Open APIs for Open Minds

Building your own IoT platform using FIWARE GEis

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FIWARE

Introduction

- **Talk Objectives**
  - Illustrate how a secured IoT platform instance can be implemented using FIWARE GEis on a container-based environment (**Docker**)
  - Understand how to **set up** a security layer on top of a Context Broker
  - Learn how to **configure** all the components at the different layers

Developer

Sign up

Registration App

Add user
Domain, Project,
Roles

Identity Manager (*Keystone*)

Get token

(domain, project, role)

Token validation

Token

Application
(Data Consumer)

NGSIv2

I9

Internet / VPN

PEP Proxy (*Steelskin*)

NGSIv2

I8

Context Broker (*Orion*)

IoT Devices

Open Data Sources

Data ingestion

Is authorized?

Allow or Deny

Authorization PDP (*Keypass*)

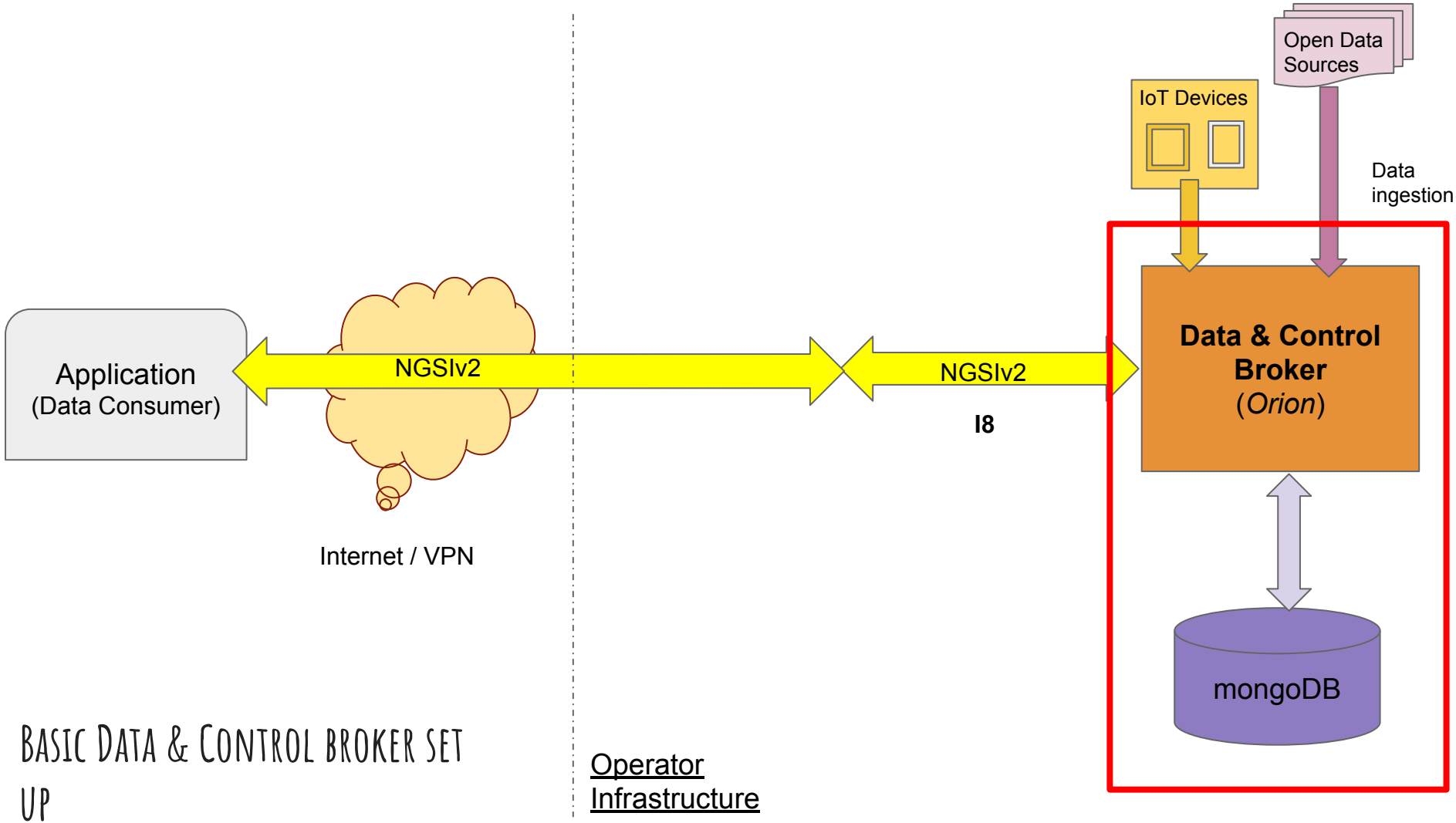
mongoDB

IoT platform Infrastructure

Target Architecture using FIWARE Security Stack

Getting started

A basic context broker set up



Basic Data & Control broker set up

Step 1 .- MongoDB (I)

- **mongoDB** is the NoSQL database used to store context data
- mongoDB is properly packaged as a docker container
- Use **mongoDB 3.2** docker container
- Prepare a folder to store mongoDB data
  - Ex. $HOME/data/mongo
- Run mongoDB

```
$ docker run --name mongo -v $HOME/data/mongo:/data/db -d
-h mongo -p 27017:27017 mongo:3.2
```

- mongoDB will be running on port **27017** (standard one)

Step 1 .- MongoDB (II)

- $ docker ps -a to list running containers
  - aa075751485b mongo:3.2 "/entrypoint.sh mongo" 5 seconds ago Up 4 seconds 0.0.0.0:27017->27017/tcp mongo
- run mongo client application to check everything is ok
  - You might need to install it https://docs.mongodb.com/v3.2/tutorial/install-mongodb-on-ubuntu/
    - $ apt-get install mongodb-org-shell
    - $ mongo> show dbs
- Or you can directly connect to the container
  - $ docker exec -it mongo bash
  - mongo:/# mongo
  - > show dbs

Step 2 .- Orion context broker (I)

- Orion is
  - an implementation of the “Data and Context Broker”
  - An open source project hosted by the FIWARE OSS
    - https://github.com/fiware/context.Orion (License Affero GPL v3.0)
  - properly packaged as a docker container running on CentOS 6
  - Orion uses **mongoDB** as the data storage
- For running Orion …

```
$ docker run --name orion -d -p 1026:1026 --link mongo -h orion fiware/orion:1.4.1 -dbhost mongo
$ docker ps -a
6c63cee20ae2        fiware/orion:1.4.1   "/usr/bin/contextBrok"   6 seconds ago       Up 5 seconds
0.0.0.0:1026->1026/tcp     orion
4f1d9298fb70        mongo:3.2            "/entrypoint.sh mongo"   20 minutes ago      Up 20 minutes
0.0.0.0:27017->27017/tcp   mongo
```

- Orion will be listening at **1026** port

STEP 2 .- ORION CONTEXT BROKER (II)

- $ curl -s localhost:1026/version | python -mjson.tool

```
{
  "orion" : {
    "version" : "1.4.1",
    "uptime" : "0 d, 0 h, 1 m, 17 s",
    "git_hash" : "905d5fa58ace7fa4f14330ddc982b41cf9b30be6",
    "compile_time" : "Mon Oct 10 15:06:02 UTC 2016",
    "compiled_by" : "root",
    "compiled_in" : "b99744612d0b"
  }
}
```

- $ mongo > show dbs > use orion
  - Now a DB named “orion” should appear if everything is ok
- db.getCollectionNames()
  - ["entities"]
- curl -s localhost:1026/v2/entities | python -mjson.tool
  - []

Step 3 .- Let's add some entities to orion (I 

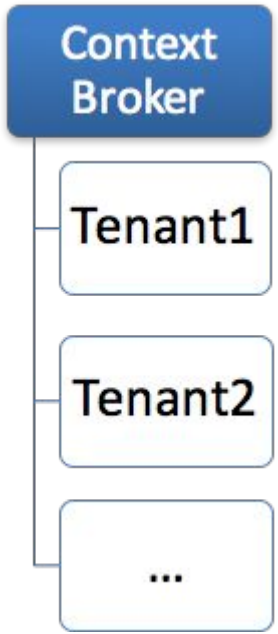
```
$ curl localhost:1026/v2/entities -s -S --header 'Content-Type: application/json' -d @- <<EOF
{
  "id": "WeatherObserved-6789",
  "type": "WeatherObserved",
  "temperature": {
    "value": 23,
    "type": "Number"
  },
  "barometricPressure": {
    "value": 720,
    "type": "Number"
  },
  "dateObserved": {
    "value": "2016-10-18T11:08:20.228Z",
    "type": "DateTime"
  },
  "source": {
    "value": "http://www.aemet.es",
    "type": "URL"
  }
}
EOF
```

Step 3 .- Let's add some entities to orion (I


```
$ curl localhost:1026/v2/entities?options=keyValues | python -mjson.tool

[
    {
        "barometricPressure": 720,
        "dateObserved": "2016-10-18T11:08:20.00Z",
        "id": "WeatherObserved-6789",
        "source": "http://www.aemet.es",
        "temperature": 23,
        "type": "WeatherObserved"
    }
]

$ mongo
> use orion
switched to db orion
> db.entities.find({})
{ "_id" : { "id" : "WeatherObserved-6789", "type" : "WeatherObserved", "servicePath" : "/" }, "attrNames" : [
"temperature", "barometricPressure", "dateObserved", "source" ], "attrs" : { "temperature" : { "type" :
"Number", "creDate" : 1476789680, "modDate" : 1476789680, "value" : 23, "mdNames" : [ ] },
"barometricPressure" : { "type" : "Number", "creDate" : 1476789680, "modDate" : 1476789680, "value" : 720,
"mdNames" : [ ] }, "dateObserved" : { "type" : "DateTime", "creDate" : 1476789680, "modDate" : 1476789680,
"value" : 1476788900, "mdNames" : [ ] }, "source" : { "type" : "URL", "creDate" : 1476789680, "modDate" :
1476789680, "value" : "http://www.aemet.es", "mdNames" : [ ] } }, "creDate" : 1476789680, "modDate" :
1476789680 }
```

Step 4 .- Multitenancy (I)

- Orion Context Broker is multitenant
  - Logical databases **isolated,** each one containing data from different organizations or domains
  - Tenant is a "***service***" in FIWARE terminology.
  - Aka a "Domain" in OpenStack terminology
- A tenant can be composed by multiple child sub-tenants
  - "***subservice***" in FIWARE terminology
  - Aka a "Project" in OpenStack terminology
- Example
  - *Tenant* : All data from a city or a domain
  - *Sub-tenants*: area, country, domain …
  - Or the other way round. Depends on **design criteria**
- If no tenant specified Orion *default tenant* is used



Step 4 .- Multitenancy (II)

- The way to address tenants are HTTP headers
  - **Fiware-Service** : <<Tenant_Name>>
  - **Fiware-Servicepath**: <<Subservice_Name>>
- Subtenants follow a hierarchical structure and there is a default subtenant, root one (‘/’)
- Example:
  - Fiware-service: weather
  - Fiware-servicepath: /Spain
- A pair **(service, subservice)** is used for security purposes
  - A user is granted permission to get access to or publish data belonging to a service and a subservice
- Let’s play a bit with tenants

Step 4 .- Multitenancy (III)

- Creating an entity in a (tenant , subtenant)

```
TENANT="Fiware-Service:$1"
SUBSERVICE="Fiware-ServicePath:/$2"

curl localhost:1026/v2/entities --header $TENANT --header $SUBSERVICE -s -S --header
'Content-Type: application/json' -d @- <<EOF
{
  "id": "WeatherObserved-6789",
  "type": "WeatherObserved",
  "temperature": {
    "value": 23,
    "type": "Number"
  },

……
 }
EOF
```

Step 4 .- Multitenancy (IV)

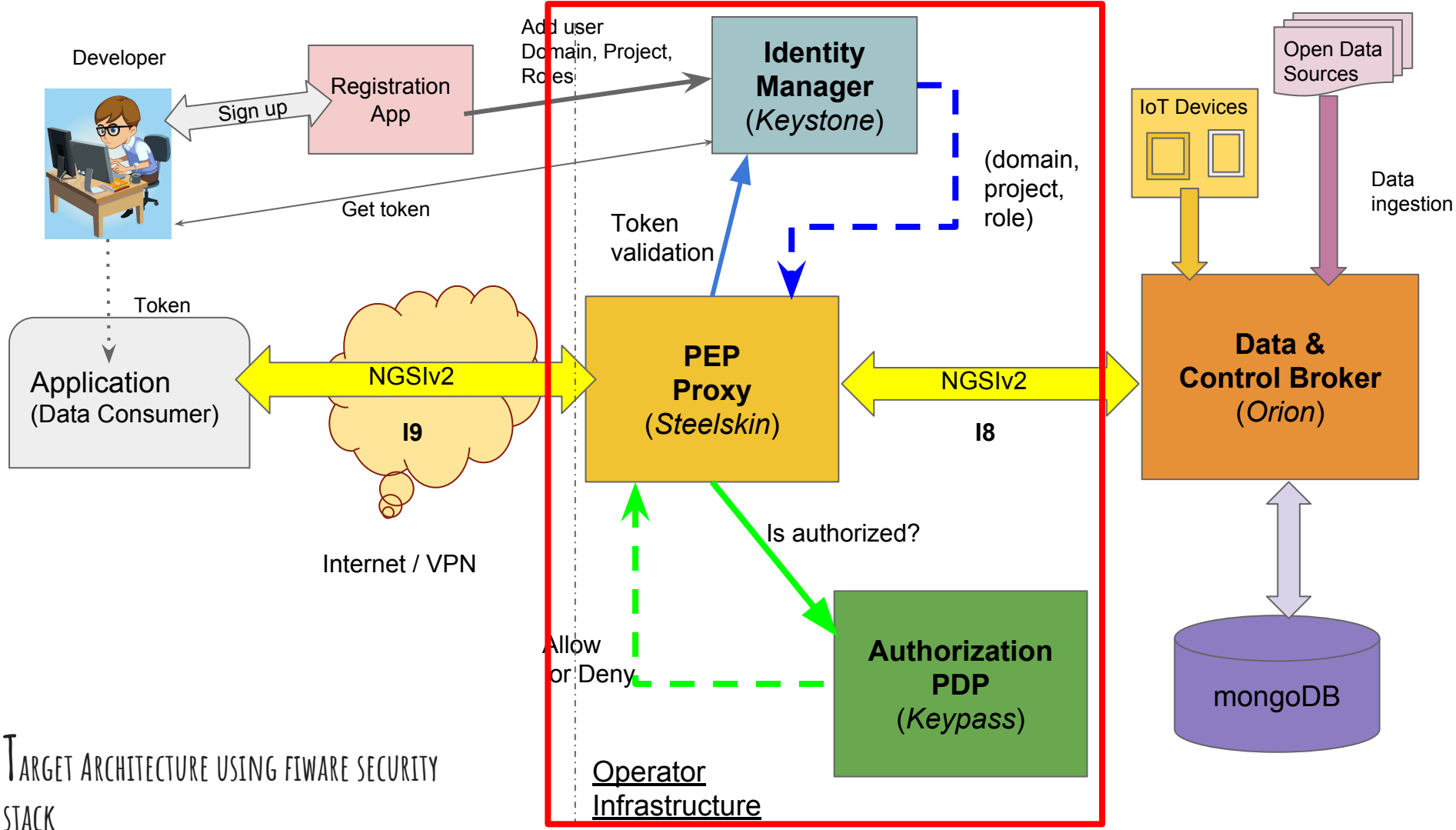
```
$mongo

> show dbs
local             0.000GB
orion             0.000GB
orion-example_a   0.000GB
orion-london      0.000GB
orion-weather     0.000GB
```

- There will be as many databases as tenants available
- "orion" is the DB which stores data in the default tenant
- DB name is "orion-" + <<tenant_name>>
- To query data of a tenant just issue regular NGSIv2 requests using ***Fiware-Service*** and ***Fiware-Servicepath*** headers

```
curl -s -S --header $TENANT --header $SUBSERVICE localhost:1026/v2/entities?options=keyValues
| python -mjson.tool
```

Deeping dive

Adding a security layer to the data & control broker



Target Architecture using FIWARE Security stack

Step 4 .- Security stack - preparation

- Security stack uses **MySQL** to store configuration data

```
$ docker run --name mysql -d -p 3306:3306 -h mysql -v $HOME/data/mysql:/var/lib/mysql -e
"MYSQL_ROOT_PASSWORD=gsma" -e "MYSQL_DATABASE=keypass" -e "MYSQL_USER=keypass" -e
"MYSQL_PASSWORD=keypass" mysql:5.5
```

Check that everything is ok. Above command creates a database named "keypass" used later .

```
$ docker exec -it mysql bash

mysql --user=root --password=gsma

mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| keypass            |
| mysql              |
| performance_schema |
+--------------------+
4 rows in set (0.00 sec)
```

Step 4.1 .- Keystone (I)

- Keystone is an open source project hosted by OpenStack OSS Community
  - https://github.com/openstack/keystone
    - (Apache 2.0 license)
- Keystone is an *Identity Manager* service capable of storing information about domains, project, users, groups or roles
- Keystone is in charge of generating tokens which can be used to get access to services requiring credentials
- For this exercise we will be using a keystone image especially tuned for our purposes
  - Keystone will store **developer credentials** and roles
  - Keystone will store information about FIWARE tenants and sub-tenants

Step 4.1 .- keystone (II)

- Running keystone

```
$ docker run --name keystone -d -p 5001:5001 --link mysql -h keystone
telefonicaiot/fiware-keystone-spassword -dbhost mysql -default_pwd 4pass1w0rd -mysql_pwd
gsma
```

- Sanity check operations

```
$ docker logs keystone

$ docker exec -it keystone bash (to open a shell session on the container)

$ curl -s -S http://localhost:5001/v3 | python -mjson.tool
```

- Once we have a keystone instance up and running different REST requests can be issued

http://developer.openstack.org/api-ref/identity/v3/index.html

Step 4.1 .- keystone (II-B)

- Checking keystone has created its database properly

```
$ docker exec -it mysql bash

root@mysql:/# mysql --user=root --password=gsma

mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| keypass            |
| keystone           |
| mysql              |
| performance_schema |
+--------------------+

mysql> use keystone;
```

```
show tables;
+------------------------+
| Tables_in_keystone     |
+------------------------+
| assignment             |
| credential             |
| domain                 |
| endpoint               |
| group                  |
| migrate_version        |
| policy                 |
| project                |
| region                 |
| role                   |
| service                |
| spassword              |
| token                  |
| trust                  |
| trust_role             |
| user                   |
| user_group_membership  |
+--------------------+
```

Step 4.1 .- Keystone (III)

- Remember:
  - Fiware-Service → **Domain** in Keystone
  - Fiware-Servicepath → **Project** in Keystone

- A developer will register in Keystone as *user in a domain* <-> Developer can get access to the data offered by the corresponding FIWARE service (tenant)

- We will later show how this works in practice

Step 4.1 .- Keystone (IV)

- List all domains

```
curl -s -S --header x-auth-token:4pass1w0rd http://localhost:5001/v3/domains/ | python -mjson.tool
```


```
{
    "domains": [
        {
            "enabled": true,
            "id": "8b883aaa740e4d75b91095eaa550b35c",
            "links": {
                "self": "http://localhost:5001/v3/domains/8b883aaa740e4d75b91095eaa550b35c"
            },
            "name": "admin_domain"
        },
        {
            "description": "Owns users and tenants (i.e. projects) available on Identity API v2.",
            "enabled": true,
            "id": "default",
            "links": {
                "self": "http://localhost:5001/v3/domains/default"
            },
            "name": "Default"
        }
    ]
```

Step 4.1 .- keystone (V)

- List all users

```
curl -s -S --header x-auth-token:4pass1w0rd http://localhost:5001/v3/users/ | python
-mjson.tool
```


```
"users": [
        {
            "description": "Cloud service",
            "domain_id": "8b883aaa740e4d75b91095eaa550b35c",
            "enabled": true,
            "id": "02cd3dbb6ceb48eb92588c7885bbcc1f",
            "links": {
                "self": "http://localhost:5001/v3/users/02cd3dbb6ceb48eb92588c7885bbcc1f"
            },
            "name": "pep"
        },
        {
            "description": "Cloud administrator",
            "domain_id": "8b883aaa740e4d75b91095eaa550b35c",
            "enabled": true,
            "id": "177cf5a4d12e4f85b7b65cbcac6d9697",
            "links": {
                "self": "http://localhost:5001/v3/users/177cf5a4d12e4f85b7b65cbcac6d9697"
            },
            "name": "cloud_admin"
        }
```

Step 4.1 .- keystone (VI)

- Get a token for the *cloud_admin* user

```
curl localhost:5001/v3/auth/tokens -s -S --header 'Content-Type: application/json' -d @- <<EOF
{ "auth": {
    "identity": {
      "methods": ["password"],
      "password": {
        "user": {
          "name": "cloud_admin",
          "domain": { "name": "admin_domain" },
          "password": "4pass1w0rd"
        }
      }
    }
  }
}
EOF

HTTP/1.1 201 Created
X-Subject-Token: 19e200834a3f4e149c7f4033a003a8f4
```

Step 4.2 .- keypass .- auth PDP (I)

- *keypass* is an implementation of the FIWARE Authorization PDP (*Policy Decision Point*)
- *Keypass* is an open source project hosted at
  - https://github.com/telefonicaid/fiware-keypass
  - License is Apache 2.0
- It complies with XACML (eXtensible Access Control Markup Language) v3.0.
- It provides an API to get authorization decisions based on authorization policies
- API summary can be found at
  - https://github.com/telefonicaid/fiware-keypass/blob/master/API.md

Step 4.2 .- keypass .- Auth PDP (II)

- Running keypass

```
$ docker run --name keypass -d -p 7070:7070 -h keypass --link mysql
telefonicaiot/fiware-keypass -dbhost mysql

$ docker logs keypass

$ curl --header 'Fiware-Service: dummy' localhost:7070/version

1.2.1
```

Step 4.3 .- Steelskin .- PEP proxy (I)

- Steelskin is an implementation of the FIWARE PEP (*Policy Enforcement Point*)
- Steelskin is an open source project hosted at
  - https://github.com/telefonicaid/fiware-pep-steelskin
  - License is Affero GPL 3.0
- A proxy which ensures that only authorized users are able to perform requests against the Data & Control Broker
  - https://github.com/telefonicaid/fiware-pep-steelskin#-rules-to-determine-the-context-broker-action-from-the-request
- The actual endpoint used by applications to get access to the Data & Control Broker

Step 4.3 .- Steelskin .- PEP proxy (II)

- Running:

```
$ docker run -d --name pep -p 1027:1026 --link orion --link keystone --link keypass  -e
LOG_LEVEL=DEBUG -e AUTHENTICATION_HOST=keystone -e AUTHENTICATION_PORT=5001 -e ACCESS_HOST=keypass
-e ACCESS_PORT=7070 -e TARGET_HOST=orion -e TARGET_PORT=1026 -e PROXY_USERNAME=pep -e
PROXY_PASSWORD=4pass1w0rd telefonicaiot/fiware-pep-steelskin

$ docker logs pep

$ docker exec -it pep bash  → $ curl localhost:11211/version

{ "version": "1.2.0-next", "port":1026 }
```

Step 4.3 .- Steelskin .- PEP proxy (III)

- Remember: Given an HTTP Request **(x-auth-token, fiware-service, fiware-servicepath)**
  - First PEP queries *keystone* to validate the auth token and obtain (user, domain, role in project)
  - Then, PEP queries *keypass* to obtain the authorization policies for the role in question
  - A match between subject policies and the requested operation is done
  - If the requested operation is allowed, the HTTP request is forwarded to the Data & Control Broker
  - If not a non-authorized error is raised

```
curl localhost:1027/v2/entities
{
  "name": "MISSING_HEADERS",
  "message": "Some headers were missing from the request:
[\"fiware-service\",\"fiware-servicepath\",\"x-auth-token\"]"
}
```

STEP 5 .- USING THEM ALL TOGETHER

```
$ docker ps -a

CONTAINER ID        IMAGE                                          COMMAND                  CREATED
STATUS              PORTS                                    NAMES
d18f7dbe7f75        telefonicaiot/fiware-pep-steelskin             "/bin/sh -c bin/pepPr"   16 minutes ago
Up 16 minutes       11211/tcp, 0.0.0.0:1027->1026/tcp   pep
7e1853f0e2c4        telefonicaiot/fiware-keypass                   "/opt/keypass/keypass"   45 minutes ago
Up 45 minutes       0.0.0.0:7070-7071->7070-7071/tcp    keypass
c4f6ab6c390f        telefonicaiot/fiware-keystone-spassword        "/opt/keystone/keysto"   About an hour
ago   Up About an hour    0.0.0.0:5001->5001/tcp                 keystone
5bf5d7e8b284        mysql:5.5                                      "docker-entrypoint.sh"   18 hours ago
Up 18 hours         0.0.0.0:3307->3306/tcp              mysql
6c63cee20ae2        fiware/orion:1.4.1                             "/usr/bin/contextBrok"   24 hours ago
Up 24 hours         0.0.0.0:1026->1026/tcp              orion
4f1d9298fb70        mongo:3.2                                      "/entrypoint.sh mongo"   24 hours ago
Up 24 hours         0.0.0.0:27017->27017/tcp            mongo
```

Step 5.1 .- Orchestrator to the rescue

- Manual provision of configurations of the three security components can be cumbersome
- TEF has developed an open source project (named *orchestrator*) that helps to provide security configurations
  - https://github.com/telefonicaid/orchestrator
  - License is Affero GPL 3.0
- It can be instantiated as a service but there are some useful scripts which can be used
  - https://github.com/telefonicaid/orchestrator/blob/master/SCRIPTS.md
  - They need a **Python 2.7** environment

Step 5.2 .- configuring a service (tenant)

```
$ git clone https://github.com/telefonicaid/orchestrator

$ cd orchestrator

$ pip install -r requirements.txt

$ export PYTHONPATH=$PYTHONPATH:$HOME/gsma/orchestrator/src
cd $HOME/gsma/orchestrator/src

./orchestrator/commands/createNewService.py http localhost 5001 admin_domain cloud_admin
4pass1w0rd weatherdata "Weather Data" weather_admin weather_admin_PWD http localhost 7070
```

- Checking that everything went ok

```
./orchestrator/commands/printServices.py http localhost 5001 admin_domain cloud_admin
4pass1w0rd
```

Step 5.3 .- configuring a Sub-service

```
$ export PYTHONPATH=$PYTHONPATH:$HOME/gsma/orchestrator/src
cd $HOME/gsma/orchestrator/src

./orchestrator/commands/createNewSubService.py http localhost 5001 weatherdata
weather_admin weather_admin_PWD "Spain" "Weather in Spain"
```

- Checking that everything went ok

```
./orchestrator/commands/printSubServices.py http localhost 5001 weatherdata weather_admin
weather_admin_PWD
```

- Now we have a pair (Fiware-Service, Fiware-Servicepath) → **('weatherdata', '/Spain`)**
- We can check that we can get access to data
  - 1/ obtain a token for the `weather_admin' user Ex. `5bb5c6e310814b93a01d74385fe52bef`
  - 2/ issue a GET request through the PEP proxy

```
curl localhost:1027/v2/entities --header 'Fiware-Service:weatherdata' --header 'Fiware-Servicepath:
/Spain' --header 'x-auth-token:5bb5c6e310814b93a01d74385fe52bef'
```

Step 5.4 .- Adding a developer with consumer permissions

```
./orchestrator/commands/createNewServiceUser.py http localhost 5001 weatherdata
weather_admin weather_admin_PWD developer1 developer1_PWD
```

Checking that everything went ok

```
./orchestrator/commands/printServiceUsers.py http localhost 5001 weatherdata weather_admin
weather_admin_PWD
```

Now we need to assign the role "SubServiceCustomer" to the user 'developer1'

```
./orchestrator/commands/assignRoleSubServiceUser.py http localhost 5001 weatherdata Spain
weather_admin weather_admin_PWD SubServiceCustomer developer1
```

Checking that everything went ok

```
./orchestrator/commands/listSubServiceRoleAssignments.py http localhost 5001 weatherdata
weather_admin weather_admin_PWD Spain True
```

Now 'developer1' is able to query weather data on the sub-service 'Spain'. However he cannot provide data as his role is 'SubServiceCustomer'

Step 5.5 .- Getting access to data with 'developer1' (I)

First of all a token must be obtained . Then :

```
$ curl -s -S localhost:1027/v2/entities --header 'Fiware-service:weatherdata' --header
'Fiware-servicepath:/Spain' --header 'x-auth-token:36a1d0558612473da438c93d74d4aefc' |
python -mjson.tool
```


```
[
    {
        "barometricPressure": {
            "metadata": {},
            "type": "Number",
            "value": 720
        },
        "dateObserved": {
            "metadata": {},
            "type": "DateTime",
            "value": "2016-10-18T11:08:20.00Z"
        },
        "id": "WeatherObserved-6789",
        "type": "WeatherObserved"
    }
]
```

Step 5.5 .- Getting access to data with 'developer1' (II)

An attempt to create a new entity on (weatherdata,/Spain) will fail

```
curl localhost:1027/v2/entities -s -S --header 'Content-Type: application/json' --header
'Fiware-Service:weatherdata' \
--header 'Fiware-servicepath:/Spain' --header 'x-auth-token:36a1d0558612473da438c93d74d4aefc' -d @- <<EOF
{
  "id": "WeatherObserved-4567",
….

}

EOF

{
  "name": "ACCESS_DENIED",
  "message": "The user does not have the appropriate permissions to access the selected action"
}
```

Developer will need to be assigned the role 'SubServiceAdmin' in order to be able to post new data

What's happening behind the scenes

- A set of predefined policies have been pre-populated to the 'keypass' database

```
docker exec -it mysql mysql --user=keypass --password=keypass

mysql> use keypass; select policy from Policies;
```

- Relevant policies are

https://github.com/telefonicaid/orchestrator/blob/master/src/orchestrator/core/policies/policy-orion-customer.xml

https://github.com/telefonicaid/orchestrator/blob/master/src/orchestrator/core/policies/policy-orion-admin.xml

And finally ...

- Remember to remove old docker containers (exited)
  - `$ docker rm <container>`
- You should **only expose** the IdM (for tokens) and the PEP Proxy (**ports**) to the developer
- Ensure the mounted volumes for database data have **enough space** for the data to be stored
- Remember, you can open a shell session on a container
  - `$ docker exec -it <<container_name> bash`
  - And then get access to the logs, databases, local services, ….
- Please use **different passwords** than the used during this presentation
  - It will be made public!
- And last but not least, **tokens** have a **limited duration**
  - (**1 hour** by default)

Questions

Thank you!

http://fiware.org
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