INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

LoRa™

LoRa over INSA

For a connected and innovative campus

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01/26/2017

THE THINGS NETWORK

INNOVATIVE SMART SYSTEMS

PART 1: Context and Project management

PART 2: LoRa network deployment

PART 3: Embedded Systems and devices

PART 4: Web platform

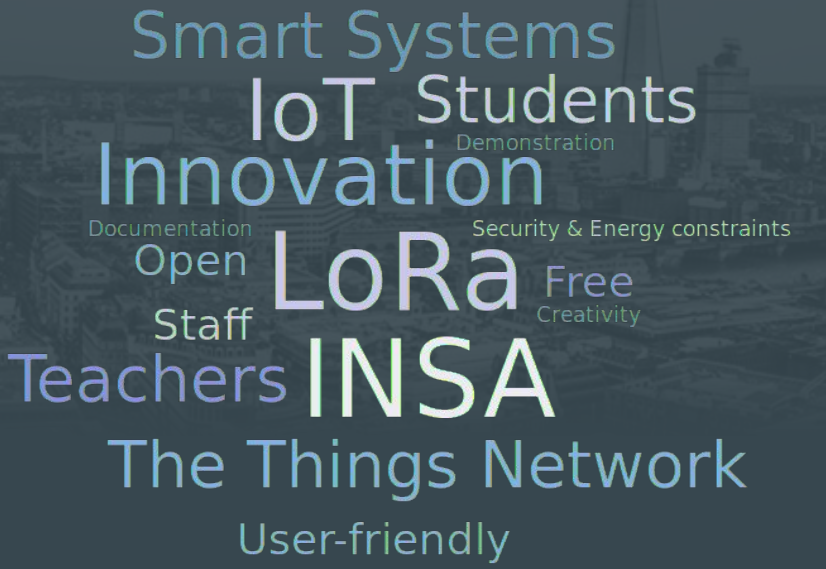
PART 5: Further developments

Demonstration

PART 1: Context and Project management

I. Specifications

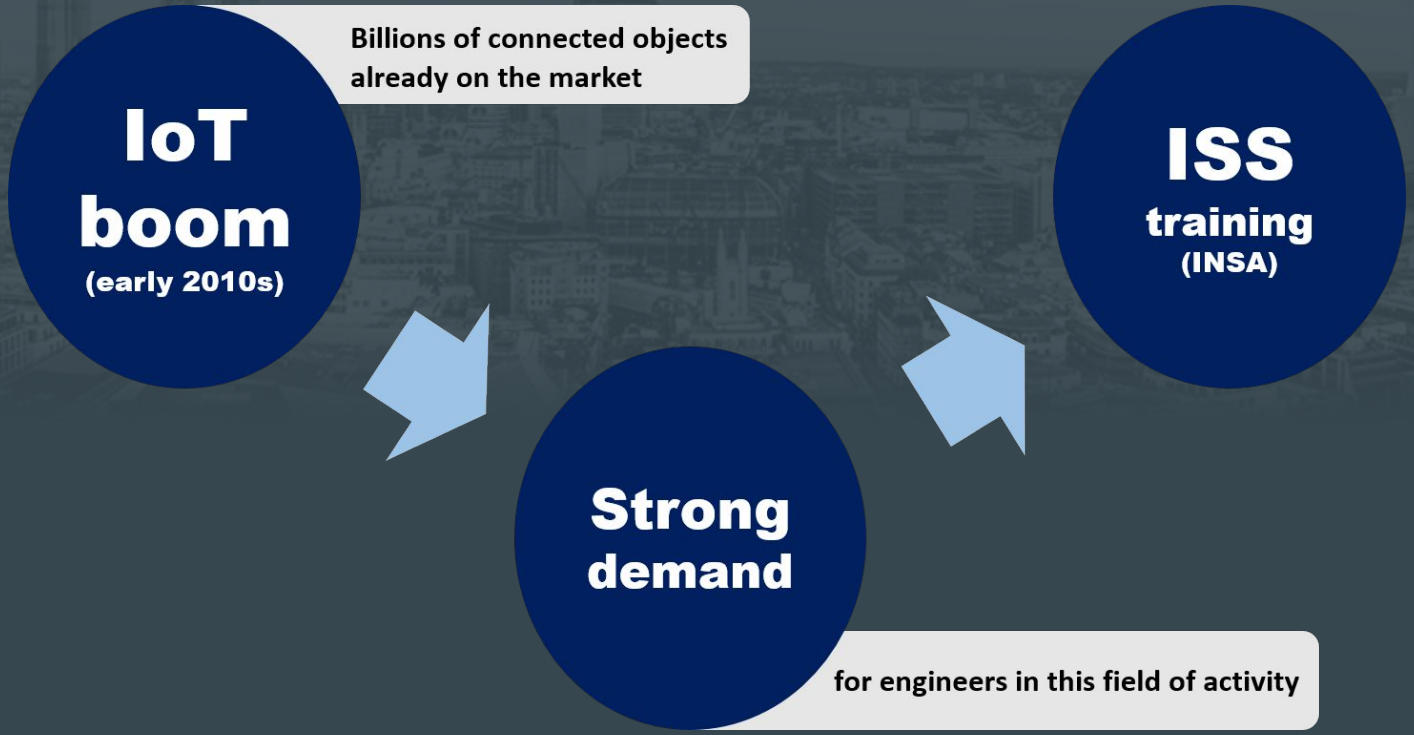
- Deployment of a LoRa network
- Via a Web platform, an access that is:
  - Free
  - User-friendly
  - Documented
  - Open
- With a concrete application:
  - A connected Weather station
- Security study



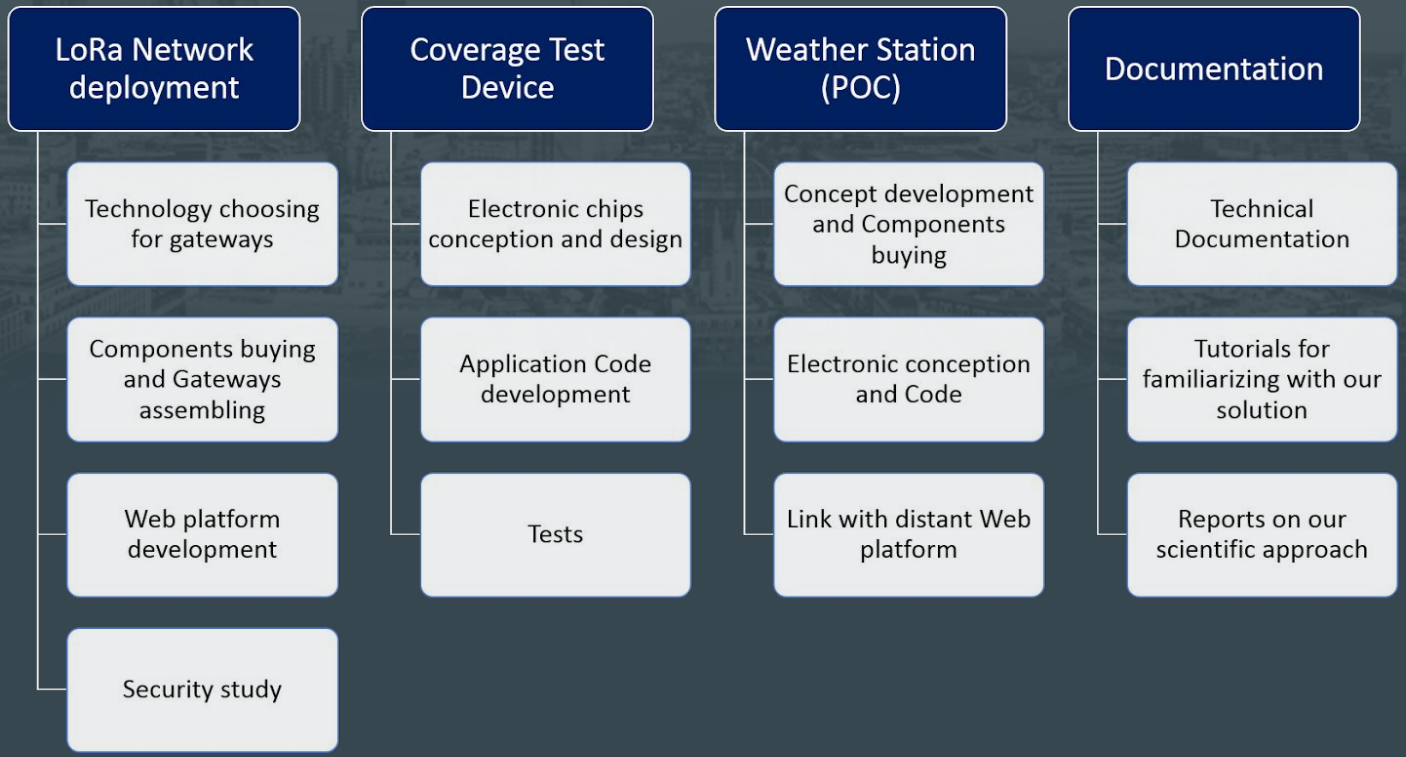
II. User's needs

- **INSA:**
  - Innovative and connected campus
- **Teachers:**
  - Tool, demonstration for labs
- **Students:**
  - IoT knowledge and skills
  - Competitivity in the IoT world
  - More personalized projects
  - Quality of life improvement on the campus

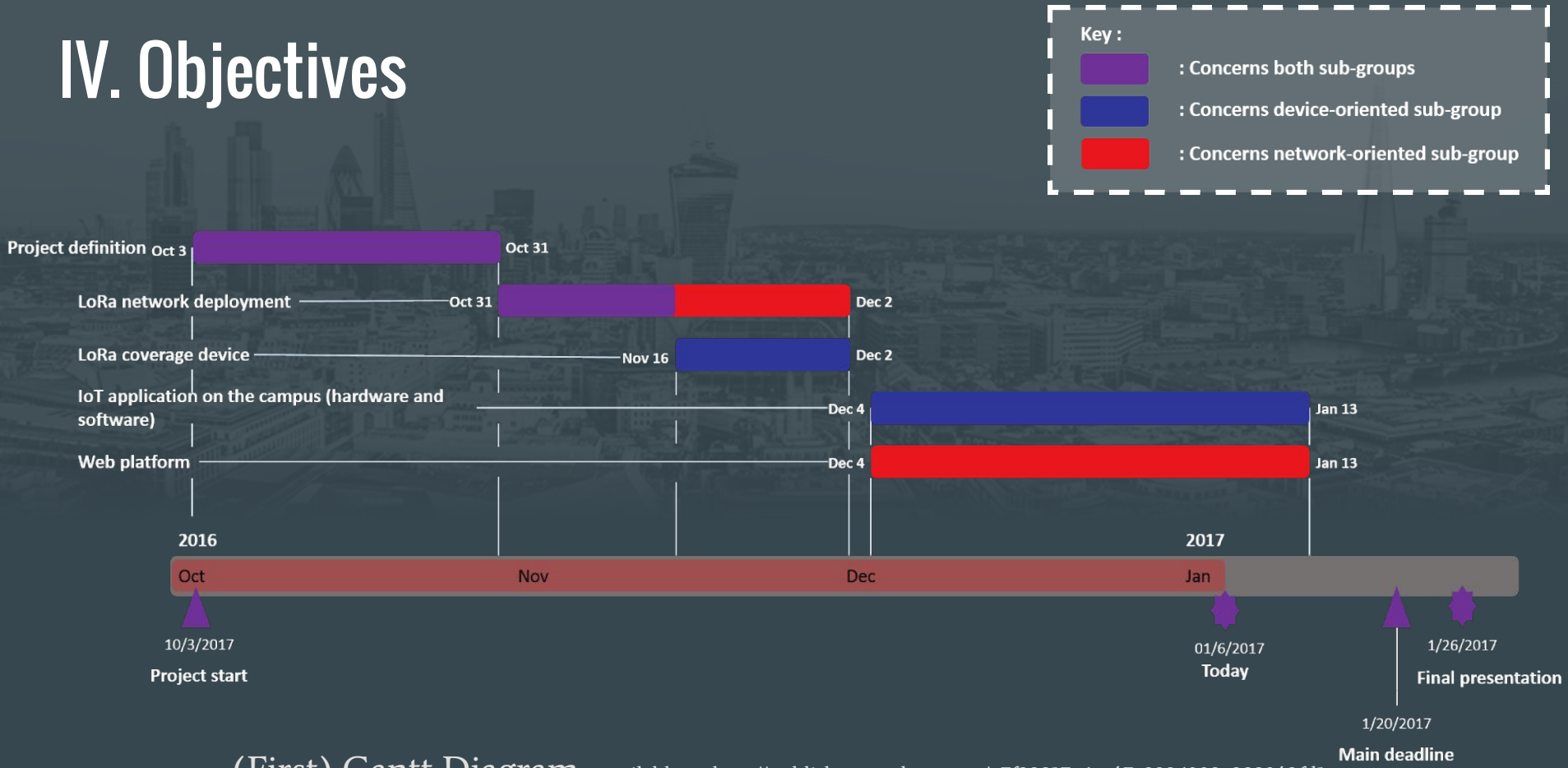
III. Context


IoT boom
(early 2010s)
Billions of connected objects already on the market
ISS training
(INSA)
Strong demand
for engineers in this field of activity

IV. Objectives

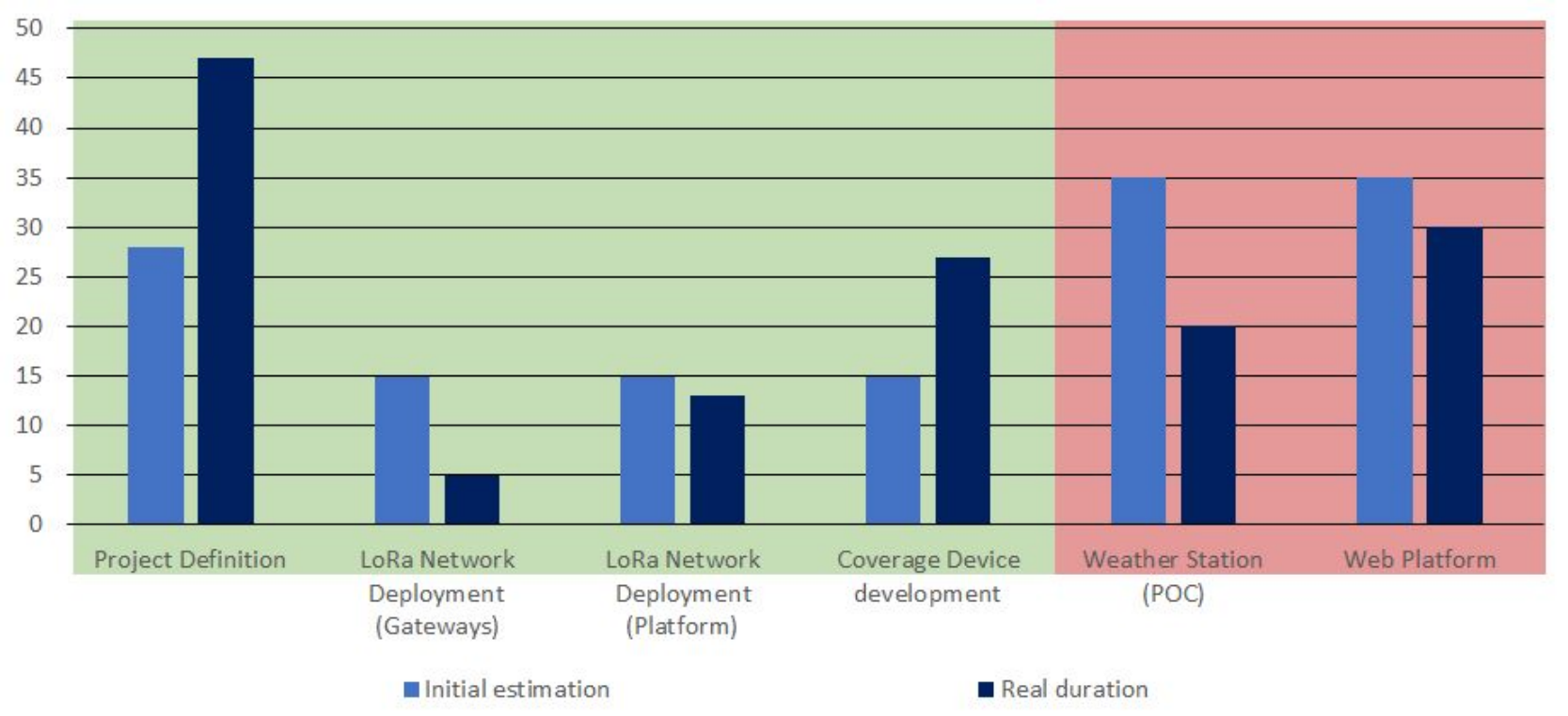


IV. Objectives



(First) Gantt Diagram - available at: http://publish.smartsheet.com/e7f29817e6ea47e9996009e282342fd1

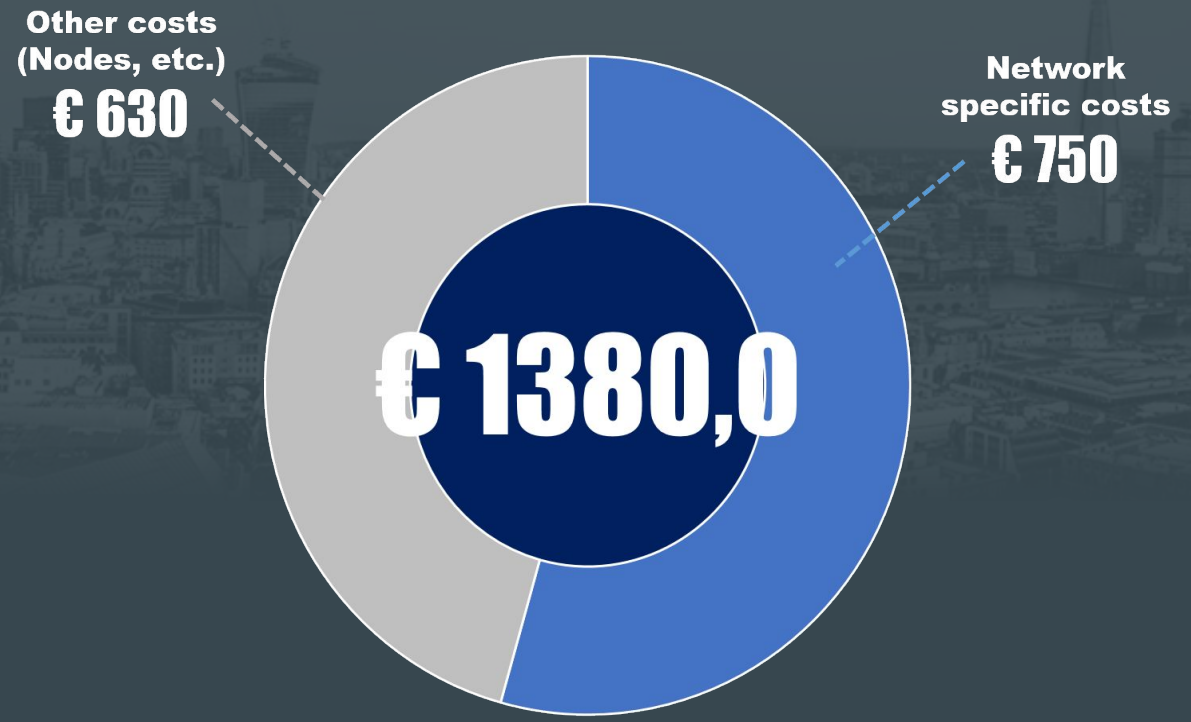
IV. Objectives



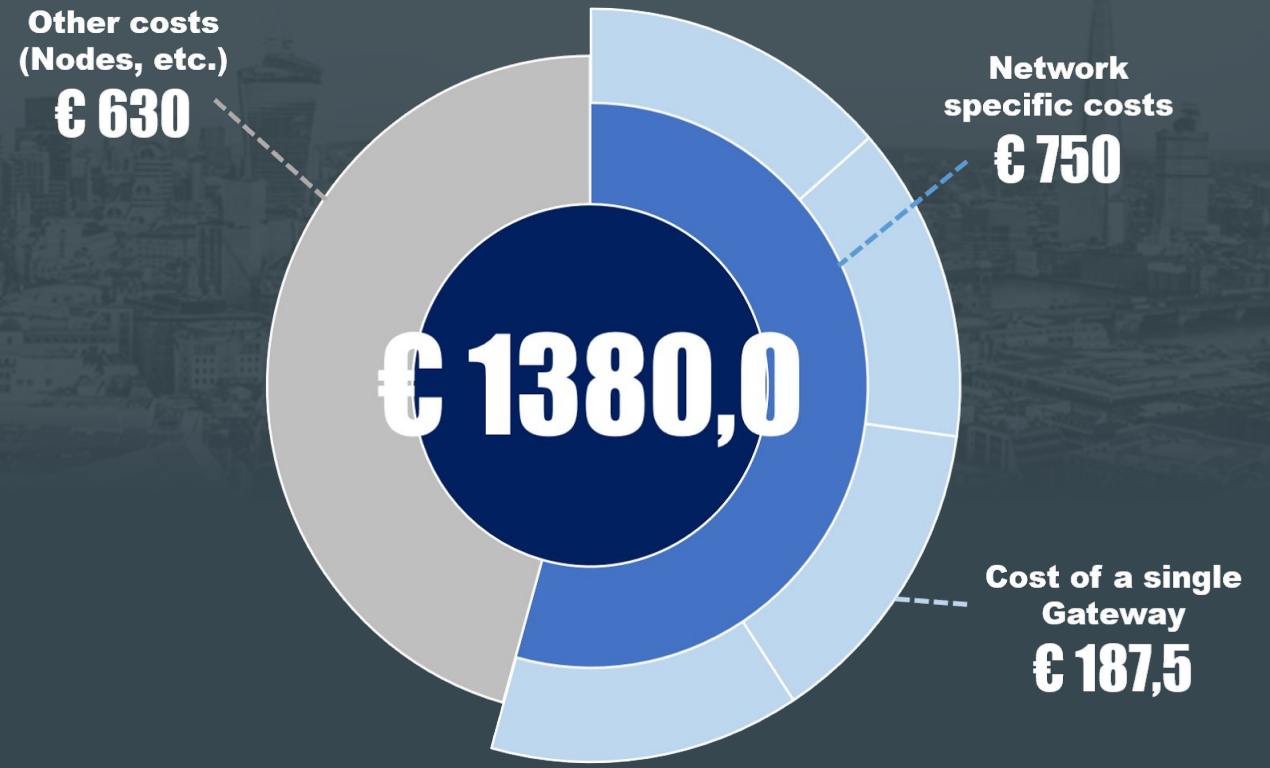
V. Costs

Total cost of the project

V. Costs



V. Costs


Other costs
(Nodes, etc.)
€ 630
Network
specific costs
€ 750
€ 1380,0
Cost of a single
Gateway
€ 187,5

PART 2: LoRa network deployment

I. Coverage simulation

Objectives:

- Verify we can cover the campus
- Determine where to place the gateways

I. Coverage simulation

Objectives:

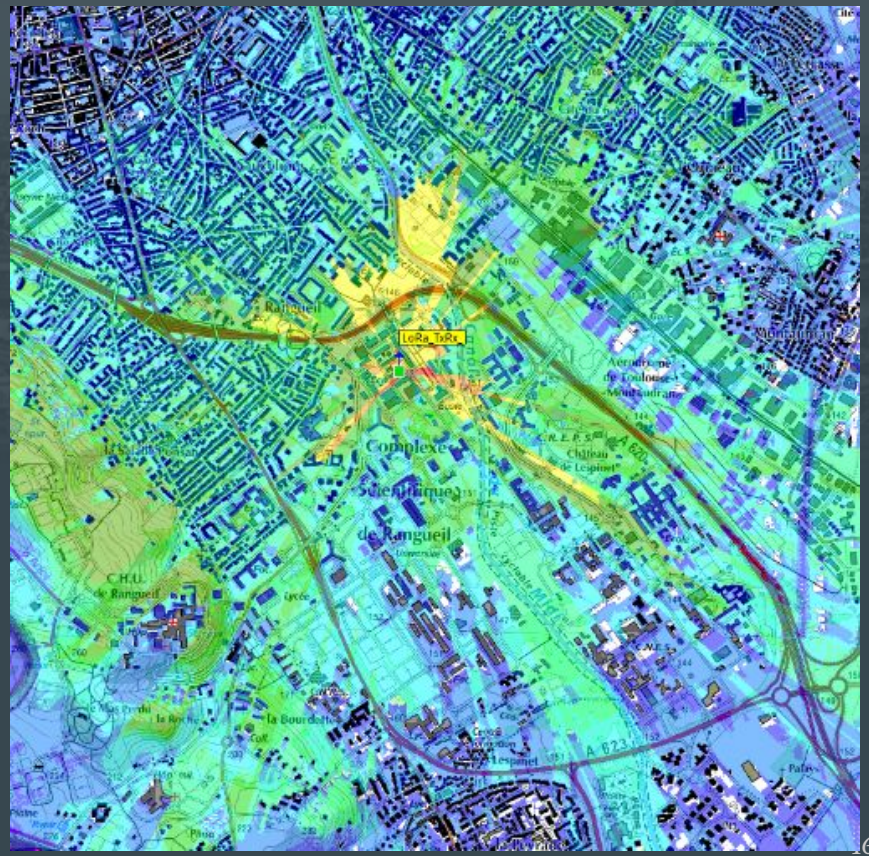
- Verify we can cover the campus
- Determine where to place the gateways

Tool

- ICS Telecom

I. Coverage simulation

11/-122	19/-114	27/-106	35/-98	43/-90	51/-82
59/-74	67/-66	75/-58	83/-50	91/-42	dBuV/m / dBm



I. Coverage simulation

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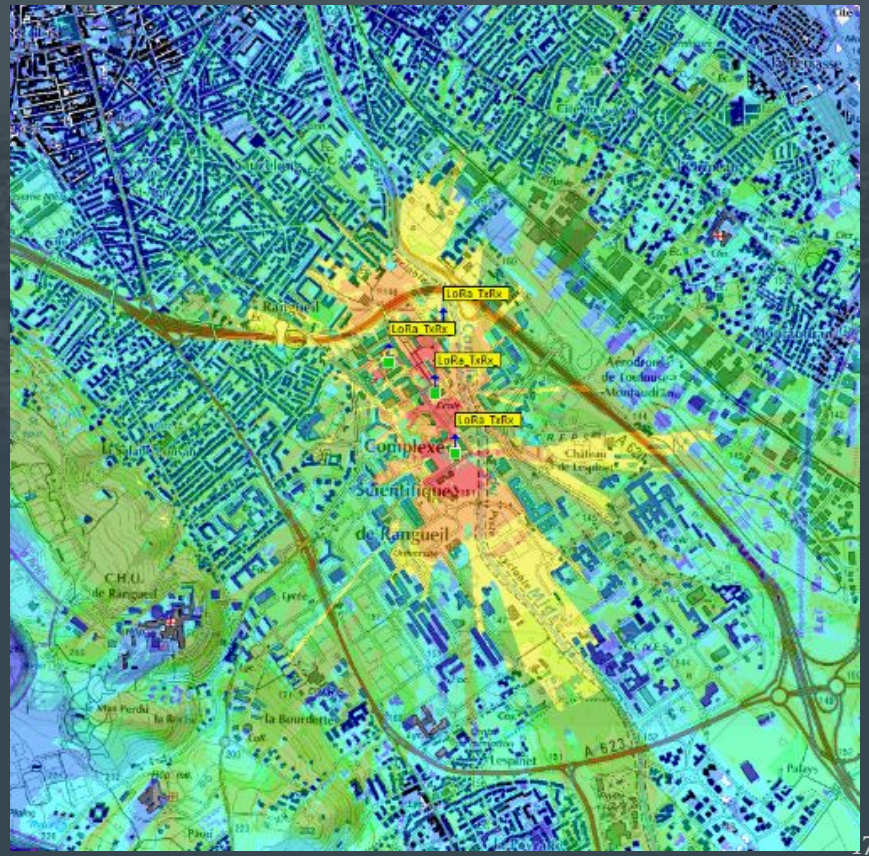
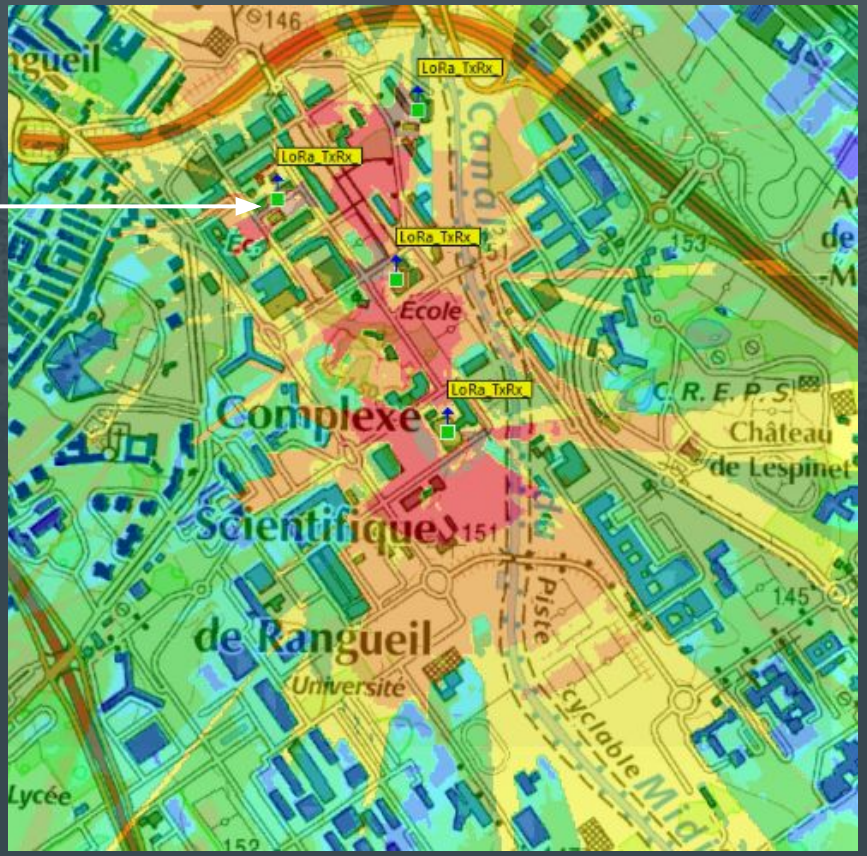


I. Coverage simulation

DGEI



II. Gateway choice and assembly

Criterias:

- Well documented
- Easy to install
- Low cost

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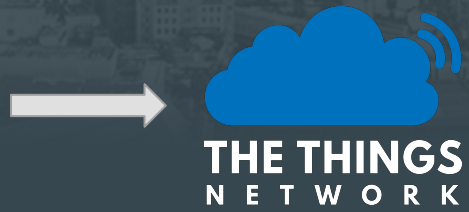

II. Gateway choice and assembly

Criterias:

- Well documented
- Easy to install
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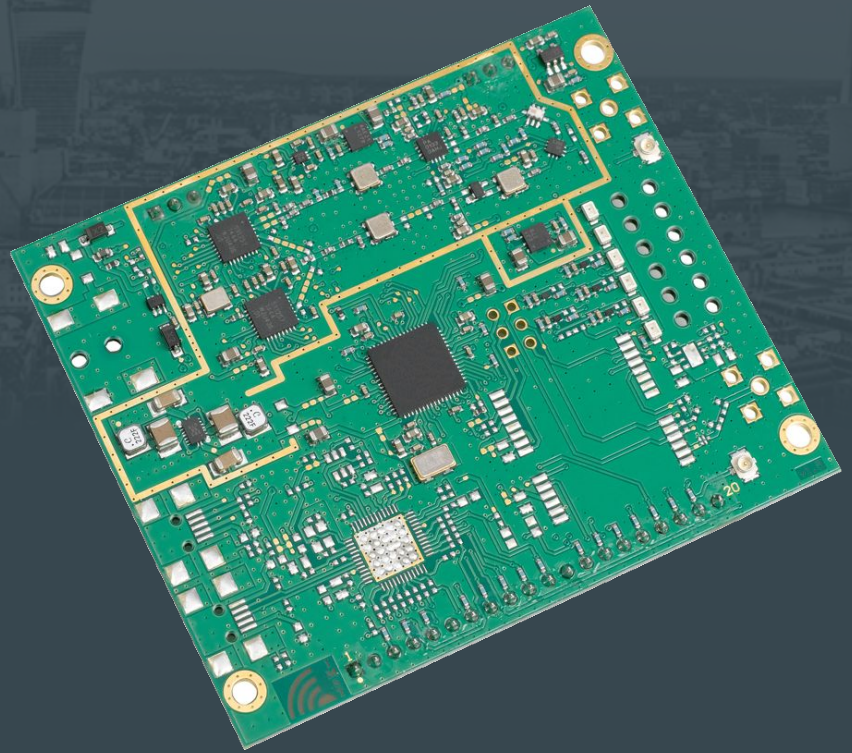
iC880A + RPi

II. Gateway choice and assembly

iC880A

Specifications:

- 8 channels
- 868 Mhz
- Plug and play

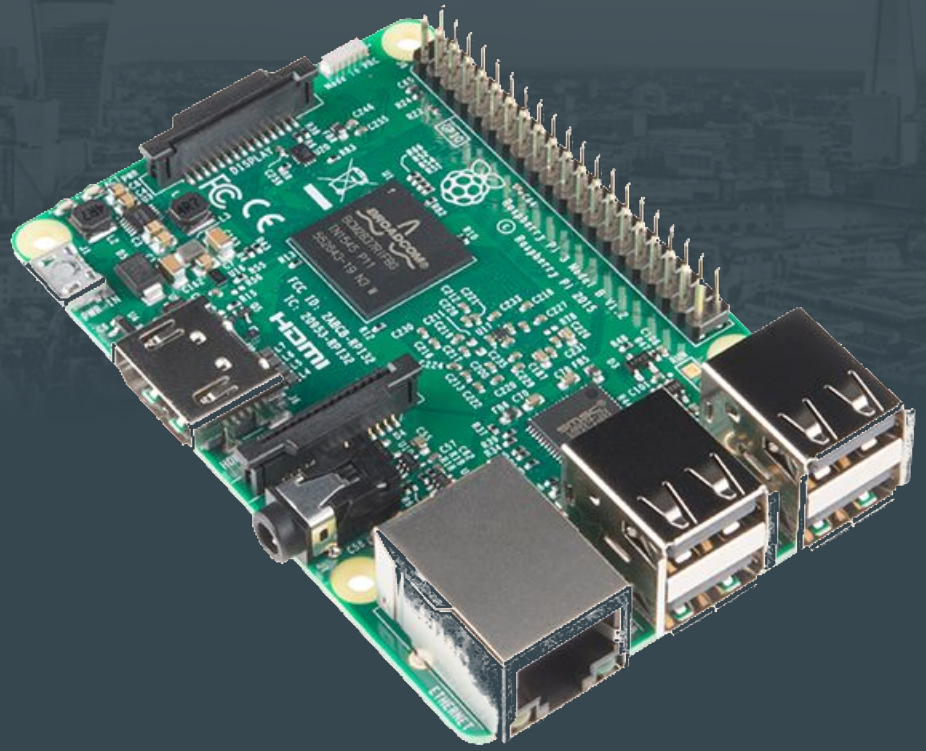


II. Gateway choice and assembly

RPi 3

Specifications:

- Integrated Wifi
- Linux OS



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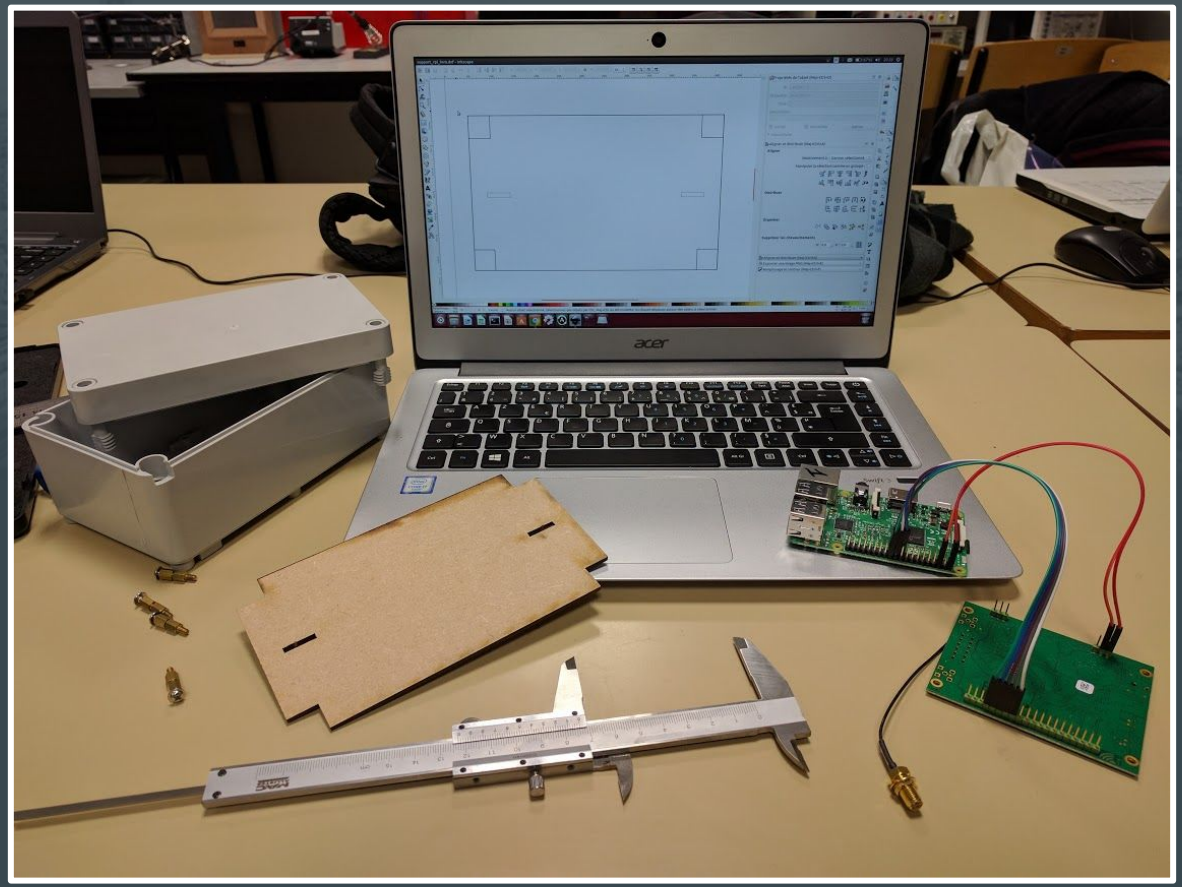
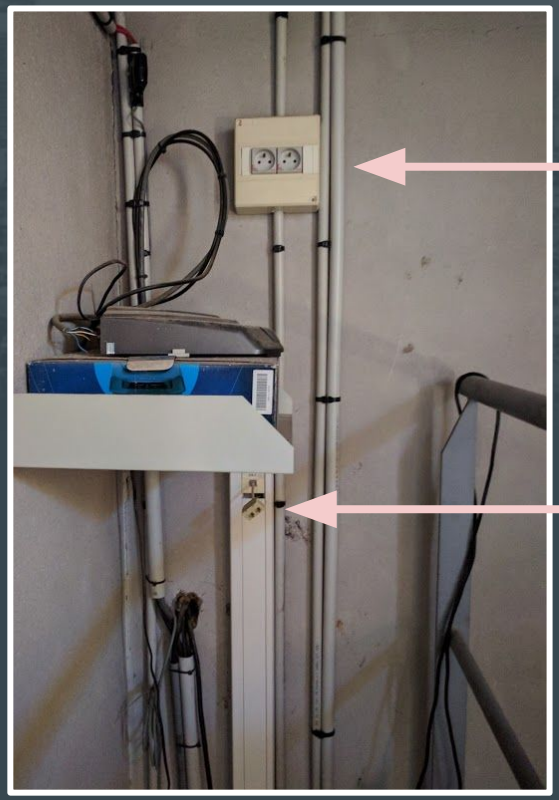


II. Gateway choice and assembly

II. Gateway choice and assembly

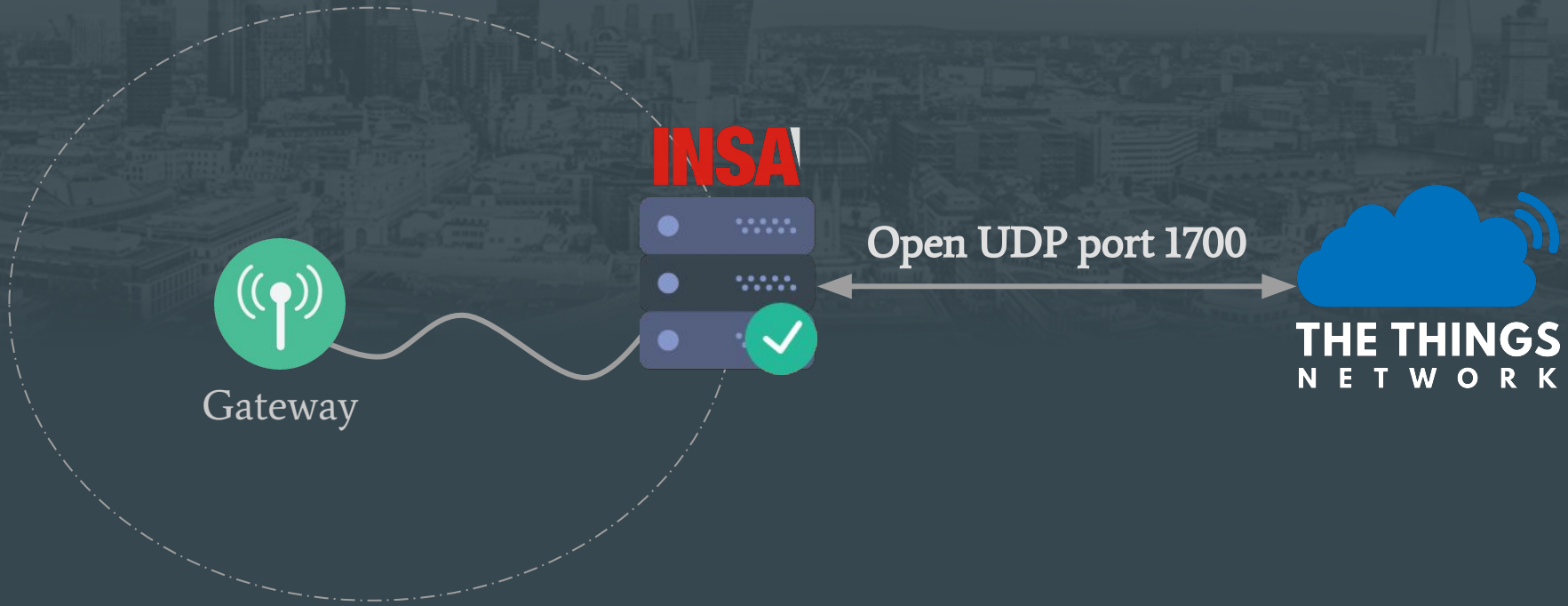
III. Gateway installation



III. Gateway installation

THE THINGS NETWORK

III. Gateway installation



PART 3: Embedded Systems and devices

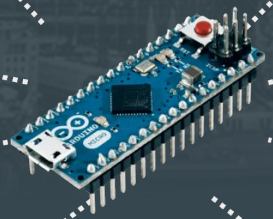
I. Choice of components

1. Microcontroller

Easy to use

Microcontroller: ATmega32U4

Compact package



32 interactive pins

Possibility to use the board as programmer

7 to 12 V power supply

Arduino Micro

High storage capacities

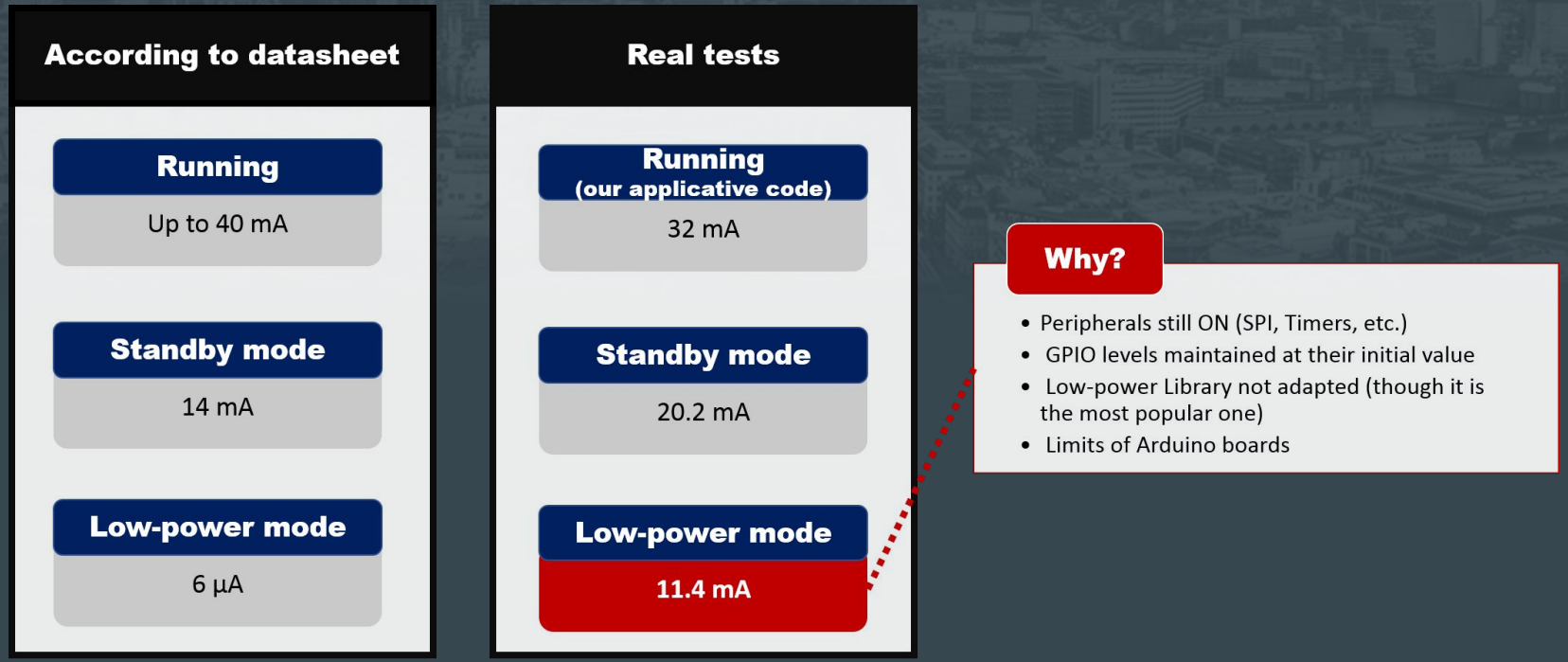
- 32kB of Flash
- 2kB of SRAM
- 1kB of EEPROM

Low-power functionalities

I. Choice of components

1. Microcontroller

- Consumption study



I. Choice of components

2. LoRa transceivers

a. Semtech SX1272

Recommended by tutors

Communication through SPI

High price : €73

3.3 V power supply

Semtech Sx 1272 RF1

No LoRaWan layer

All-in-one eval board

LoRaWan provided by microcontroller

- Use of IBM LMIC library

I. Choice of components

2. LoRa transceivers

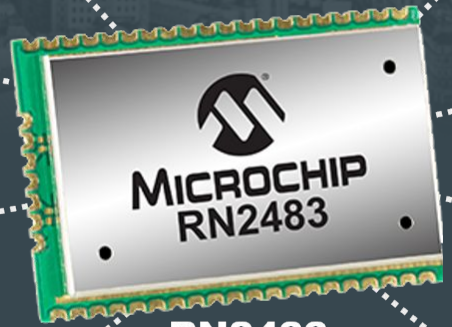
b. Microchip RN2483

User-friendly device

Based on a sx1276

Compact package

Embeds a PIC microcontroller



SMC component → creation of a daughter board

3.3 V power supply

RN2483 (from Microchip)

Costs €13.24

Embeds the LoRaWAN stack

I. Choice of components

2. LoRa transceivers

b. Microchip RN2483

- Consumption study

According to datasheet	
Transmit mode	26.1 mA
Receive mode	14.2 mA
Idle mode	2.8 mA
Low-power mode	9.9 µA

Real tests	
Transmit mode	23.2 mA
Receive mode	Not Tested
Idle mode	3.35 mA
Low-power mode	Not Tested

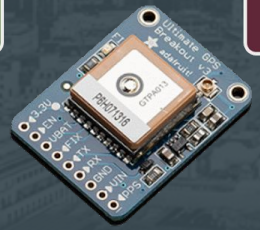
I. Choice of components

3. Sensors

UART communication

3.3 V power supply

3 m accuracy



GPS Adafruit Ultimate Breakout v3

Passive component

Up to 5 V power supply

Value between 0 and 1023

Light sensor

Passive component

-40 – 125°C

Up to 5 V power supply

0% – 100% RH

Temperature & humidity sensor Aosong AM2303

II. Coverage test device

1. Context

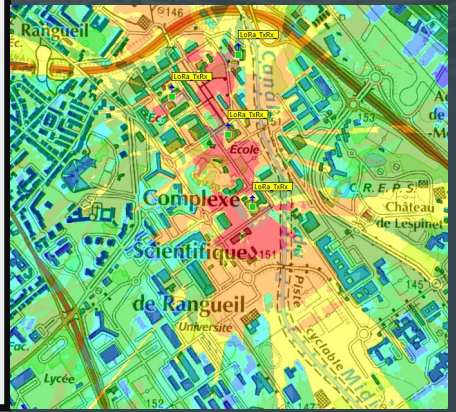
- The LoRa network being deployed, we needed a device to test it

Main functioning

- When pushing a button, a Lora frame is sent
- This frame contains the current GPS location of the device
- The gateway associates a SNR to this message
- The Web platform displays a map indicating the quality of the loRa coverage at that location

Goals of such a device

- Test the performances of our network
- Make a comparison with a theoretical study we made
- Test our gateway positions
- Practise different technical IoT concepts



II. Coverage test device

2. Development phase

a. Semtech version

Considered functional without LoRaWan stack

Issues:

No official LMIC (LoRa WAN in C) library for Arduino

LMIC adapted for Arduino to heavy and not dedicated to 32U4 microprocessor

Lot of time spent

→ No significant results

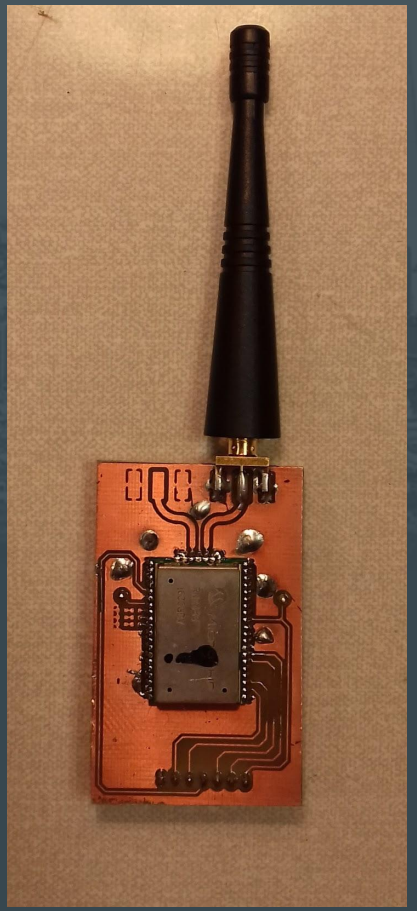
II. Coverage test device

2. Development phase

b. RN2483 version (hardware part)

- Daughter board for RN2483
  - Designed on Eagle
  - Adds two SMA connectors for the antennas
  - Adds an ergonomic pinout
  - Adds traces for debug LEDs

- First tests on breadboard

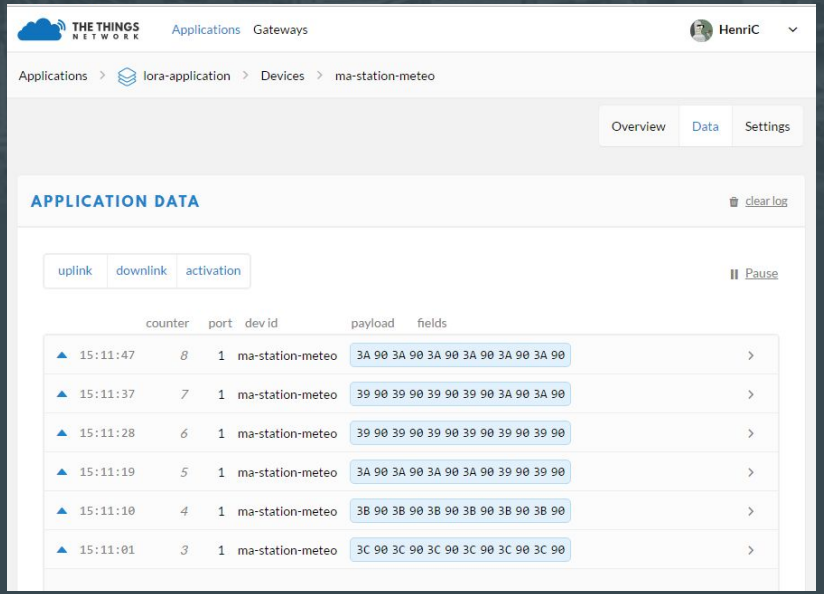


II. Coverage test device

2. Development phase

b. RN2483 version (hardware part)

- First connexion to TTN servers through our Gateway:
  - gets devEUI: unique identifier of our RN2483
  - User creates a new device under TTN console
  - User gives the devEUI of his RN to TTN
  - TTN generates identifiers dedicated to the RN
  - User enters those identifiers in his node's code.
  - 2 communication modes (OTAA & ABP)
  - Data transmission



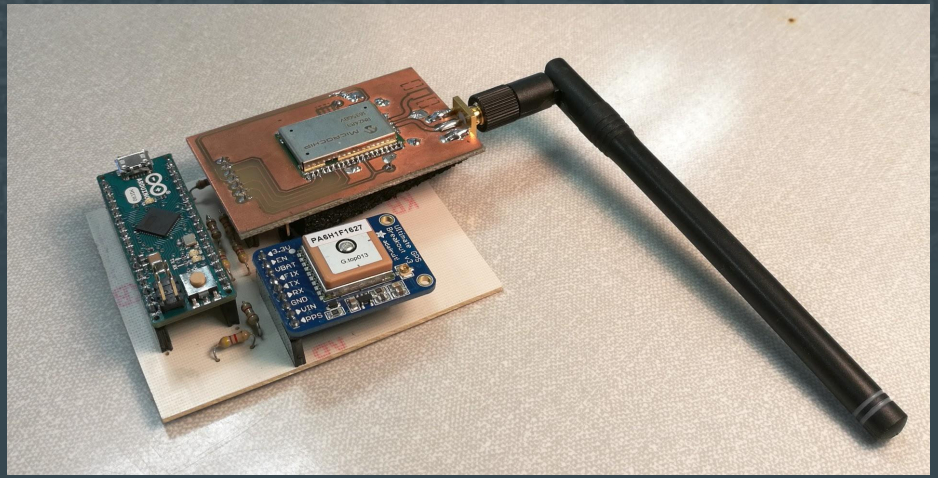
II. Coverage test device

2. Development phase

b. RN2483 version (hardware part)

Conception:

- Breadboard first version & tests
- Eagle conception
- Printed using Fablab's equipment
- Mounted and tested



Contains:

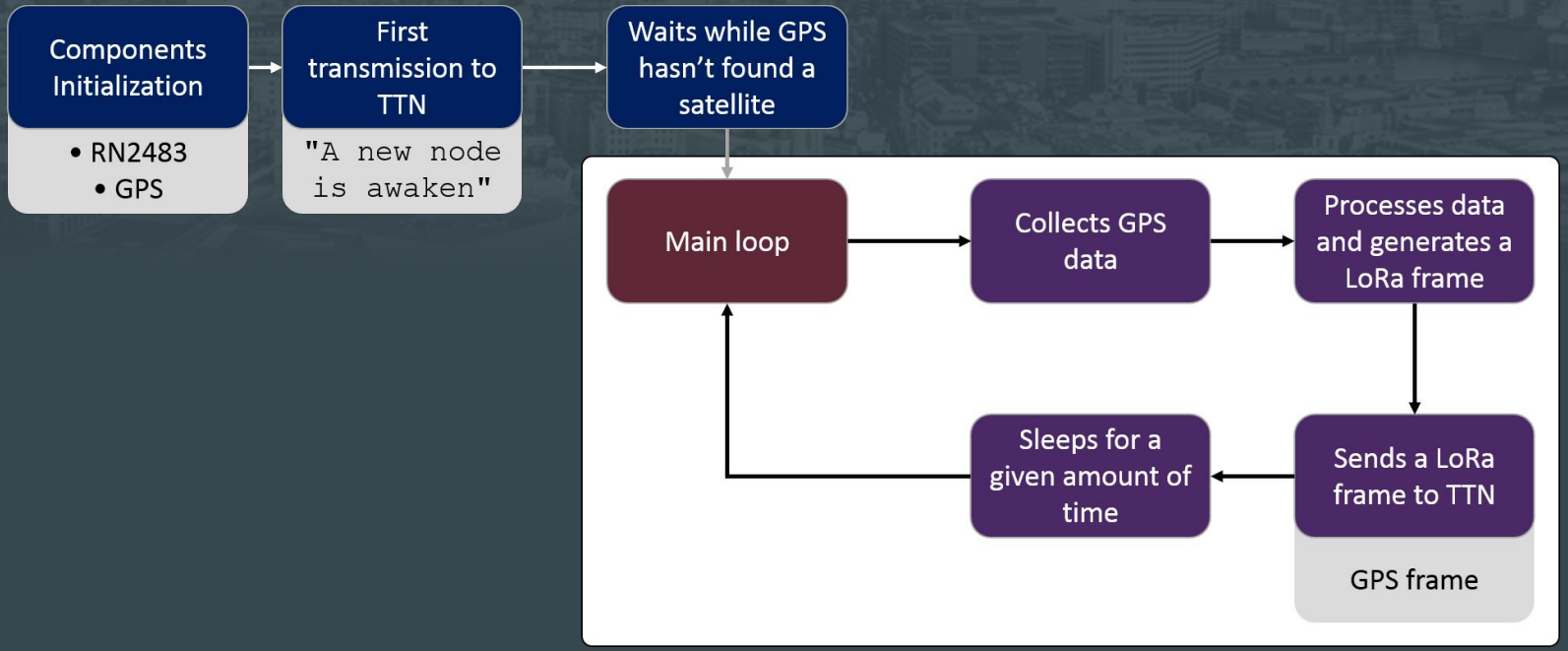
- RN2483 daughter board
- GPS module
- Arduino Micro

II. Coverage test device

2. Development phase

b. RN2483 version (software part)

- Code Architecture

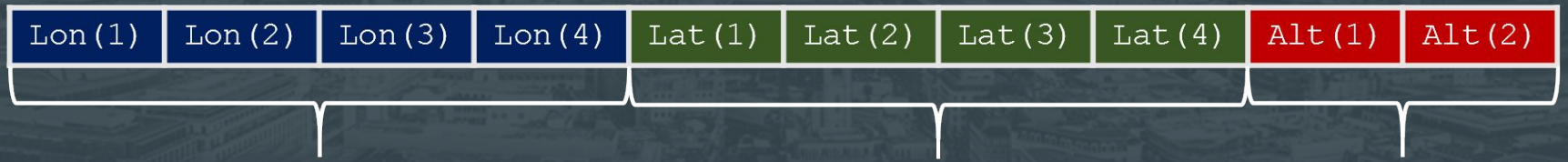


II. Coverage test device

2. Development phase

b. RN2483 version (software part)

- **LoRa frames format**



- Longitude: 1 float (4 bytes)
- Value between 0 and 360°
- 0° → International Date Line

- Latitude: 1 float (4 bytes)
- Value between 0 and 180°
- 0° → South pole

- Altitude: 1 short integer (2 bytes)
- Value between 0 and 65535

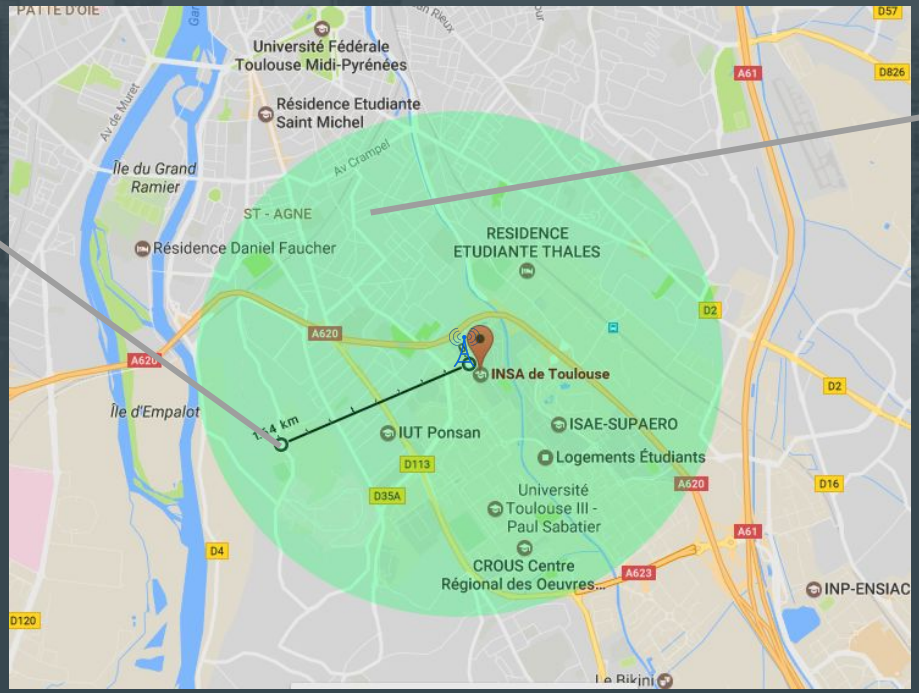
- **Energy consumption**
  - Not taken into account for this device
  - Main goal of the device is to accompany user aver short distances
  - A USB battery will be enough

II. Coverage test device

3. Test phase and result analysis

Open field
Pech-David:
Dist: 1.64 km
SNR: 6 to 8

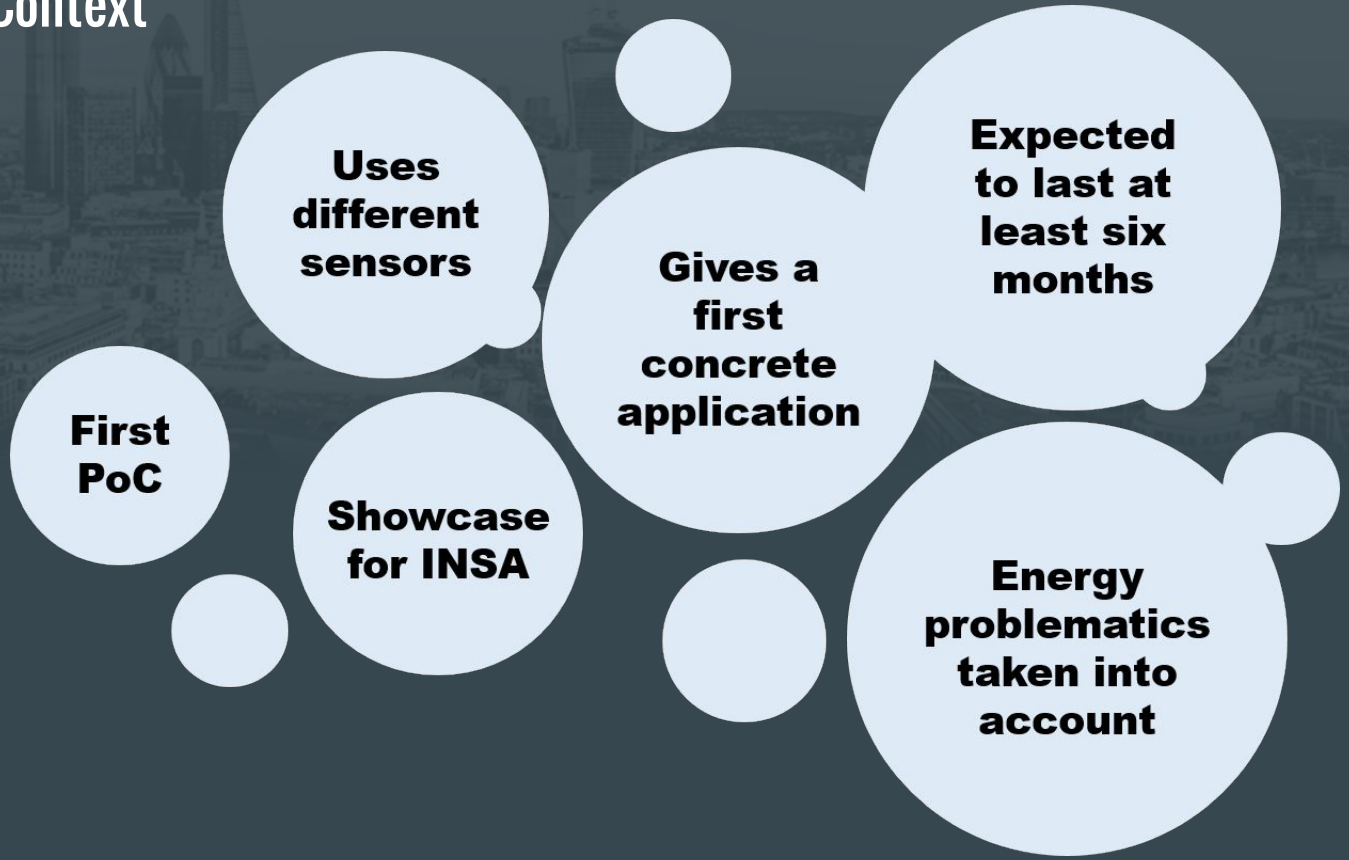
Under 30 km/h!



Restricted field
Saouzelong:
Dist: 1.45 km
SNR: -2 to -4.8

III. Weather station

1. Context



III. Weather station

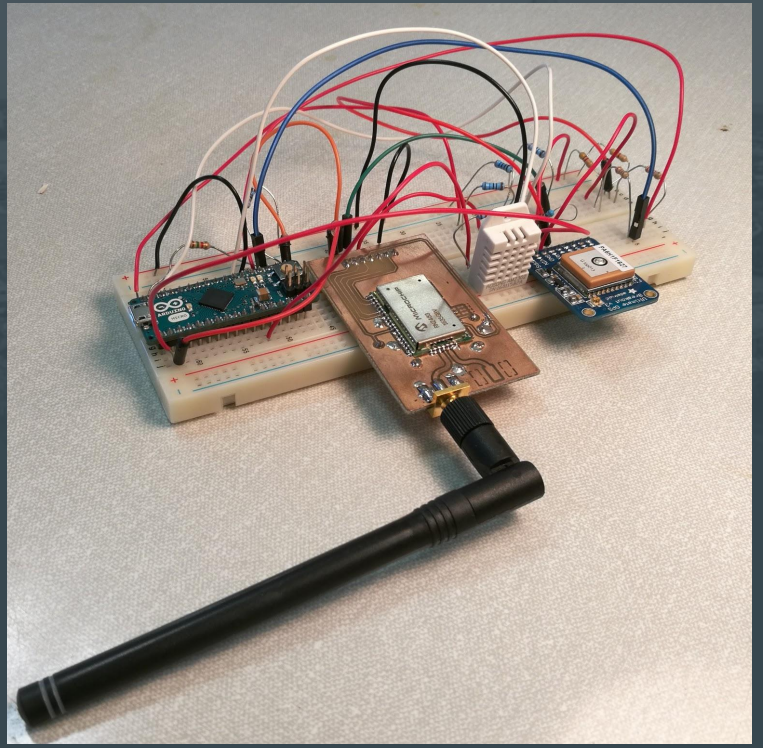
2. Development phase (hardware part)

Conception:

- Breadboard & tests (lack of development time)
- Integration of coverage device's components
- Extra sensors

Contains:

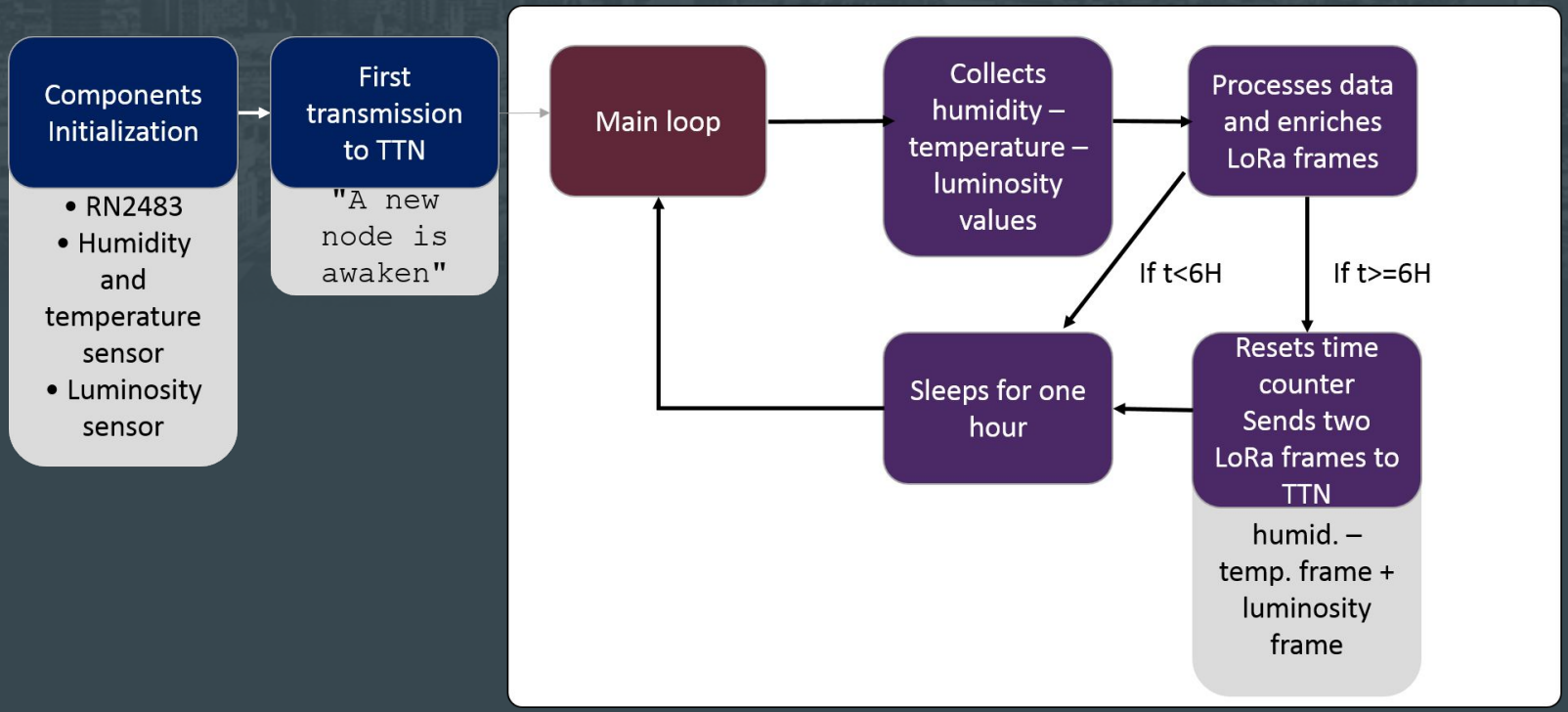
- RN2483 daughter board
- GPS module
- Arduino Micro
- Temperature & humidity and luminosity sensors



III. Weather station

2. Development phase (software part)

- Code Architecture



III. Weather station

2. Development phase (software part)

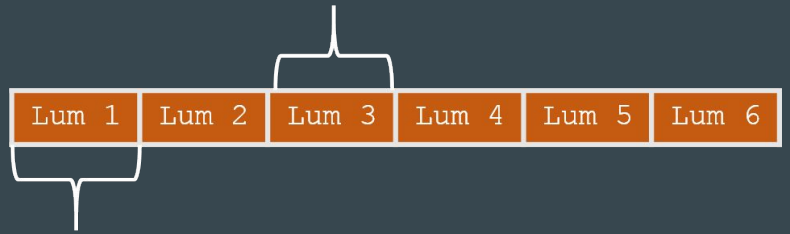
- **LoRa frames format**

• 1 humidity value + 1 temperature value each hour

- Humidity: 1 short int (1 byte)
- Value between 0% and 100%
- 2x multiplication ➔ 0,5% accuracy
- Sent value: between 0 and 200

- Luminosity: 1 short int (1 byte)
- Value between 0 and 1023
- Division by 4
- Sent value: between 0 and 254

- Temperature: 1 short int (1 byte)
- Value between -50°C and 77°C
- 50°C shift + 2x multiplication ➔ 0,5°C accuracy
- Sent value: between 0 and 254

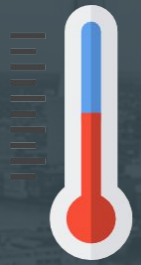


• 1 Luminosity value each hour

III. Weather station

3. Test phase and results analysis

Relevant humidity and temperature values (indoors: 22°C / approx 40%)

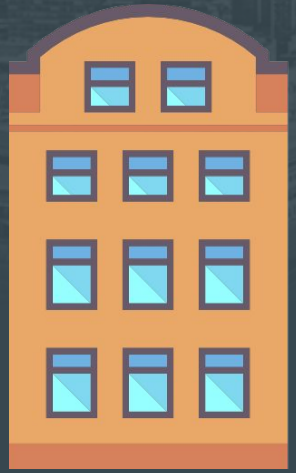


Luminosity value: only between 0 and 254 (no unit)

PART 4: Web platform

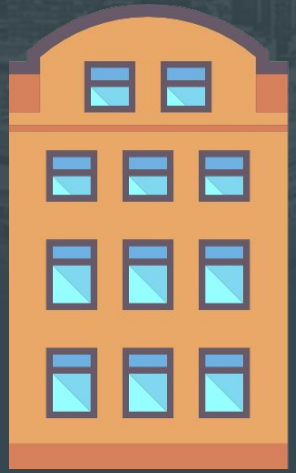
IV. Web platform

1. Use cases



IV. Web platform

1. Use cases



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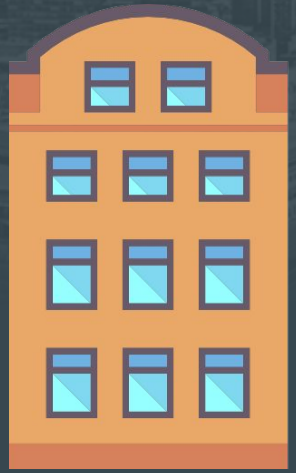
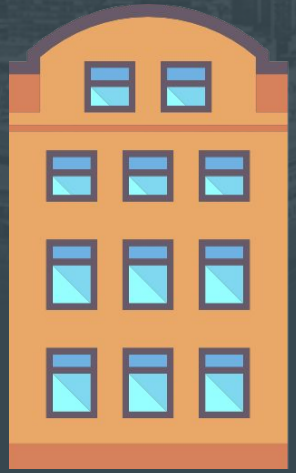
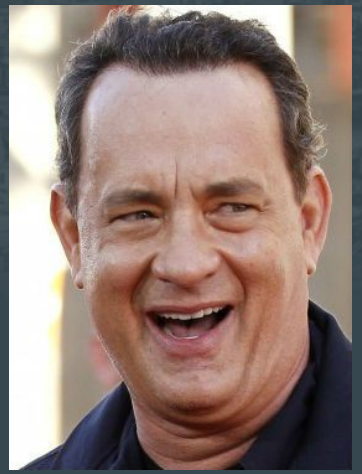


IV. Web platform

1. Use cases





IV. Web platform

1. Use cases

IV. Web platform

1. Use cases

IV. Web platform

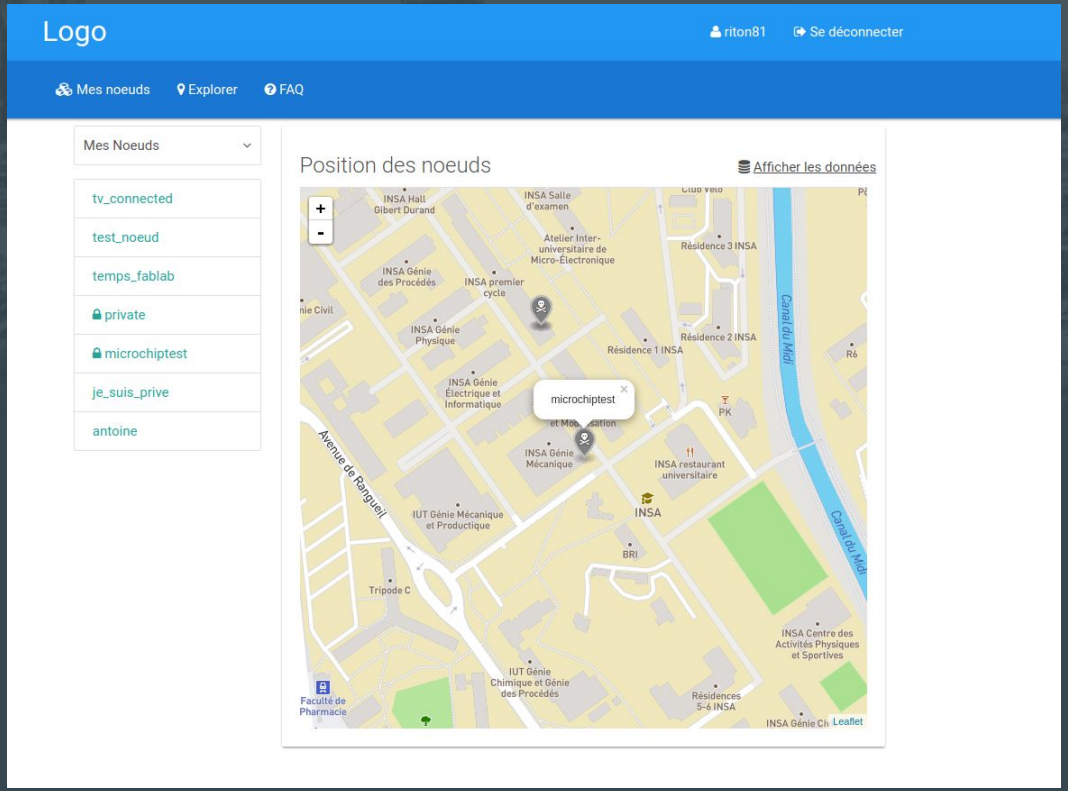
1. Use cases

IV. Web platform

1. Use cases

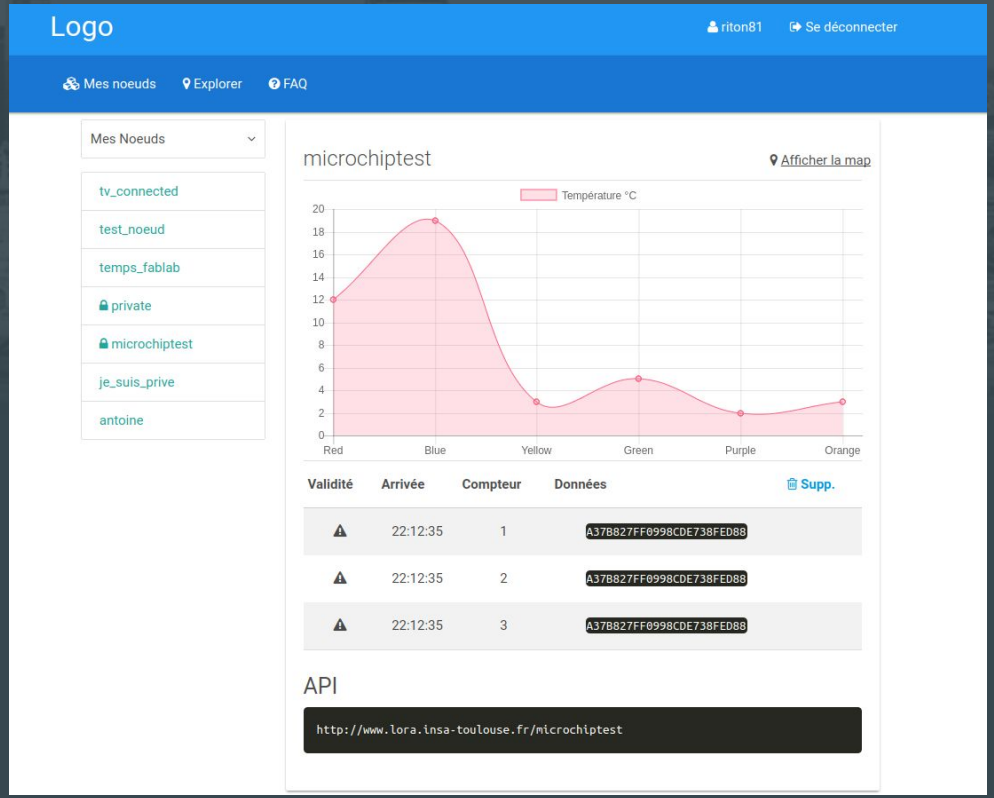
IV. Web platform

2. Explore nodes and data



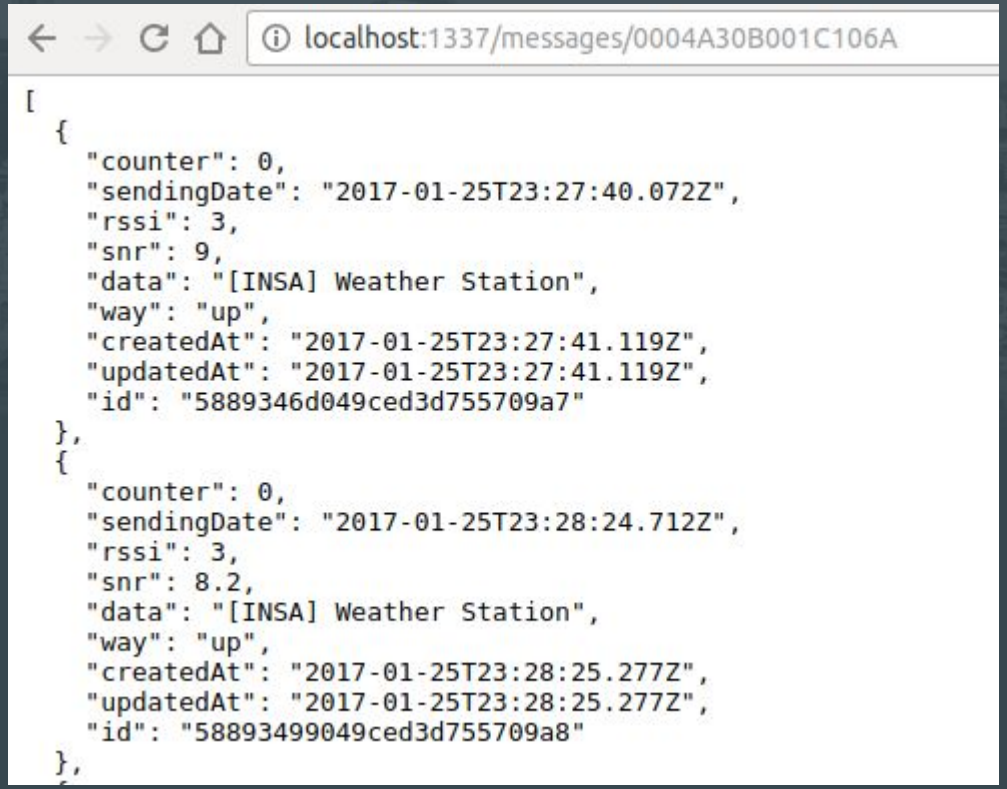
IV. Web platform

2. Explore nodes and data



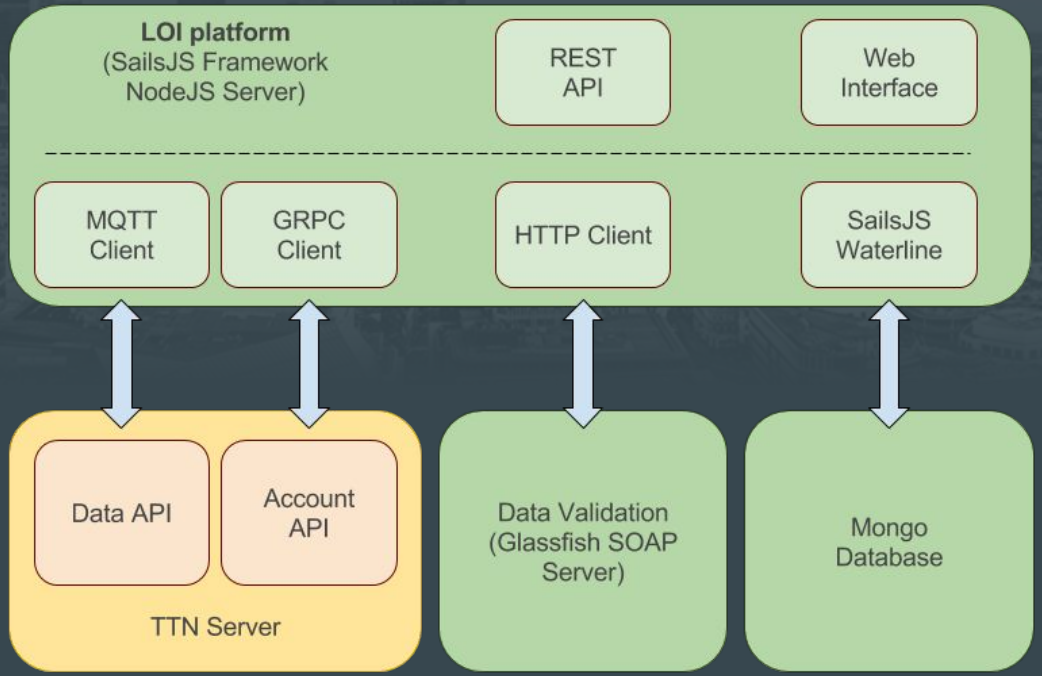
IV. Web platform

3. REST API



IV. Web platform

4. Architecture



IV. Web platform

4. Architecture

https://bitbucket.org/lorawebapp/lorawebapp

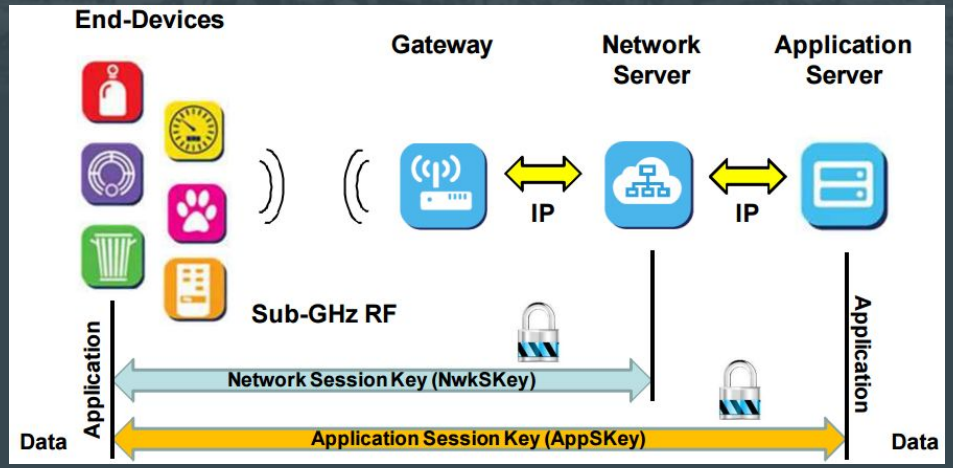
PART 5: Further developments

Further developments

1. Security Features

Initially

- Two-level encryption
- OTAA or ABP methods for nodes to join the network



Further developments

1. Security Features

Our work

- Study of different attacks, solutions and hypotheses
- Best practices
- Use of OTAA
- SOAP/BPEL service to check data integrity

Ideas

- Integration of our SOAP/BPEL service
- Intrusion Detection Systems (nodes, gateway, network)
- Denial Of Service attacks

Further developments

2. Energy issues

Problem

- Energy consumption way too high!
- Arduino microcontroller → not adapted to energy constraints

Solution

- Use of an STM32 microcontroller instead for example

Further developments

3. Software improvement

Platform

Pre-definition of standard formats for data frames

→ Automatic display of data on graphs for example

Embedded software

→ Improvement of libraries

Further developments

4. Hardware improvement

Gateway

- More efficient antenna
- Better shield
- Test of the heat resistance

Node

- Addition of sensors on the weather station
- Autonomous device

Demonstration

Conclusion

A project...

- Based on open-source technologies
- Documented to enable maintenance and export

...with two main goals

- To provide an educational IoT platform
- To create a “showcase” for INSA

But

- More time needed for development
- The project needs successors

Conclusion

- More time needed for development
- The project needs successors

Labs/Projects ideas:

- Maintain, extend and improve our network
- Test and improve the security of our network
- Implement an open Physical Layer using SDR
- Install a NetServer instead of using the TTN Server

Special thanks to ...

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Mr

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THE THINGS NETWORK

Thank you for your attention!

Do you have any question?

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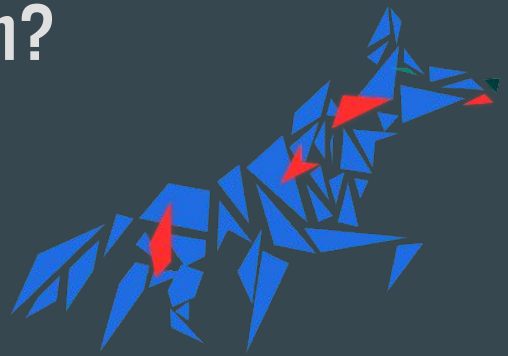

INNOVATIVE SMART SYSTEMS