



Institut Universitaire  
de Technologie  
Aix-Marseille Université



**Institut Universitaire de Technologie,  
Aix-Marseille Université**

**INTERNSHIP REPORT  
Diplôme Universitaire de Technologie  
Spécialité Réseaux et Télécommunications**

**STUDY OF THE LORA NETWORK**

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**Academic tutor : Corinne HOUSSAIN**

**2018**



# Acknowledgments

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I would like to thank through these few lines the people who contributed to the success of my internship.

It's never easy for a student to find an internship abroad, which is why I thank Mrs. **Corinne HOUSSAIN**, my English teacher, Mrs. **Marie-Françoise TREDY** and Mrs. **Patricia SALIERES**, international coordinators for their contribution. They helped me to face many adventures in setting up this internship.

Within the University of the West of Scotland, I thank:

- Particularly Mr. **Ducan THOMSON** and Mr. **Joseph HEFFERNAN** for organizing my arrival on the spot as well as their support during my stay.
- And of course, my internship tutor, Mr. **Jose ALCARAZ-CALERO** for his patience and his listening until my last day in Scotland.

Finally, thanks to the IUT R&T, the professors, the administrative and the management for the past two years.



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# 1 Introduction

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The internship is the last step before obtaining the DUT\*. This 10-weeks internship are an important step in the training of each student. We can put into practice the skills acquired during the two years of training and gain a first experience as a network technician.

Nowadays, all companies tend to have an international dimension. This is true especially as talking about networks and telecommunications.

Therefore, I particularly wanted to do my internship closing the DUT in a foreign country.

Moreover perform an internship in a foreign country allow you to improve your English skills. But also and mostly that gives you the opportunity to discover a new culture, to meet different people and to have an open mind which is, in my opinion, useful perhaps even essential in professional and personal life.

When Mrs. HOUSSAIN offered me the opportunity to do my internship at the University of the West of Scotland, I did not hesitate.

My task in the IT department, initially a little vague, was clarified during the internship, to finally become the study of the telecommunication protocol LoRa\*.

I propose myself after a presentation of the university to continue with an exhibition my tasks and works carried out. In order to give myself to a reflection around the experience bring by this internship.

## 2 Host organization presentation

### 2.1 The University of the West of Scotland

The University of the West of Scotland (UWS) is a public university. There are four campuses in Scotland, in the towns of Paisley, Hamilton, Dumfries and Ayr (Figure 1), as well as a campus in London. The current campus in Hamilton will be relocated in a brand new Lanarkshire Campus which will open in September 2018.



Figure 1 : Map with the different UWS campuses

The current university dates from August 2007, but has a heritage dating back 120 years. We can trace its roots to the late 19th century and it has undergone many mergers and a gradual expansion throughout the Scotland region.

UWS is ranked by Times World University Rankings as being in the top 3% of universities worldwide.

The university hold a regional reputation for vocational undergraduate and post-graduate courses.

It currently has approximately 1,300 staff and around 17,000 students whose 3,000 international students from more than 70 countries worldwide, spread across six schools of learning :

- School of business & enterprise
- School of education
- School of health, nursing & midwifery
- School of media, culture & society
- School of science & sport
- School of engineering and computing

It is in the last one, located in campus of Paisley (Figure 2), that I perform my internship.

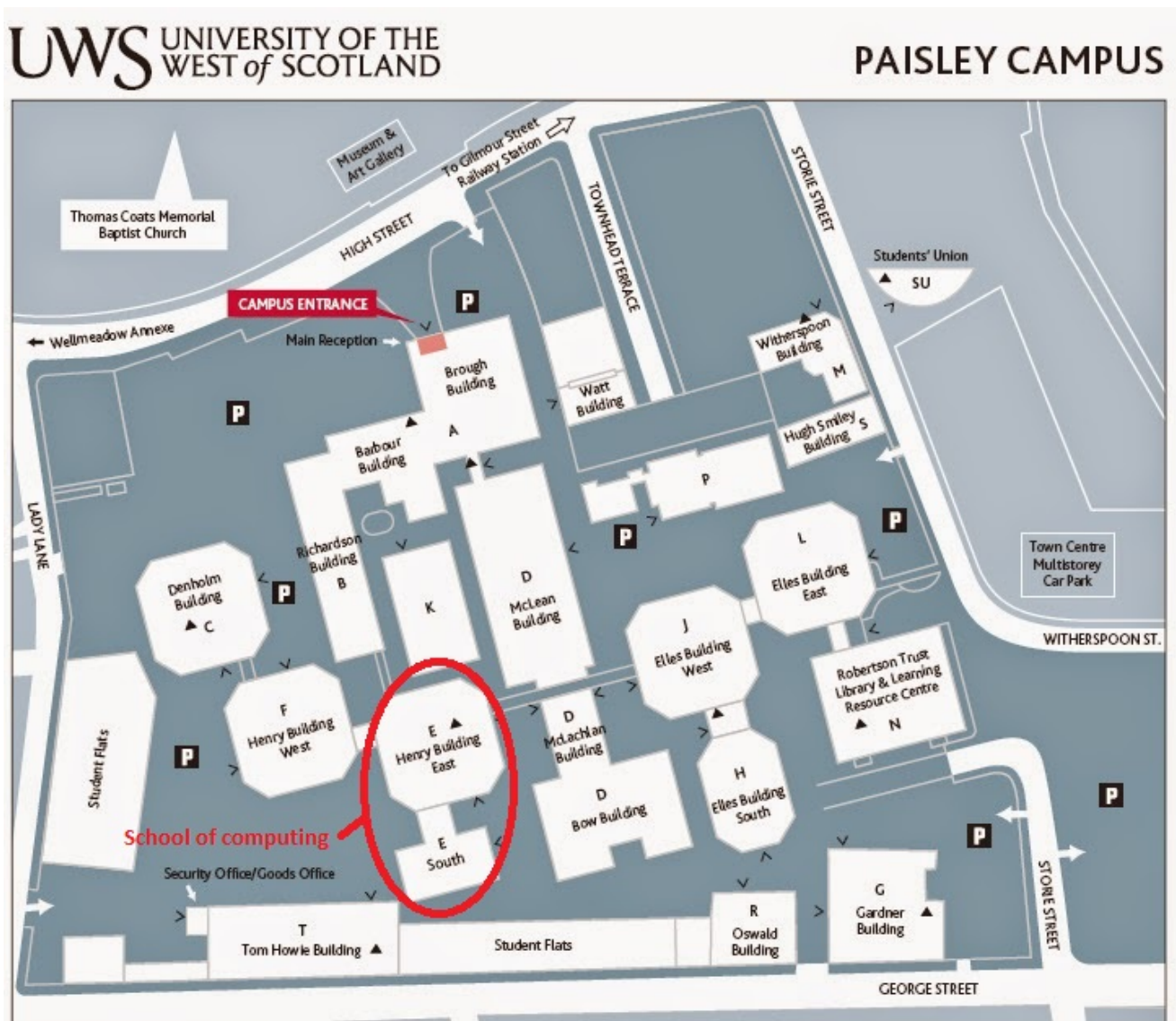
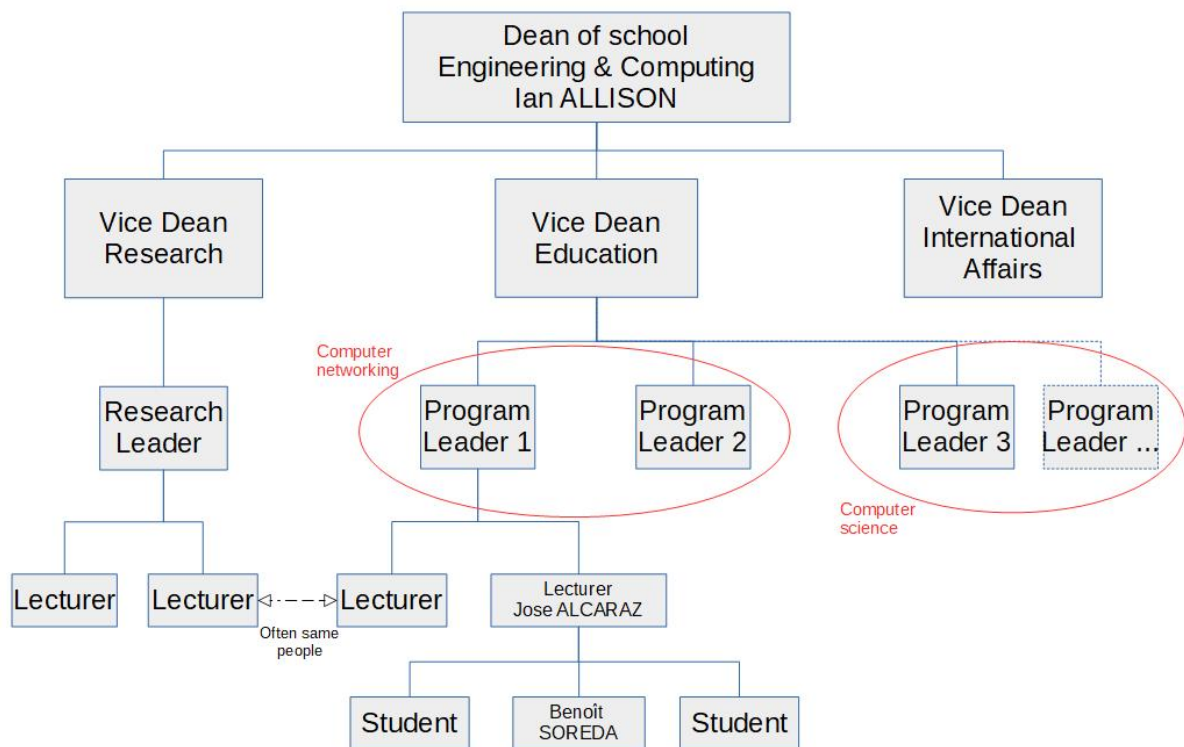


Figure 2 : Map of Paisley's campus

## 2.2 Engineering and computing school

For my internship I was placed under the tutorship of Mr. ALCARAZ-CALERO, lecturer in the engineering and computing school in the campus of Paisley. Being directly under his tutelage I was not tied to a work team.

The complete organization chart of the university is complex. I chose to represent only the School of Engineering & Computing. Knowing that there is no official organization chart, I made one myself by simplifying as much as possible (Figure 3).



**Figure 3 :** School of Engineering & Computing Organization chart

### 3 Mission's setting

Within UWS, my mission was centered around the LoRa protocol and its applications.



#### 3.1 LoRa quick overview

LoRa is a physical layer developed by Semtech that enables long distance wireless communications. LoRaWAN defines the communication protocol and network architecture.

LoRaWAN belongs to the category of LPWAN\*, low-power, long-range networks, suitable for connected objects, called IoT\*, whose application requires significant autonomy. They use ISM\* free-use frequency bands, shared with other wireless technologies.

End-Nodes do not communicate exclusively with a defined gateway but with all the concentrators that cover them. This mechanism is very effective, especially in the case of a mobile network (Figure 4).

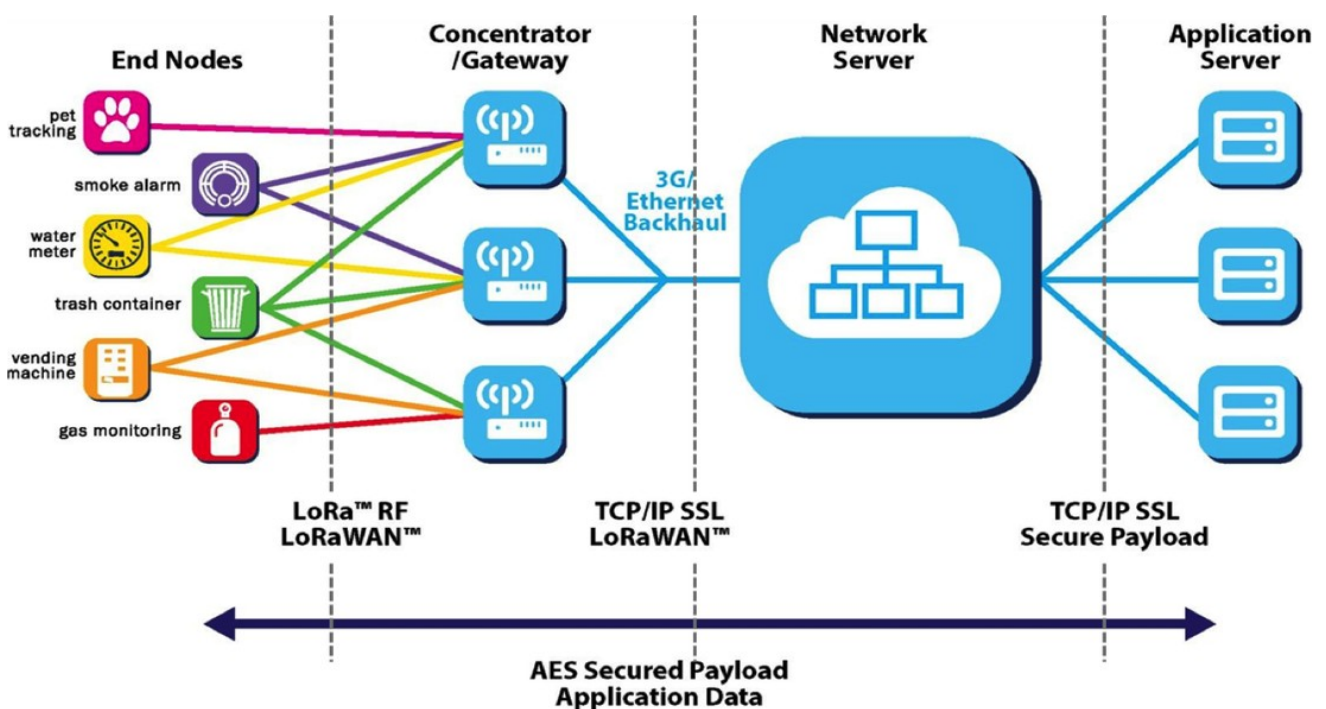


Figure 4 : LoRa Network Architecture

LoRaWan protocol is defined and managed by the LoRa Alliance. Created in 2015, the LoRa Alliance is an industrials and operators ensemble, grouped around LoRa whose objective is the standardization of LPWAN long-distance networks and in particular to allow the interoperability of these telecommunication networks.

## 3.2 Overall mission

The project I worked on during these two months of internship was very theoretical.

The first part consisted in make a documentation in order to define what is LoRa and LoRaWAN protocol. This document should be a presentation of the LoRa network so that to be read by IT team of the university.

Then I had to set up this system to test it and to write a procedure which could be use later by lecturers and students to realize tests themselves.

## 4 Works details

### 4.1 LoRa and his applications

#### 4.1.1 Overall presentation

The Lora alliance is at the origin of the LoRaWAN protocol which makes it possible to build networks using the LoRa modulation as a physical layer.

The following figure (Figure 5) shows the LoRaWAN layer architecture using the terminology of the OSI model.

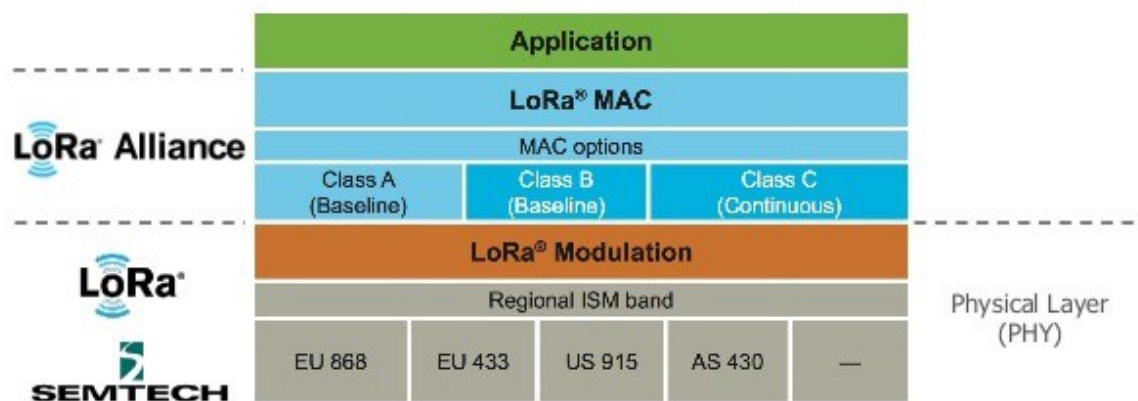


Figure 5 : LoRaWAN layers architecture

#### Frequency bands

LoRaWAN operates in unlicensed radio spectrum. This means that anyone can use the radio frequencies without having to pay million dollar fees for transmission rights. It is similar to WiFi, which uses the 2.4GHz and 5GHz ISM bands worldwide.

Anyone is allowed to set up WiFi routers and transmit WiFi signals without the need for a license or permit.

LoRaWAN uses lower radio frequencies with a longer range. The fact that frequencies have a longer range also comes with more restrictions that are often country-specific. This poses a challenge for LoRaWAN, that tries to be as uniform as possible in all different regions of the world. As a result, LoRaWAN is specified for a number of bands for these regions. In Europe, LoRaWAN operates in the 863-870 MHz frequency band.

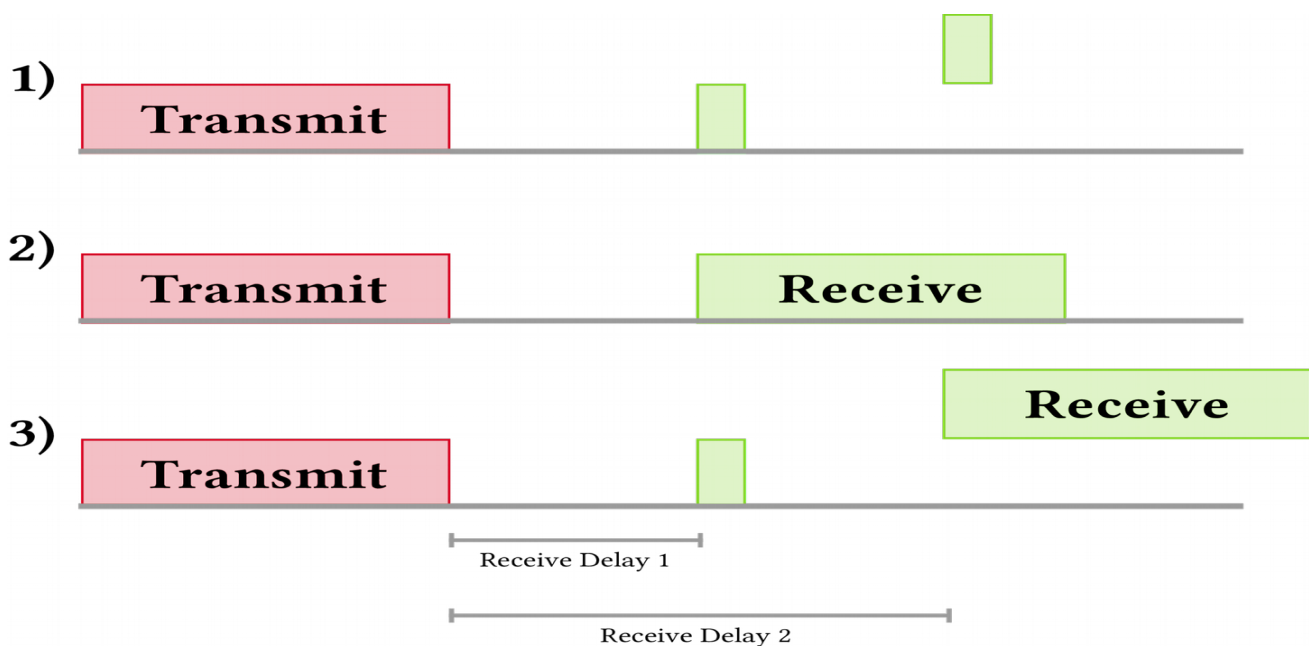
#### LoRa Modulation

In many cases, LoRa modulation uses a variant of spread spectrum called Chirp Spread Spectrum to encode the information. Spectrum spreading is when spread the spectrum over a wide band of frequencies with very low transmission power.

## End devices (nodes)

The LoRaWAN specification defines three device types. All LoRaWAN devices must implement Class A, whereas Class B and Class C are extensions to the specification of Class A devices.

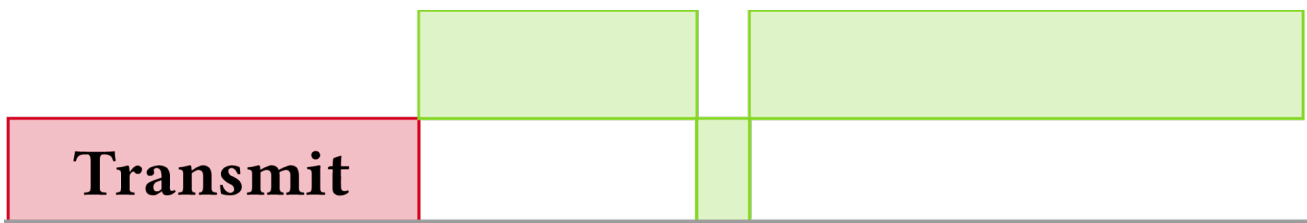
**Class A** devices support bi-directional communication between a device and a gateway. Uplink messages (from the device to the server) can be sent at any time (randomly). The device then opens two receive windows at specified times (1s and 2s) after an uplink transmission. If the server does not respond in either of these receive windows (situation 1 in the figure), the next opportunity will be after the next uplink transmission from the device. The server can respond either in the first receive window, or in the second receive window, but should not use both windows (Figure 6).



**Figure 6 :** Communication example

**Class B** devices extend Class A by adding scheduled receive windows for downlink messages from the server. Using time-synchronized beacons transmitted by the gateway, the devices periodically open receive windows.

**Class C** devices extend Class A by keeping the receive windows open unless they are transmitting, as shown in the figure below (Figure 7). This allows for low-latency communication but is many times more energy consuming than Class A devices.



**Figure 7 : Class C communication**

### **MAC commands**

The network server and device can perform network-related administration and management using MAC\* commands. The LoRaWAN specification specifies a number of commands that can be extended in future versions of LoRaWAN or extended with proprietary commands. There are commands for checking connectivity, requesting the status of a device, adapting the data rate of a device, and modifying channel settings.

## 4.1.2 Applications examples

ThingsBoard is an online platform which provides ready-to-use solutions using IoT. These solutions are intended for both professionals and individuals. They are based on LoRa.

Here are some examples that use this technology.

A smart farming and smart agriculture solution which gets the data from three silos, here is dashboard (Figure 8) :

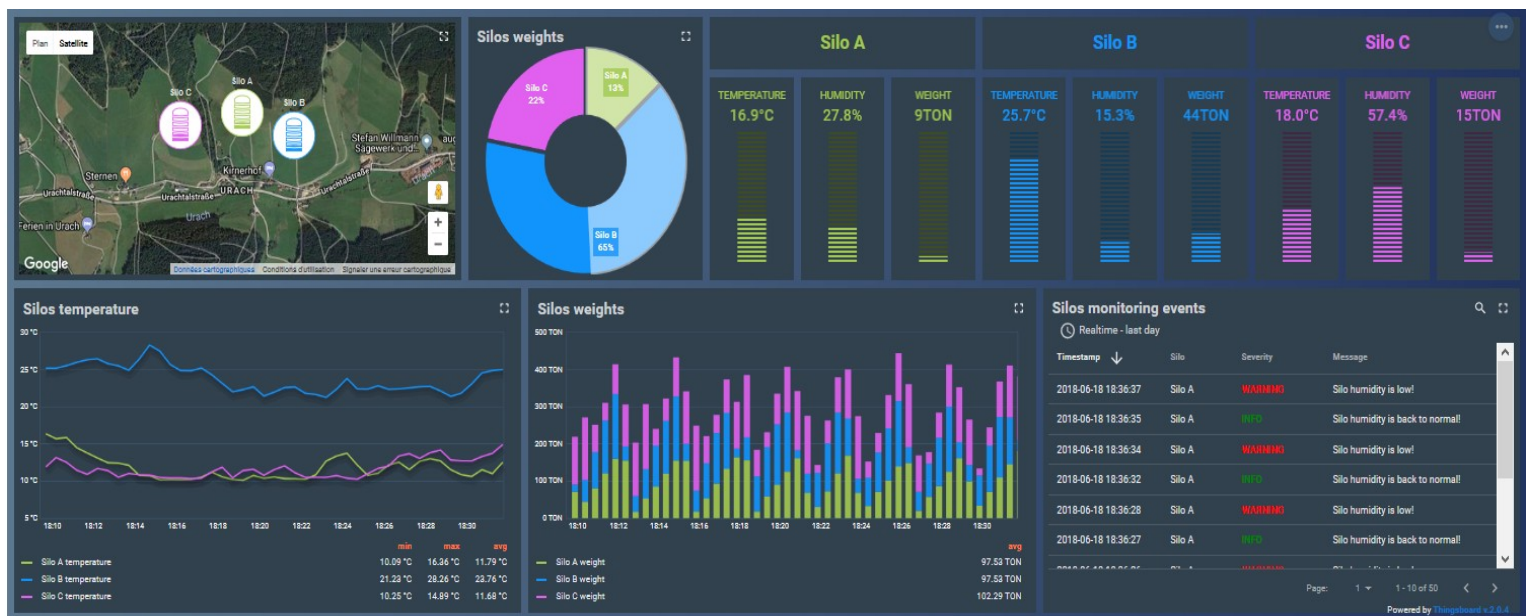


Figure 8 : Smart farming dashboard

Here an other example: a fleet tracking and a fleet management for bus (Figure 9).

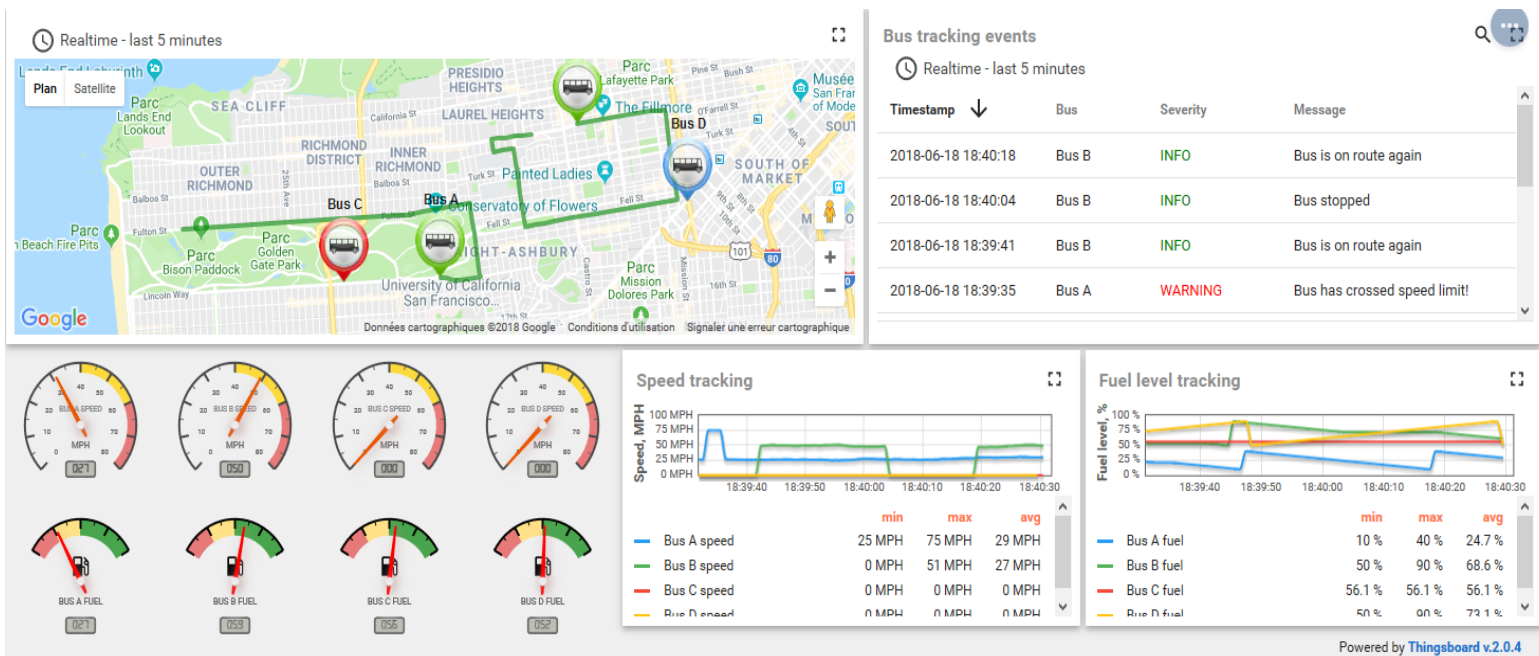


Figure 9 : Fleet tracking dashboard

In France :

SNCF plans to use this system to monitor the proper closing of the doors of its CORAIL trains.

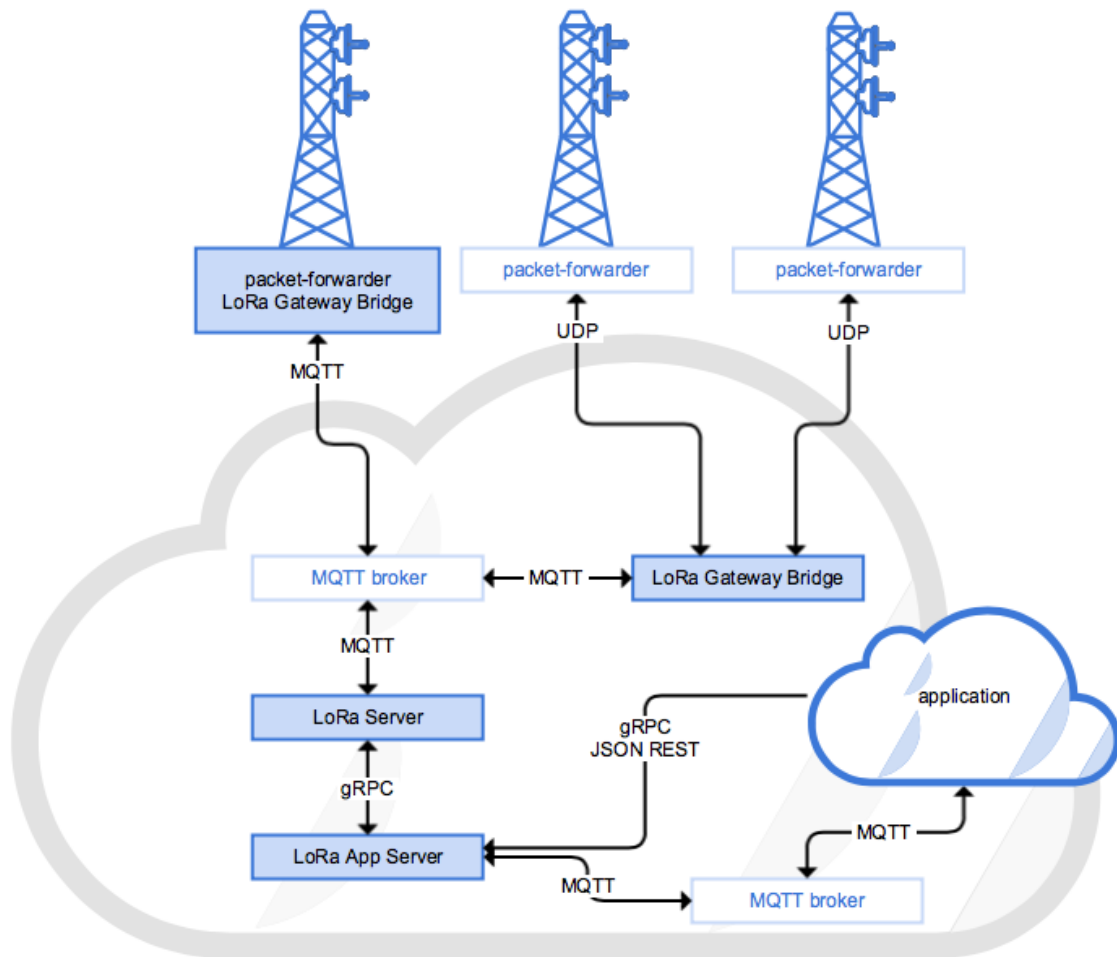
Orange and Bouygues Telecom use LoRaWAN network to provide telephone coverage since 2016.

## 4.2 Work done on LoRa Server

### 4.2.1 Overall presentation

In order to test the LoRa network I chose to set up the architecture proposed by LoRa Server.

This installation is composed as follows (Figure 10).



**Figure 10 : LoRa Server architecture**

It consists of multiple components :

- **LoRa nodes**, IoT devices also known as “nodes” (not pictured above) send data through LoRa gateways to LoRa network. These devices could be for example sensors measuring temperature, location, humidity...
- **LoRa gateways** are receiving data from the nodes and typically run an implementation of the packet-forwarder software. This software is responsible for the interface with the LoRa hardware on the gateway.
- **LoRa Gateway Bridge** is the component which is responsible for the communication with the gateway. By using MQTT\* it changes the packet-forwarder UDP\* protocol into JSON\*, because the rest of the structure works with JSON over MQTT.
- **LoRa Server** is the central component of the network. It allows to know at any time the status of the nodes. With a request from the app server it manages the addition of new nodes in the network and their settings. LoRa Server implements a gRPC\* API\* so that you could easily build your own application-server.

- *LoRa App Server* component implements an application-server compatible with LoRa Server component. It offers a global management all over the network. LoRa App Servers offers a basic web-interface that can be used to manage nodes and gateways, but you can also integrated your own system because it offers API endpoints.

### 4.2.2 Basic configuration

Before I could install this network on real hardware, I had to perform a simulation by installing this system on a single computer.

In the first place, I had to install a virtual machine because the different components works on a Linux operating system. I took version of the Linux distribution Ubuntu. The version 16.04 LTS\* because LoRa Server project including all requirements on it.

To create the virtual machine I chose to use VirtualBox, a software that I have already manipulated several times in the IUT.



I set the virtual machine in a very basic way to not obstruct it with unnecessary data [Screenshot of setting in annex 1].

All LoRa Server components and their dependencies can be installed on a single server instance, but the LoRa gateway bridge component can also be installed on the gateway itself. For the simulation I preferred to install all components on the same instance and same virtual machine.

### 4.2.3 Required installations

After that I focused on the installation of LoRa gateway bridge, LoRa Server and LoRa App Server.

The aim was to have access to the web interface in order to set up the simulated network.

LoRa Server got 3 software dependencies, so the first step was to install these dependencies on the Ubuntu 16.04 LTS server. Those three software are :

- *PostgreSQL*, a long-term storage database.

- *Redis*, used to store transient data.

- MQTT broker, A publish/subscribe protocol where users publish information that others can subscribe to. That is the famous open-source implementation Mosquitto of MQTT protocol that is used in LoRa Server.

The entire installation up to the web interface can be done by command line and modification of configuration files.

To install the three software quote above, open a terminal and enter the command line :

```
sudo apt install mosquitto mosquitto-clients redis-server redis-tools postgresql
```

Then you need to create two database with PostgreSQL, one for the LoRa App Server the other one for the LoRa Server.

To enter PostgreSQL configuration mode :

```
sudo -u postgres psql
```

Inside this prompt, to set up server you must create two database and two users linked to them. Execute the following queries :

```
-- set up the users and the passwords
create role loraserver_as with login password 'dbpassword';
create role loraserver_ns with login password 'dbpassword';

-- create the database for the servers
create database loraserver_as with owner loraserver_as;
create database loraserver_ns with owner loraserver_ns;

-- change to the LoRa App Server database
\c loraserver_as

-- enable the pq_trgm extension
create extension pg_trgm;

-- exit psql
\q
```

Now set Lora Server software repository. LoRa Server provides a repository that is compatible with the Ubuntu apt package system.

Set up the key for this new repository:

```
sudo apt-key adv --keyserver keyserver.ubuntu.com --recv-keys 1CE2AFD36DBCCA00
```

Then by creating a new file add the repository to the repository list:

```
sudo echo "deb https://artifacts.loraserver.io/packages/1.x/deb stable main" |  
sudo tee /etc/apt/sources.list.d/loraserver.list
```

Update the apt system:

```
sudo apt update
```

#### 4.2.4 LoRa Gateway, Server, App Server installation

As we had defined earlier we will now install LoRa Gateway Bridge on the instance. Install the package using apt :

```
sudo apt install lora-gateway-bridge
```

No additional configuration is required. LoRa Gateway Bridge will by default bind to *0.0.0.0:1700* for receiving UDP data from your gateway(s). You can also configure an authentication on the gateway using Mosquitto authentication, you will need to update the configuration file */etc/lora-gateway-bridge/lora-gateway-bridge.toml* .But I chose not to use it here .

We will now install Lora Server and Lora App Server with the respective commands:

```
sudo apt install loraserver  
  
--and  
  
sudo apt install lora-app-server
```

In LoRa Server configuration file */etc/loraserver/loraserver.toml* go to the *postgres.dsn* section, this is the URL postgres sever. Add *username:password@* to the URL. If you haven't changed the users or the password this line should be : *postgres://loraserver\_ns:dbpassword@localhost/loraserver\_ns?sslmode=disable*

Leave all other default settings.

The LoRa App Server configuration must be changed too. You can find the configuration file at `/etc/lora-app-server/lora-app-server.toml`, go to the `postgresql.dsn` section and add in the same way as the first file `username:password@`. If you haven't changed the users or the password this line should be :  
`postgres://loraserver_as:dbpassword@localhost/loraserver_as?sslmode=disable`

Leave all other default settings.

Then start the servers :

```
sudo systemctl start loraserver  
sudo systemctl start lora-app-server
```

Logs are available via :

```
journalctl -u loraserver
```

And :

```
journalctl -u lora-app-server
```

### 4.2.5 In the end

Finally to access the application section go to LoRa Sever web-interface: open a browser and enter the IP address of your server and the port as defined in the Lora App Server configuration file at `application_server.external_api.bind`.

By default this should be : `https://localhost:8080`.

You should get something like this (Figure 11) :



The screenshot shows the LoRa Server web interface. At the top, there is a blue header with the text "LoRa Server". Below the header, there is a red error message box that reads "Error invalid username or password (code: 16)" with a close button (X) on the right. Below the error message, there is a light gray box with the text "Login". Below that, there is a white form with two input fields. The first field is labeled "Username" and contains the text "admi". The second field is labeled "Password" and contains six dots. At the bottom right of the form, there is a blue button with the text "LOGIN".

**Figure 11** : LoRa Server web-interface

A default administrator account is available at installation time with the username of *admin* and a password of *admin*. From there you can start to set up your applications and devices.

I unfortunately can not go further in the setting of this network. It took me a long time to solve the problems and debug to get to this section.

However an application on real hardware (a raspberry pi) only with this part could be already considered.

## 5 Conclusion

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All away from this internship abroad I have developed my open-mindedness and my adaptability to everyday life. Due to the nature of the place I could become more autonomous : the university setting giving me more freedom than in a company. Furthermore, this internship was also a way to learn a little more about his desires and oneself.

From the technical point of view the results obtained were inconclusive. Indeed, a lot of my work was about documentation and theoretical aspects, but the discovery of the LoRa process was very interesting. I was able to apply some technical skills and my knowledge learned during my last two years of DUT.

My tutor left me a lot of freedom. Regarding the way of working that implied to organize me in order to guide my work as best as possible even if sometimes I had the feeling to don't advance.

The internship taught me a different method of work based essentially on the organization and the rigor of the tasks to be done on a daily basis. It allowed me to acquire skills and knowledge on a subject that I did not know. Destabilized at times, my experience and my will power acquired during my DUT gives me the energy to move forward. However, I will remember an error during my internship that I regret a little. Indeed, I didn't known how to take more time with my tutor to work along him, although he was making himself available despite his busy schedule.

This internship was a good experience of life, apart from family comfort. An experience where these few words stand out and make sense : become mature, grow up, emancipate. This internship in Scotland was a real human experience, a personal adventure.

This experience reinforced me in my desire to work abroad. That also allowed me to know that I want to turn myself toward a job more in the field. I remain nevertheless on a positive note. I am always eager to discover other various professions and I stay open to all future careers.

## 6 Glossary

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**AES**, Advanced Encryption Standard, a specification for the encryption of electronic data.

**API**, Application Programming Interface, a set of definitions, protocols and tools for bundling software.

**DUT**, Diplôme Universitaire de Technologie

**gRPC**, is an open source remote procedure call (RPC) system initially developed at Google . RPC is when a computer program causes a procedure (subroutine) to execute in a different address space.

**IoT**, Internet of things is the network of physical devices embedded with electronics and software which enables these things to connect and exchange data.

**IP**, Internet Protocol, a set of rules for sending data across a network.

**ISM**, Industrial, Scientific and Medical radio bands reserved internationally for the use of radio frequency energy for industrial, scientific and medical purposes other than telecommunications.

**IUT**, Institut Universitaire de Technologie

**JSON**, JavaScript Object Notation or JSON (<sup>i</sup><sup>d</sup><sup>ʒ</sup><sup>eɪ</sup><sup>s</sup><sup>ə</sup><sup>n</sup>/ "Jason", <sup>d</sup><sup>ʒ</sup><sup>eɪ</sup><sup>ˈ</sup><sup>s</sup><sup>ɒ</sup><sup>n</sup><sup>/</sup><sup>1</sup>) is an open-standard file format that uses human-readable text to transmit data objects

**LoRa**, Long Range

**LoRaWAN**, Long Range Wide Area Network

**LPWAN**, Low Power Wide-Area Network

**LTS**, Long-term support

**MAC**, MAC address, or Ethernet Hardware Address

**MQTT**, Message Queuing Telemetry Transport, a publish-subscribe-based messaging protocol

**REST**, Representational State Transfer

**RF**, Radio Frequency

**SSL**, Secure Sockets Layer or Transport Layer Security, a cryptographic protocol

**TCP**, Transmission Control Protocol, a fundamental Internet standard

**UDP**, User Datagram Protocol, a network communications method

## 7 Webliography

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LoRaWAN technology specification by LoRa Alliance :

<https://lora-alliance.org/resource-hub/lorawantm-specification-v11>

LoRa tutorial on 3gpteinfo website :

<http://www.3gpteinfo.com/lora/>

LoRa Server website :

<https://www.loraserver.io/>

ThingsBoard website

<https://thingsboard.io/>

UWS website :

<https://www.uws.ac.uk/>



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**ANNEX**  
**Diplôme Universitaire de Technologie**  
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# Annex 1 : Virtual machine settings

The screenshot displays the Oracle VM VirtualBox Manager interface. At the top, the title bar reads "Oracle VM VirtualBox - Gestionnaire de machines". The menu bar includes "Fichier", "Machine", and "Aide". The toolbar contains icons for "Nouvelle", "Configuration", "Oublier", and "Démarrer". The main window shows the settings for a virtual machine named "LoRa1".

**General**  
Nom : LoRa1  
Système d'exploitation : Ubuntu (64-bit)

**Système**  
Mémoire vive : 1024 Mo  
Ordre d'amorçage : Disquette, Optique, Disque dur  
Accélération : VT-x/AMD-V, Pagnation mbrquée, Paravirtualisation KVM

**Affichage**  
Mémoire vidéo : 16 Mo  
Serveur bureau distant : Désactivé  
Capture vidéo : Désactivée

**Stockage**  
Contrôleur : IDE  
Maître secondaire IDE : [Lecteur optique] Vide  
Contrôleur : SATA  
Port SATA 0 : LoRa1.vdi (Normal, 10,00 Go)

**Son**  
Pilote hôte : Windows DirectSound  
Contrôleur : ICH AC97

**Réseau**  
Interface 1 : Intel PRO/1000 MT Desktop (NAT)

**USB**  
Contrôleur USB : OHCI  
Filtres : 0 (0 actif)

**Dossiers partagés**  
Aucun

**Description**  
Aucune

At the bottom right, there is a "Prévisualisation" window showing a black screen with the text "LoRa1". To its right are buttons for "Machine Tools" and "Global Tools".