

LoRa over INSA

For a connected and innovative campus

...

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01/26/2017



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

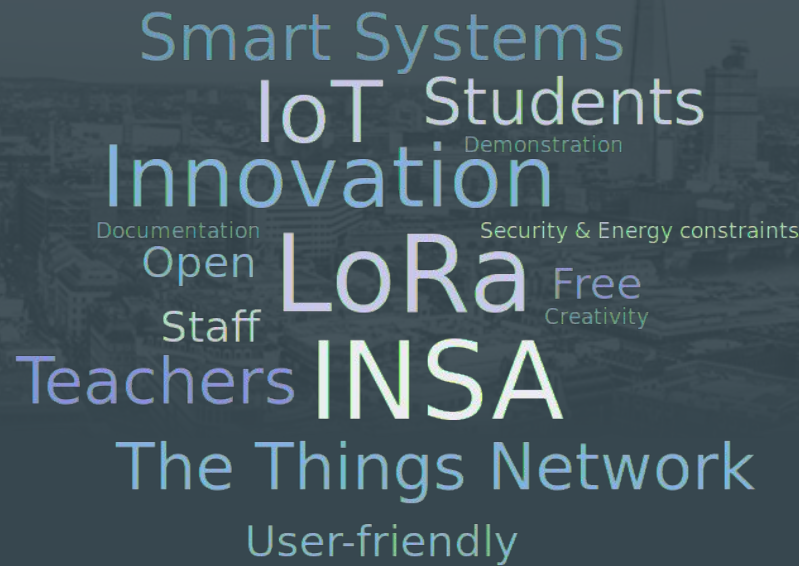
Demonstration



PART 1: Context and Project management

I. Specifications

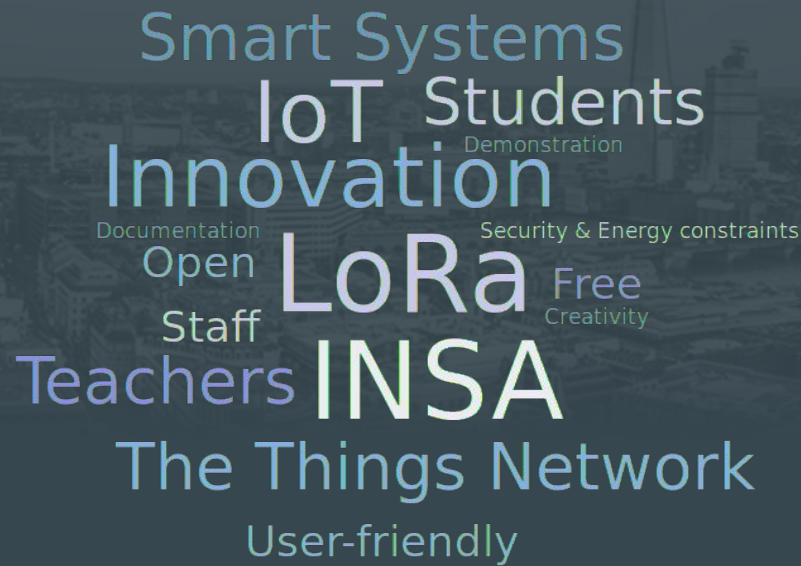
- **Deployment of a LoRa network**
- **Via a Web platform, an access that is:**
 - Free
 - User-friendly
 - Documented
 - Open
- **With a concrete application:**
 - A connected Weather station
- **Security study**

A word cloud graphic on the right side of the slide, set against a dark background with a faint city skyline. The words are in various sizes and colors (blue, green, white). The most prominent words are 'LoRa' and 'INSA'. Other visible words include 'Smart Systems', 'IoT', 'Students', 'Innovation', 'Teachers', 'The Things Network', 'User-friendly', 'Open', 'Staff', 'Documentation', 'Security & Energy constraints', 'Free', 'Creativity', and 'Demonstration'.

Smart Systems
IoT Students
Innovation
Documentation Open Staff
LoRa Free Creativity
Teachers INSA
The Things Network
User-friendly
Security & Energy constraints
Demonstration

II. User's needs

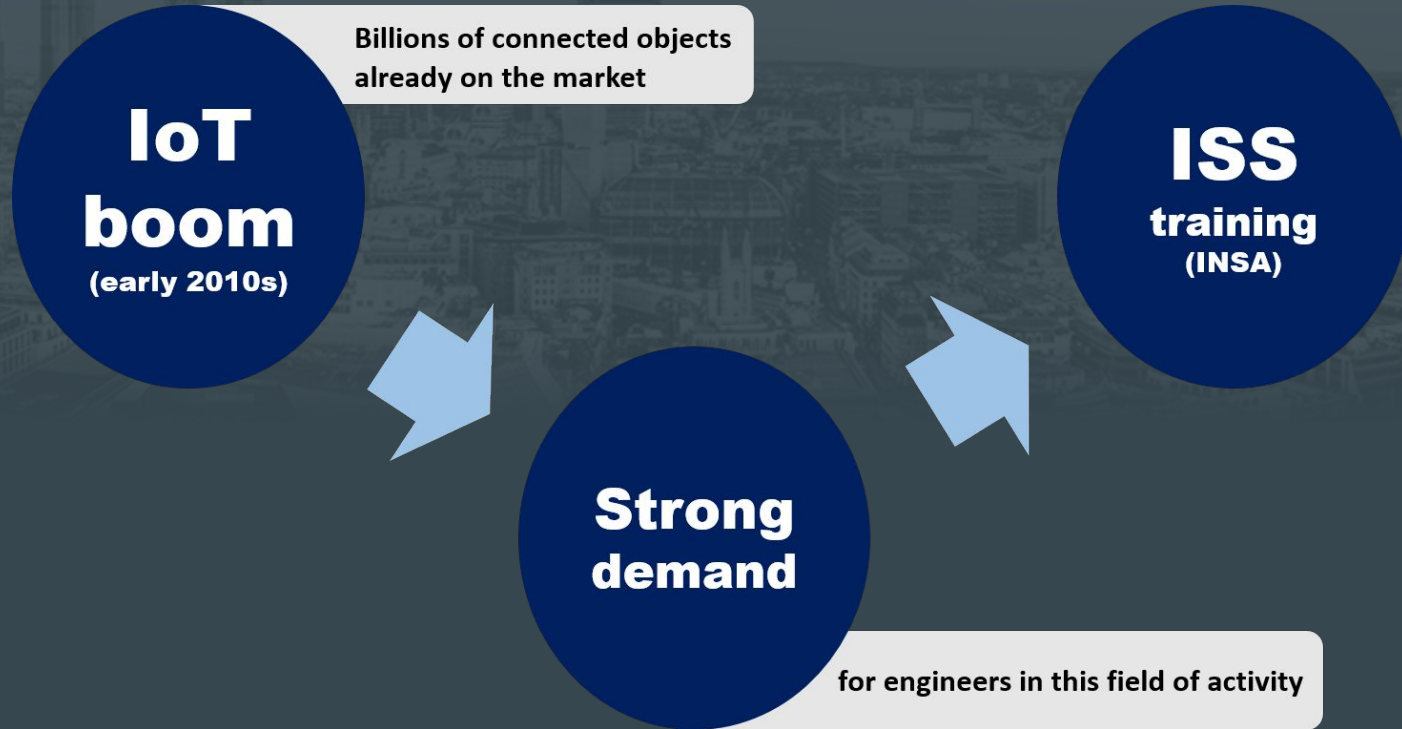
- **INSA:**
 - Innovative and connected campus
- **Teachers:**
 - Tool, demonstration for labs
- **Students:**
 - IoT knowledge and skills
 - Competitivity in the IoT world
 - More personalized projects
 - Quality of life improvement on the campus



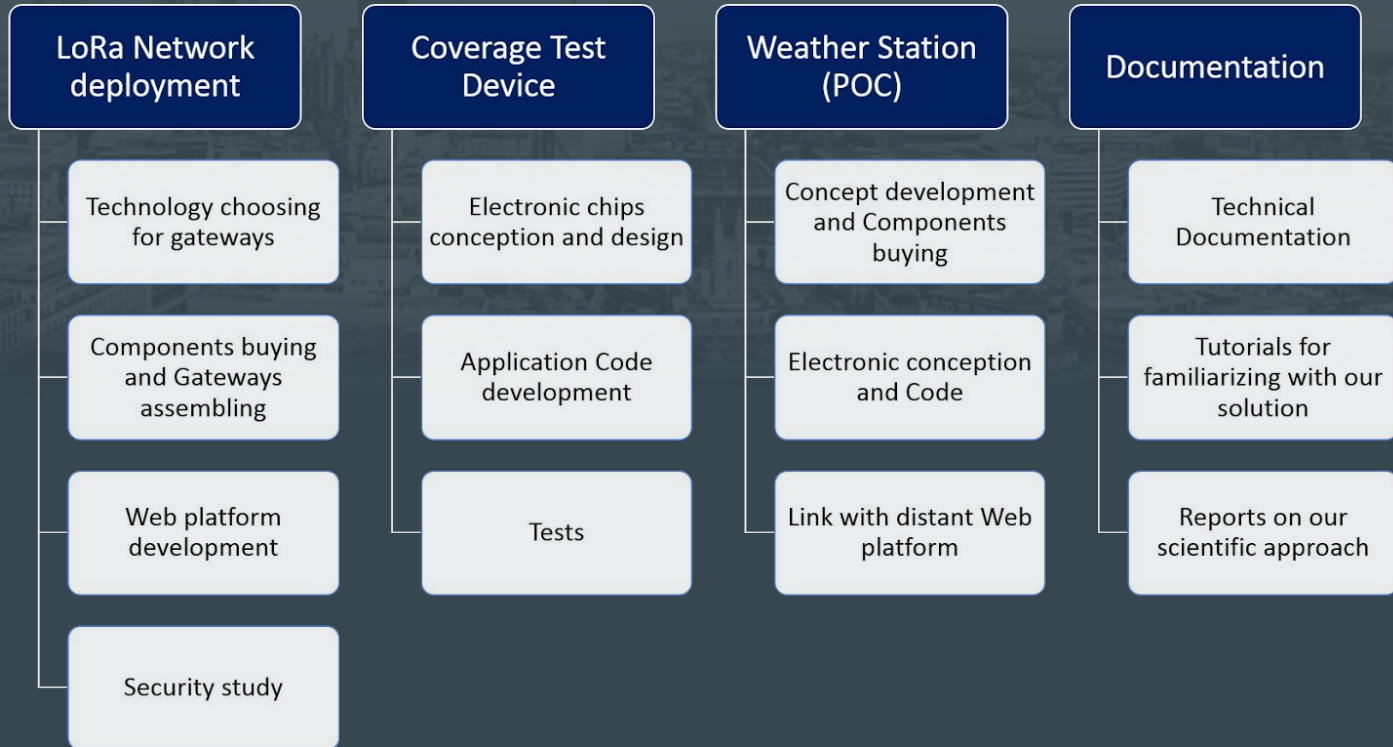
A word cloud of IoT-related terms. The words are arranged in a cluster, with 'INSA' being the largest and most prominent. Other large words include 'LoRa', 'The Things Network', 'Innovation', 'Smart Systems', 'IoT', and 'Students'. Smaller words include 'Documentation', 'Open', 'Staff', 'Teachers', 'User-friendly', 'Security & Energy constraints', 'Free Creativity', and 'Demonstration'. The background of the word cloud is a faint, grayscale image of a city skyline, likely London, with the Shard being a prominent feature.

Smart Systems
IoT Students
Innovation
Documentation Open Staff Teachers INSA
The Things Network
User-friendly
Security & Energy constraints
Free Creativity
Demonstration

III. Context



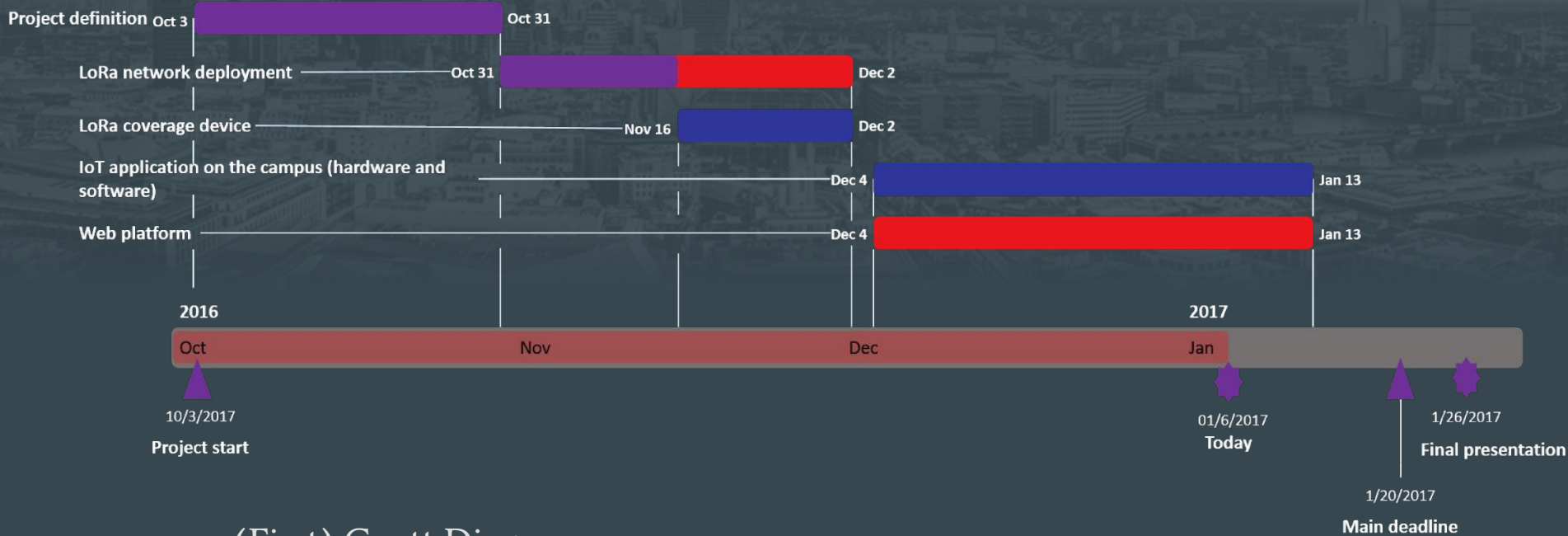
IV. Objectives



IV. Objectives

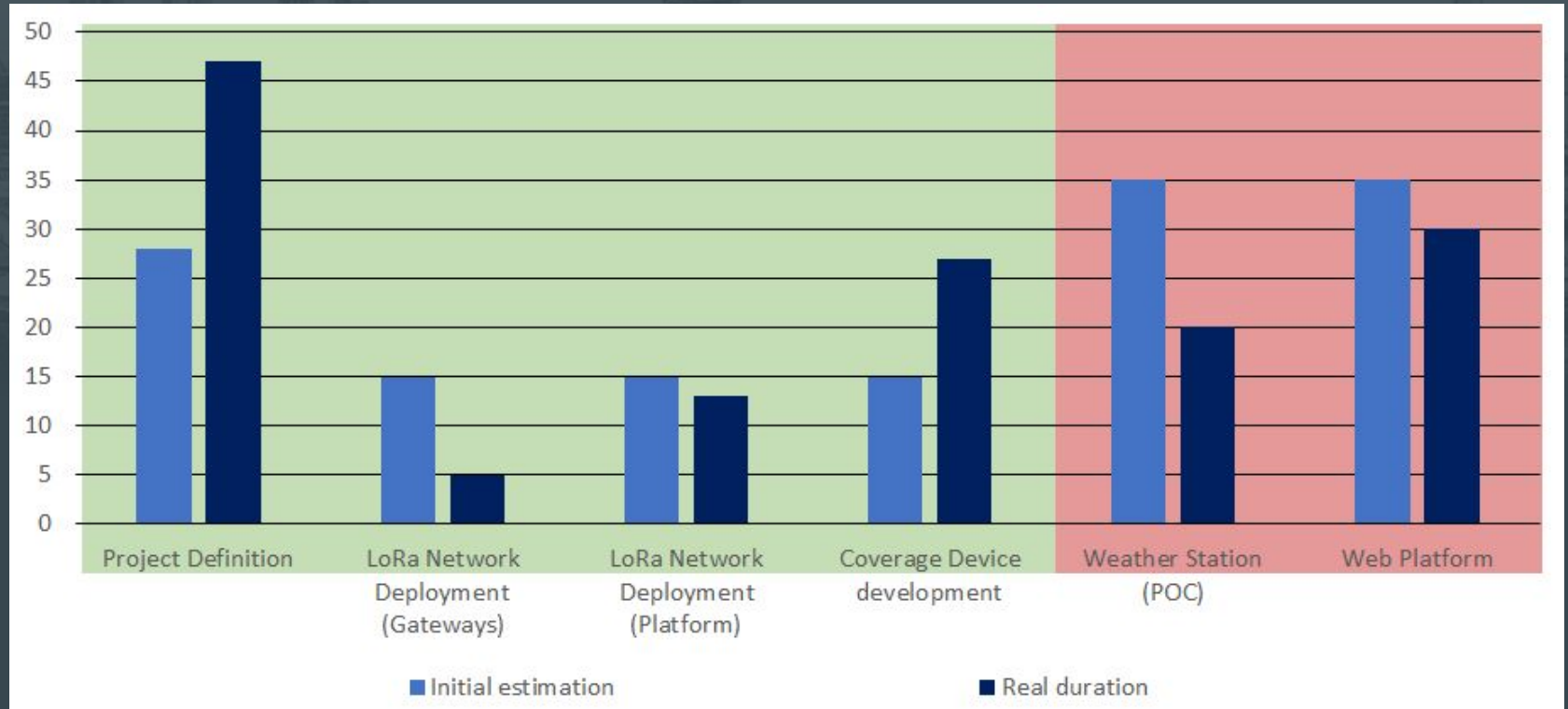
Key :

- : Concerns both sub-groups
- : Concerns device-oriented sub-group
- : Concerns network-oriented sub-group



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

IV. Objectives



V. Costs



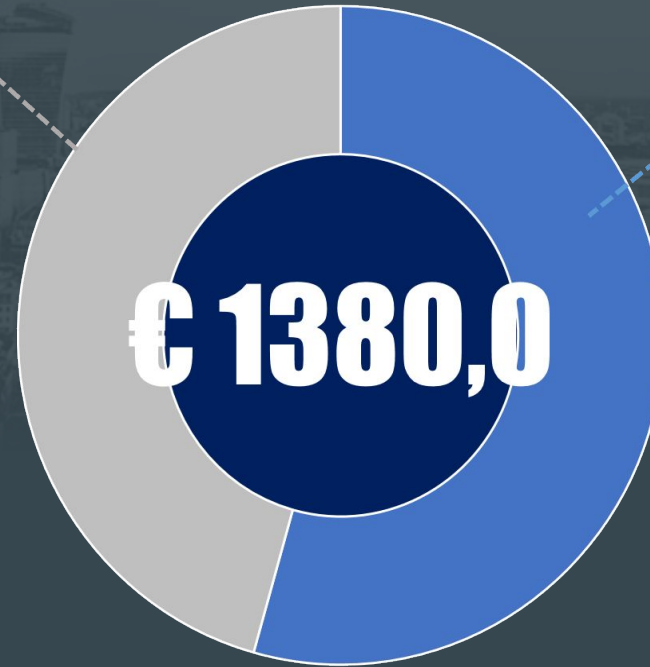
€ 1380,0

Total cost of the project

V. Costs

**Other costs
(Nodes, etc.)
€ 630**

**Network
specific costs
€ 750**



V. Costs

**Other costs
(Nodes, etc.)**

€ 630

**Network
specific costs**

€ 750

**Cost of a single
Gateway**

€ 187,5

€ 1380,0



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



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



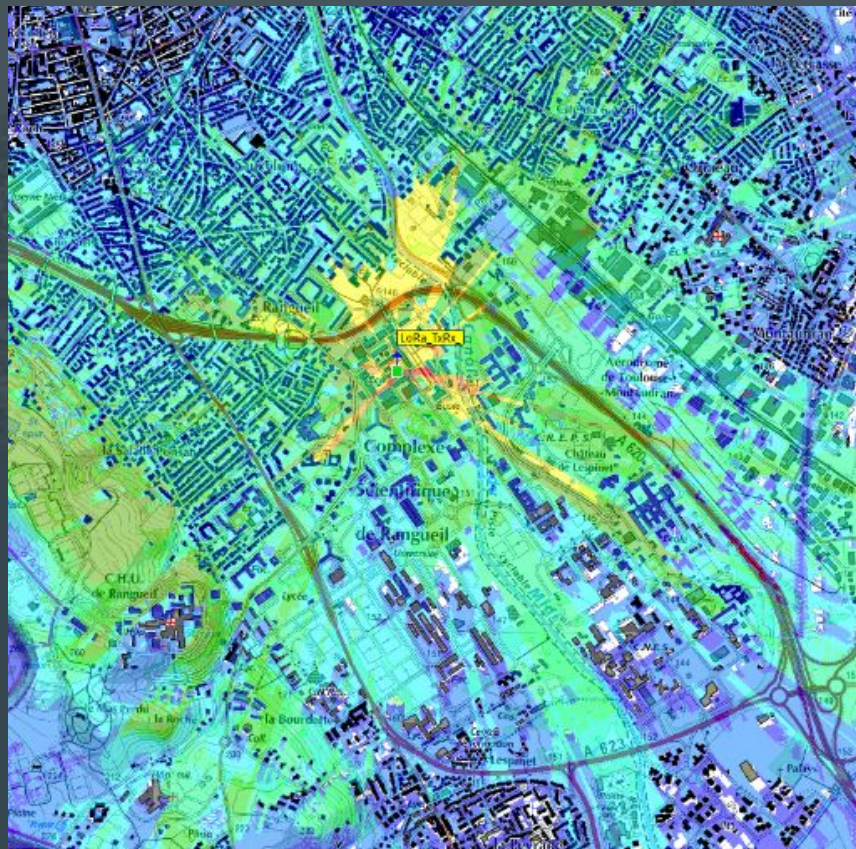
Tool

- 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



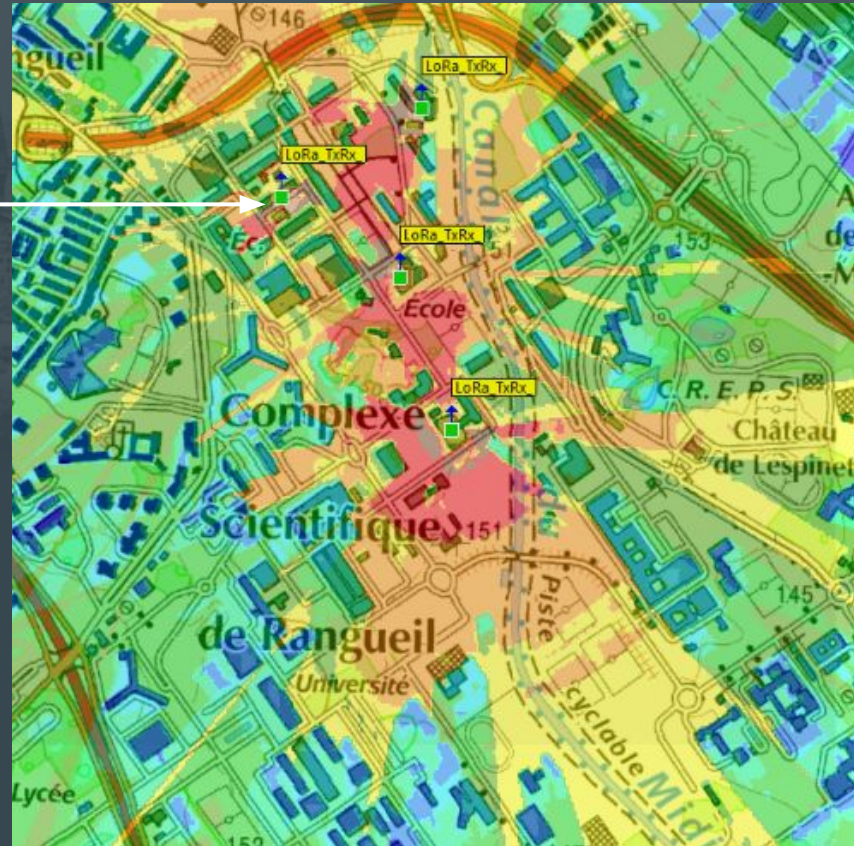
I. Coverage simulation

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

DGEI



II. Gateway choice and assembly

Criteria:

- Well documented
- Easy to install
- Low cost

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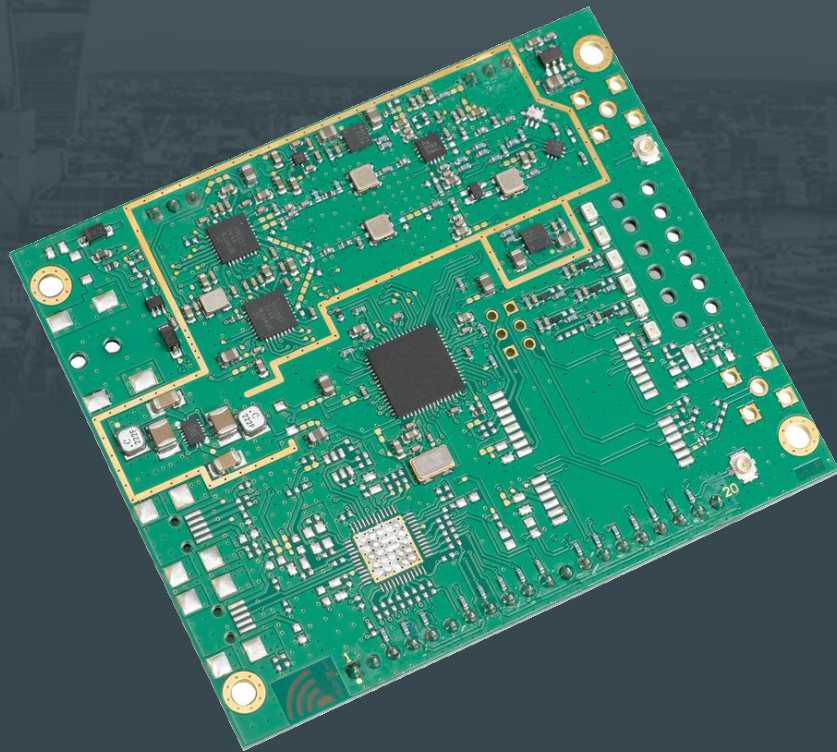
iC880A + RPi

II. Gateway choice and assembly

iC880A

Specifications:

- 8 channels
- 868 Mhz
- Plug and play

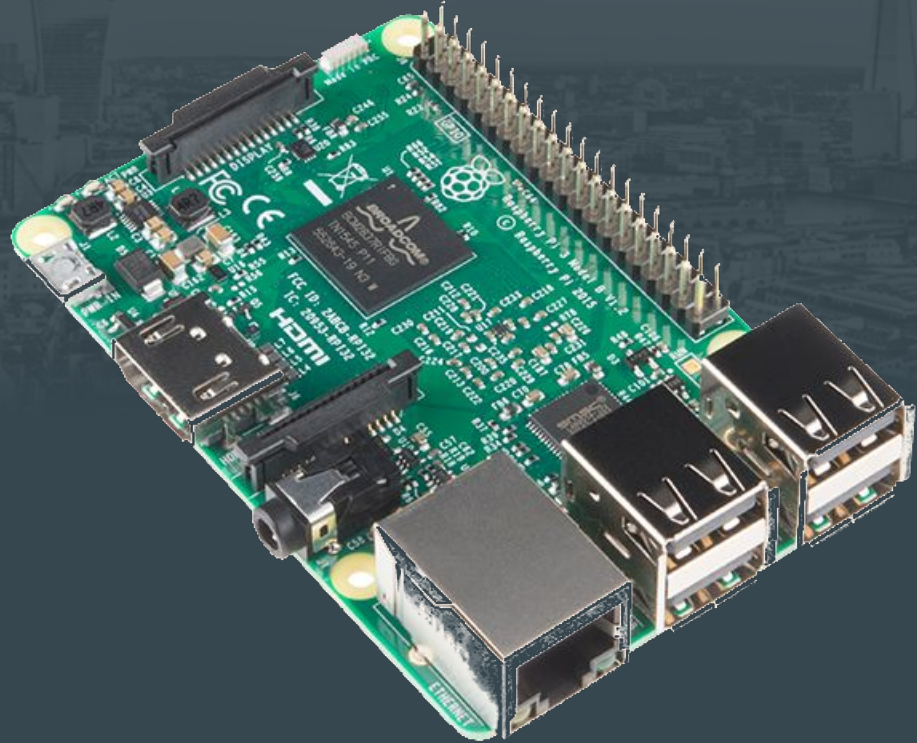


II. Gateway choice and assembly

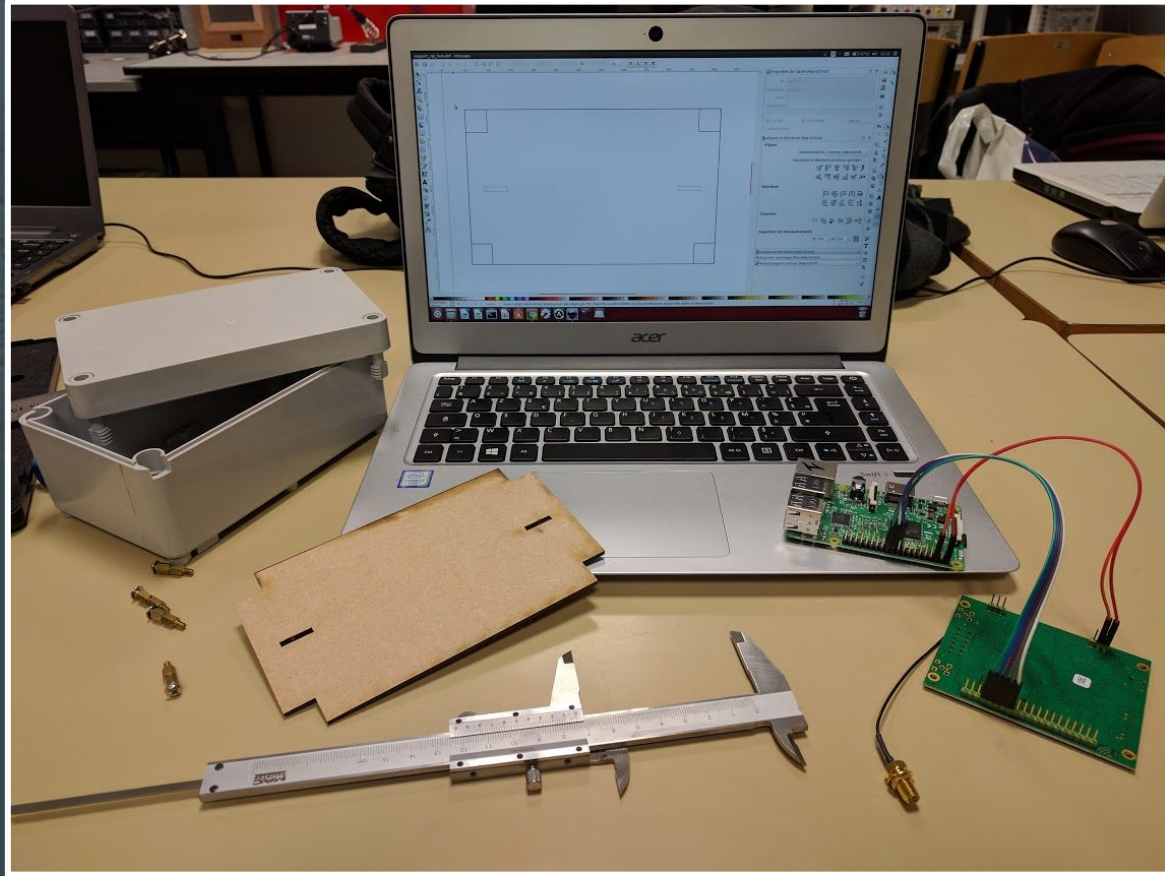
RPi 3

Specifications:

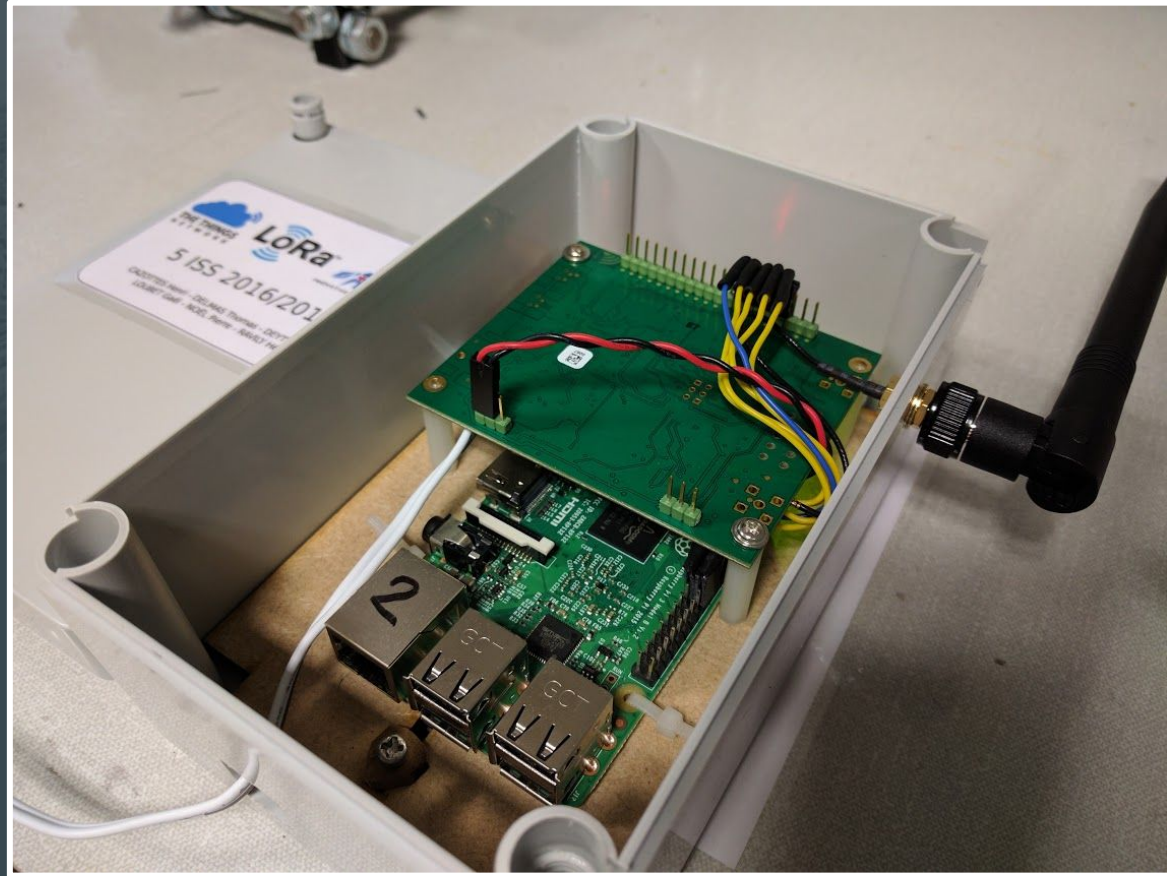
- Integrated Wifi
- Linux OS



II. Gateway choice and assembly



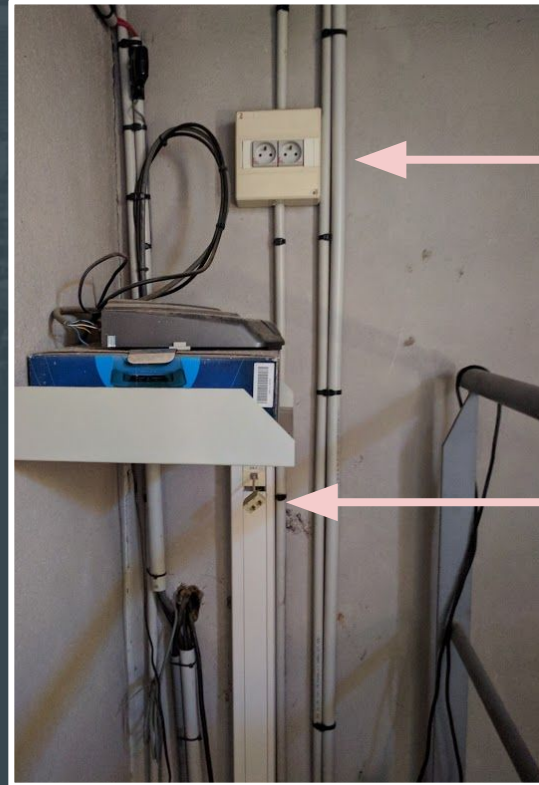
II. Gateway choice and assembly



II. Gateway choice and assembly



III. Gateway installation



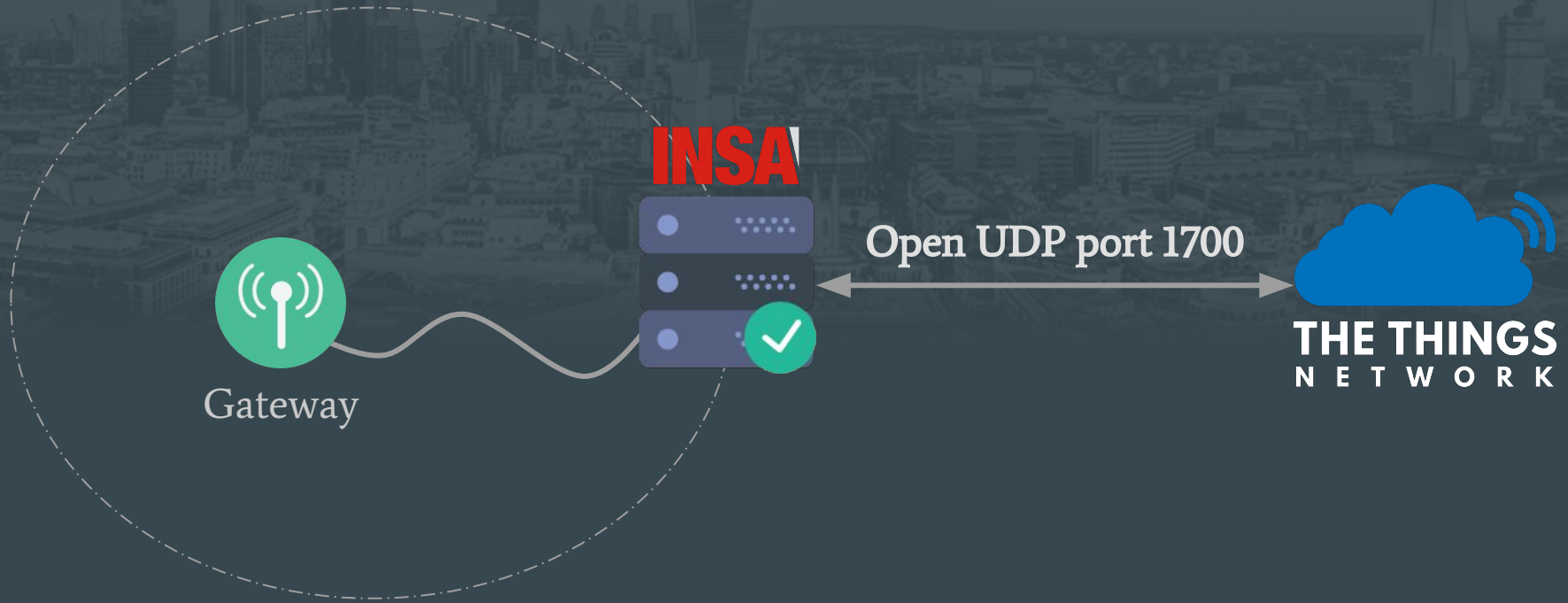
Power supply

Ethernet access

III. Gateway installation



III. Gateway installation

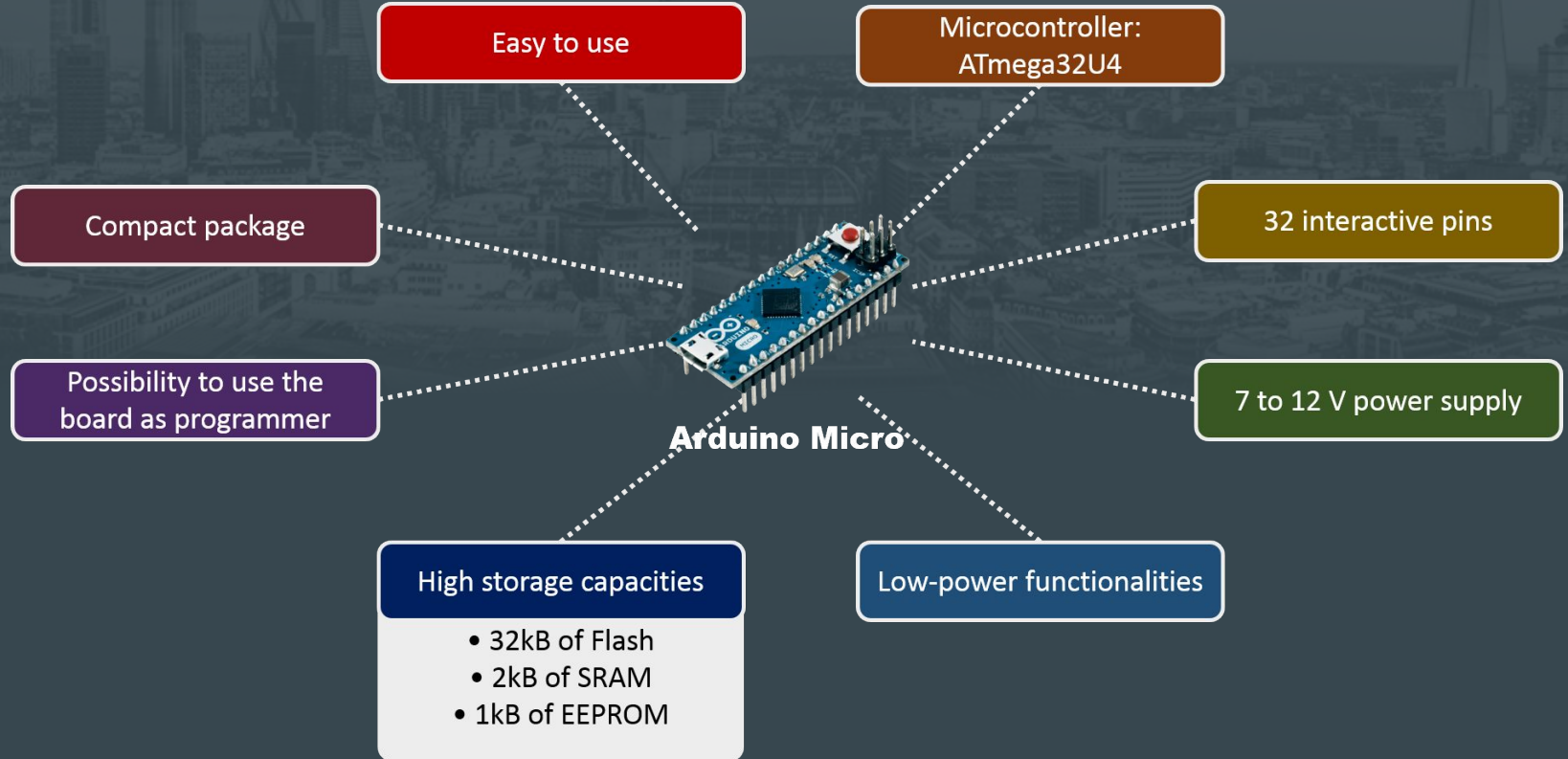




PART 3: Embedded Systems and devices

I. Choice of components

1. Microcontroller



I. Choice of components

1. Microcontroller

- Consumption study

According to datasheet

Running

Up to 40 mA

Standby mode

14 mA

Low-power mode

6 μ A

Real tests

Running

(our applicative code)

32 mA

Standby mode

20.2 mA

Low-power mode

11.4 mA

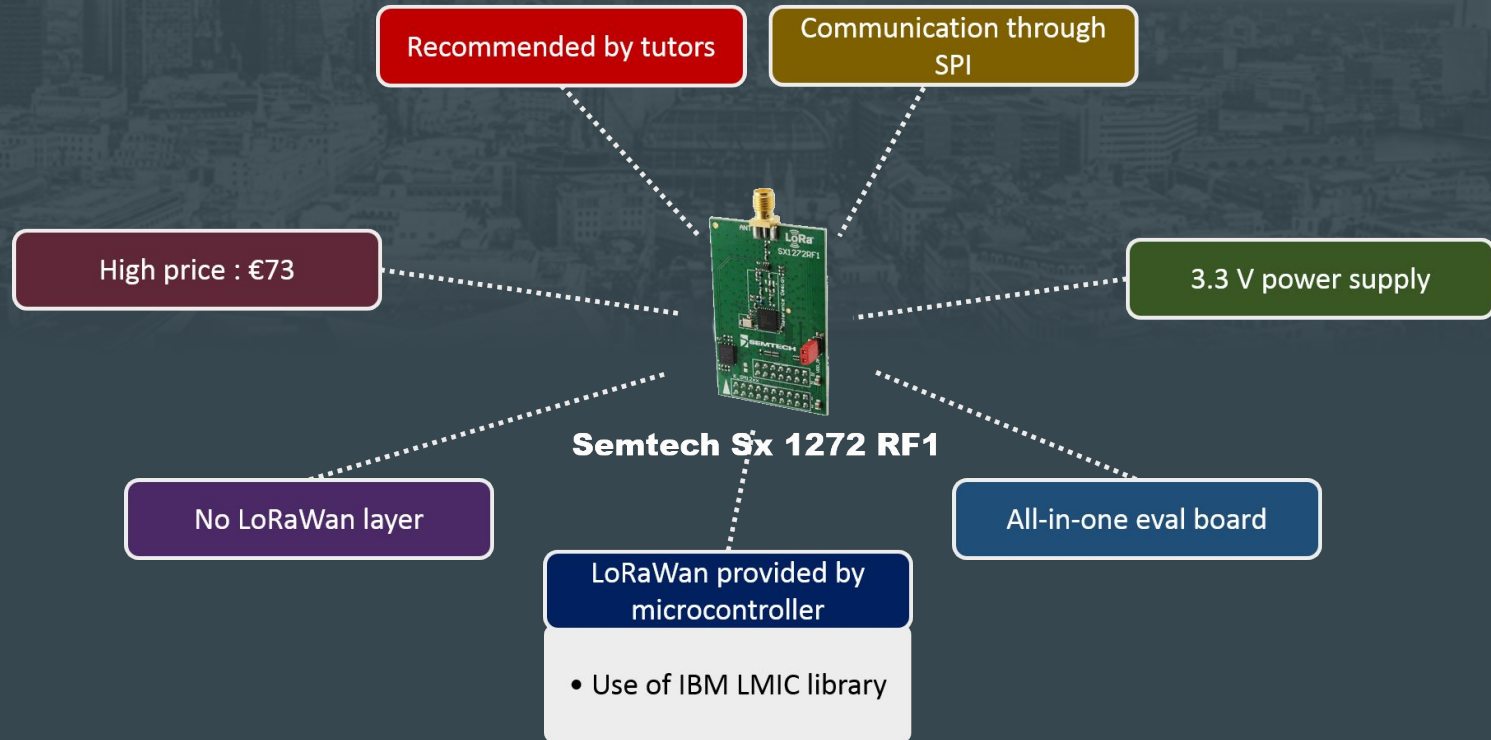
Why?

- Peripherals still ON (SPI, Timers, etc.)
- GPIO levels maintained at their initial value
- Low-power Library not adapted (though it is the most popular one)
- Limits of Arduino boards

I. Choice of components

2. LoRa transceivers

a. Semtech SX1272



I. Choice of components

2. LoRa transceivers

b. Microchip RN2483

User-friendly device

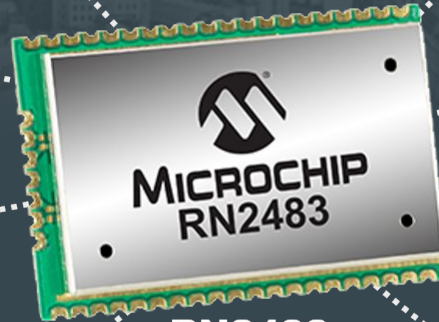
Based on a sx1276

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 μ A

Real tests

Transmit mode

23.2 mA

Receive mode

Not Tested

Idle mode

3.35 mA

Low-power mode

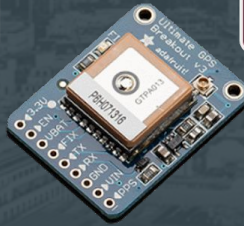
Not Tested

I. Choice of components

3. Sensors

UART communication

3.3 V power supply



**GPS Adafruit
Ultimate Breakout v3**

3 m accuracy

Passive component

Up to 5 V power supply



Value between 0 and
1023

Light sensor

Passive component

Up to 5 V power supply



-40 – 125°C

0% – 100% RH

**Temperature & humidity sensor
Aosong AM2303**

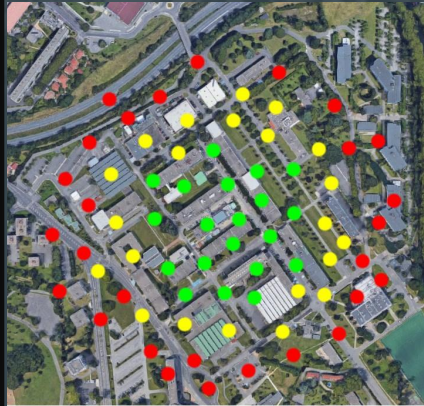
II. Coverage test device

1. Context

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

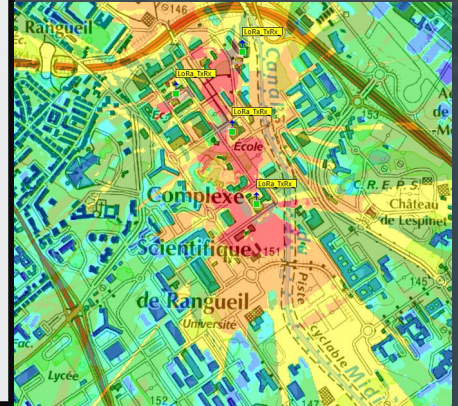
Main functioning

- 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 too heavy and not dedicated to 32U4 microprocessor

Lot of time spent

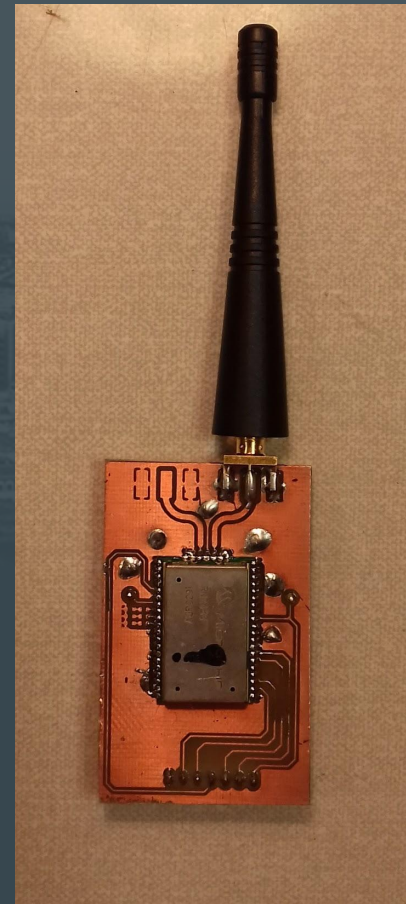
→ No significant results

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



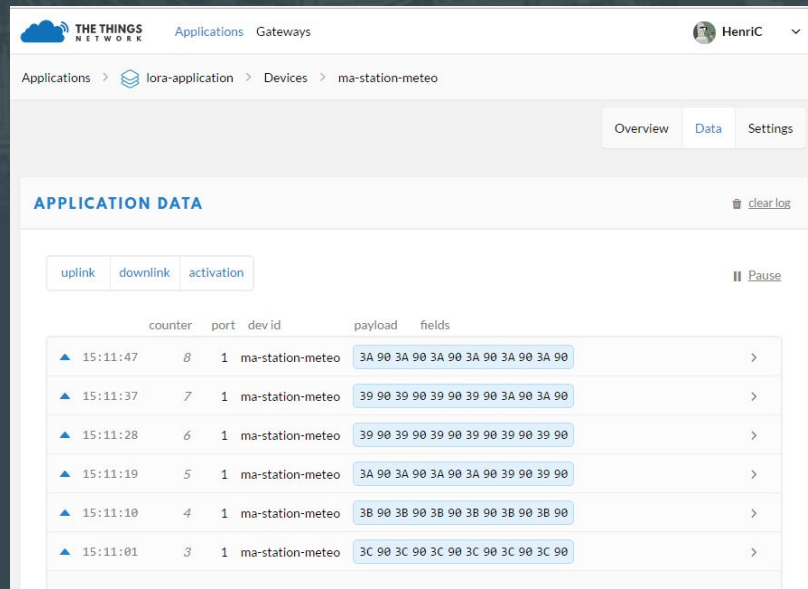
II. Coverage test device

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



The screenshot displays the 'The Things Network' console interface. The top navigation bar includes the logo, 'Applications', and 'Gateways'. The user 'HenriC' is logged in. The breadcrumb trail shows 'Applications > lora-application > Devices > ma-station-meteo'. On the right, there are tabs for 'Overview', 'Data', and 'Settings', with 'Data' being the active tab. Below this, the 'APPLICATION DATA' section is visible, with a 'clear log' link. There are three sub-tabs: 'uplink', 'downlink', and 'activation', with 'uplink' selected. A 'Pause' button is on the right. The main data table has columns for 'counter', 'port', 'dev id', 'payload', and 'fields'. It contains six rows of data, each representing an uplink message from the device 'ma-station-meteo'.

	counter	port	dev id	payload	fields
▲ 15:11:47	8	1	ma-station-meteo	3A 90 3A 90 3A 90 3A 90 3A 90 3A 90	>
▲ 15:11:37	7	1	ma-station-meteo	39 90 39 90 39 90 39 90 3A 90 3A 90	>
▲ 15:11:28	6	1	ma-station-meteo	39 90 39 90 39 90 39 90 39 90 39 90	>
▲ 15:11:19	5	1	ma-station-meteo	3A 90 3A 90 3A 90 3A 90 39 90 39 90	>
▲ 15:11:10	4	1	ma-station-meteo	3B 90 3B 90 3B 90 3B 90 3B 90 3B 90	>
▲ 15:11:01	3	1	ma-station-meteo	3C 90 3C 90 3C 90 3C 90 3C 90 3C 90	>

II. Coverage test device

2. Development phase

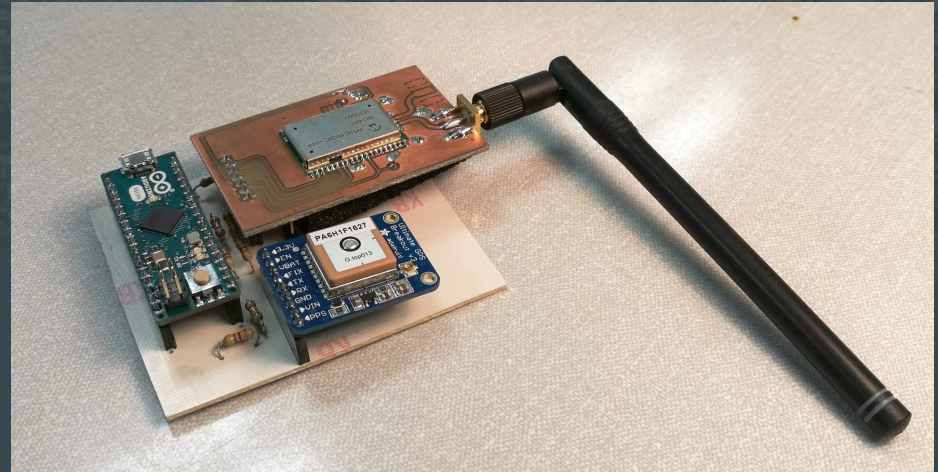
b. RN2483 version (hardware part)

Conception:

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

Contains:

- RN2483 daughter board
- GPS module
- Arduino Micro

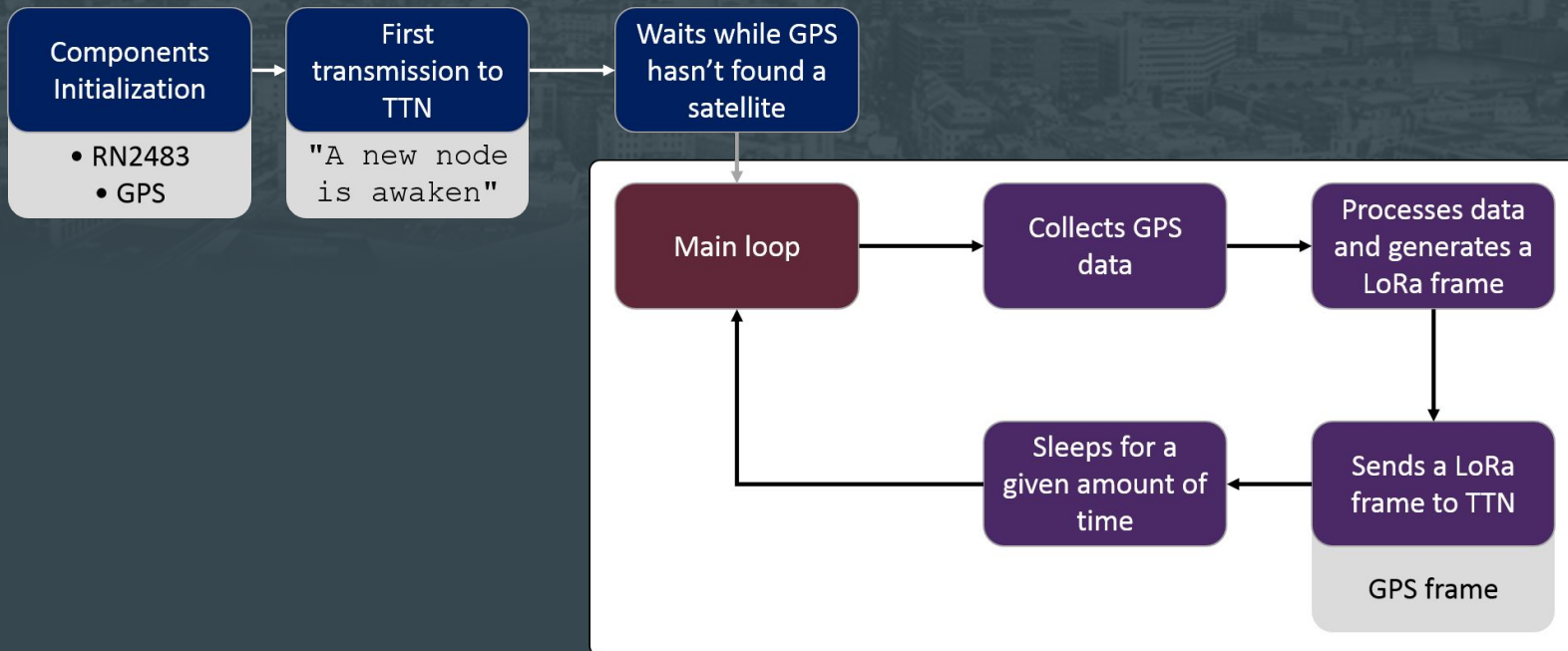


II. Coverage test device

2. Development phase

b. RN2483 version (software part)

- Code Architecture

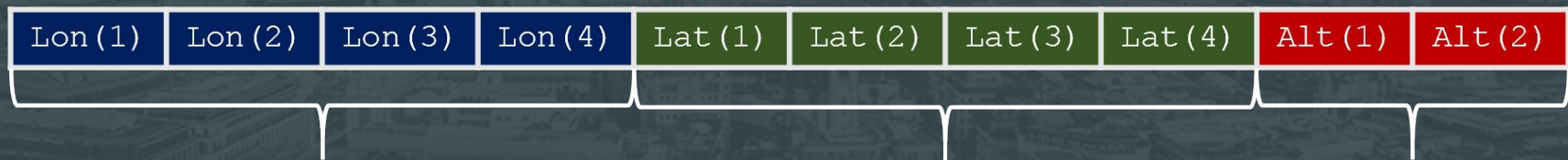


II. Coverage test device

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 over short distances
- A USB battery will be enough



II. Coverage test device

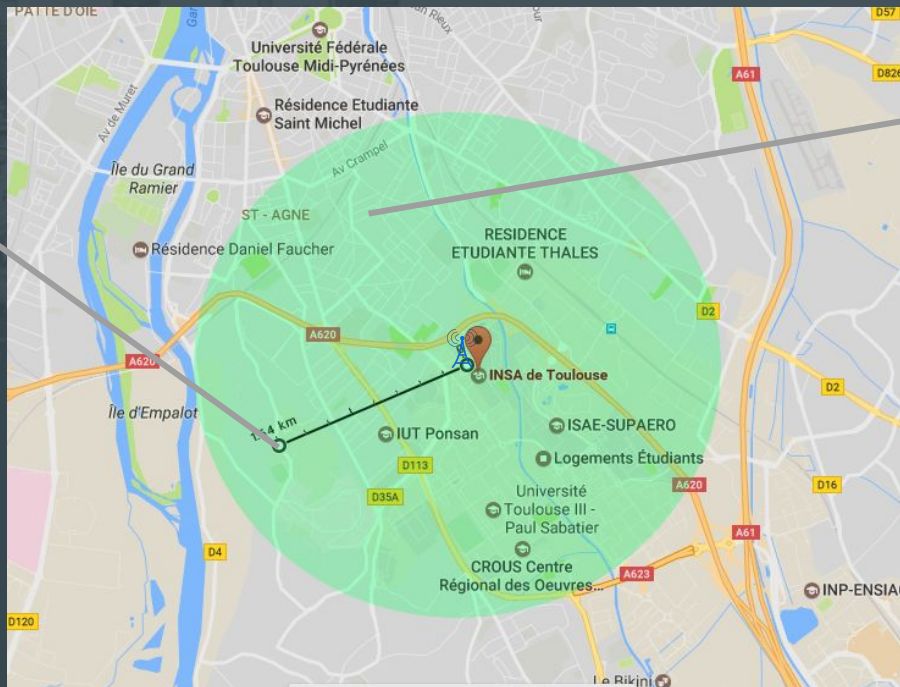
3. Test phase and result analysis

Open field

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



Under 30 km/h!

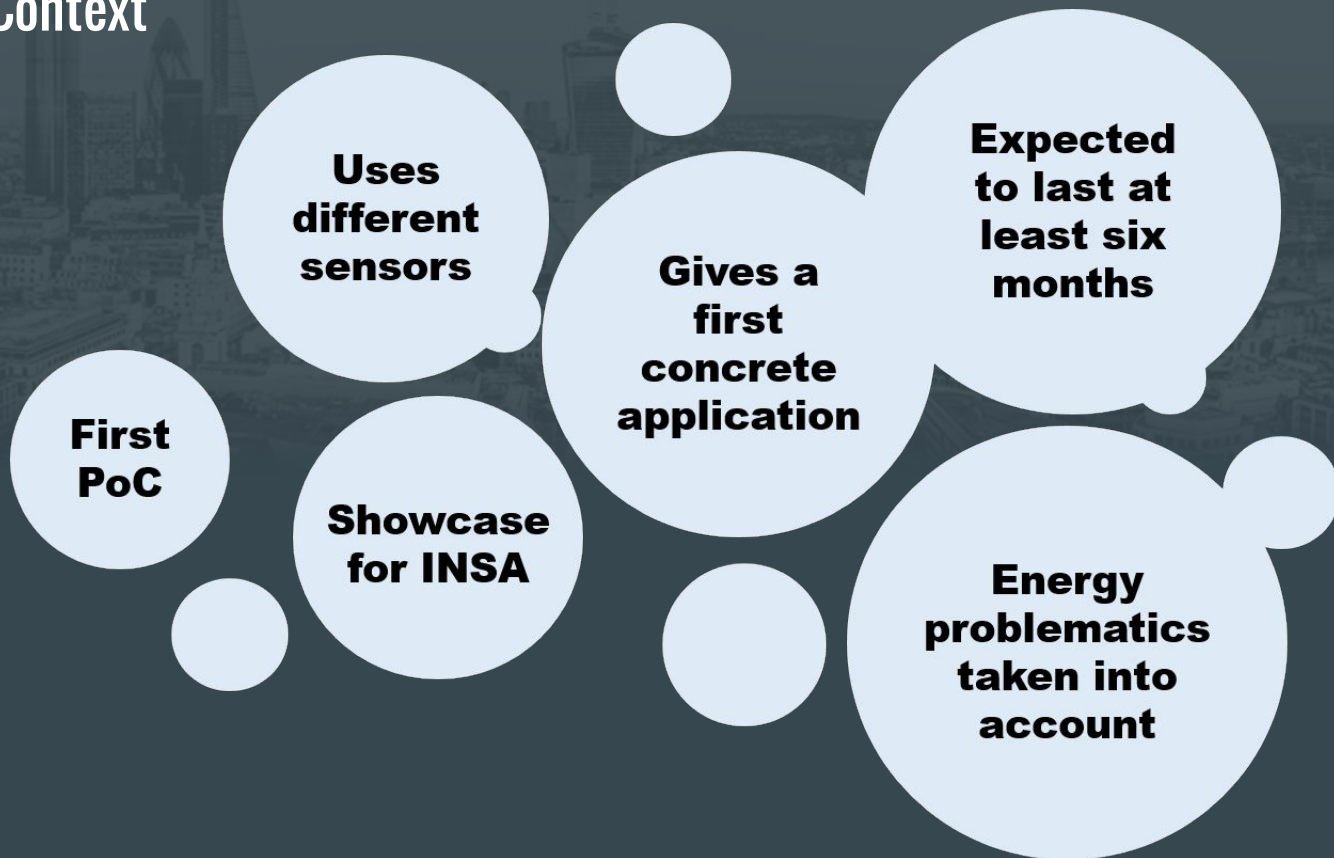


Restricted field

Sauzelong:
Dist: 1.45 km
SNR: -2 to -4.8

III. Weather station

1. Context



III. Weather station

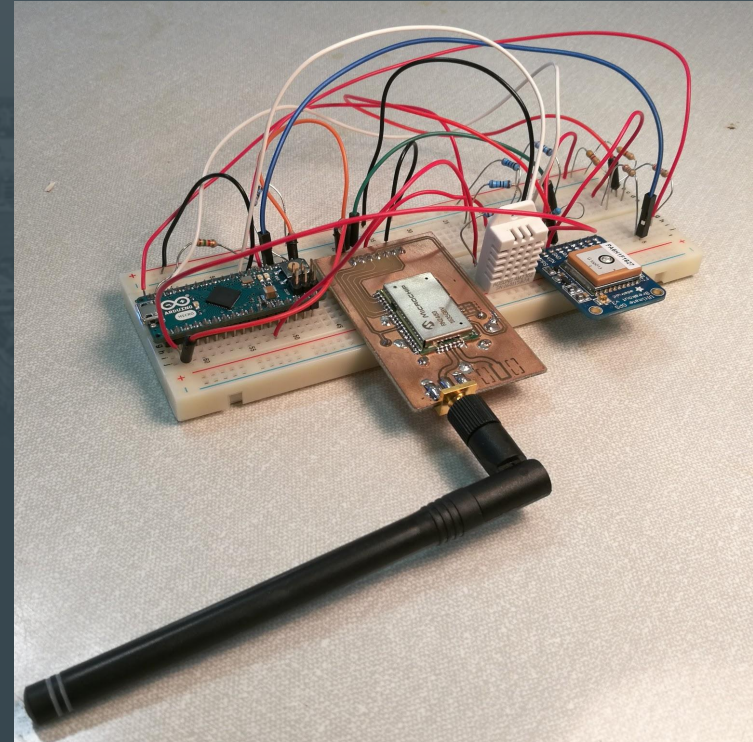
2. Development phase (hardware part)

Conception:

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

Contains:

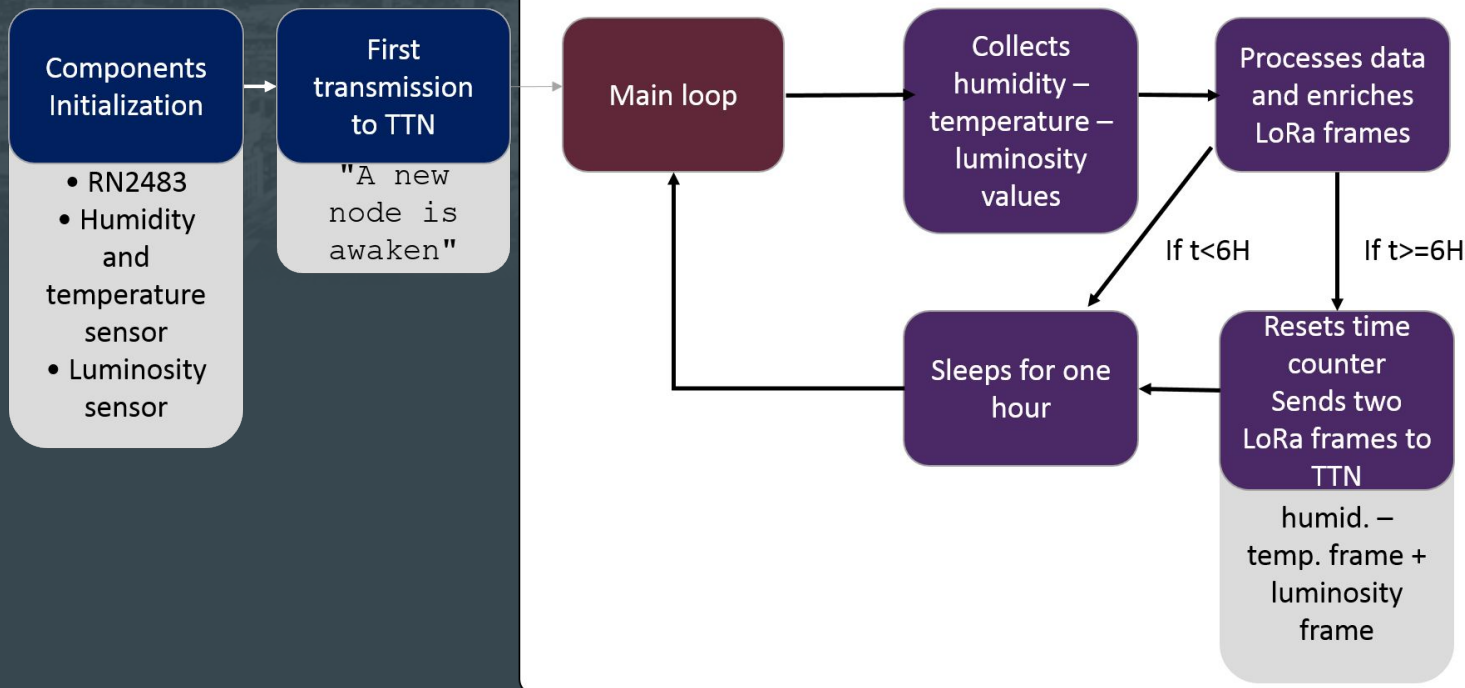
- RN2483 daughter board
- GPS module
- Arduino Micro
- Temperature & humidity and luminosity sensors



III. Weather station

2. Development phase (software part)

- Code Architecture



III. Weather station

2. Development phase (software part)

- LoRa frames format

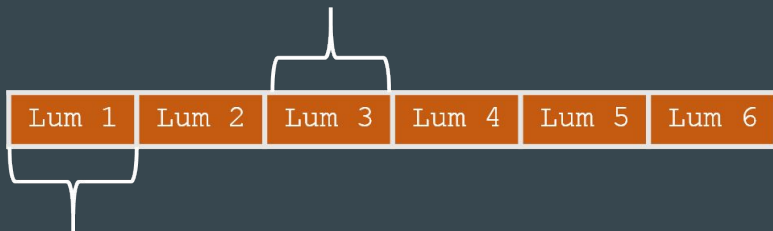
- 1 humidity value + 1 temperature value each hour



- 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

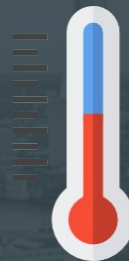


- 1 Luminosity value each hour

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



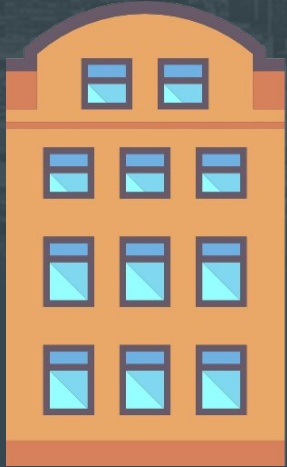
IV. Web platform

1. Use cases



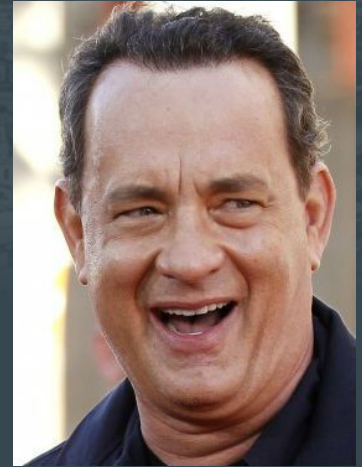
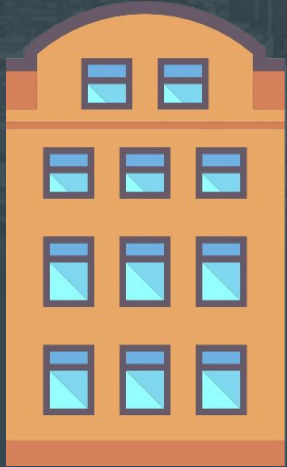
IV. Web platform

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

1. Use cases



IV. Web platform

2. Explore nodes and data

Logo

riton81 Se déconnecter

Mes noeuds Explorer FAQ

Mes Noeuds

- tv_connected
- test_noeud
- temps_fablab
- private
- microchiptest
- je_suis_privé
- antoine

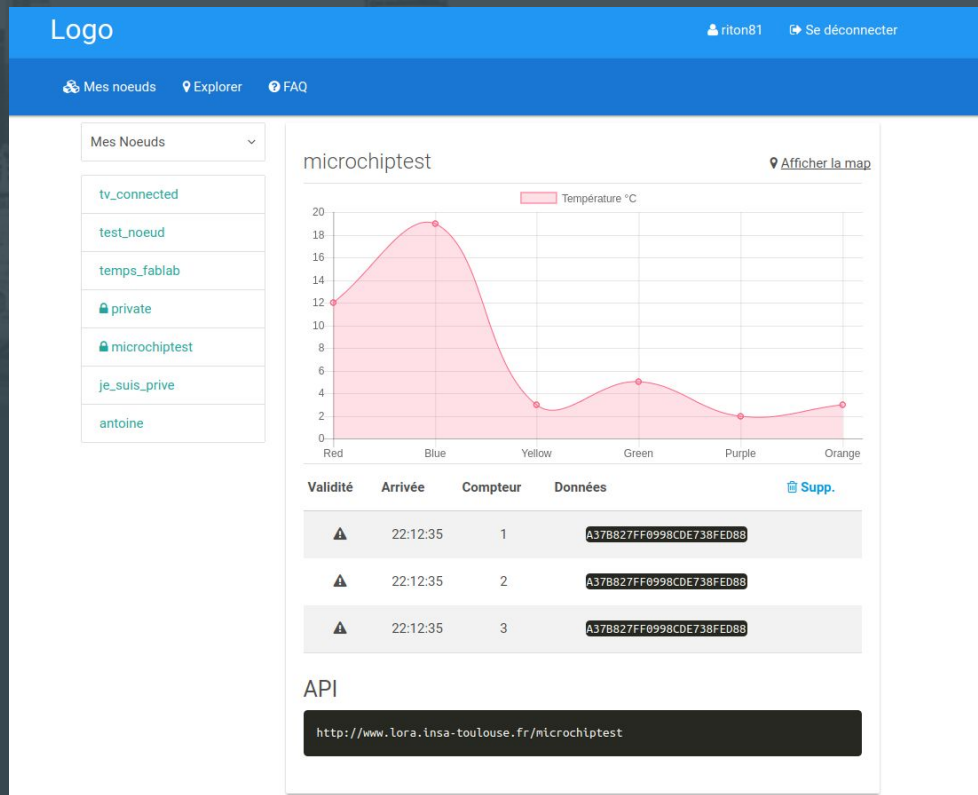
Position des noeuds

Afficher les données

The map displays the INSA Lyon campus with various buildings and landmarks. A callout for 'microchiptest' is visible, indicating its location on the map. Other labeled locations include INSA Halli Gilbert Durand, INSA Salle d'examen, Club velo, Résidence 3 INSA, Résidence 2 INSA, Résidence 1 INSA, INSA Génie des Procédés, INSA premier cycle, Atelier Inter-universitaire de Micro-Electronique, INSA Génie Physique, INSA Génie Électrique et Informatique, INSA Génie Mécanique, IUT Génie Mécanique et Productique, IUT Génie Chimique et Génie des Procédés, INSA restaurant universitaire, INSA Centre des Activités Physiques et Sportives, Résidences 5-6 INSA, INSA Génie Ch, Faculté de Pharmacie, and Tripode C. The map also shows the Canal du Midi and Avenue de Rangueil.

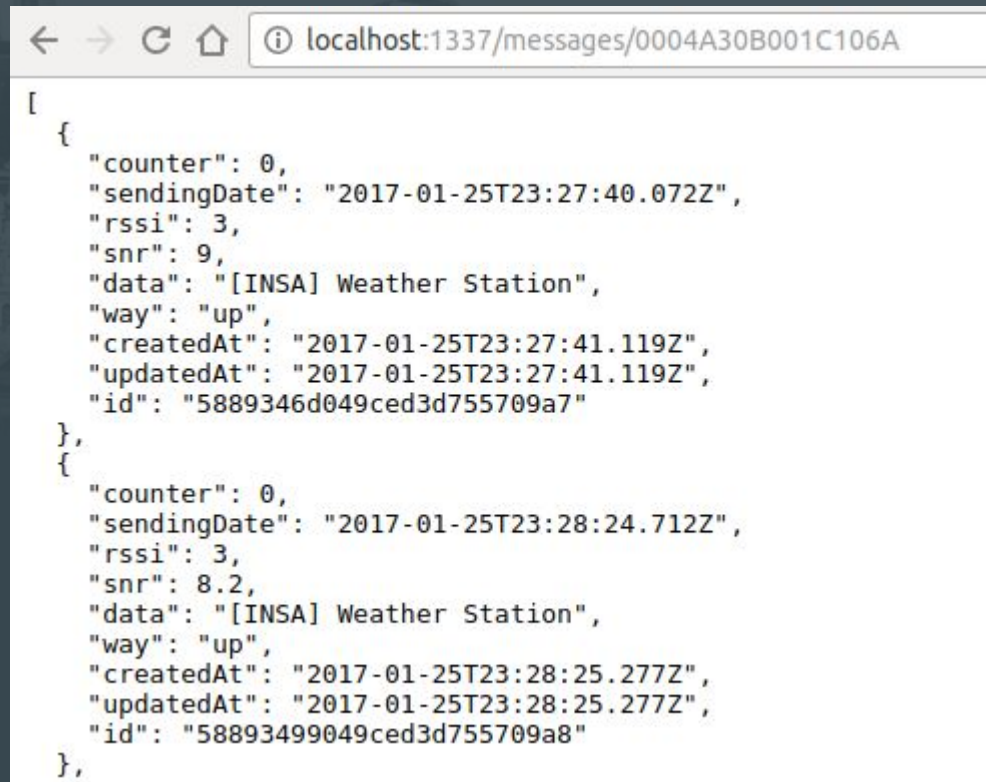
IV. Web platform

2. Explore nodes and data



IV. Web platform

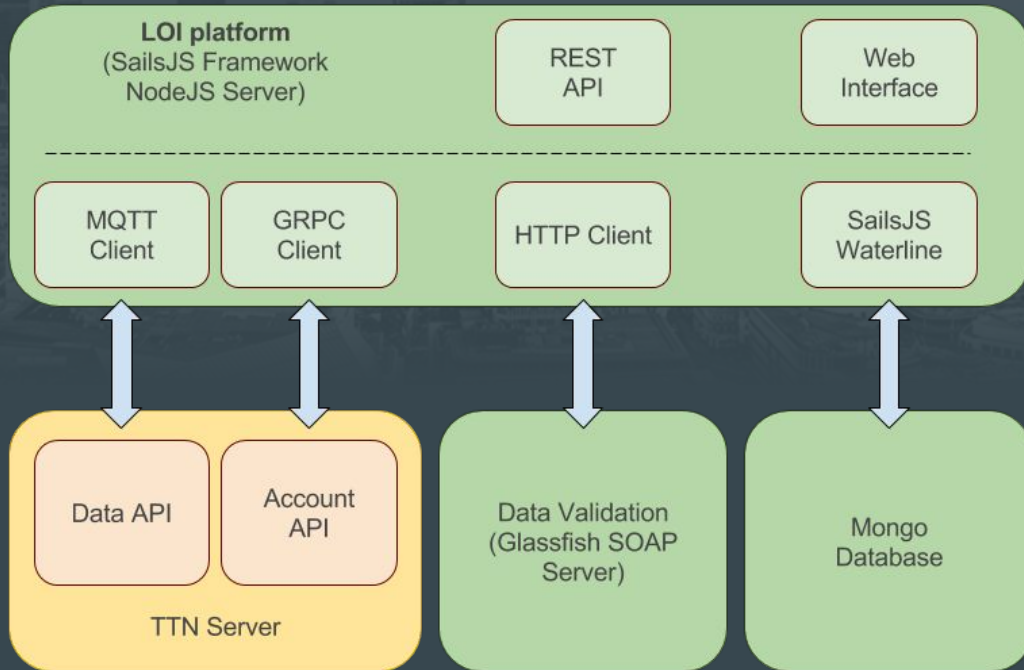
3. REST API



```
[
  {
    "counter": 0,
    "sendingDate": "2017-01-25T23:27:40.072Z",
    "rssi": 3,
    "snr": 9,
    "data": "[INSA] Weather Station",
    "way": "up",
    "createdAt": "2017-01-25T23:27:41.119Z",
    "updatedAt": "2017-01-25T23:27:41.119Z",
    "id": "5889346d049ced3d755709a7"
  },
  {
    "counter": 0,
    "sendingDate": "2017-01-25T23:28:24.712Z",
    "rssi": 3,
    "snr": 8.2,
    "data": "[INSA] Weather Station",
    "way": "up",
    "createdAt": "2017-01-25T23:28:25.277Z",
    "updatedAt": "2017-01-25T23:28:25.277Z",
    "id": "58893499049ced3d755709a8"
  }
]
```


IV. Web platform

4. Architecture



IV. Web platform

4. Architecture



<https://bitbucket.org/lorawebapp/lorawebapp>



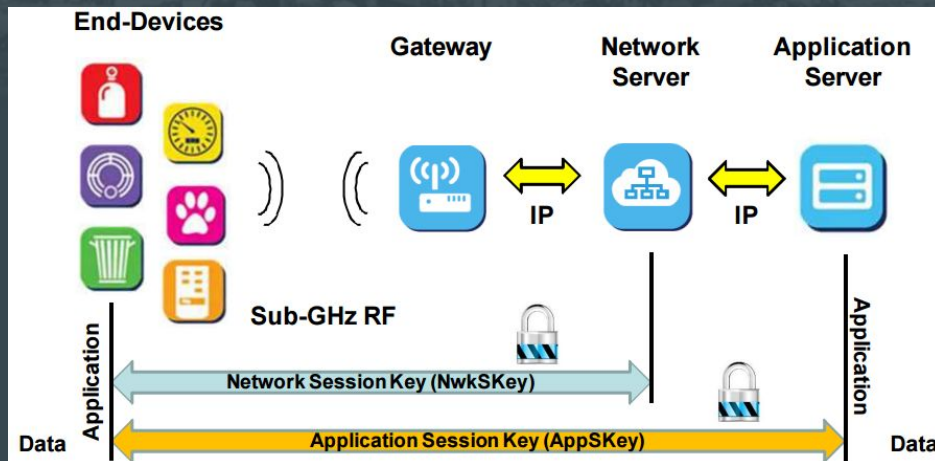
PART 5: Further developments

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



An aerial, wide-angle photograph of the London skyline, featuring prominent skyscrapers like The Shard and the Gherkin. The image is dimmed with a dark grey overlay. The word "Demonstration" is centered in a large, white, sans-serif font.

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 ...

Mrs Daniela Dragomirescu

Mr Eric Alata

Mr Etienne Sicard

Mr Fabien Nougarrowles

Mr Alexandre Boyer

Mr



Génie Électrique
et Informatique

INSA



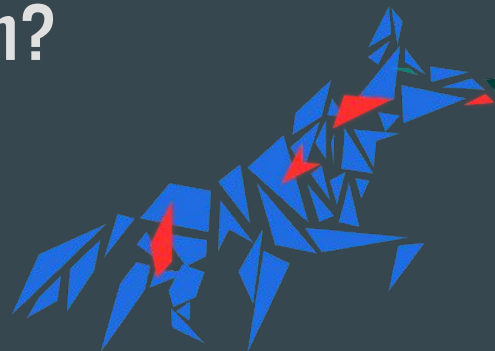
**THE THINGS
NETWORK**

Thank you for your attention!

Do you have any question?

INSA

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