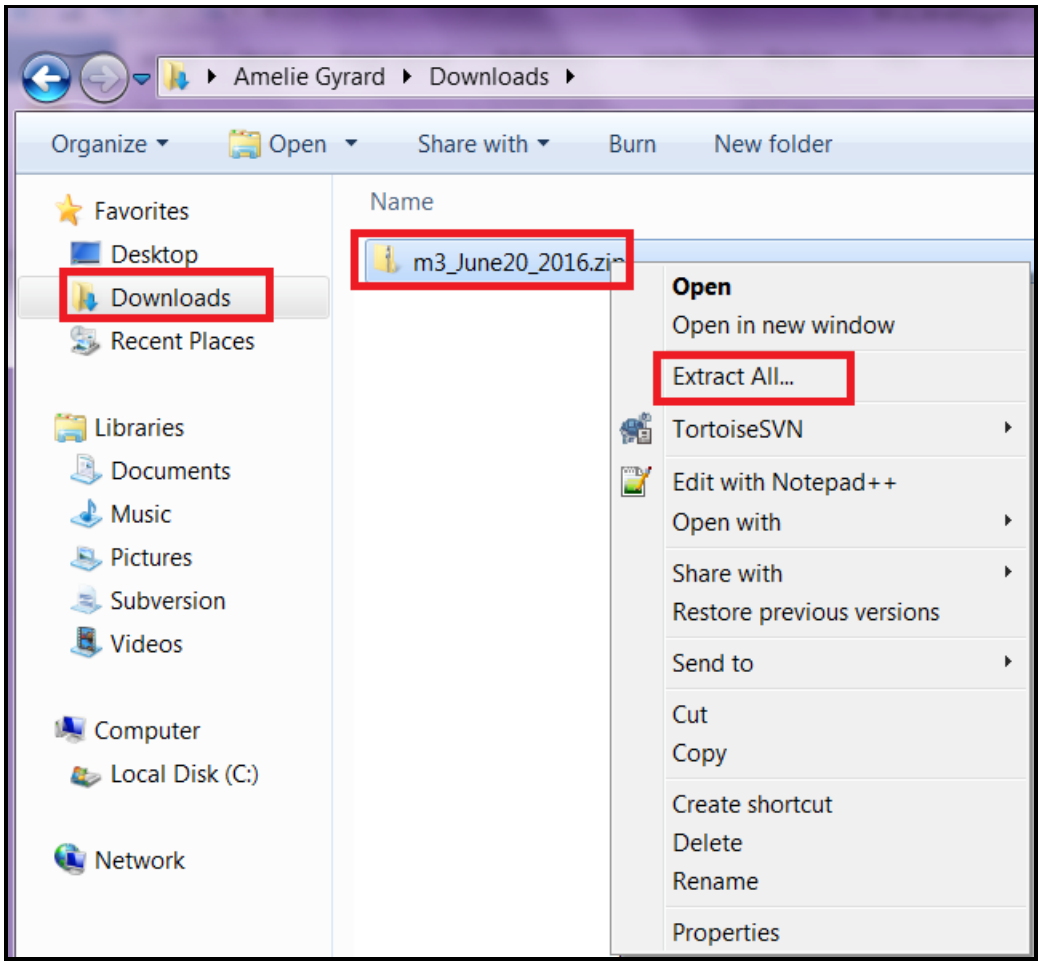


Figure 18. Extract the M3 code

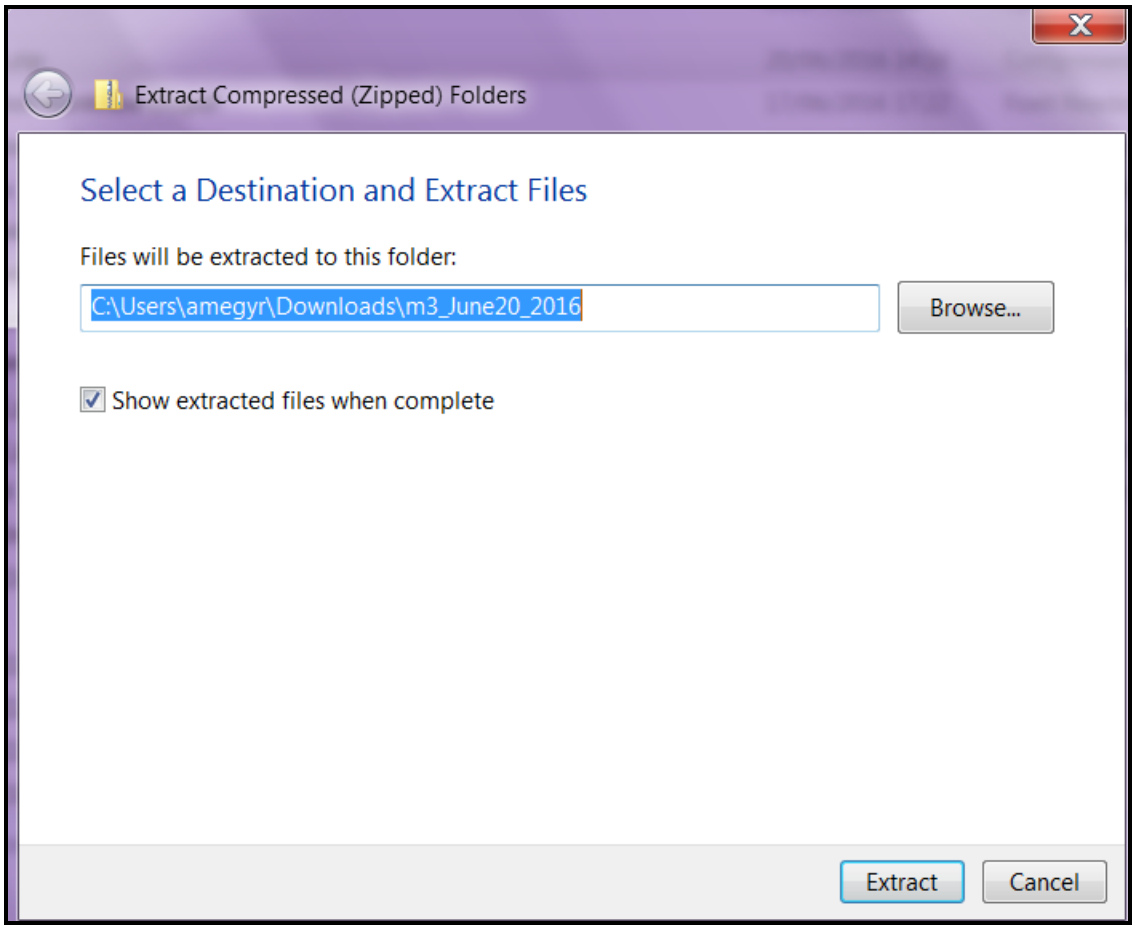


Figure 19. Extract the M3 code

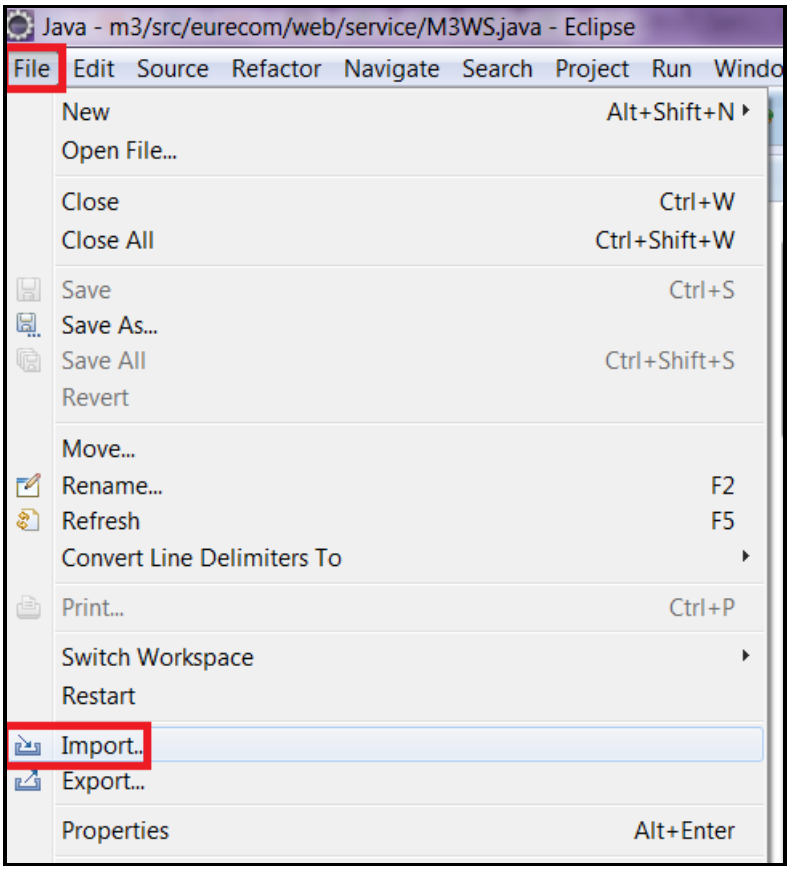


Figure 20. File -> Import a new project

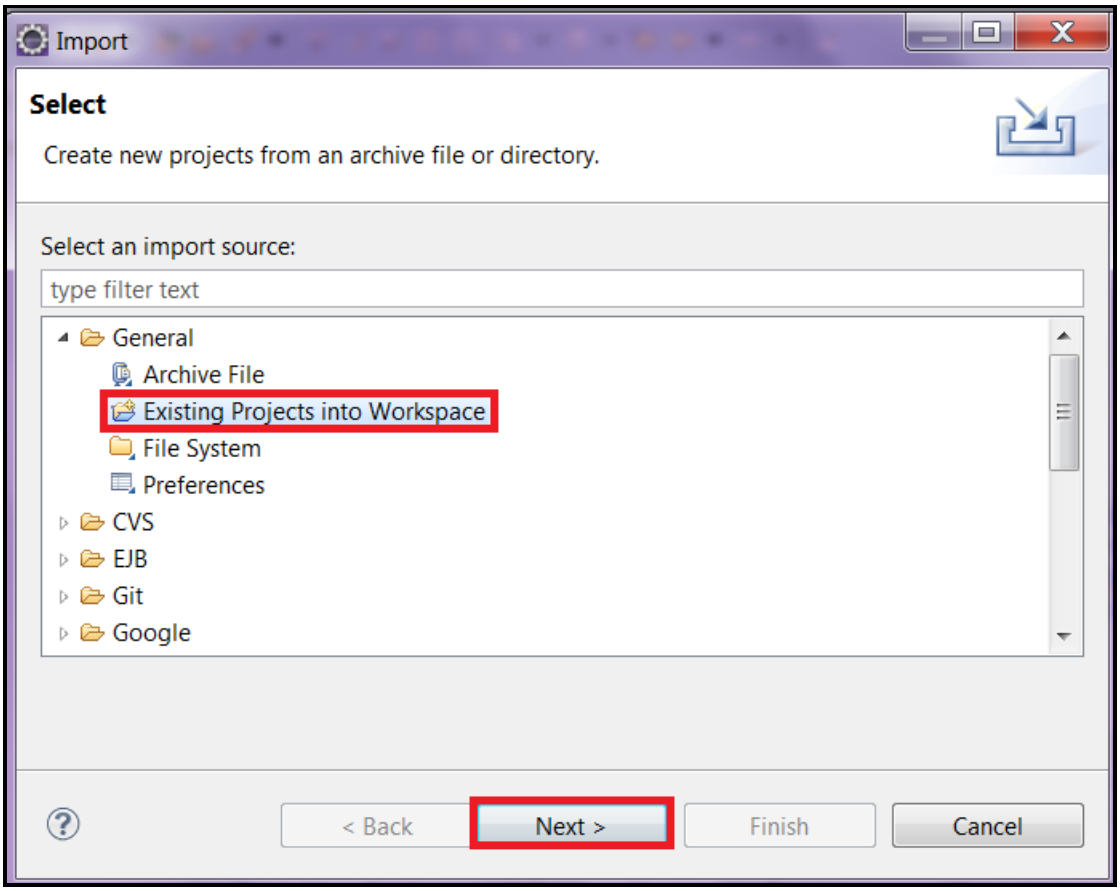


Figure 21. Import a new project within Eclipse

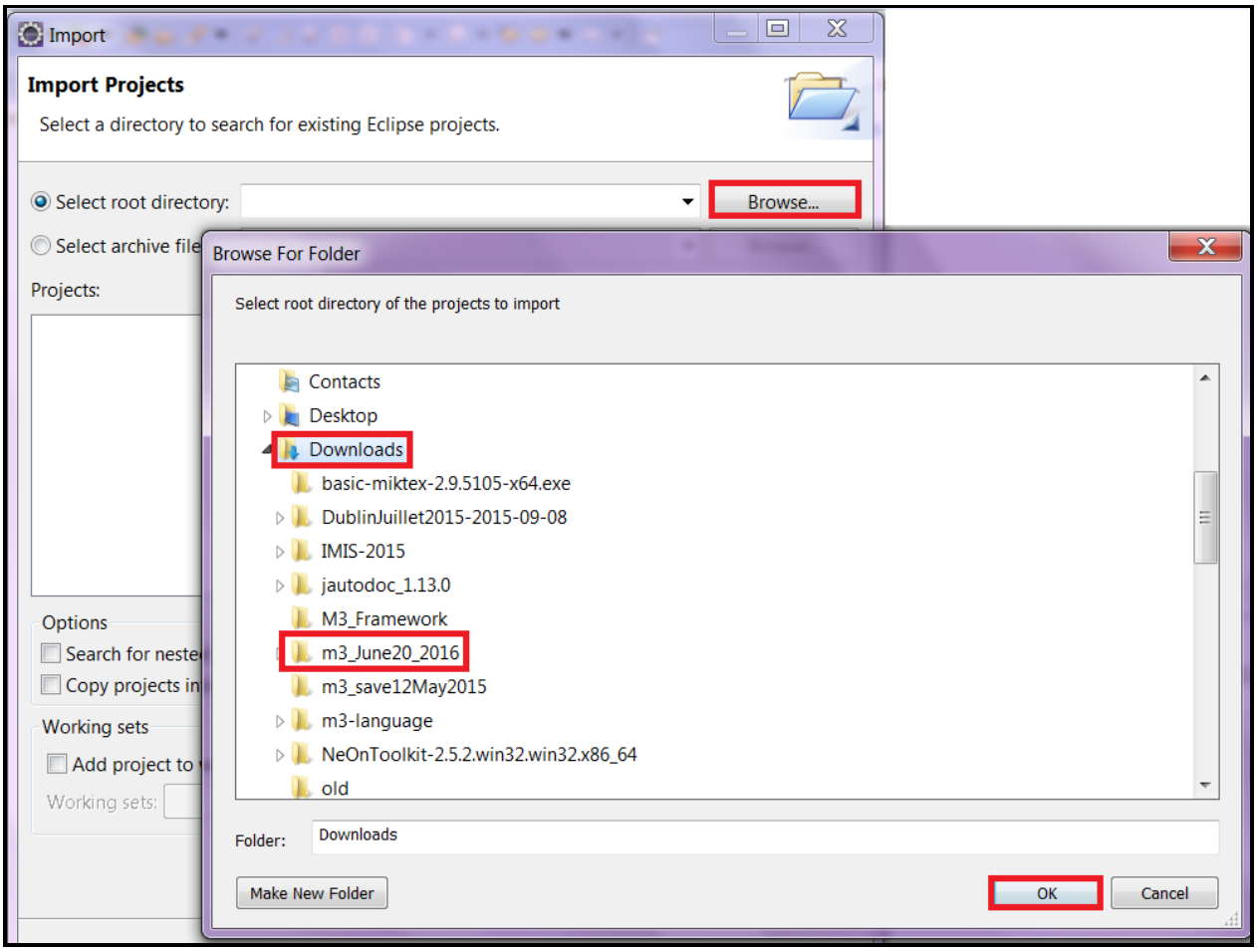


Figure 22. Import M3 code within Eclipse

We have to fix the following issues:

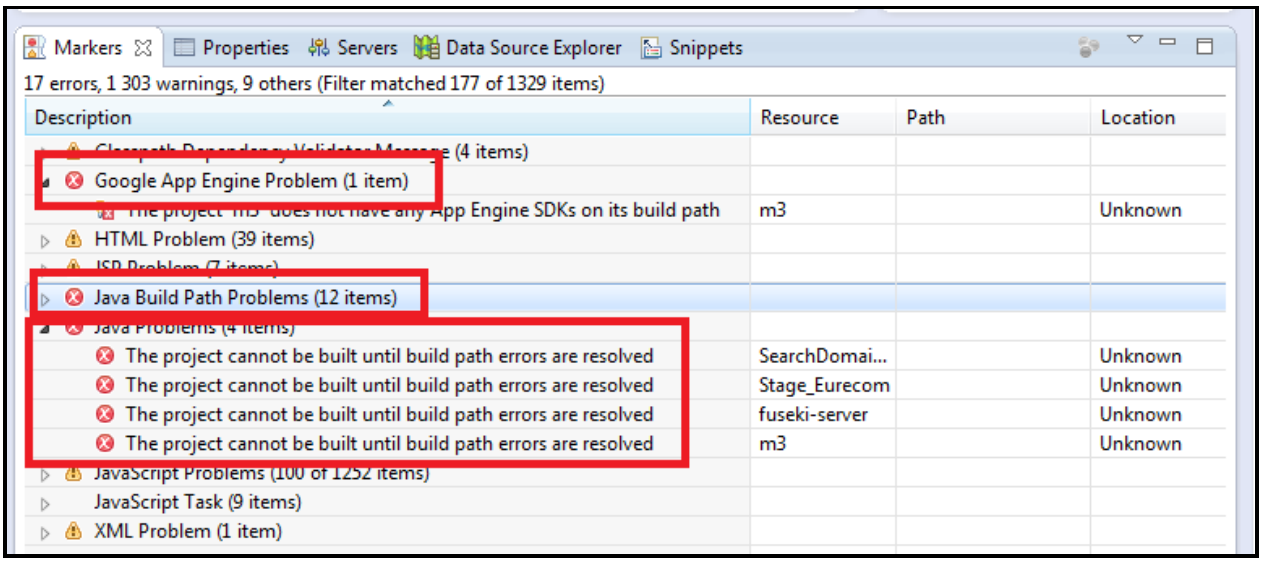


Figure 23. Fix issues to run the M3 project

II. Integrating all Jars requires (Solve Java Build Path Problems)

Fixing Google App Engine Problem (Java Build Path Problems)

Two solutions:

1) Copy/Paste the JAR directory that we provided in the M3 project
2) or Modify the Build Path

Modify the build path:

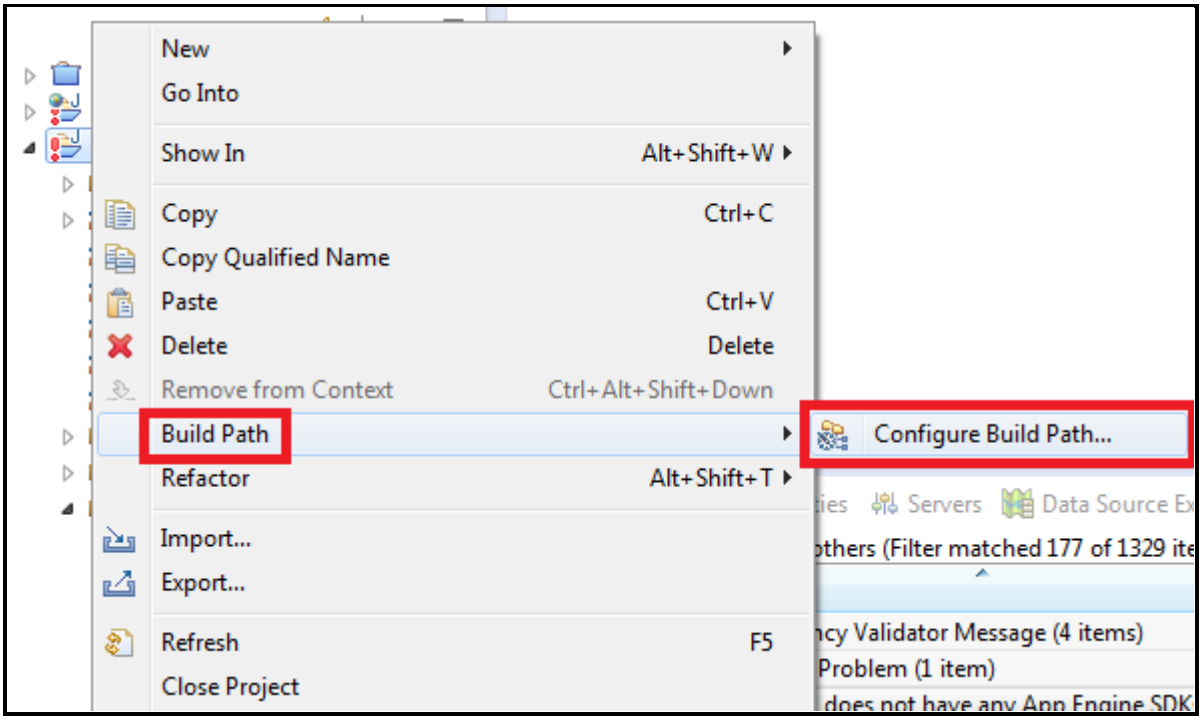


Figure 24. Modify the build paths to reference the JARs required

Modify the build path of all jar libraries:

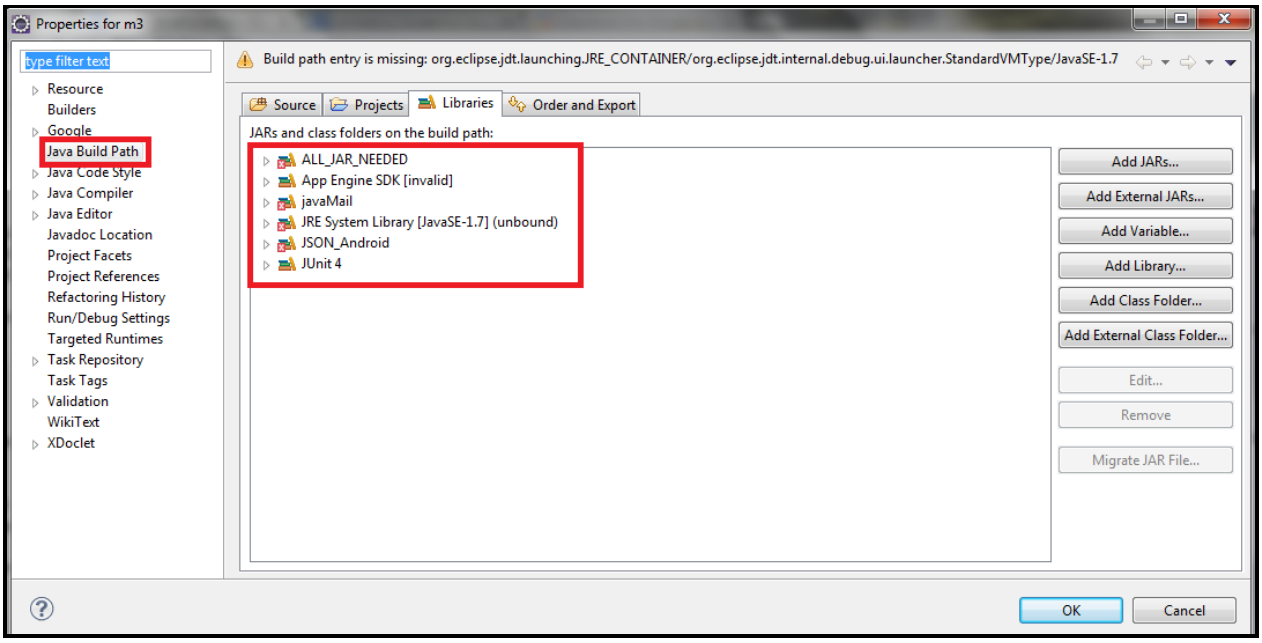


Figure 25. Add the JARs required

Add all jars required, that are available in the JAR directory.

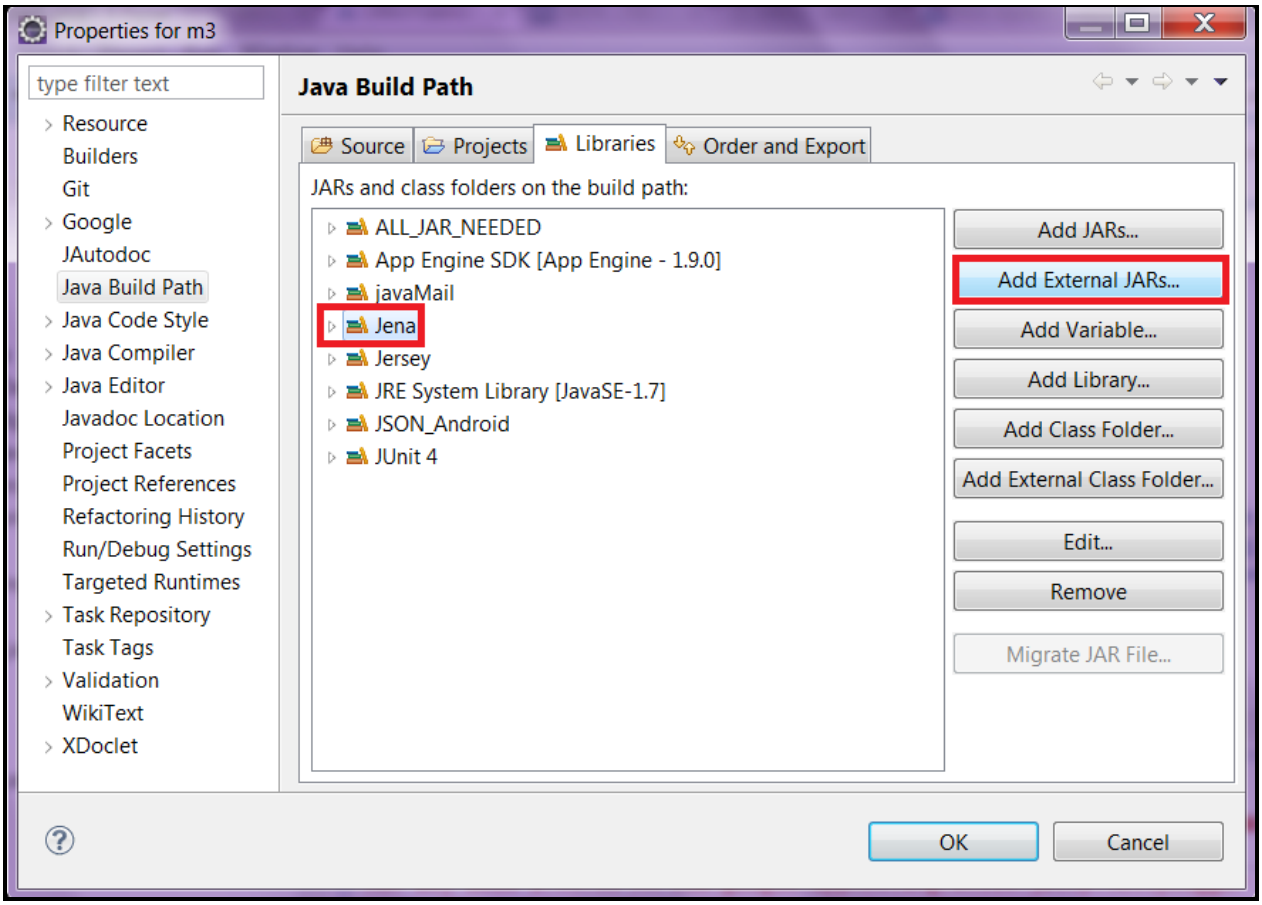


Figure 26. Import the jena library

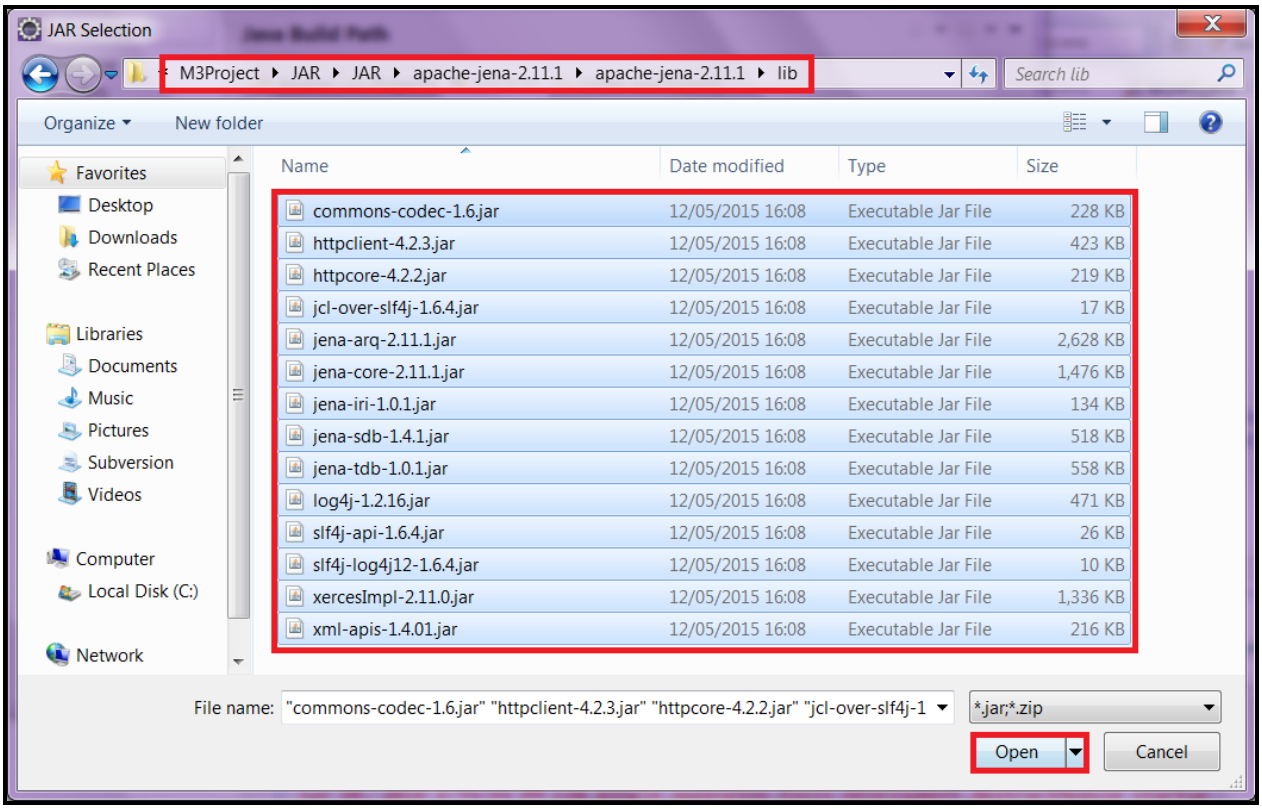


Figure 27. Import the jena library with all jar files

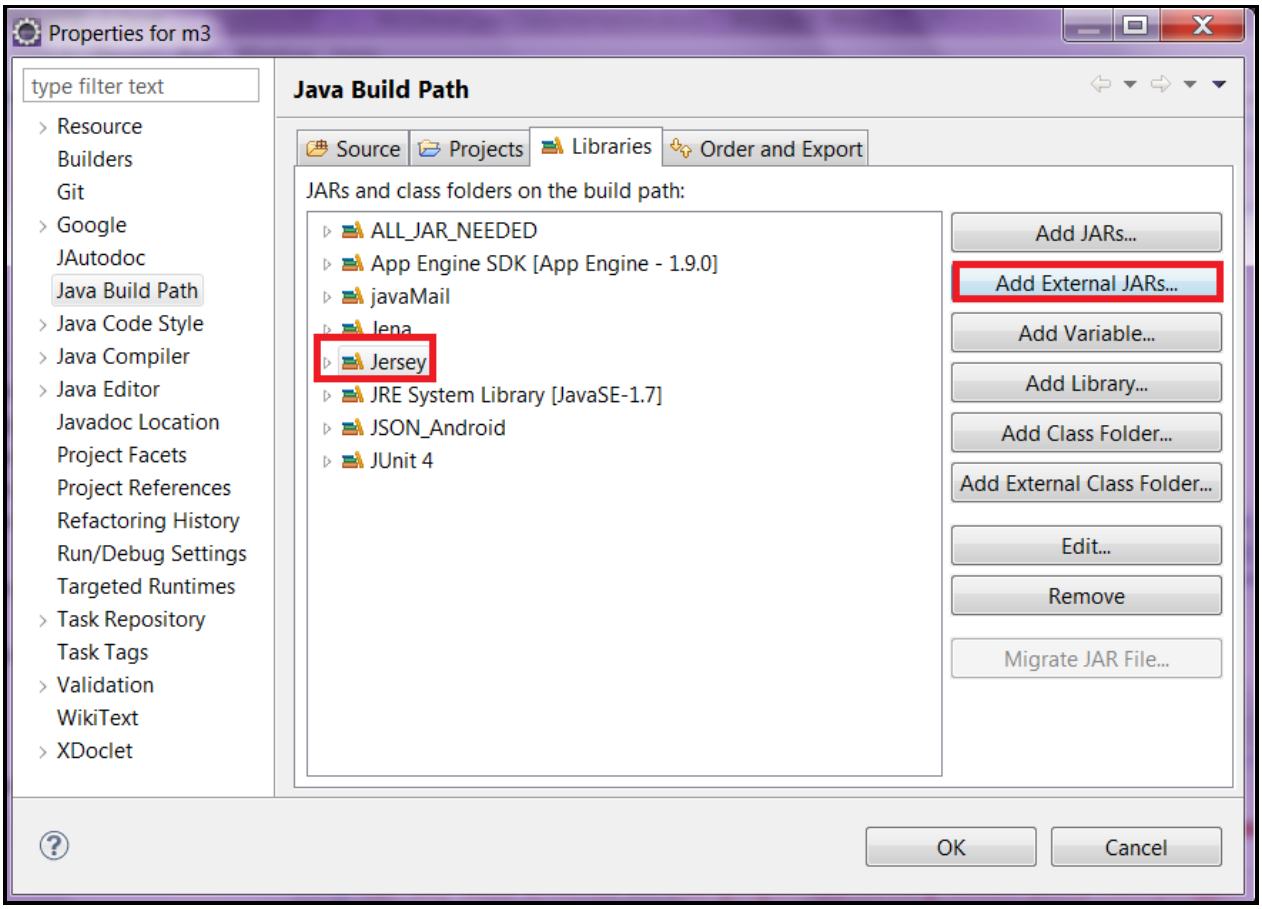


Figure 28. Import the Jersey (JAX-RS) library

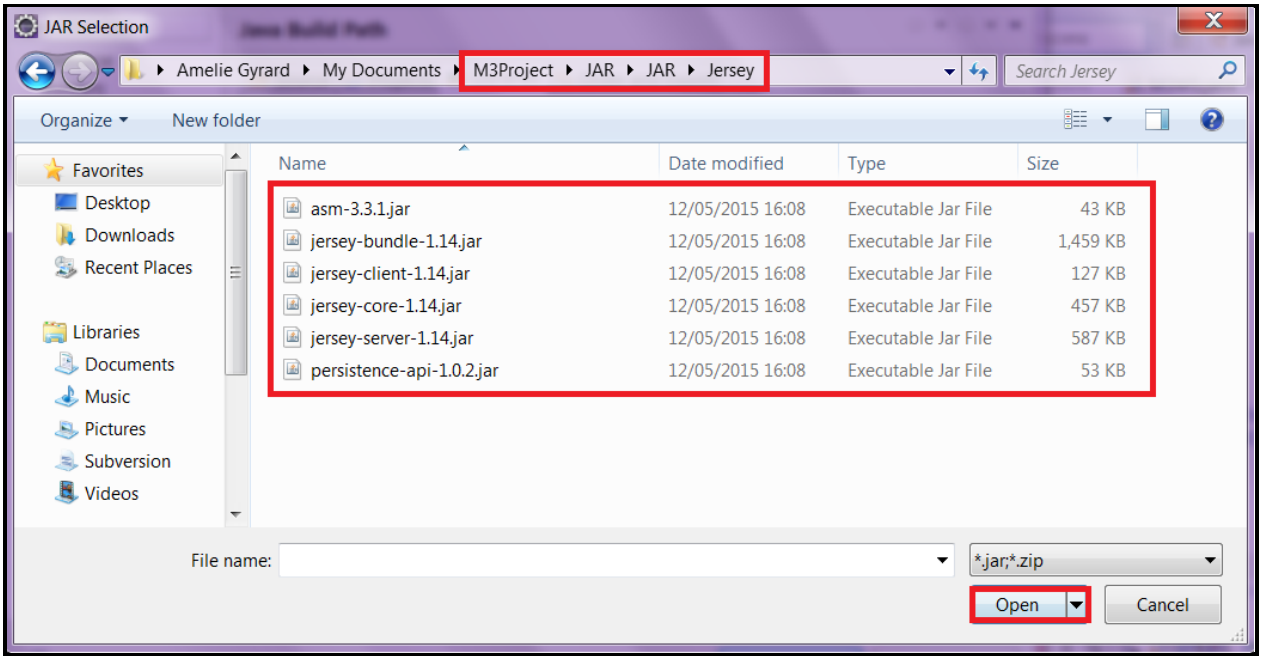


Figure 29. Import the Jersey (JAX-RS) library with all jar files

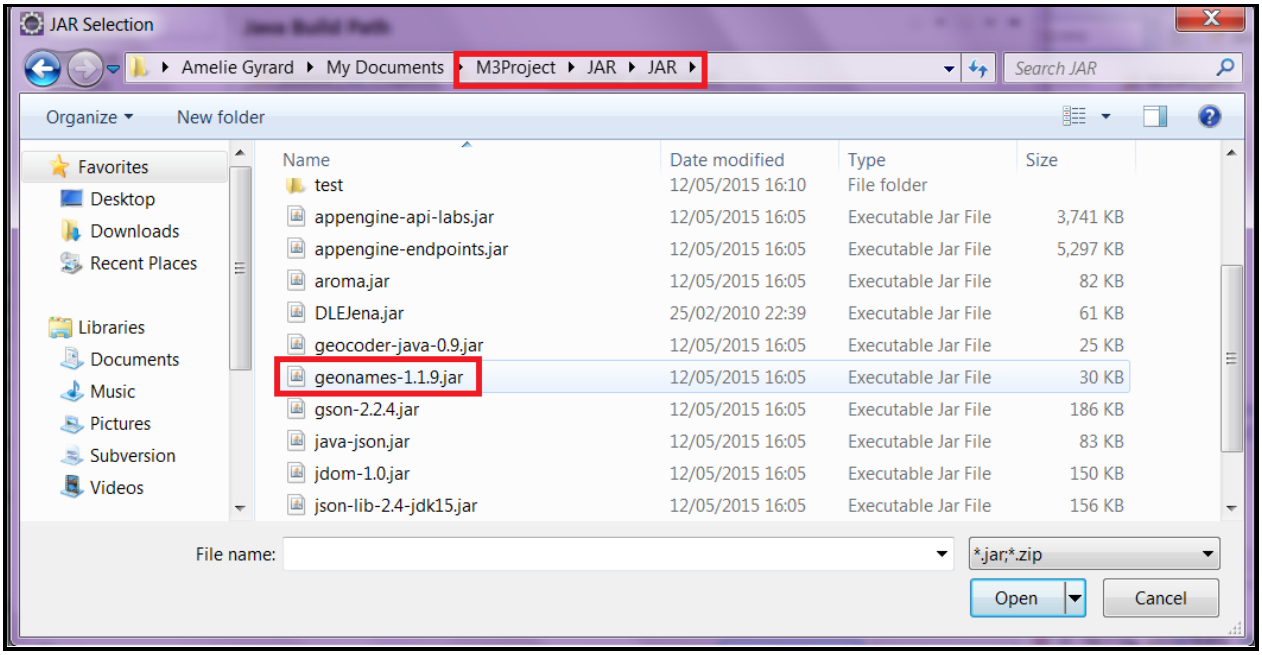


Figure 30. Import Geonames library

III. (Optional) Install Jena inside Eclipse

In case you encounter some issues, you can follow the following tutorial:
http://www.iandickinson.me.uk/articles/jena-eclipse-helloworld/

IV. Check that you have the Java Compiler 1.7 within Eclipse

In case you encounter some trouble to run the project, check that you have the right Java compiler 1.7 as follows.

Did your run the JDK 1.7 that I provided in the NecessaryToSepUpM3.
If not double click on it, and follow the instructions.

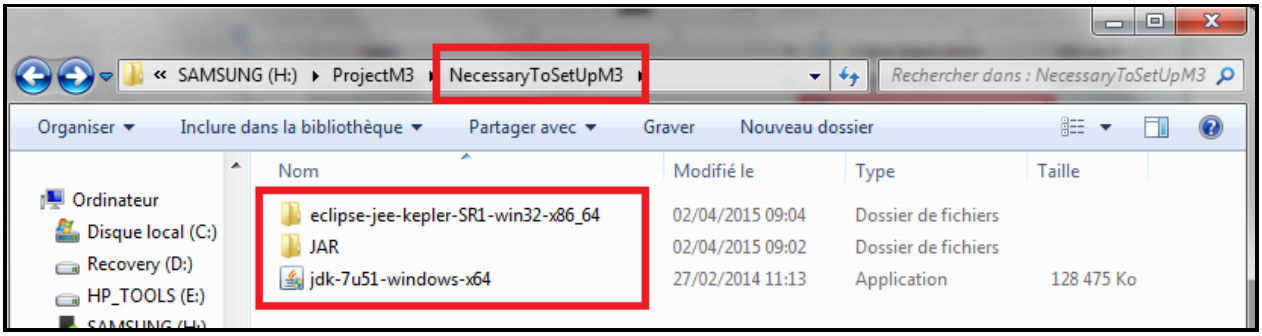
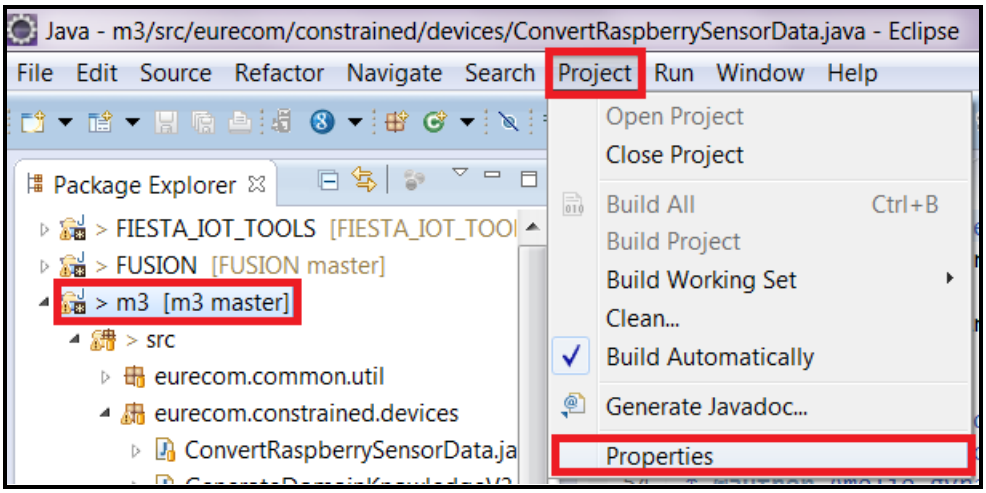


Figure 31. Check that you set up the JDK 1.7

Check that you are using the Compiler Java 1.7 within Eclipse as follows:



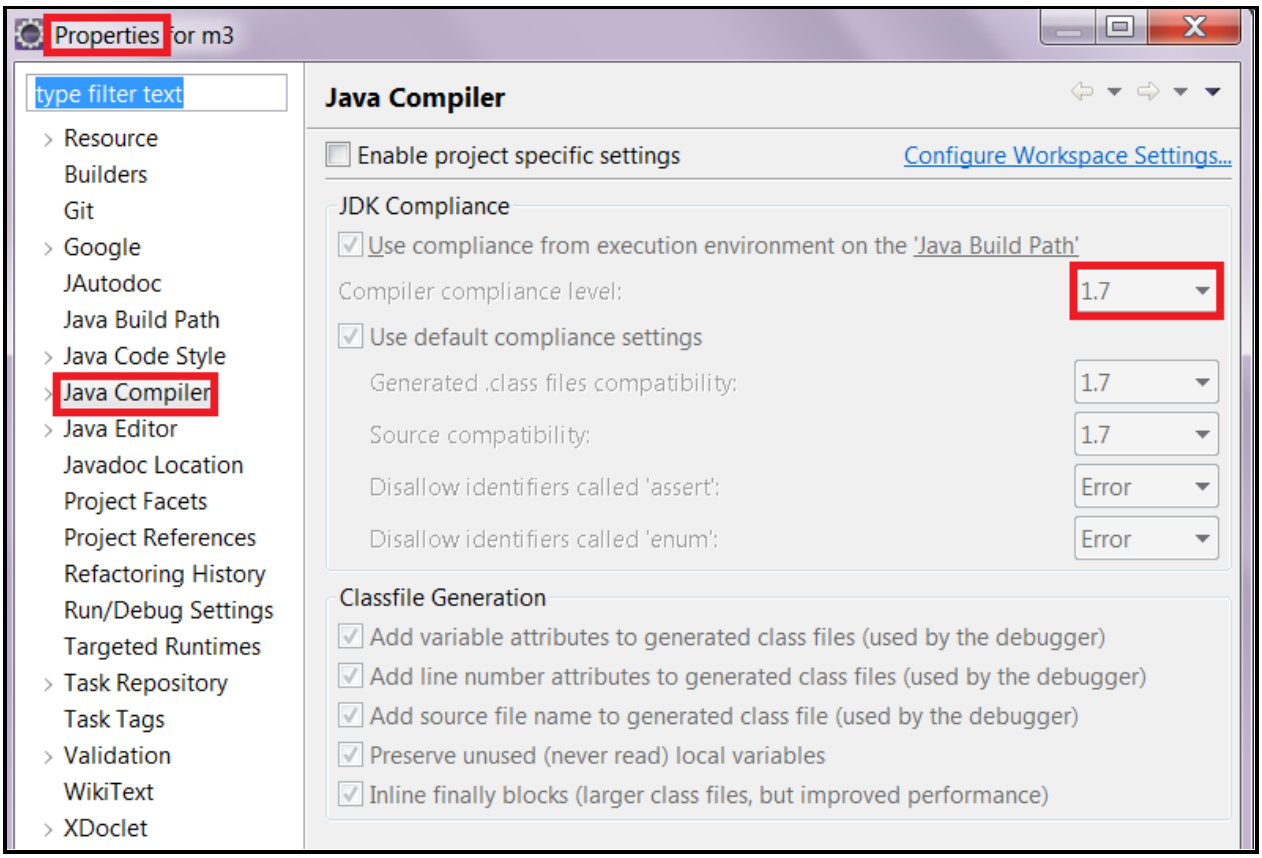


Figure 32. Check the Java compiler it should be 1.7

V. Run M3 on localhost

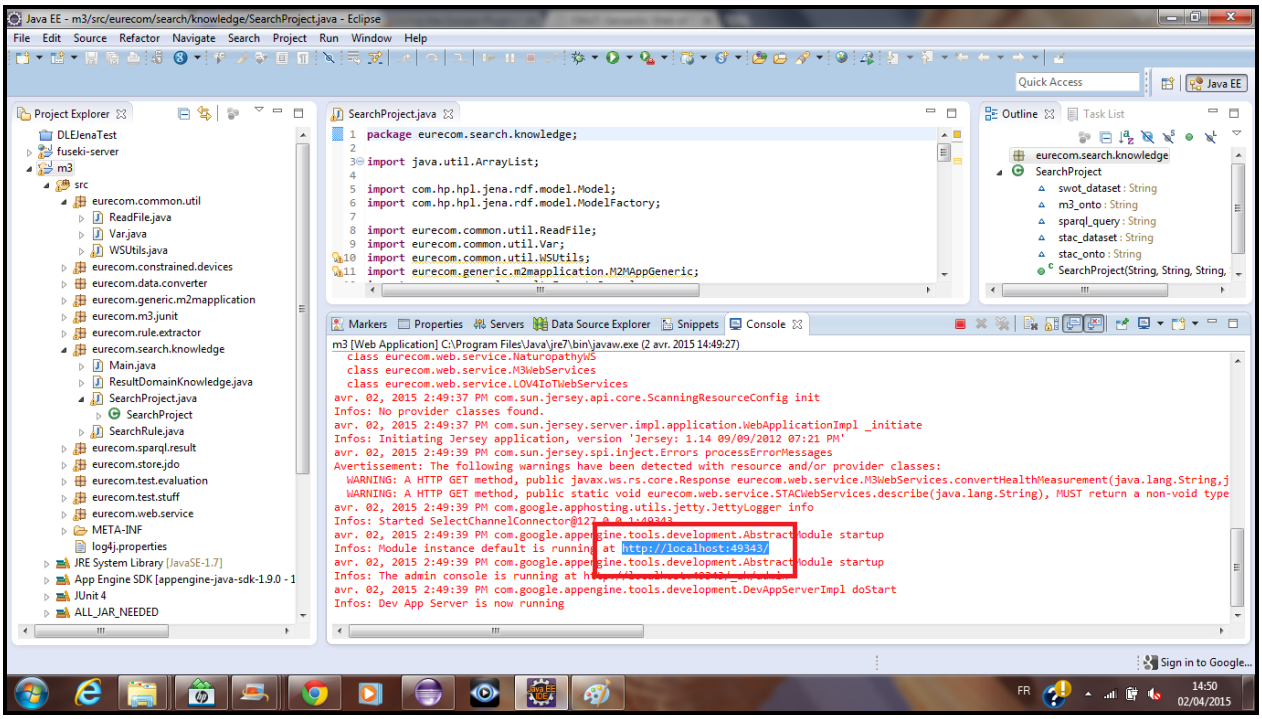


Figure 33. Get the localhost address

Copy paste the URL in red with the localhost address on the Browser (e.g., Chrome).

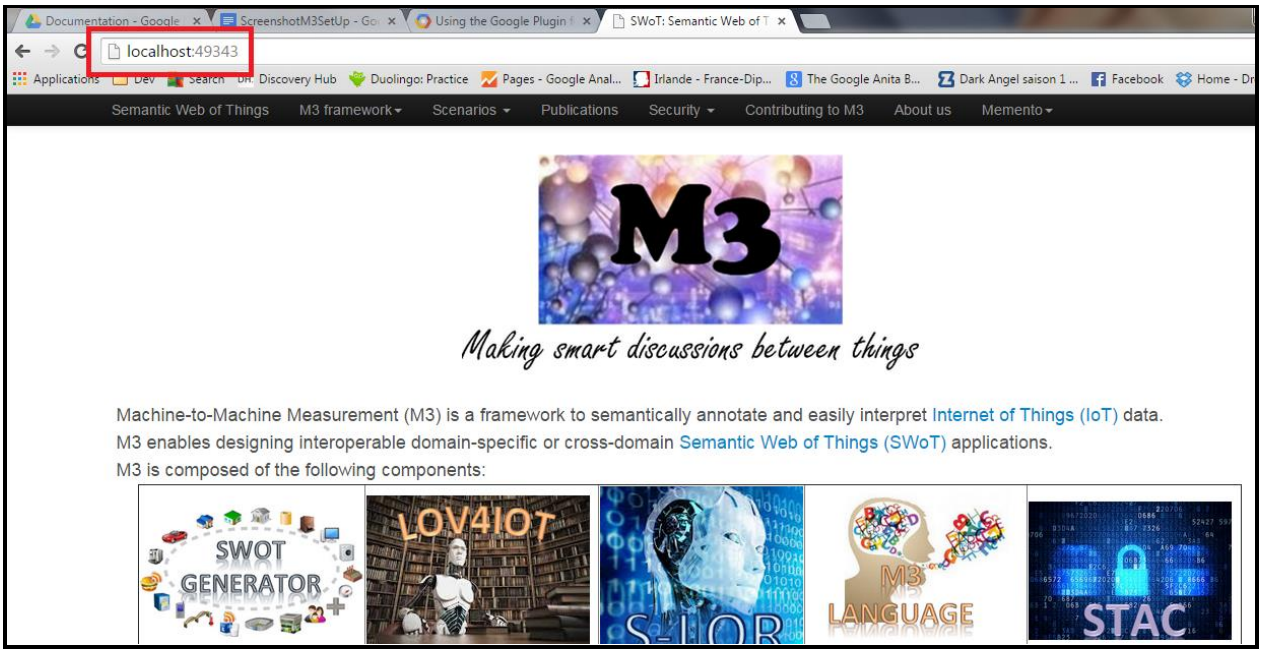


Figure 34. M3 is running on localhost, it works!

Part IV : Deploying M3 on the Web (Optional)

Right click on the M3 project on Eclipse:

- ➔ Select Google
- ➔ Select App Engine Settings

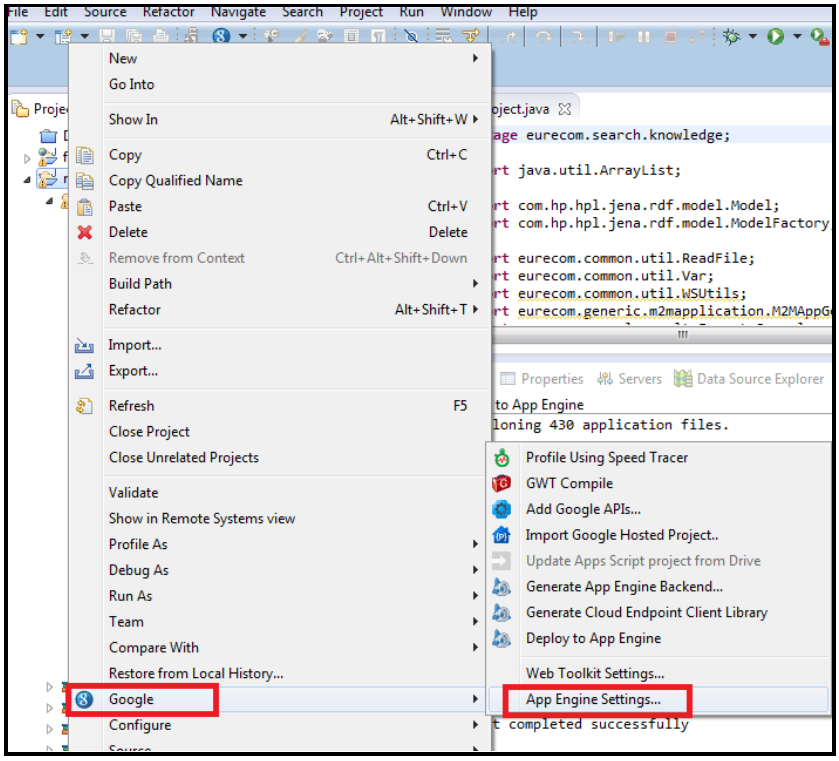


Figure 35. Check Google App Settings

- ➔ You will have the following screen. In the Application ID enter **securitytoolbox**, this is the web site to try it. For this, we need to give you access rights in case you are collaborating on this project.
- ➔ Otherwise, you can create your own hostname. Please follow the documentation to deploy you app engine with Google[3].
- ➔ Click OK

[3] https://developers.google.com/eclipse/docs/appengine_deploy

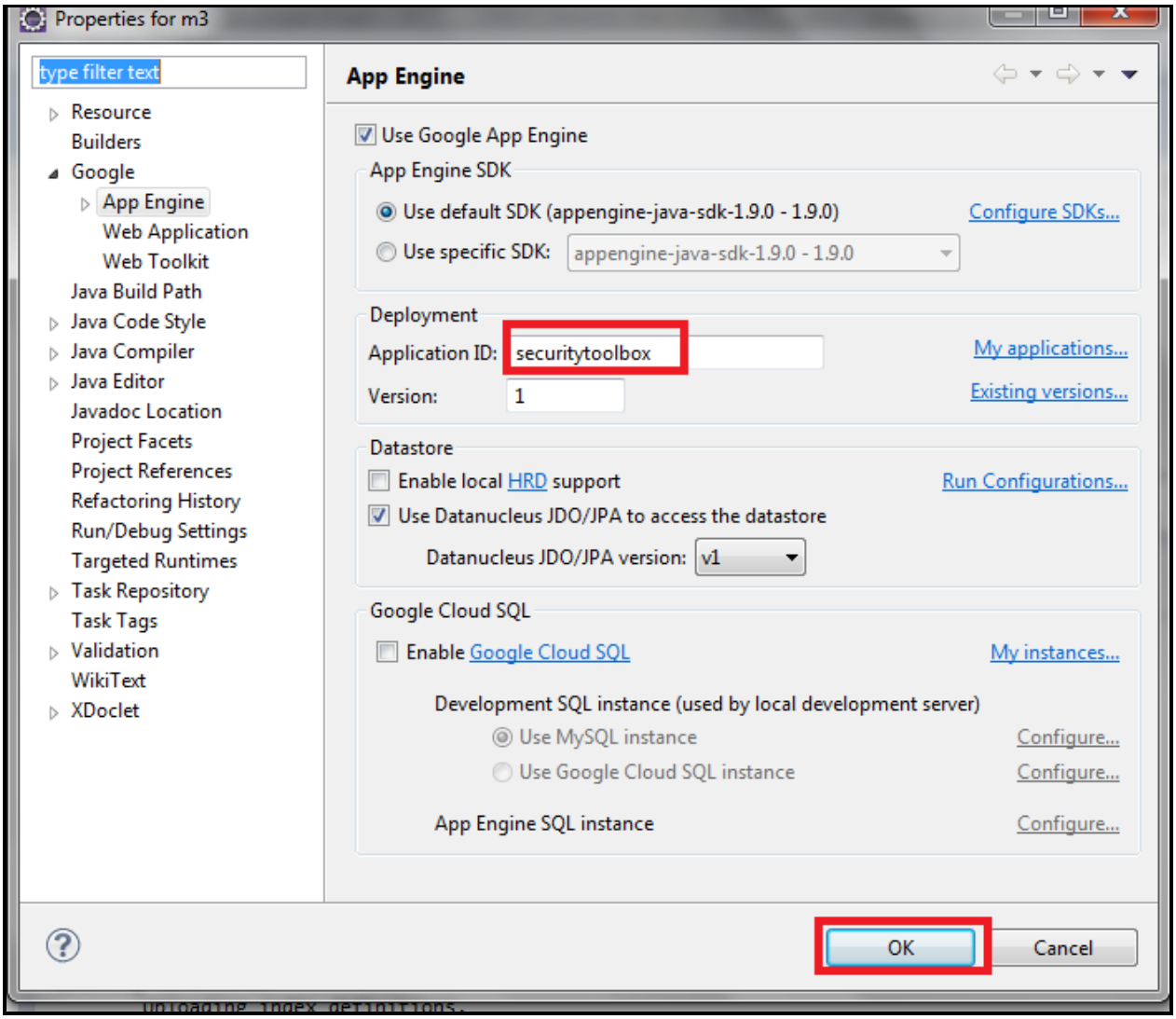


Figure 36. Indicate the name of the application where it will be deployed on the Web

Then right click on M3 again:

- ➔ Select Google
- ➔ Select Deploy to App Engine

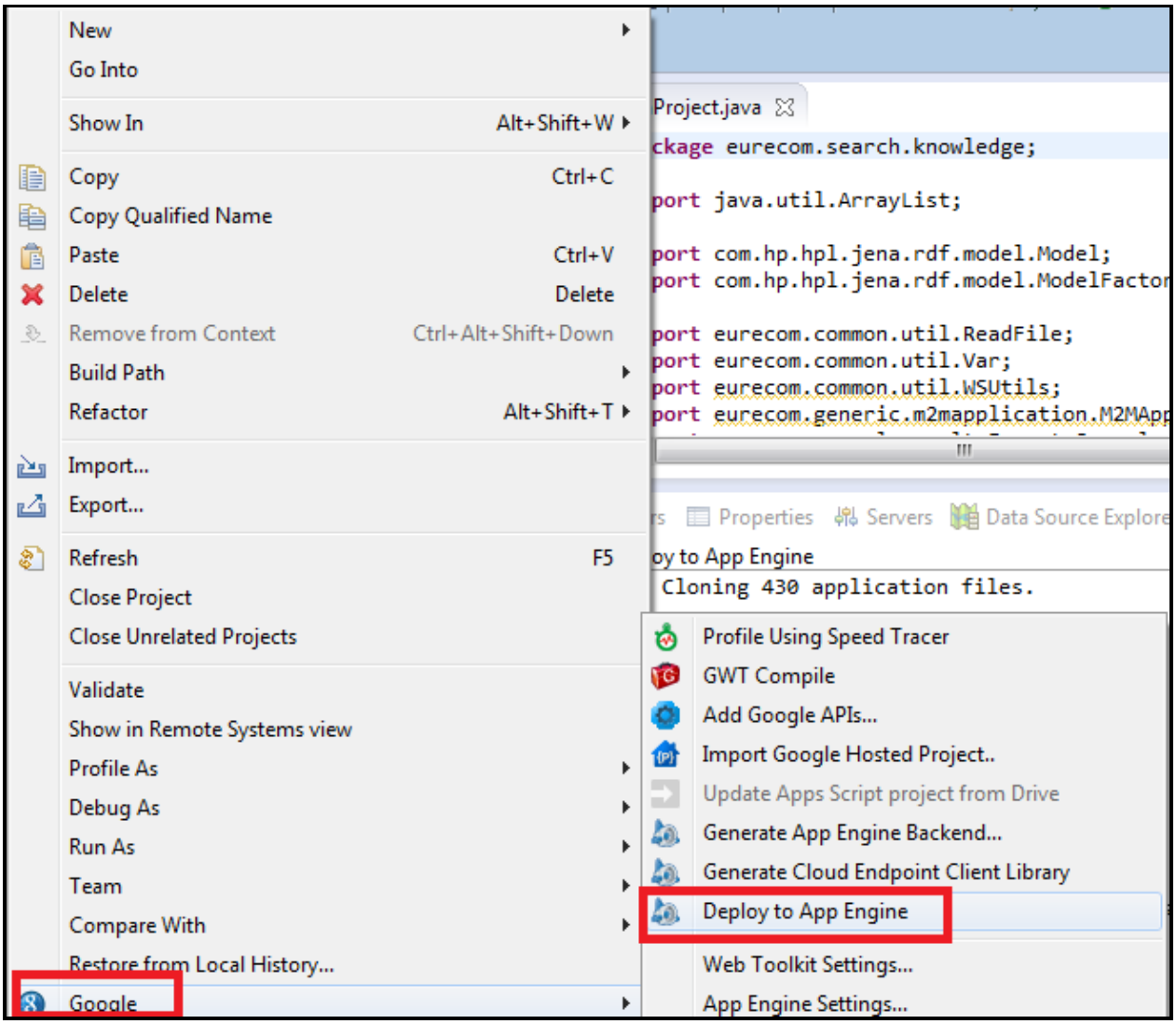


Figure 37. Deploy the M3 project on the web

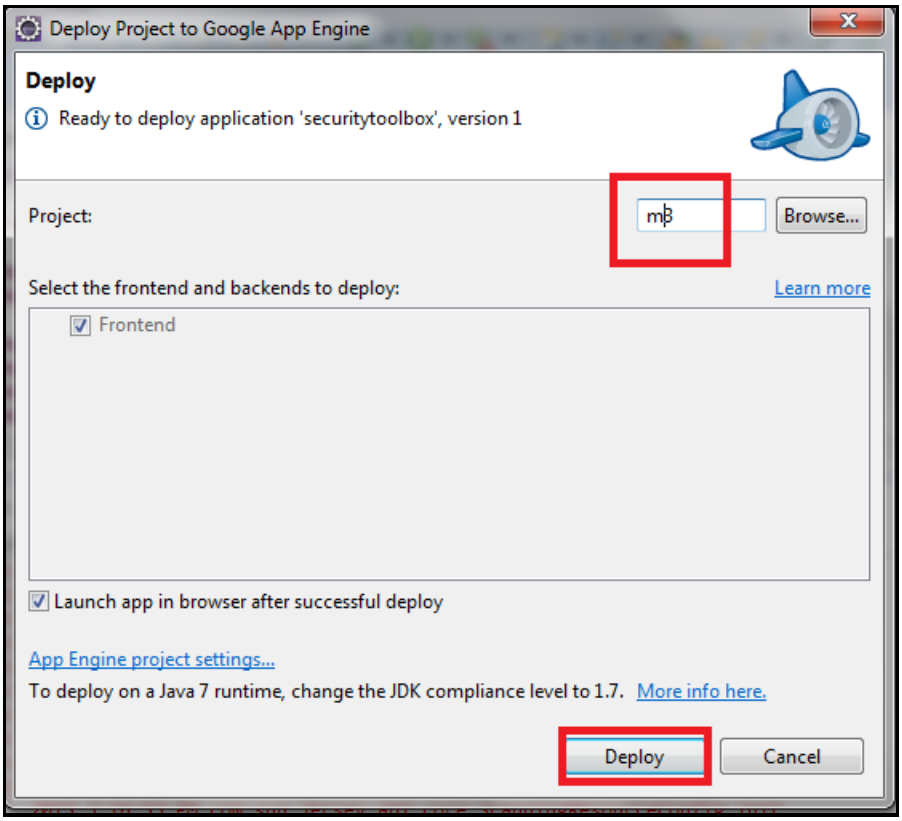


Figure 38. Confirm that you deploy the M3 project on the web

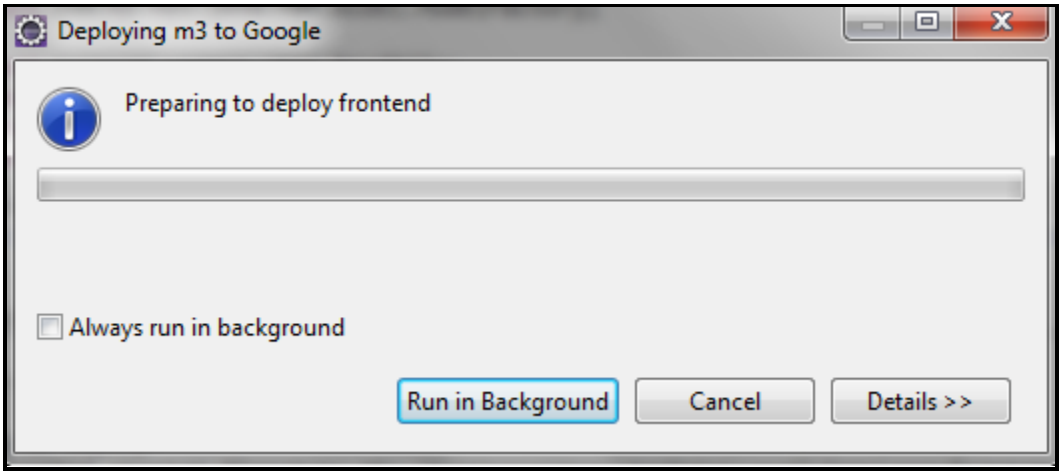


Figure 39. Wait, M3 is deploying on the web

Google will ask you to authenticate, you need to be authenticated on the project.

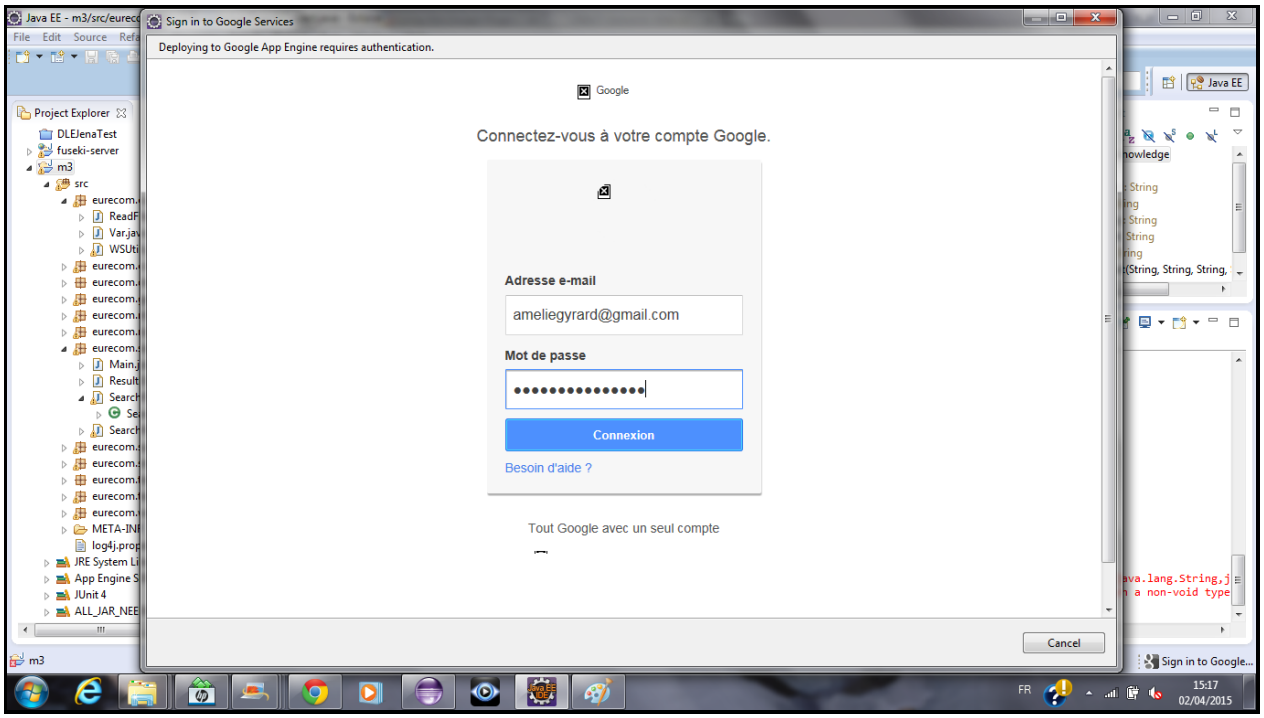


Figure 40. Authenticate yourself with Google App Engine

➔ Click on the button Accept:

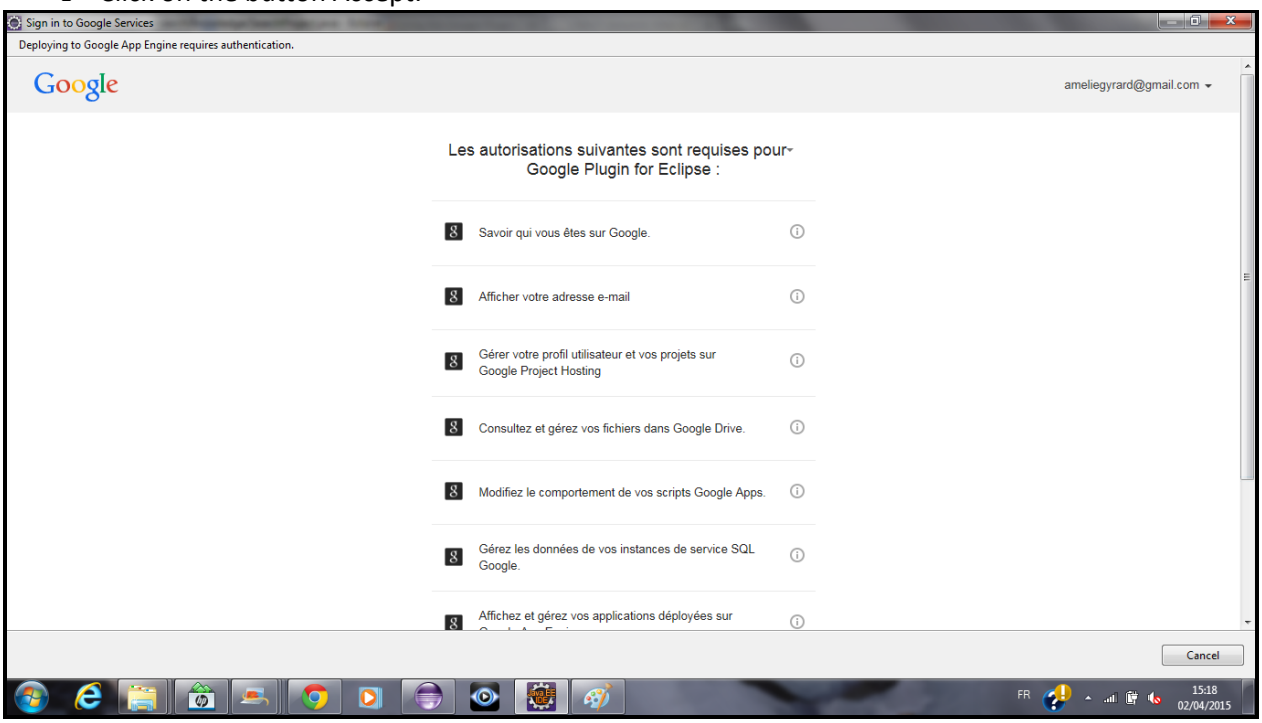


Figure 41. Accept the authentication on Google App Engine

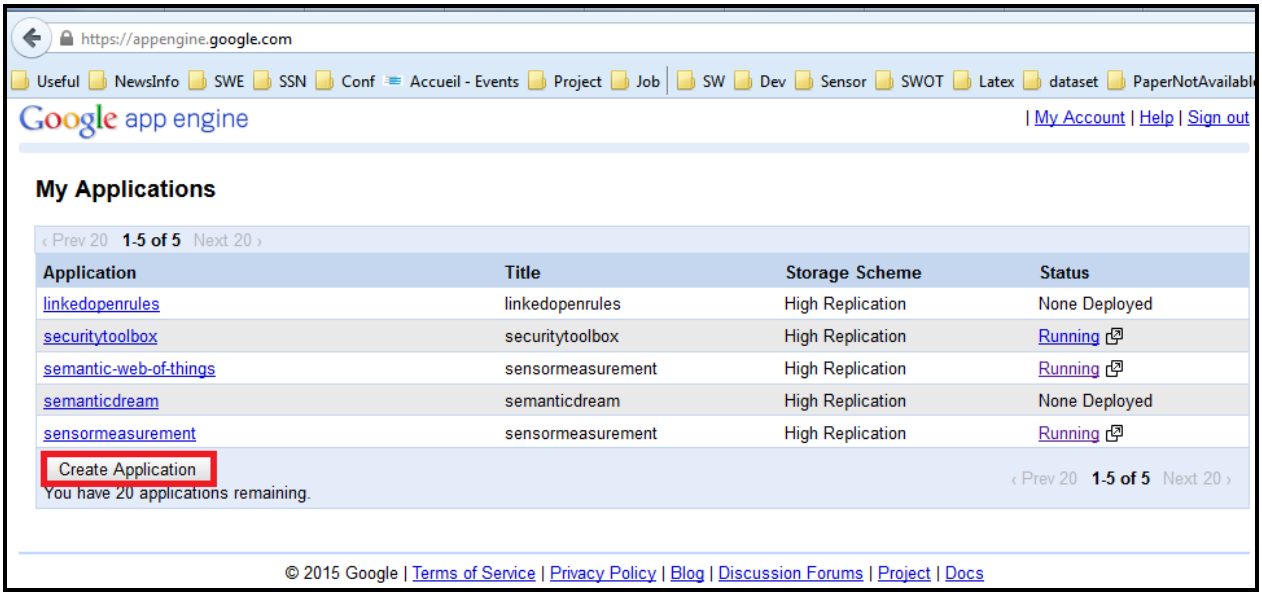
Check that it works:

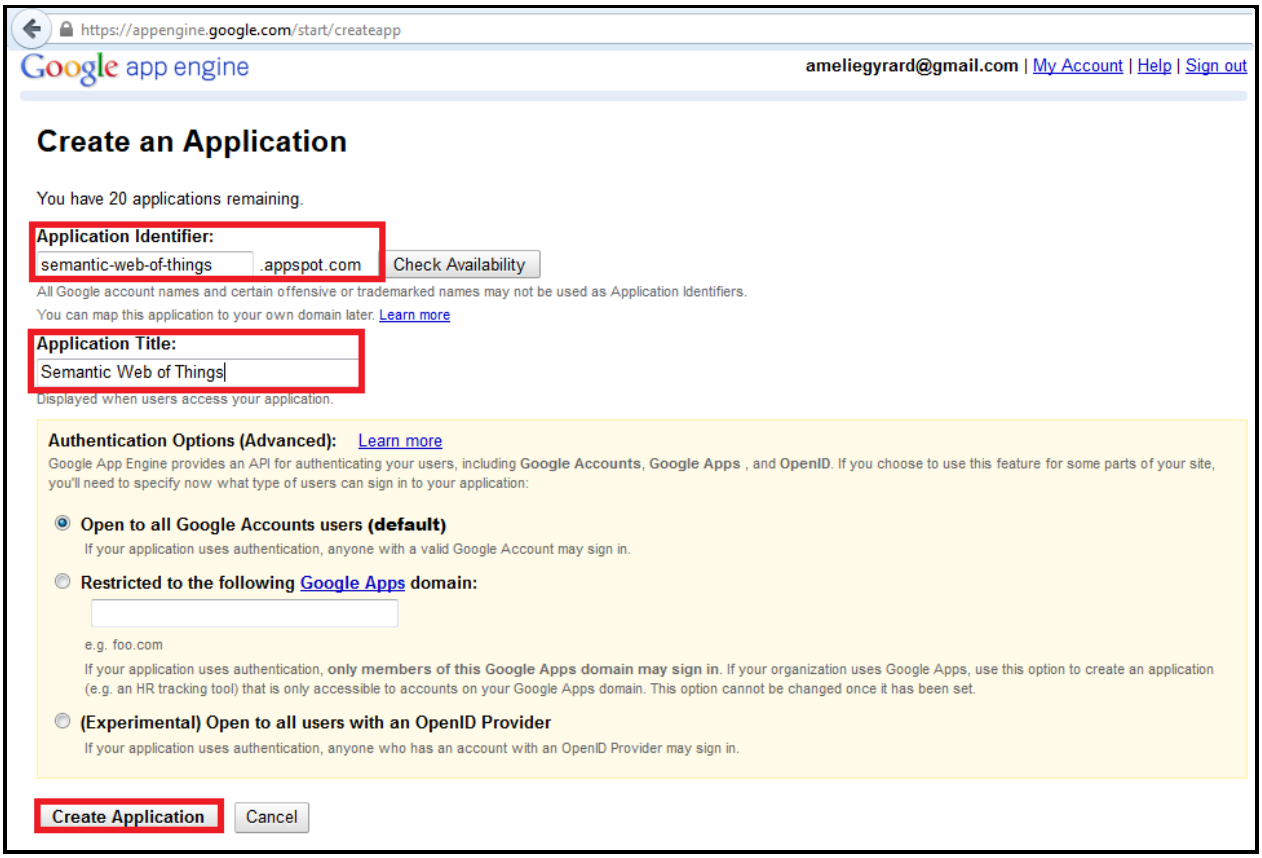
Figure 42. M3 deployed on the web

I. Creating an application on app engine

We can deploy on the semantic-web-of-things.appspot.com web site.

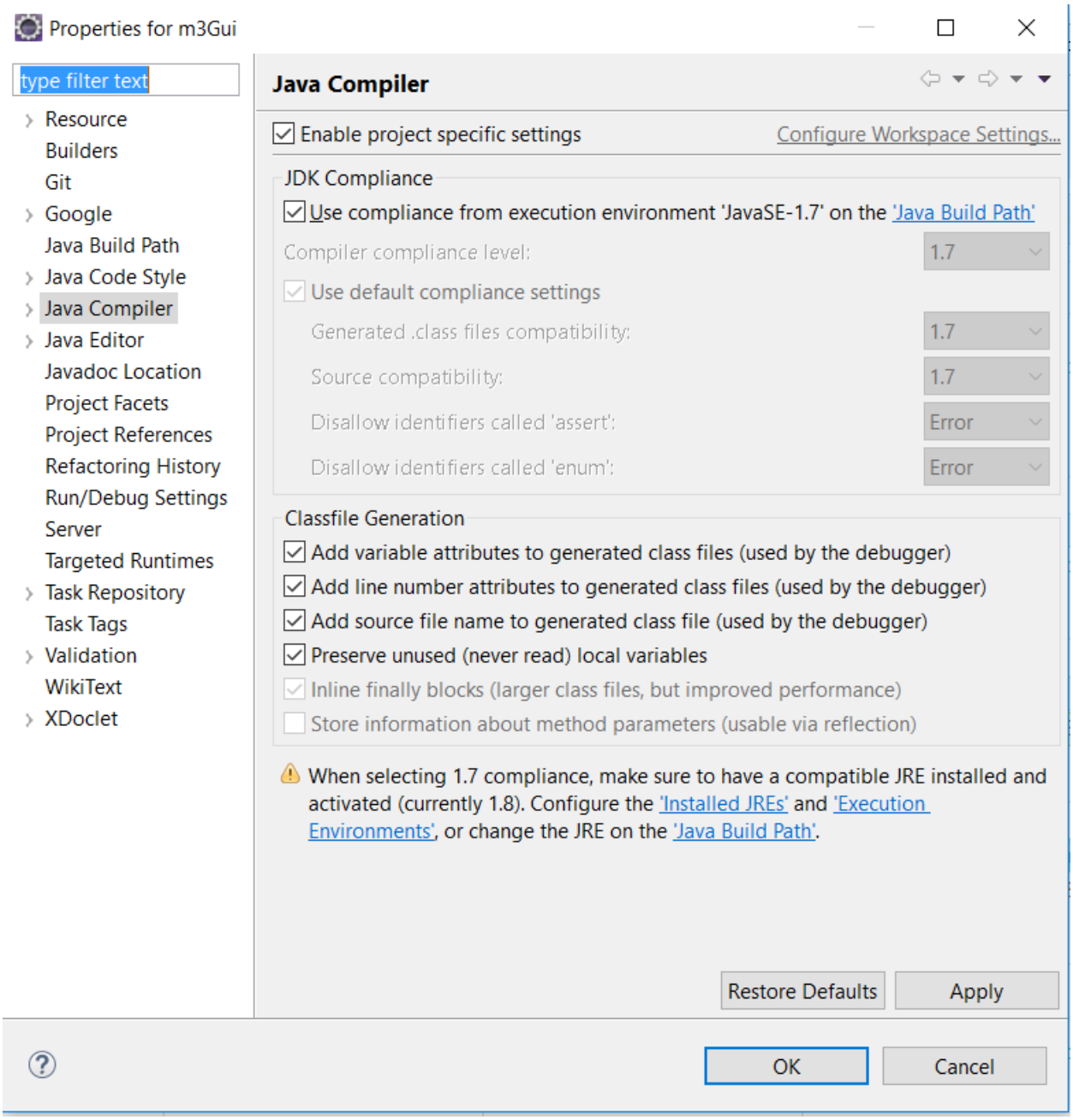
You will have to find another name (check availability button)



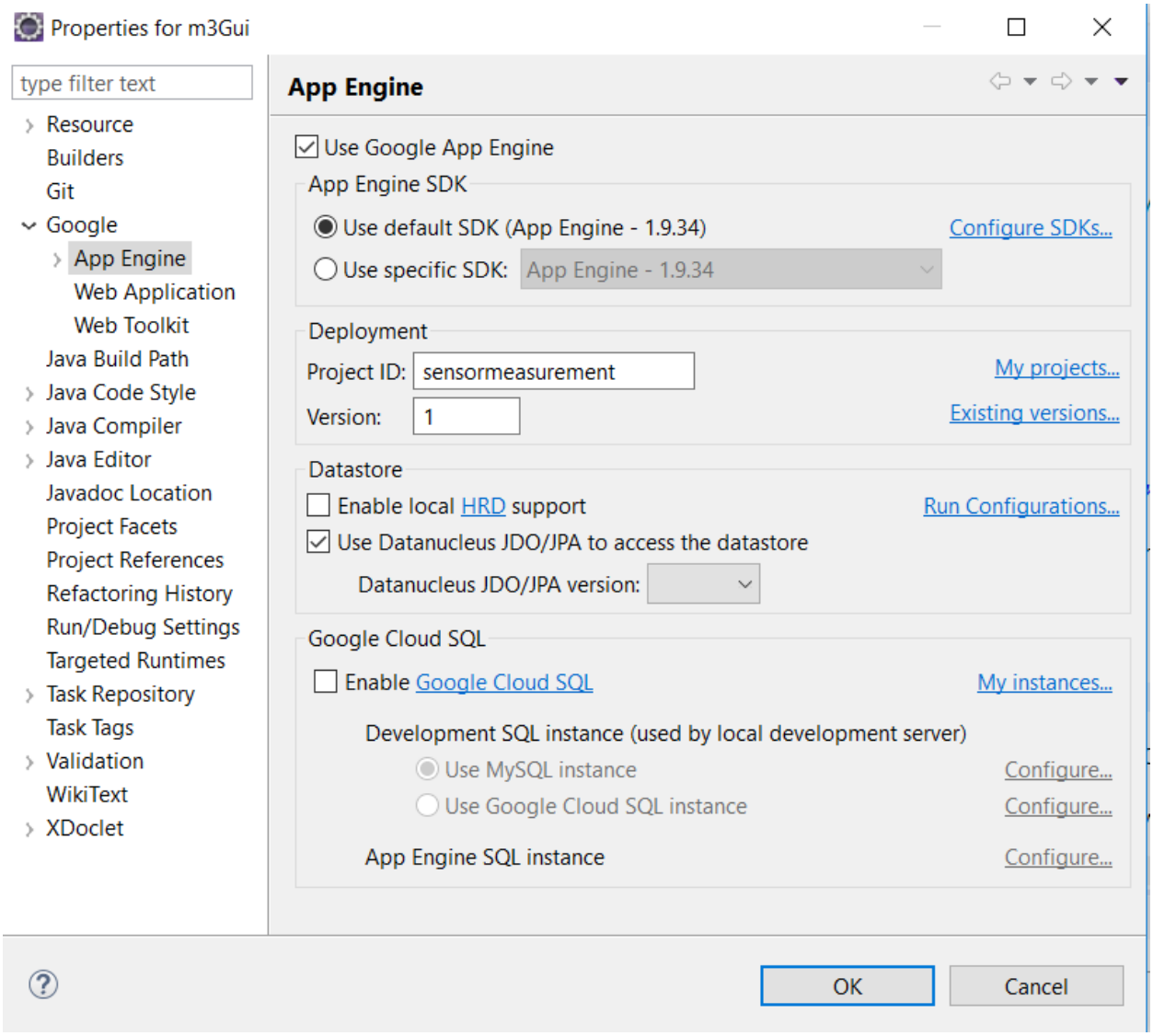

https://appengine.google.com/start/createapp
Google app engine
ameliegyrard@gmail.com | My Account | Help | Sign out
Create an Application
You have 20 applications remaining.
Application Identifier:
semantic-web-of-things
.appspot.com
Check Availability
All Google account names and certain offensive or trademarked names may not be used as Application Identifiers.
You can map this application to your own domain later. Learn more
Application Title:
Semantic Web of Things
Displayed when users access your application.
Authentication Options (Advanced): Learn more
Google App Engine provides an API for authenticating your users, including Google Accounts, Google Apps , and OpenID. If you choose to use this feature for some parts of your site, you'll need to specify now what type of users can sign in to your application:
Open to all Google Accounts users (default)
If your application uses authentication, anyone with a valid Google Account may sign in.
Restricted to the following Google Apps domain:
e.g. foo.com
If your application uses authentication, only members of this Google Apps domain may sign in. If your organization uses Google Apps, use this option to create an application (e.g. an HR tracking tool) that is only accessible to accounts on your Google Apps domain. This option cannot be changed once it has been set.
(Experimental) Open to all users with an OpenID Provider
If your application uses authentication, anyone who has an account with an OpenID Provider may sign in.
Create Application
Cancel

II. Sometimes Issues: Localhost works, but not the online version

Right Click on the project on Eclipse -> Properties, check the following configuration:



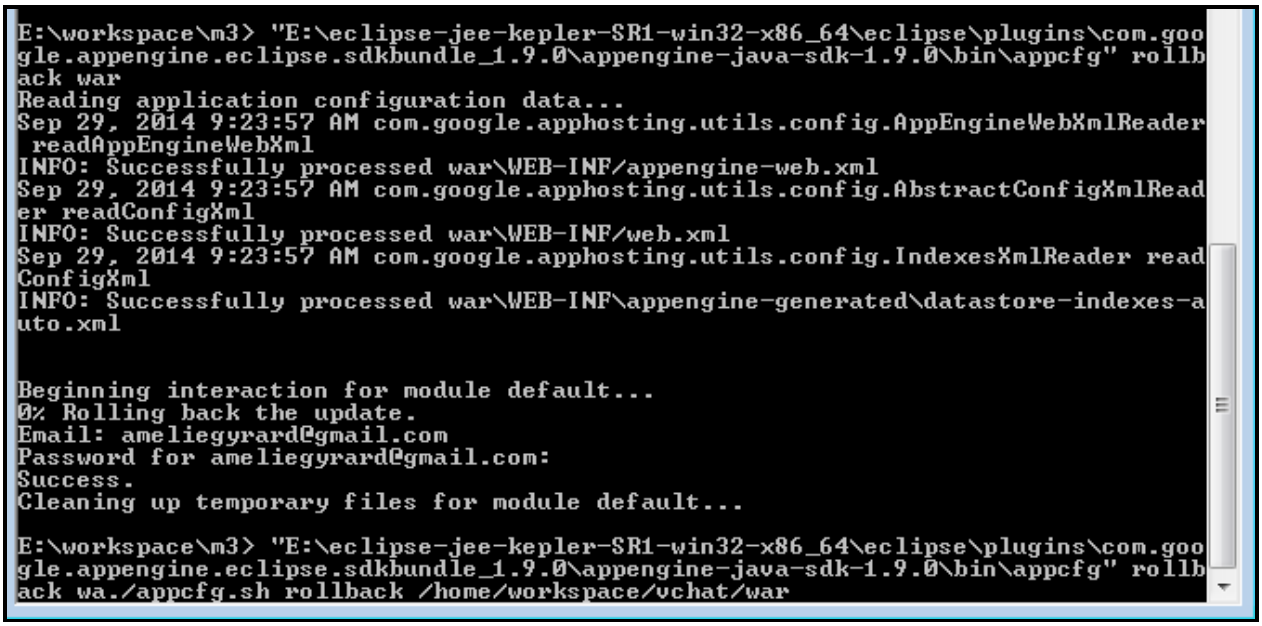
Right Click on the project on Eclipse -> Google -> App EngineSettings, check the following configuration:



III. Error App engine when deploying

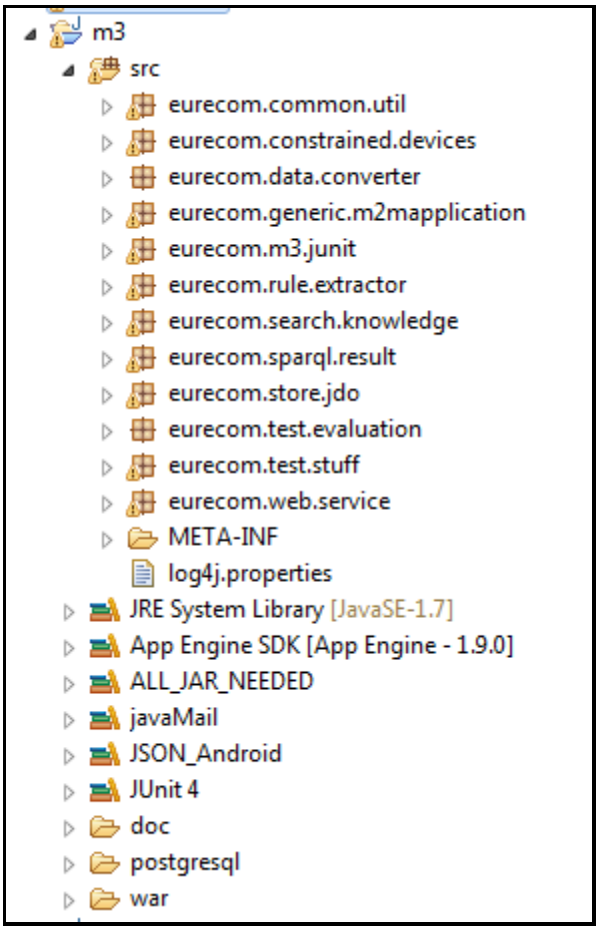
Error when you want to deploy your application on app engine:

Another transaction by user … is already in progress for this app and major version



Part V : Understanding the M3 project

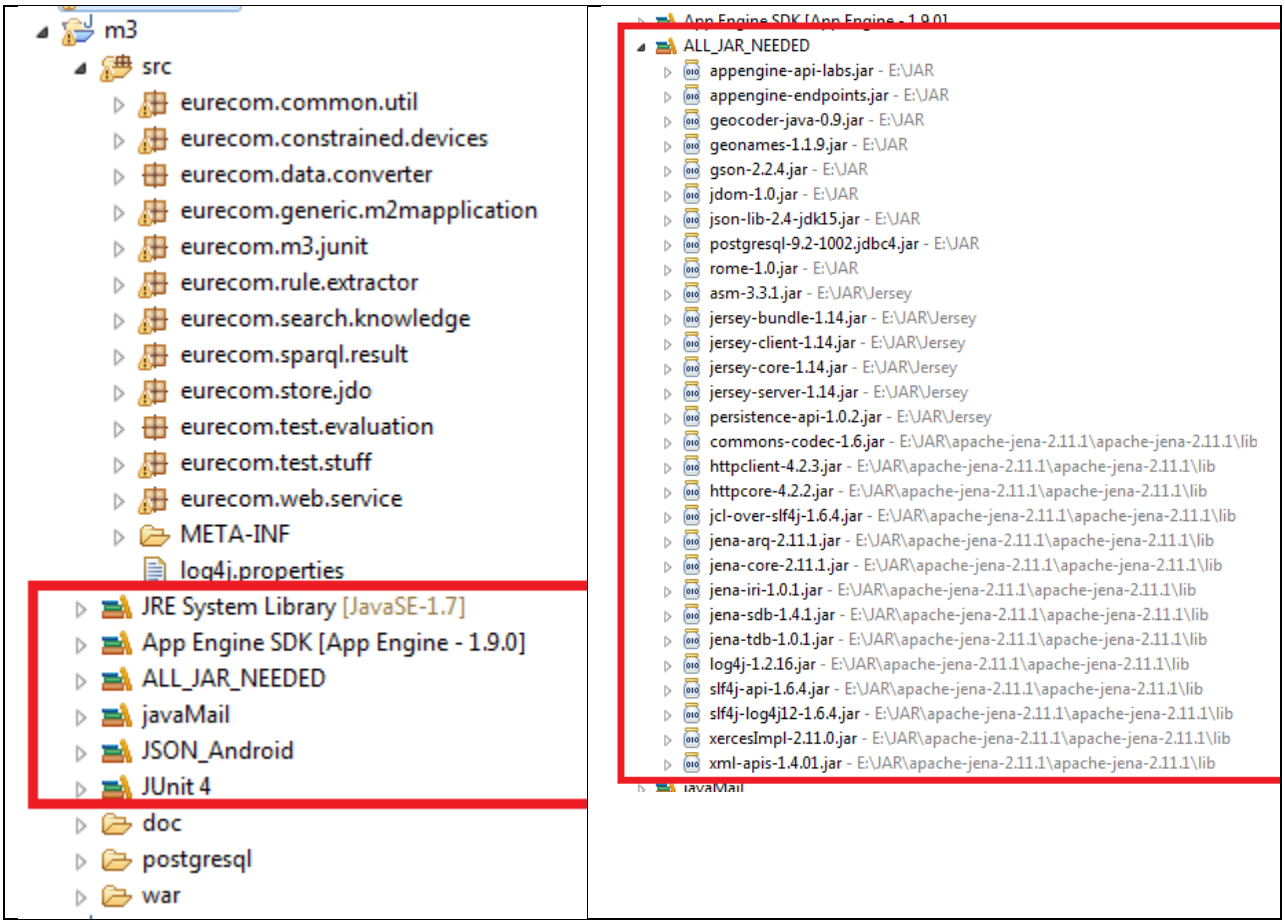
I. M3 framework overview



- WAR/CSS
- WAR/dataset
- WAR/html
- WAR/images
- WAR/javascript
- WAR/ont: all ontologies
- WAR/publication
- WAR/RULES: ruleM3NewType.txt is used in the M3 Converter to add the right sensor, measurement, unit or domain type
    - LinkedOpenRules*.txt: M3 rules implemented according to the Jena syntax compliant with the Jena reasoned, they are classified by domains (e.g., weather,, environment, health, Home)
    - ruleM3NewType.txt used by the M3 converter to convert SenML[4] sensor data in RDF m3 sensor data
    - WAR/RULES/OTHER: files are from domain experts and just shared in the ontologie.html web page
- WAR/SPARQL all SPARQL queries
- WAR/WEB-INF

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

II. Libraries (Jars) required



To run the M3 project, you will need the following libraries:

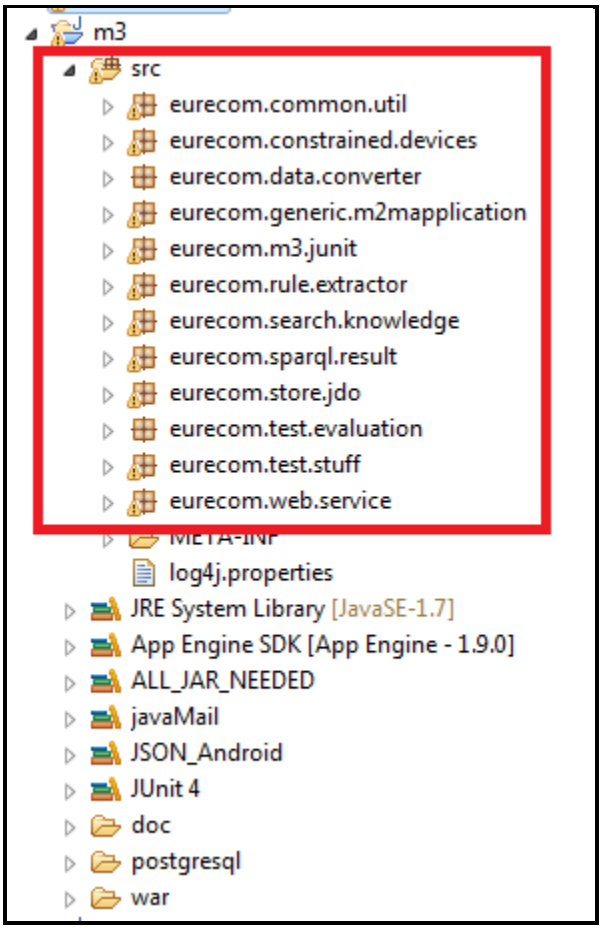
- **JRE System library**, should be the Java 1.7
- **App engine SDK** [App engine - 1.9.0] used to host our project online.
- **ALL_JAR_NEEDED is comprised of**
    - **Jersey 1.14** to develop RESTful web services in JAVA. These web services are then called in HTML web pages through AJAX and Javascript.
    - **Jena 2.11**, a framework uses to build semantic web applications. In the M3 project, more specifically, semantic web of things applications. We use the jena reasoner, the sparql engine, etc.
    - **Geonames**[5] used in the restaurant scenario. From a location (longitude and latitude), we can get additional information such as city, country, etc.
- **javaMail** to send emails, used for the LOV4IoT tool
- **JSON_Android** used to convert sensor data, semantically annotate them and return it in JSON
- **JUnit4** to develop java unit tests

[5] http://www.geonames.org/

III. Descriptions of packages

The M3 project is comprised of 12 packages:

- **eurecom.common.util**: some useful functions such as read a file, query a web service, etc.
- **eurecom.constrained.devices**: code tested to adapt the M3 framework to Android powered devices. For instance, we used JSON instead of XML, etc.
- **eurecom.data.converter**: to semantically annotate SenML data with the M3 nomenclature
- eurecom.generic.m2mapplication: to try to find a way to develop generic applications using the same reasoning process.
- eurecom.m3.junit: some Junit tests to test the M3 framework. Otherwise, the M3 framework has been tested manually with demos.
- eurecom.rule.extractor (work in progress): some tests to extract rules from the ontology catalogue called LOV4IoT.
- eurecom.search.knowledge: used to look for all projects using a specific sensor
- eurecom.sparql.result: to execute the SPARQL query and get the results in different formats.
- eurecom.store.jdo: to store data in the Google datastore
- eurecom.test.evaluation: used to evaluate the software performances
- eurecom.test.stuff: to test new technologies, new tools to integrate, etc.
- **eurecom.web.service**: all web services implemented in the M3 framework



1. eurecom.common.util

Var.java: Java class where all the static variable are set. Add to this there are sorted by what they are used for. Furthermore, all the URL are saved here.
WSUtils.java: Class behaviour to read ontology, data measurement, and SPARQL results. Moreover it implements the behaviour to execute a web service remotely. This class contains noticeable and useful functions:

- convertXmlToJson(<string>) and convertJsonToXml(<string>) : do like their name, before to use this object there is a pre-processing, the JSON (or the Xml) have to be send to the function in a String type.
- queryWebService(<string> url, enum) : execute remotely a web service, the first argument is the URL of the web service, the second is an enumeration (JSON or Xml), it depends if you want to use an Xml or JSON web service. Return the result of the request (<string>)
- readXMLFile(<string> filename) : read an xml file and transform the data in to RDF data, return the data object of type Measurements (see package eurecom.data.convert).
- readFile(optional <model> (from jena library), <string> filename) : if model is send to the function, read ontologies otherwise read a file).

2. eurecom.constrained.devices

To query sensor data provided by the raspberry pi

Java-json.jar used in eurecom.constrained.devices package
java json android parser for sensor data provided by the raspberry pi

3. 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).

4. eurecom.generic.m2mapplication

Coordinates.java: Object to describe a coordinate on earth. Composed by a longitude and a latitude.
LOVClient.java: One function executeSparql(<string> sparql) return InputStream.
VariableSparql.java: Object that describe variable used in a sparql request.

M2MAppGeneric.java: Main behaviour of the application. Can load the dataset of the ontologies provide by the application. Execute the SPARQL queries and linked open rules.
Main function implemented:

- load<ontologyName>Dataset(): add the ontology in the model. There is one load for each kind of ontology.
- executeLinkedOpenRulesAndSparqlQuery(<string> SparqlQueri, ArrayList of variables of the query): prepare and call the function that can execute the SPARQL query.

M2MAppResto.java / M2MAppNaturopathy.java / M2MAppRecipe.java / M2MAppStac.java: These are an extension of M2MAppGeneric which have the same behaviour but with additional specific function that execute almost implemented SPARQL queries. A future goal is to make a real generic class which will make these classes depreciated.
Place.java: Same as Coordinates, object that describe a place in the world. However there is no getter or setter.
WlboxApi.java: Class that allows to get the hierarchy classes of a certain model. Could be depreciated.

5. eurecom.sparql.result

ExecuteSparqlGeneric.java: Java class that implements all type of SPARQL queries (delete or find some labels, replace/update). Concerning queries, you can specify (using a function) how to store the value of the query.
ExecuteSparql.java: Same as ExecuteSparqlGeneric.java but it uses to define one and only one SPARQL request, the object define must not execute other SPARQL request.
ExecuteSparqlHealth.java / ExecuteSparqlRecipe.java / ExecuteSparqlRestaurant.java / ExecuteSparqlRecipeNaturopathy.java: Implement the SPARQL request function associated to an ontology, should be deleted and use a more generic function in ExecuteSparqlGeneric.java instead.
SparqlResultGeneric.java, SparqlResultRecipe.java, SparqlResultRecipeNaturopathy.java, SparqlResultRestaurant.java: Describe the object result of a query, composed of variables, getters and setters.
VariableSparql.java: Object that describe variable used in a SPARQL request.

6. eurecom.store.jdo

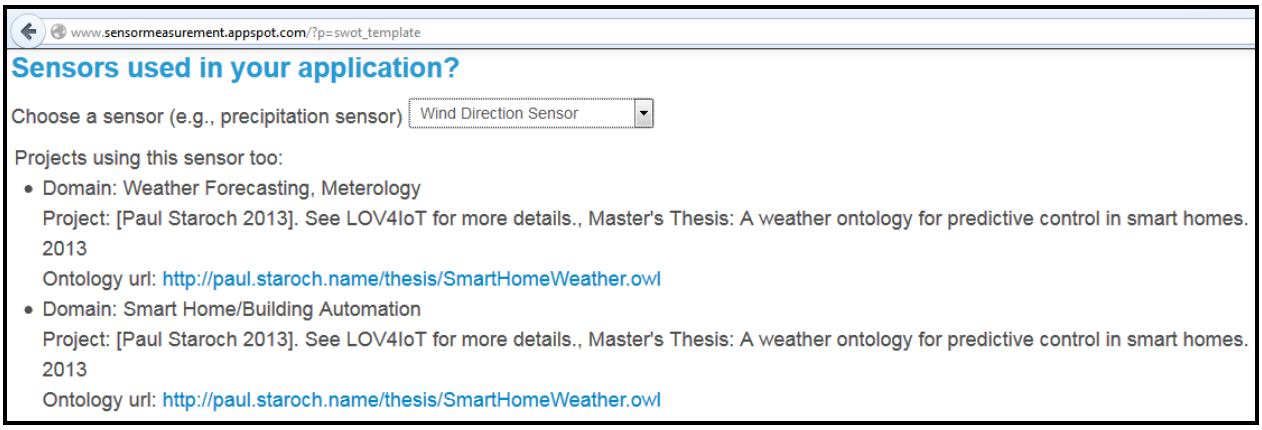
GenericJDO: This class manipulates the measurements object get, create or delete it.
Util.java: Composed of useful function to manipulate entities and especially to get JSON strings.

JDO Java Data object, datastore compatible with google to store data (e.g., M3 rdf sensor data)

7. eurecom.search.knowledge

The code is used in this web page[6] through web services.
According to a specific sensor given in the drop-down list, we can retrieve all projects using this sensor.

[6] http://www.sensormeasurement.appspot.com/?p=swot_template

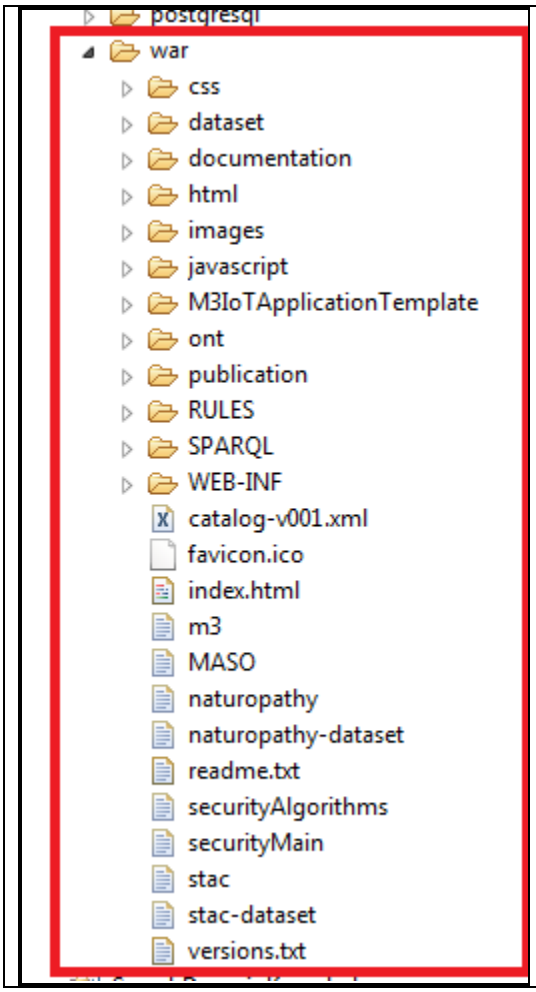


8. eurecom.web.service

All the classes here are Web Services. There is one class for each type of ontology. Before every method, there are some important parameters:

- @GET: Indicate the kind of protocol used (here is Get by opposition of POST for instance).
- @Path("String"): This is the URL where the method is called. This URL is relative.
- @Consumes(MediaType): What kind of string this method takes.
- @Produces(MediaType): What kind of string this methods produces (It is often a JSON string or Xml).

IV. The WAR directory



The WAR directory to build web applications.

m3 MASO naturopathy naturopathy-dataset readme.txt securityAlgorithms securityMain stac stac-dataset	 **At the beginning of the project, we had the following ontologies and datasets directly in the WAR file. We keep these ontologies and datasets since they have been referenced in research articles. We do not remove them to avoid 'error 404: page not found'.** **But now, all modifications of ontologies and datasets are in the corresponding directory.**  **TO DO: A solution would be to use the PURL tool7 to avoid such issues!**

1. WAR/CSS

All CSS file for the web application user interface.

2. WAR/dataset

All datasets such as sensor data, sensor data semantically annotated with M3, domain knowledge bases, etc.

3. WAR/documentation

All documentation to understand the project or use the tools.

4. WAR/html

All HTML web pages used for the user interface.

5. WAR/images

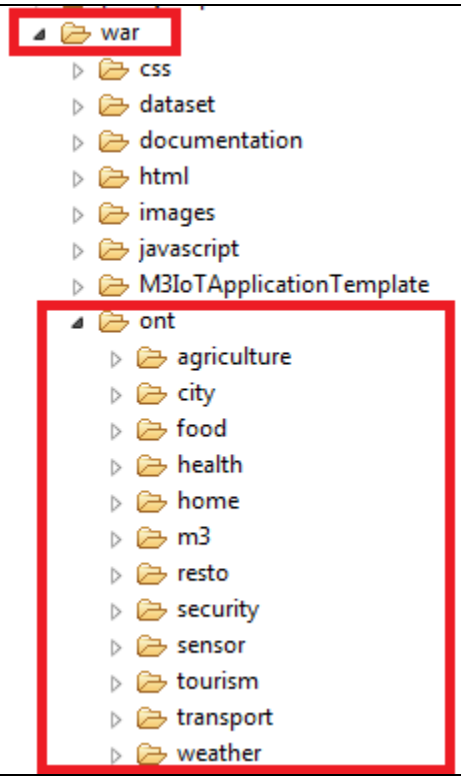
All images used in the projects.

6. WAR/javascript

The HTML web pages will send AJAX queries to web services and get the results.
The result is parsed in JavaScript and displayed on HTML web pages.

[7] https://purl.oclc.org/docs/index.html.

7. WAR/ont



All new ontologies should be in this directory. They are classified by domains.

Some old ontologies are still in WAR/WEB-INF/ontologies. The less interesting ones, that we did not move to the new directory.

In WAR/ont/m3: you will find the M3 interoperable domain ontologies.

8. WAR/publication

All publications related to this thesis to understand better the M3 project. You will find slides, research articles, participation to standards, etc.

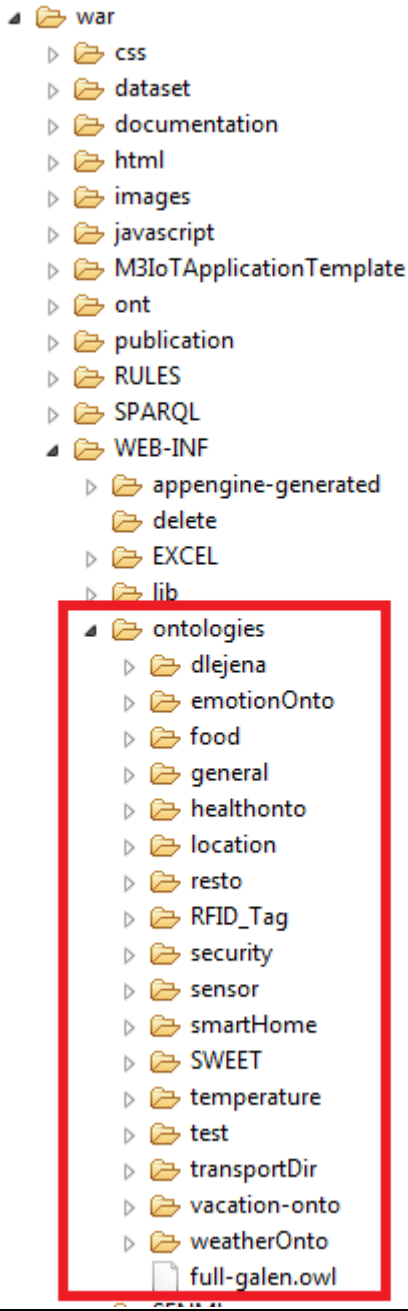
9. WAR/RULES

You will find in this directory all the interoperable rules that we designed.
This is the Sensor-based Linked Open Rules (S-LOR) tool. The SWoT generator has predefined-templates to build semantic-based IoT application. The templates will referenced these pre-defined set of rules classified by domains.

10. WAR/SPARQL

You will find in this directory all SPARQL queries.

11. WAR/WEB-INF/ontologies



Why do we have several directeroy related to ontologies?
Be careful: Ontologies and datasets duplicated
We are agree this is a total mess! Some ontologies required to be shared online, but if we move all ontologies and datasets in the same place, we will have issues with path and namespace already defined in previous ontologies and referenced in the LOV4IoT dataset!

WAR/ont: we added this directory to host the ontology that we found online

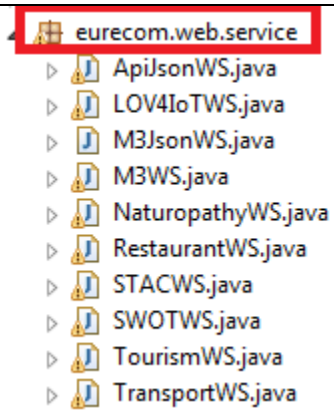
WEB-INF/ontologies/: old repository with all ontologies that we found but not necessarily use them.

Solve this issue with PURL[8] or URL redirection?
If if we migrate the ontologies in the other directory, we will have error page not found in some web pages.
TO DO: delete WEB-INF/ ontology and merge it with WAR/ontologies and WAR/datasets.
BIG ISSUE: change namespaces everywhere (ontologies, datasets, rules, sparql) to be accessible online (URI deferencable)
URL already used in publications links.

[8] https://purl.oclc.org/docs/index.html

Part VI : Understanding M3 web services

There is also the documentation to use the web services if required[9].
Root path web service: http://www.sensormeasurement.appspot.com/
In the package eurecom.web.service, you will find all web services, implemented in Java using the Jersey[10] implementation.

	All web services names ended by WS in Java class

1. APIJsonWS Java class (deprecated)

The web services provided by this Java class were focused on returning the result in JSON.
After, I found the solution to return the result either as JSON or as XML by adding:

```
@Produces({ MediaType.APPLICATION_XML, MediaType.APPLICATION_JSON })
public static Response nameFunction( @QueryParam(value = "format") String format) {
if (format.equals("xml")){
        resultSparql = req.getSelectResultAsXML(var);
    }
    else if (format.equals("json")){
        resultSparql = req.getSelectResultAsJson(var);
    }
    return Response
            // Set the status and Put your entity here.
            .ok(resultSparql)
            // Add the Content-Type header to tell Jersey which format it should marshall the entity into.
            .header(HttpHeaders.CONTENT_TYPE, "json".equals(format) ? MediaType.APPLICATION_JSON : MediaType.APPLICATION_XML)
            .build();
```

Figure 43. Code example to return the result either as JSON or XML

2. LOV4IoTWS Java class

All web services related to the Linked Open Vocabularies for Internet of Things (LOV4IoT) dataset[11] to automatically count the number of ontologies in this dataset (e.g., by domains, by ontology status, etc.):

[9] http://www.sensormeasurement.appspot.com/documentation/M3APIDocumentation.pdf
[10] https://jersey.java.net/
[11] http://www.sensormeasurement.appspot.com/?p=ontologies

- 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
- /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)

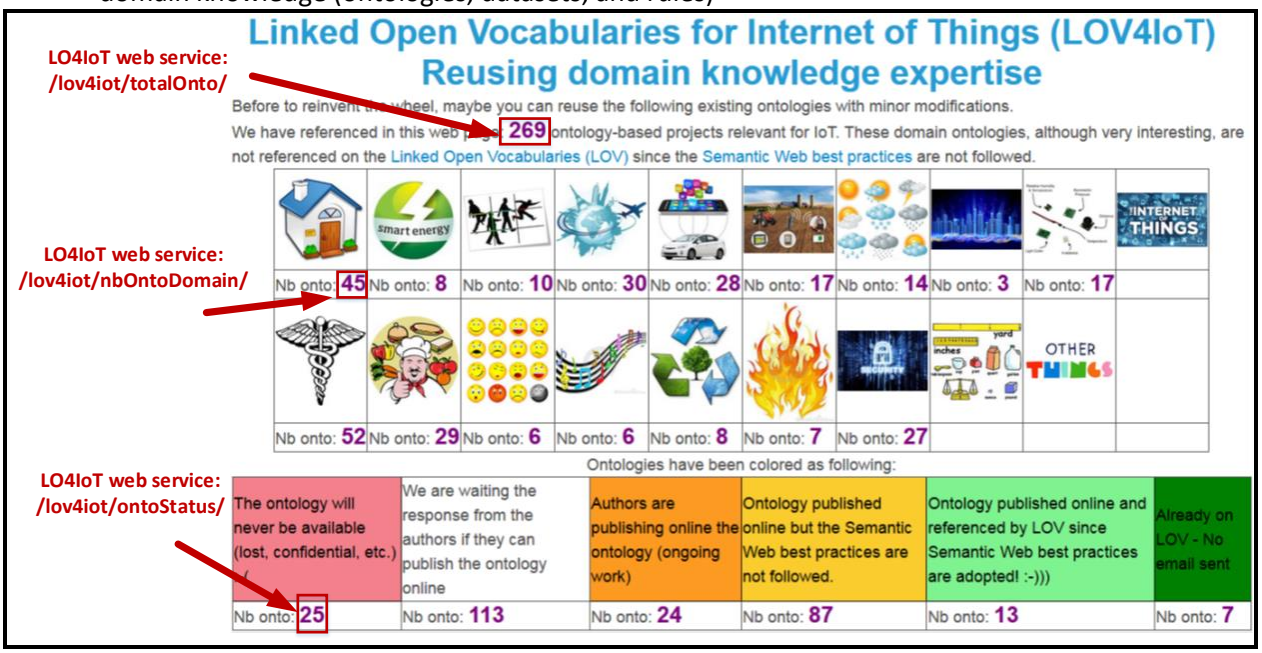


Figure 44. LOV4IoT web services

```
@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 45. Example of the lov4iot/totalOnto: web service

3. M3JsonWS (deprecated)

The web services provided by this Java class were focused on returning the result in JSON.
After, I found the solution to return the result either as JSON or as XML by adding:

These web services enable to query the M3 ontology to get:

- Get all M3 sensors (/json/m3/sensor)
- Get all M3 domains (/json/m3/featureOfInterest)
- Get all M3 measurement type (/json/m3/measurement)

4. M3WS

All web services related to the M3 nomenclature implemented in the ontology.
Support new web services handling both XML and JSON format.
Should replace M3JsonWS and APIJsonWS Java classes:

- To semantically annotate sensor, IoT, M2M data (/m3/convert)
- Get all M3 sensors (/m3/subclassOf/sensor). This web service replaced M3JsonWS.
- Get all M3 domains (/m3/subclassOf/featureOfInterest). This web service replaced M3JsonWS.
- Get all M3 measurement type (/m3/subclassOf/measurement). This web service replaced M3JsonWS.

All web services related to the SWoT generator[12]:

- To look for templates (/m3/searchTemplate)
- To get the template (/m3/generateTemplate)
- To replace variables in the SPARQL query (/m3/getSparqlQuery)

[12] http://www.sensormeasurement.appspot.com/?p=m3api

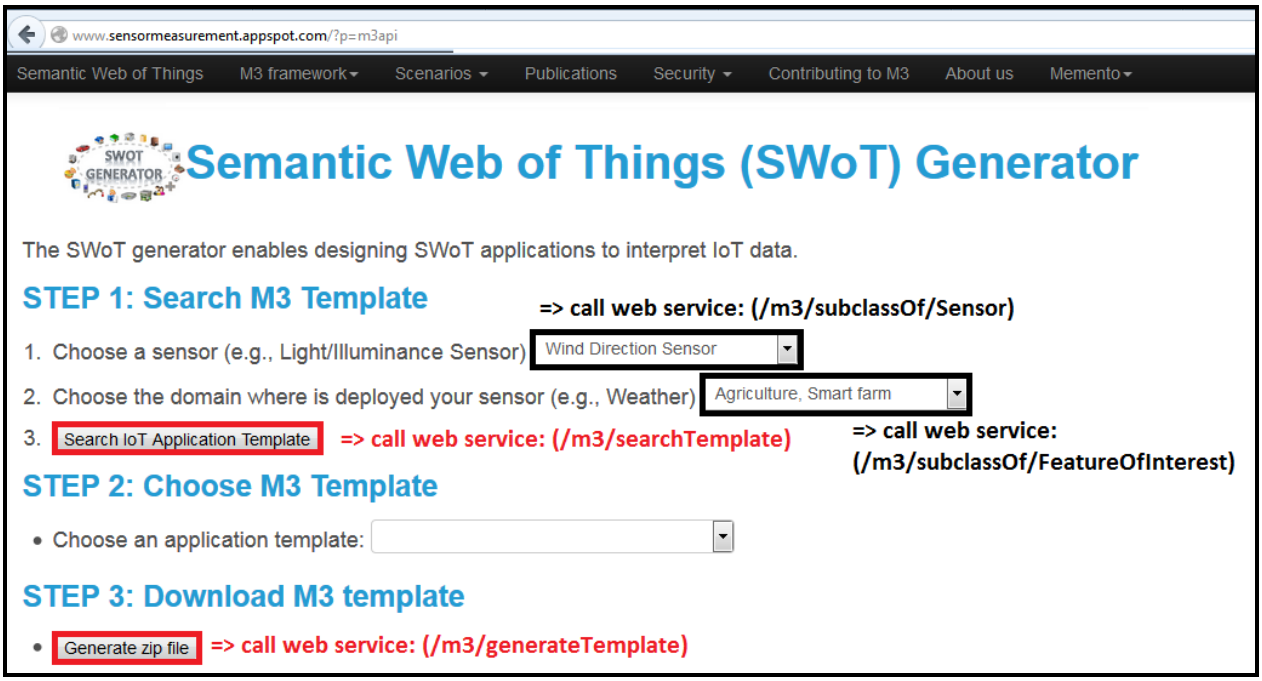


Figure 46. M3 web services used in the SWOT generator

5. NaturopathyWS

All web services used for the restaurant scenario[13]:

- Suggest home remedies according to the body temperature (/naturopathy/sick)
- Deducing mood according to the external luminosity (/naturopathy/emotion_luminosity/)
- Suggesting food according to the outside temperature (/naturopathy/seasonTemperatureFoodRecipe/)
- Deducing mood or diseases from:
    - heart beat (/naturopathy/emotion_disease/HeartBeat)
    - skin conductance (/naturopathy/emotion_disease/SkinConductance)
    - blood pressure (/naturopathy/emotion_disease/BloodPressure)
- See the comments in the Java class for more web services

[13] http://www.sensormeasurement.appspot.com/?p=naturopathy

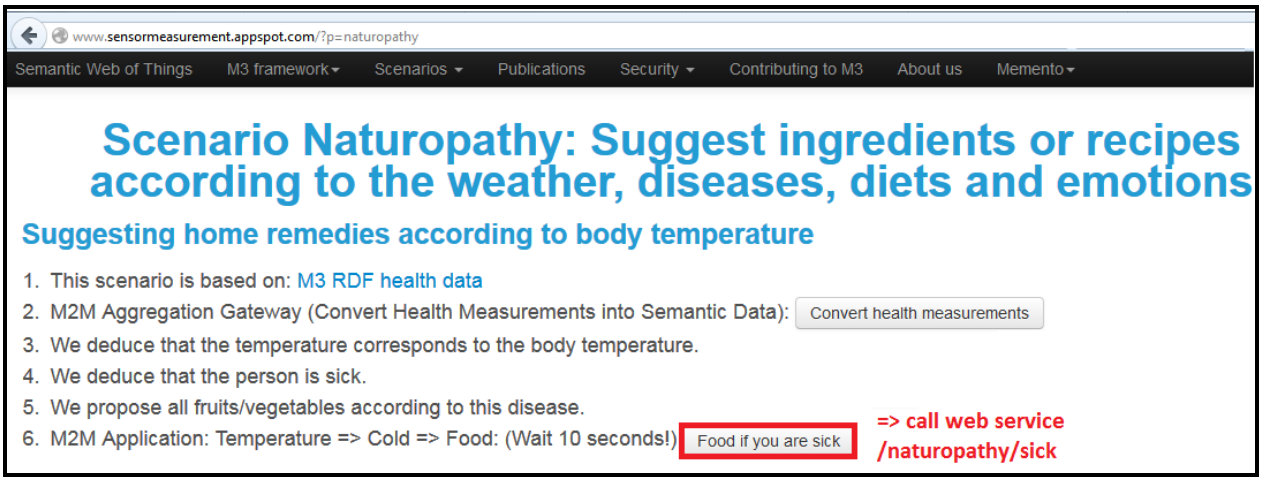


Figure 47. Naturopathy web services used in the naturopathy scenario

6. RestaurantWS

All web services used for the restaurant scenario[14].

See Java Class comments.

This scenario does not work exactly in the same way that last scenarios (naturopathy, transport, tourism). It was our second scenario who helps us to design the semantic engine, to reuse the domain knowledge, etc.

7. STACWS

All web services used for security application[15], called STAC (Security Toolbox: Attacks & Countermeasures):

- Get all technologies referenced in the STAC dataset (stac/subclassOf/Technology)
- Get all attacks related to a specific technology (e.g., stac/attack/SensorTechnology)
- Get all features related to a specific security mechanism (e.g., stac/hasFeature/SSH)

[14] http://www.sensormeasurement.appspot.com/?p=restaurant

[15] http://www.sensormeasurement.appspot.com/?p=stac

- Get all security mechanisms related to a specific technology (e.g., stac/techno/SensorTechnology)
- See Java class for all web services and their comments

The name of the technology should be referenced in the STAC ontology[16]!

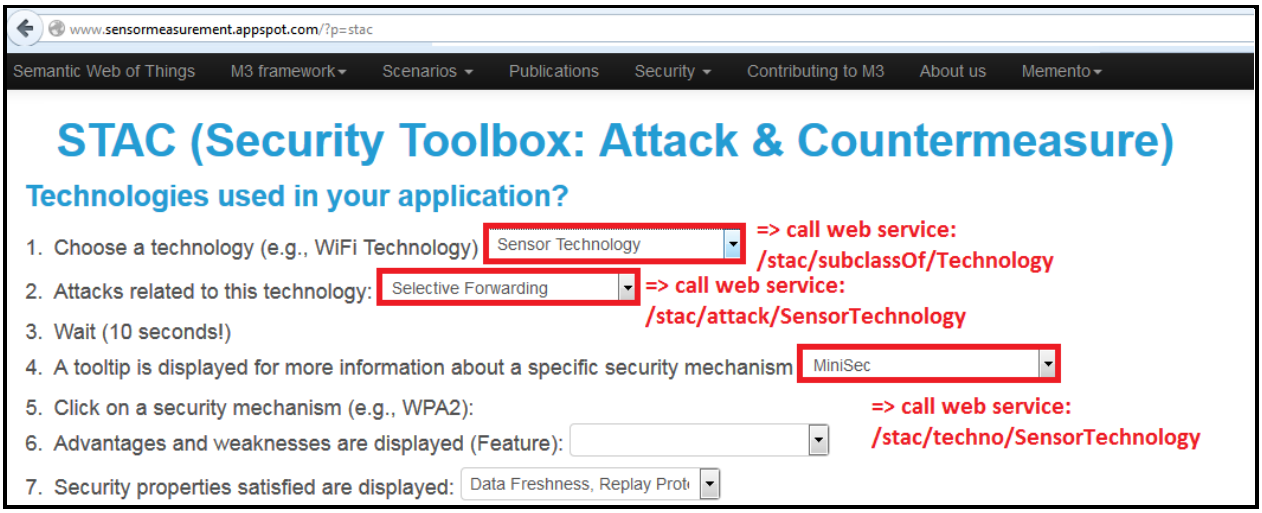


Figure 48. STAC web services

8. SWOTWS

- Web service for the M3 converter (/swot/convert_senml_to_rdf)
- Web service to get all rules associated to a specific sensor (/swot/convert_senml_to_rdf)

Figure 49. Web service to convert senML data to RDF according to the M3 nomenclature

[16] securitytoolbox.appspot.com/stac#

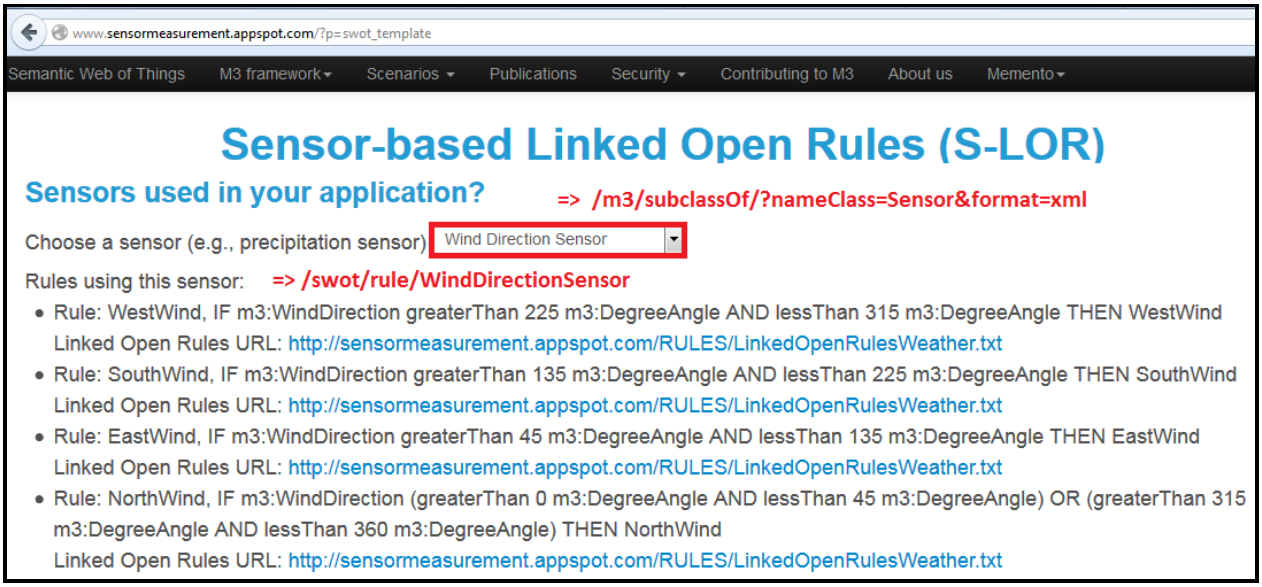


Figure 50. Web service to get rules related to a specific sensor

This Java class should be merged with M3WS in future versions or create new Java file SLORSW and M3ConverterWS and then update the user interface in HTML and JavaScript.

9. TourismWS

All web services used for the tourism scenario[17]:

- tourism/clothes_weather/{nameMeasurement}: to suggest activities according to weather measurements
- tourism/activity_weather/{nameMeasurement}: to suggest activities according to weather measurements
- /tourism/snowGarment/: to deduce snow, a more scenario involving two sensors at the same time

nameMeasurement is described in the M3 nomenclature[18]. For instance, it can be WeatherLumininosity, Precipitation, WeatherTemperature

See comments in the Java Class

[17] http://www.sensormeasurement.appspot.com/?p=tourism
[18] http://www.sensormeasurement.appspot.com/documentation/NomenclatureSensorData.pdf

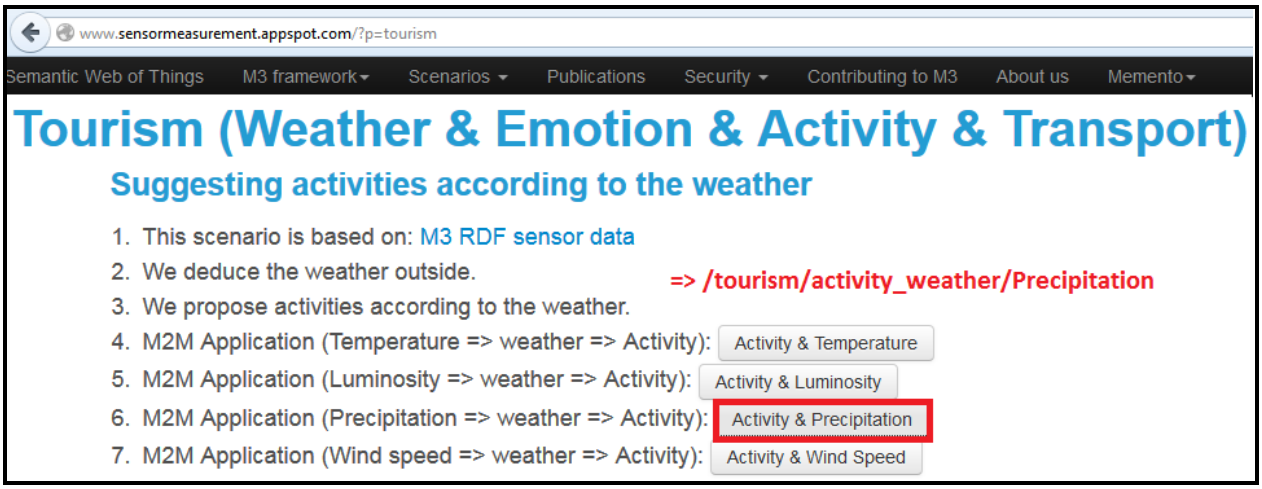


Figure 51. Tourism web services

10. TransportWS

All web services used for the transportation scenario[19]:

- tourism/safety_device_weather/{nameMeasurement}: to suggest safety devices in the smart car according to weather measurements
- /tourism/snow/: to deduce snow, a more scenario involving two sensors at the same time

nameMeasurement is described in the M3 nomenclature[20]. For instance, it can be WeatherLumininosity, Precipitation, WeatherTemperature

See comments in the Java Class

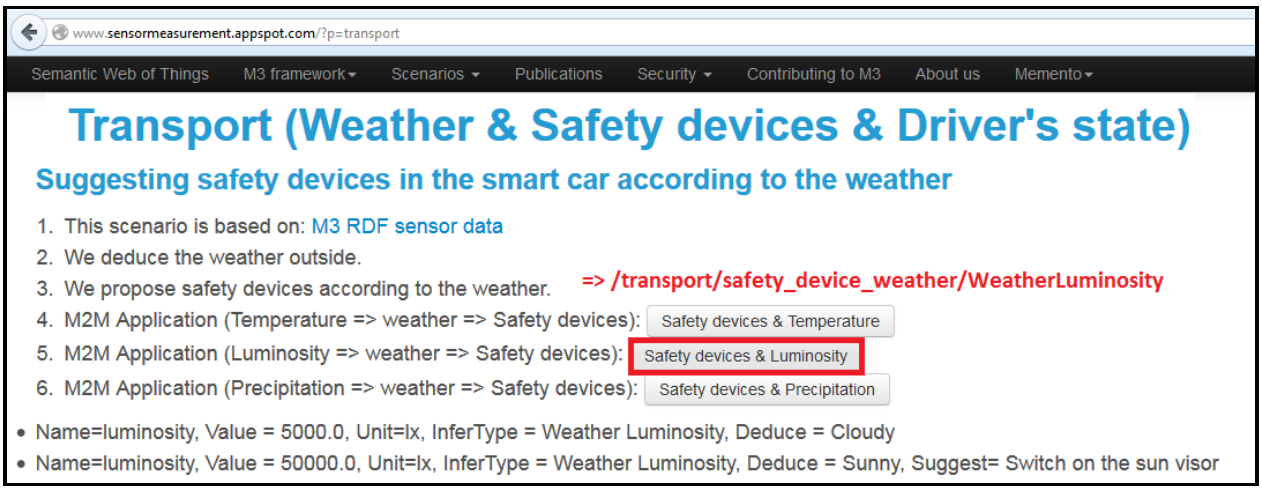


Figure 52. Transport web services

[19] http://www.sensormeasurement.appspot.com/?p=transport
[20] http://www.sensormeasurement.appspot.com/documentation/NomenclatureSensorData.pdf

11. Design a new web service

To design a new web service, take inspiration from all of these web services.

Part VII : Adding a new SWoT template

Add a new template in the template dataset[21]:

- M3 is the prefix of the ontology.
- <m3:hasM2MDevice rdf:resource="&m3;LightSensor"/> means that the template is related to the light sensor which is already referenced in the M3 ontology
- <m3:hasContext rdf:resource="&m3;Weather"/> means that the template is related to the weather domain.
- <m3:hasUrlOntology rdf:resource="&weather;"/> the URL of the domain ontology required to build the Semantic Web of Things (SWoT) application
- <m3:hasUrlDataset rdf:resource="&transport-dataset;"/> the URL of the domain dataset required to build the Semantic Web of Things (SWoT) application
- <m3:hasUrlSparql rdf:resource="&sparql;m3SparqlGeneric.sparql"/> The URL of the SPARQL query
- <m3:hasSparqlVariableinferTypeUri rdf:resource="&m3;WeatherLuminosity"/> to replace variable in generic sparql queries (optionnal)
- <m3:hasSparqlVariabletypeRecommendedUri rdf:resource="&transport;SafetyDevice"/> to replace variable in generic sparql queries (optionnal)
- <m3:hasUrlRule rdf:resource="&lorWeather;"/> the URL of the Linked Open Rules dataset to get high level abstractions
- <m3:hasUrlRule rdf:resource="&ruleM3Converter;"/>the URL of the rule dataset to semantically annotate IoT data according to the M3 nomenclature and M3 ontology.

```
<m3:M2MApplication rdf:about="&m3;WeatherTransportationSafetyDeviceLight">
   <m3:hasContext rdf:resource="&m3;Weather"/>
   <m3:hasContext rdf:resource="&m3;Transportation"/>
   <rdfs:label xml:lang="en">Luminosity, Transportation and Safety Device</rdfs:label>
   <rdfs:comment xml:lang="en">IoT application to suggest safety devices according to the luminosity
   <m3:hasM2MDevice rdf:resource="&m3;LightSensor"/>                                    </rdfs:comment>
   <m3:hasUrlOntology rdf:resource="&m3;"/>
   <m3:hasUrlOntology rdf:resource="&weather;"/>
   <m3:hasUrlDataset rdf:resource="&weather-dataset;"/>
   <m3:hasUrlOntology rdf:resource="&transport;"/>
   <m3:hasUrlDataset rdf:resource="&transport-dataset;"/>
   <m3:hasUrlSparql rdf:resource="&sparql;m3SparqlGeneric.sparql"/>
   <m3:hasSparqlVariableinferTypeUri rdf:resource="&m3;WeatherLuminosity"/>
   <m3:hasSparqlVariabletypeRecommendedUri rdf:resource="&transport;SafetyDevice"/>
   <m3:hasUrlRule rdf:resource="&lorWeather;"/>
   <m3:hasUrlRule rdf:resource="&ruleM3Converter;"/>
</m3:M2MApplication>
```

Figure 53. A SWoT template

[21] www.sensormeasurement.appspot.com/dataset/iot-application-template-dataset

Part VIII : Adding a new ontology in LOV4IoT

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. 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.

2. LOV4IoT RDF dataset

In the LOV4IoT RDF dataset[22], add a new ontology-based project.

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

```
<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 54. An ontology-based project referenced in the LOV4IoT RDF dataset

Part IX : Understanding the M3 converter

I. Semantically annotate SenML/XML data with the M3 converter

We stored the semantic sensor data in the Google App Engine Datastore called Java Data Objects (JDO).
When you see this code or params, it means that I use Google datastore:
- Var.KIND_JDO_HEALTH_V2
- Var.KEY_NAME_JDO_HEALTH_V2
- String kindJDO
- String keyNameJDO

In the file ConvertSensorDataToM3.java,
you should delete all variables with the name kindJDO and keyNameJDO.
the data will be stored in a jena model:
Model model = ModelFactory.createDefaultModel();
So you have to replace the params kindJDO and keyNameJDO by the model

public Model convertJavaObjectsToM3(Domain senmls, String kindJDO, String keyNameJDO) throws IOException{
//HERE YOU HAVE DATA SEMANTICALLY ANNOTATED

```
// Where will be the resulting RDF dataset be saved if I want to perform the conversion on local disk?
infModel.write(System.out);
//then you can store your jena model as you want
// YOU CAN DELETE THIS
//GenericJDO.createOrUpdateMeasurementsSaved(kindJDO, keyNameJDO, infModel);
System.out.println("kindJDO:" + kindJDO + " keyNameJDO:" + keyNameJDO);

return infModel;
}
```

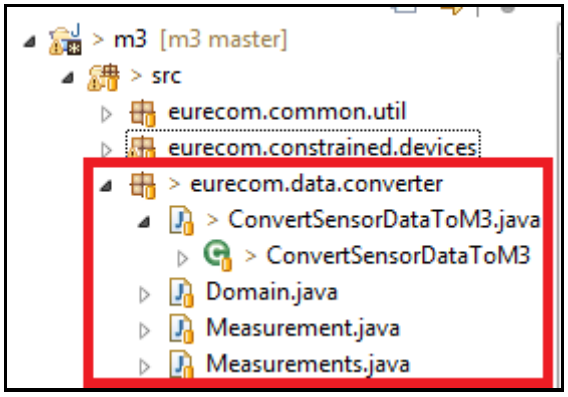


Figure 55. The M3 converter code to semantically annotate SenML/XML data

II. Semantically annotate SenML/JSON data with the M3 converter

We build another Java package called “eurom.constrained.devices”, since we had to convertSenML/JSON sensor data.

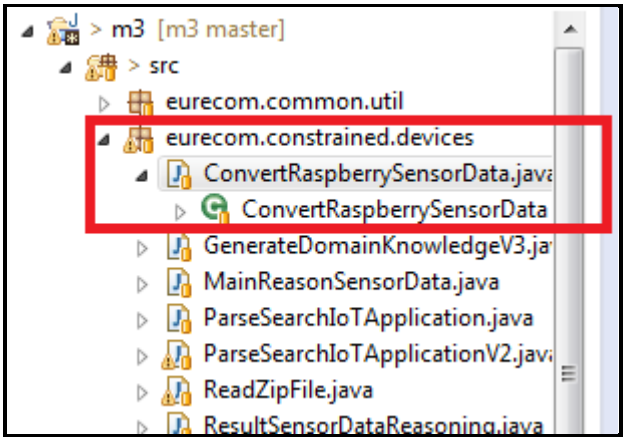


Figure 56. The M3 converter code to semantically annotate SenML/JSON data

Part X : Extending STAC

You can either manually update the STAC ontology and dataset or use ontology editor tools such as Protégé. In this section, we display screenshot of the code.

I. Adding a new technology to the STAC ontology

STAC ontology: http://securitytoolbox.appspot.com/stac#

To add a new technology to the STAC ontology is simple.

1. You have to add a new class (e.g., `BluetoothTechnology`), which is a subclass of `stac:Technology` (see Figure 57). Then, add the restriction regarding Attack. The technology is vulnerable to some attacks (e.g., `BluetoothAttack`) (see Figure 57).
2. Create a new subclass of `stac:Attack` (e.g., `BluetoothAttack`) (see Figure 58).
3. Create a new subclass of `stac:SecurityMechanism` (e.g., `BluetoothSecurityMechanism`) and the related restriction (see Figure 59).

```
<owl:Class rdf:ID="BluetoothTechnology">
    <rdfs:label xml:lang="en">Bluetooth Technology</rdfs:label>
    <rdfs:comment xml:lang="en">A protocol for short-range (up to 100 meters) wireless networks.</rdfs:comment>
    <rdfs:subClassOf rdf:resource="#Technology"/>
    <rdfs:seeAlso rdf:resource="&serviceContext;Bluetooth"/>
    <rdfs:seeAlso rdf:resource="&ct;BluetoothConnectivity"/>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#hasVulnerability"/>
            <owl:someValuesFrom rdf:resource="#BluetoothAttack"/>
        </owl:Restriction>
    </rdfs:subClassOf>
</owl:Class>
```

Figure 57. Creating a new STAC technology

```
<owl:Class rdf:ID="BluetoothAttack">
    <rdfs:label xml:lang="en">Bluetooth Attack</rdfs:label>
    <rdfs:comment xml:lang="en"></rdfs:comment>
    <rdfs:subClassOf rdf:resource="#Attack"/>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#hasSecurityMechanism"/>
            <owl:someValuesFrom rdf:resource="#BluetoothSecurityMechanism"/>
        </owl:Restriction>
    </rdfs:subClassOf>
</owl:Class>
```

Figure 58. Creating a new STAC attack

```
<owl:Class rdf:ID="BluetoothSecurityMechanism">
    <rdfs:label xml:lang="en">Bluetooth SecurityMechanism</rdfs:label>
    <rdfs:comment xml:lang="en"></rdfs:comment>
    <rdfs:subClassOf rdf:resource="#SecurityMechanism"/>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#protects"/>
            <owl:someValuesFrom rdf:resource="#BluetoothTechnology"/>
        </owl:Restriction>
    </rdfs:subClassOf>
</owl:Class>
```

Figure 59. Creating a new STAC security mechanism

II. Enriching the STAC dataset

STAC dataset: http://securitytoolbox.appspot.com/stac-dataset

3. Updating the STAC dataset with a new security mechanism

Figure 60 shows the way to add a new instance of the `BluetoothSecurityMechanism` in the STAC dataset. This new instance is called JSR82. Do not forget to add the label and the comment to describe this new instance. In this example, we also explain that this instance is a type of stac:`ProgrammingLanguageSecurityMechanism`.

```
<stac:BluetoothSecurityMechanism rdf:about="JSR82">
    <rdfs:label xml:lang="en">JSR-82</rdfs:label>
    <rdf:type rdf:resource="&stac;ProgrammingLanguageSecurityMechanism"/>
    <rdfs:comment xml:lang="en">JSR-82 is the official Java Blutooth Application
</stac:BluetoothSecurityMechanism>    Programming Interface (API)</rdfs:comment>
```

Figure 60. Add a new instance of BluetoothSecurityMechanism

Figure 60 shows the way to add a new instance of the `BluetoothAttack` in the STAC dataset.
In this example, the new Bluetooth attack is called “Bluejacking”.

```
<stac:BluetoothAttack rdf:about="Bluejacking">
    <rdfs:label xml:lang="en">Bluejacking</rdfs:label>
    <rdfs:comment xml:lang="en">Bluejacking is the sending of either a picture or a message
</stac:BluetoothAttack>                    from one user through Bluetooth.</rdfs:comment>
```

Figure 61. Add a new instance of BluetoothAttack

You can add more explanations to the security mechanisms instance, for instance the stac:satisfies property. In the example depicted in Figure 62, we describe that the SSH satisfies three security properties called Authentication, Integrity and Confidentiality.

```
<stac:WebSecurityMechanism rdf:about="SSH">
    <rdfs:label xml:lang="en">Secure Shell (SSH)</rdfs:label>
    <rdfs:comment xml:lang="en">SSH is the now ubiquitous program for logging into or executing
    <rdf:type rdf:resource="&stac;Protocol"/>                commands on a remote machine.</rdfs:comment>
    <stac:protectsInLayer rdf:resource="ApplicationLayer"/>
    <stac:satisfies rdf:resource="Authentication"/>
    <stac:satisfies rdf:resource="Integrity"/>
    <stac:satisfies rdf:resource="Confidentiality"/>
    <stac:hasFeature rdf:resource="Popular"/>
    <dcterms:hasPart rdf:resource="AsymmetricAlgorithm"/>
</stac:WebSecurityMechanism>
```

Figure 62. Add the security property to the instance

Figure 63 show the creation of a new security property instance called Confidentiality. We add links to the existing security ontologies (owl:samesAs) describing the same instance.

```
<stac:SecurityProperty rdf:about="Confidentiality">
    <rdfs:label xml:lang="en">Confidentiality/Privacy </rdfs:label>
    <rdfs:comment xml:lang="en">Confidentiality means that only destined user must
    <owl:sameAs rdf:resource="&herzog;Confidentiality"/>  be able to read data. </rdfs:comment>
    <owl:sameAs rdf:resource="&denker;Confidentiality"/>
    <owl:sameAs rdf:resource="&kim;Confidentiality"/>
    <owl:sameAs rdf:resource="&maso;Confidentialite"/>
    <owl:sameAs rdf:resource="&securitysw;Confidentiality"/>
</stac:SecurityProperty>
```

Figure 63. Add a new security property instance.

Part XI : Limits

During an event, we got this issue at the end of the day, perhaps too many people querying the web site. It seems the limit with Google App engine (basic versions) is maximum 1000 request per day.

Figure 64. Error Over Quota. This application is temporarily over its serving quota. Please try again later.

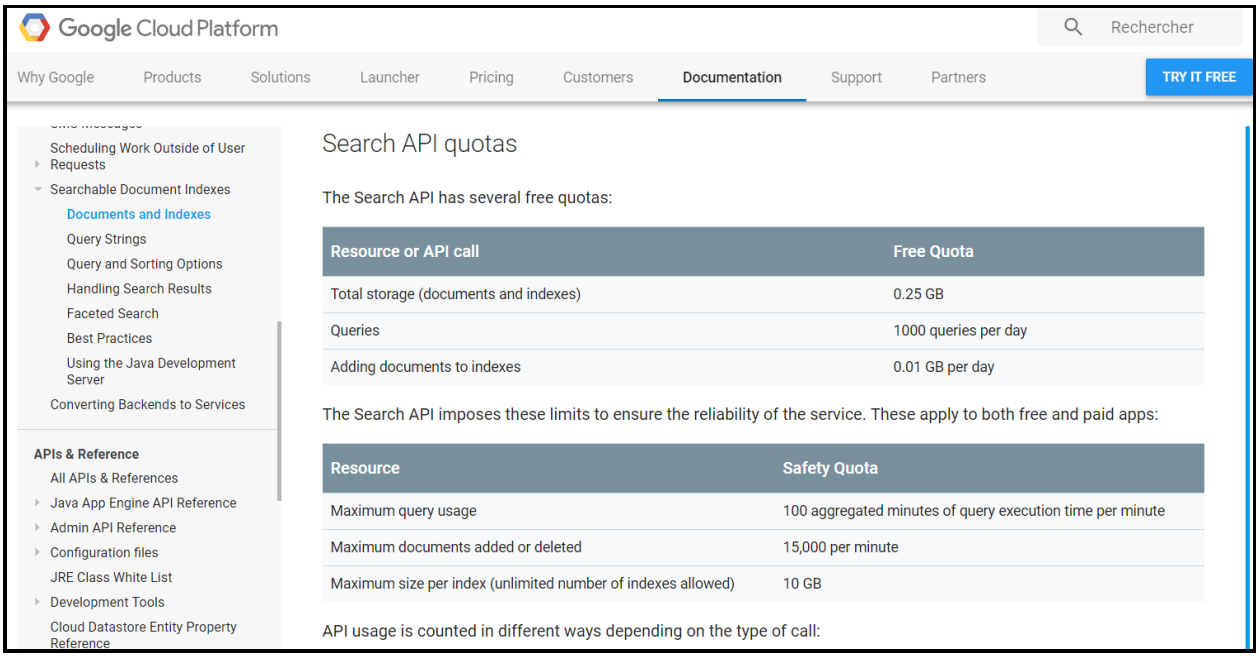


Figure 65. Documentation Google App Engine: Search API Quotas

Documentation if web site down, perhaps for the following reasons:
https://cloud.google.com/appengine/docs/standard/java/search/#Java_Search_API_quotas

Part XII : Additional

I. Jena TDB and Jena Fuseki (Internship Amira)

The project is available in the same BSCW directory

Install Jena TDB
Does not work with App Engine but the server tomcat
See documentation Internship

Install Jena Fuseki
Does not work with App Engine but the server tomcat
See documentationInternship

II. Security issues to execute JavaScript with the project

to disable the browser security (javascript problem)
command name_browser -disable-web-security
chrome -disable-web-security