

Ateliers Creactifs - IoT

Connection d'un objet réel au monde de l'internet

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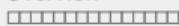
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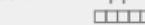
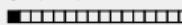
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INSTITUT DE RECHERCHE POUR LES TECHNOLOGIES CREATIVES DE L'UMONS

8 novembre 2021



Outline

- 1 Overview**
- 2 About LoRa**
- 3 Installations**
- 4 Programming the LoPy4**
- 5 Node-Red**
- 6 Exercices Session 1**
- 7 Exercices Session 2**
- 8 Application example : UMons**



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2 About LoRa

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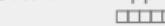
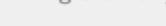
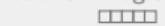
8 Application example : UMons

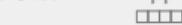
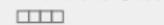
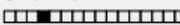
The Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.^{1 2}



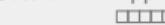
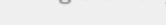
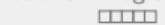
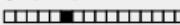
Following examples from :^{3 4}

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1. <https://www.oracle.com/internet-of-things/what-is-iot/>
 2. <https://securelist.com/new-trends-in-the-world-of-iot-threats/87991/>
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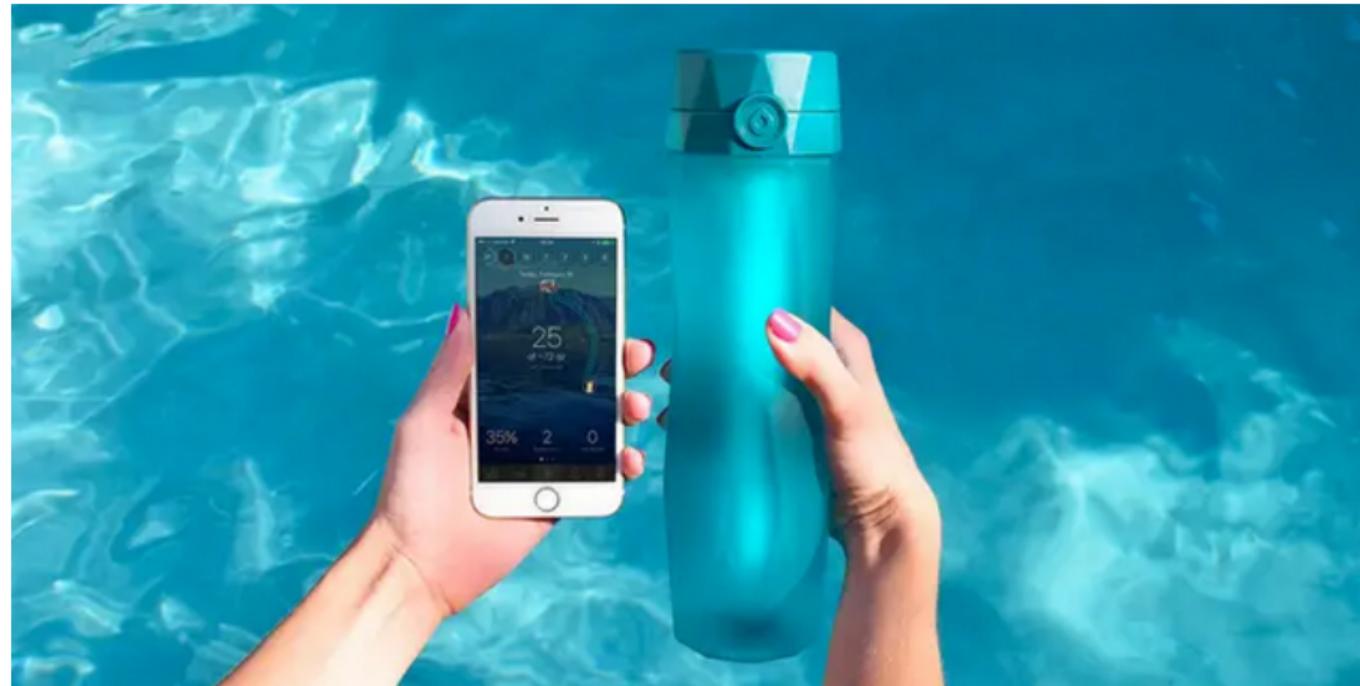




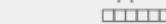
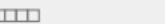
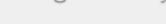
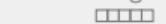
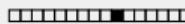












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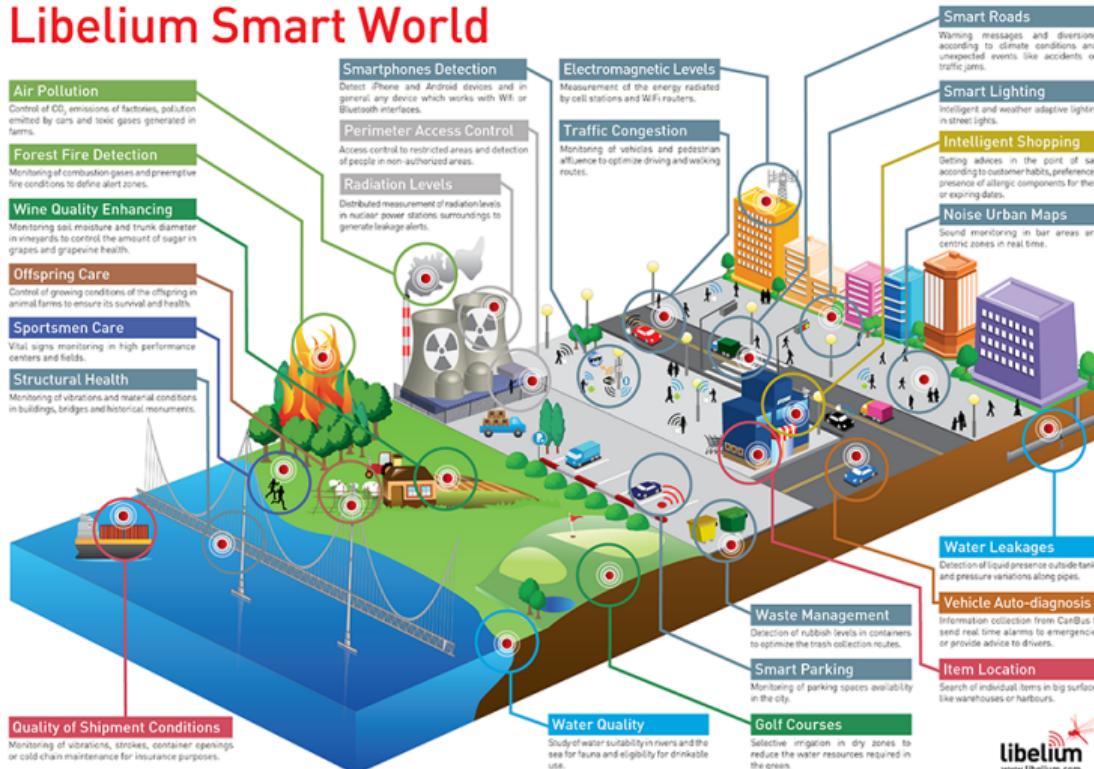


Figure –

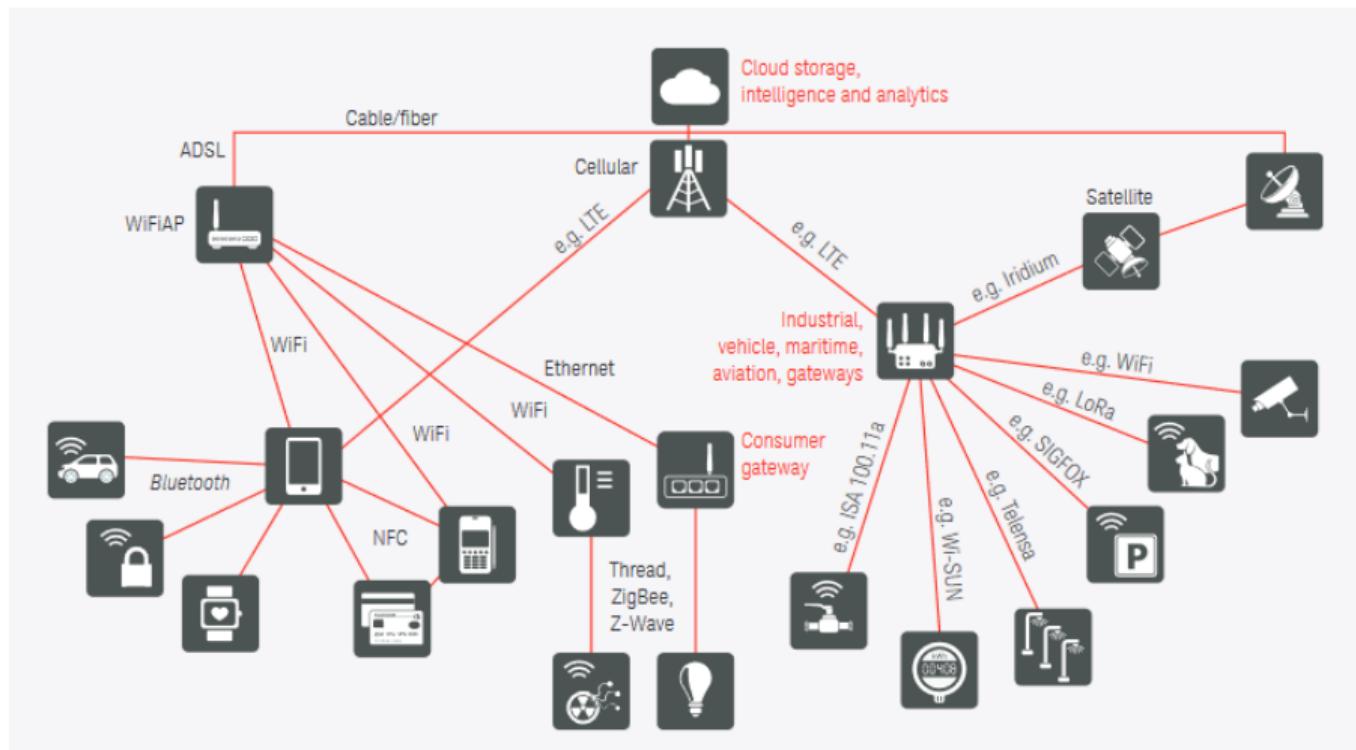
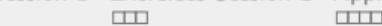
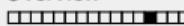
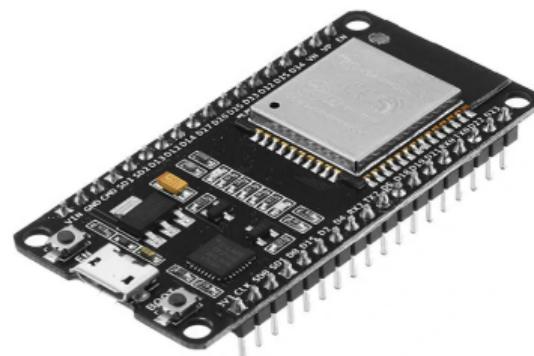


Figure –

<https://www.keysight.com/be/en/assets/7018-05008/application-notes/5992-1175.pdf>



Wi-Fi and LoRa



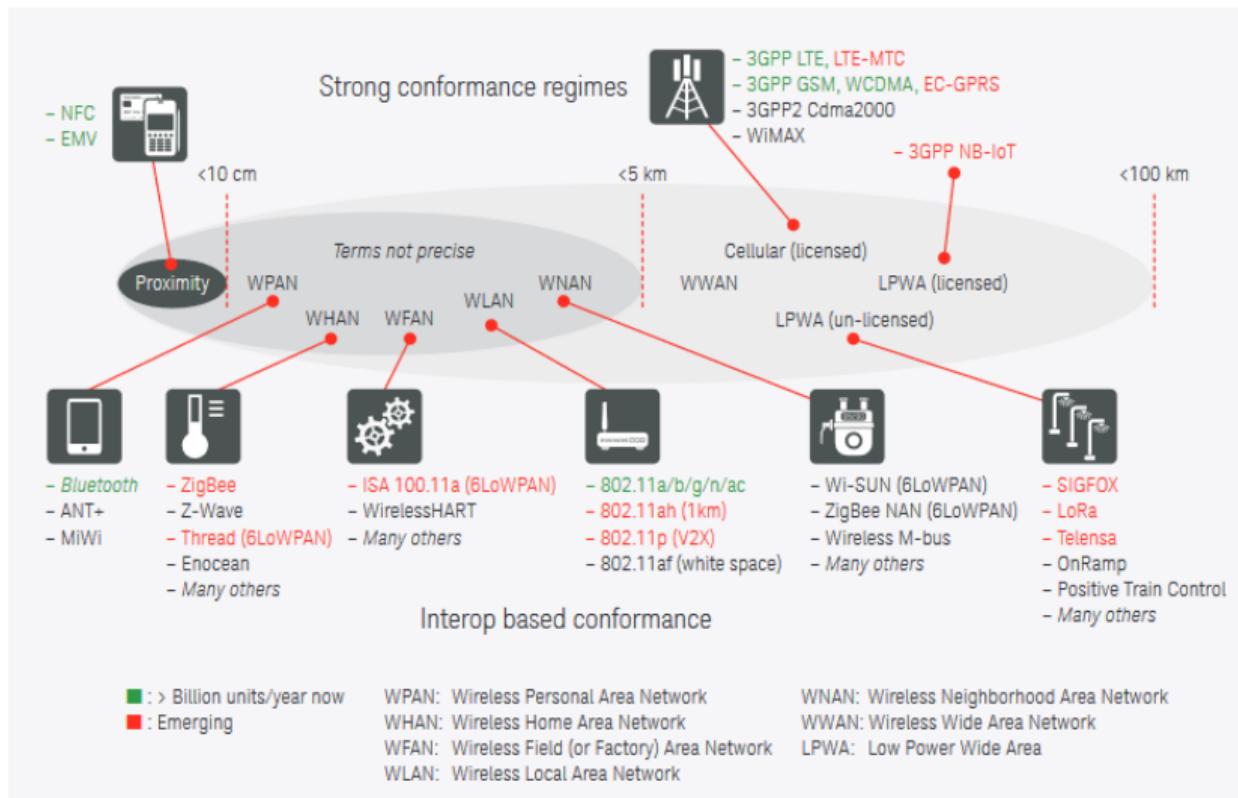
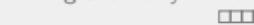
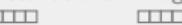
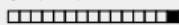


Figure –

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IoT-Lab

- Séance1 : Communication WiFi-ESP32 : apprendre à communiquer en WiFi avec le micro-contrôleur ESP32
- Séance2 : Communication WiFi-ESP32 : commander un servo-moteur grâce à l'ESP32 via son SmartPhone
- Séance3 : Communication LoRa : apprendre à communiquer en LoRa via le réseau TTN (The Things Network)
- Séance4 : Communication LoRa : récupérer des données d'un capteur sur une plateforme de collecte de datas grâce au réseau TTN

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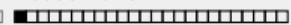
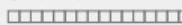
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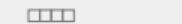
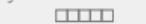
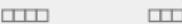
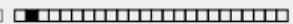
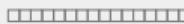
4 Programming the LoPy4

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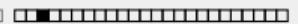
7 Exercices Session 2

8 Application example : UMons



References

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- <https://flows.nodered.org/node/node-red-dashboard>



LoRa

LoRa, essentially, is a clever way to get very good receiver sensitivity and low bit error rate (BER) from inexpensive chips.

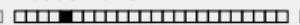
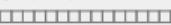
LoRa is a wireless modulation technique derived from Chirp Spread Spectrum (CSS) technology. It encodes information on radio waves using chirp pulses - similar to the way dolphins and bats communicate! LoRa modulated transmission is robust against disturbances and can be received across great distances.

LoRa is ideal for applications that transmit small chunks of data with low bit rates. Data can be transmitted at a longer range compared to technologies like WiFi, Bluetooth or ZigBee. These features make LoRa well suited for sensors and actuators that operate in low power mode.



Why is LoRaWAN so awesome?

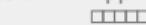
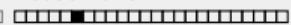
- **Ultra low power** - LoRaWAN end devices are optimized to operate in low power mode and can last up to 10 years on a single coin cell battery.
- **Long range** - LoRaWAN gateways can transmit and receive signals over a distance of over 10 kilometers in rural areas and up to 3 kilometers in dense urban areas.
- **Deep indoor penetration** - LoRaWAN networks can provide deep indoor coverage, and easily cover multi floor buildings.
- **License free spectrum** - You don't have to pay expensive frequency spectrum license fees to deploy a LoRaWAN network.
- **Geolocation**- A LoRaWAN network can determine the location of end devices using triangulation without the need for GPS. A LoRa end device can be located if at least three gateways pick up its signal.
- **High capacity** - LoRaWAN Network Servers handle millions of messages from thousands of gateways.
- **Public and private deployments** - It is easy to deploy public and private LoRaWAN networks using the same hardware (gateways, end devices, antennas) and software (UDP packet forwarders, Basic Station software, LoRaWAN stacks for end devices).
- **End-to-end security**- LoRaWAN ensures secure communication between the end device and the application server using AES-128 encryption.
- **Firmware updates over the air** - You can remotely update firmware (applications and the LoRaWAN stack) for a single end device or group of end devices.
- **Roaming**- LoRaWAN end devices can perform seamless handovers from one network to another.
- **Low cost** - Minimal infrastructure, low-cost end nodes and open source software.
- **Certification program**- The LoRa Alliance certification program certifies end devices and provides end-users with confidence that the devices are reliable and compliant with the LoRaWAN specification.
- **Ecosystem**- LoRaWAN has a very large ecosystem of device makers, gateway makers, antenna makers, network service providers, and application developers.



LoRaWAN use cases

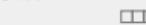
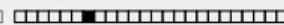
Here are a few great LoRaWAN use cases provided by [Semtech](#), to give you some insight into how LoRaWAN can be applied:

- **Vaccine cold chain monitoring** - LoRaWAN sensors are used to ensure vaccines are kept at appropriate temperatures in transit.
- **Animal conservation** - Tracking sensors manage endangered species such as Black Rhinos and Amur Leopards.
- **Dementia patients** - Wristband sensors provide fall detection and medication tracking.
- **Smart farms**- Real time insights into crop soil moisture and optimized irrigation schedule reduce water use up to 30%.
- **Water conservation**- Identification and faster repair of leaks in a city's water network.
- **Food safety**- Temperature monitoring ensures food quality maintenance.
- **Smart waste bins** - Waste bin level alerts sent to staff optimize the pickup schedule.
- **Smart bikes**- Bike trackers track bikes in remote areas and dense buildings.
- **Airport tracking** - GPS-free tracking monitors vehicles, personnel, and luggage.
- **Efficient workspaces** - Room occupancy, temperature, energy usage and parking availability monitoring.
- **Cattle health** - Sensors monitor cattle health, detect diseases and forecast calves delivery time.
- **LoRa in space** - Satellites to provide LoRaWAN-based coverage worldwide.

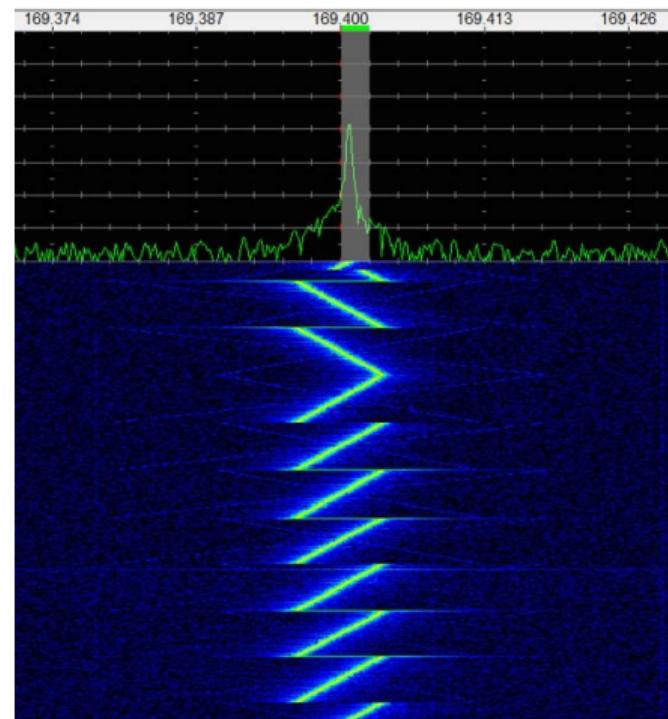


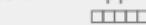
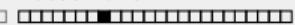
Preamble

When processing a LoRa message, additional processing gain is achieved due to the modem's ability to filter on the constant ramp chirp signal. This is how high sensitivity is achieved. In order to achieve "lock" to the LoRa signal, a long "constant chirp" preamble is transmitted. (See Figure 1.) This is really the power of LoRa—that an inexpensive chip with a cheap crystal can achieve very high sensitivity.



Preamble



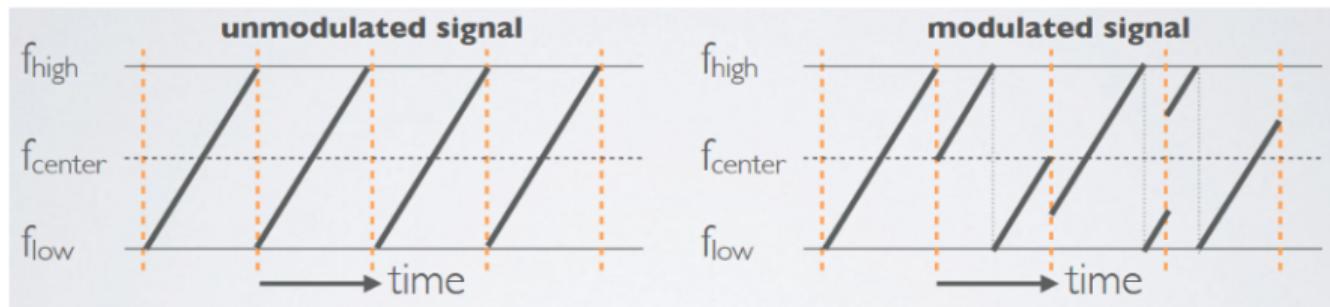


Data signal

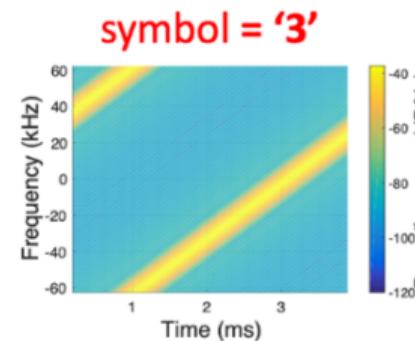
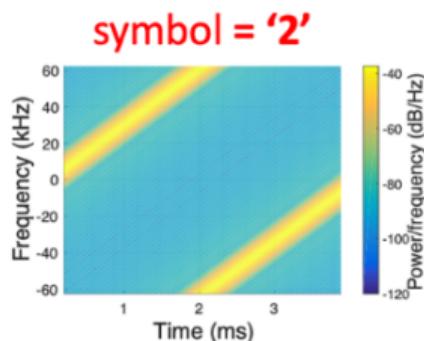
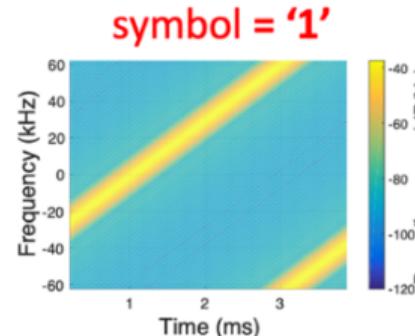
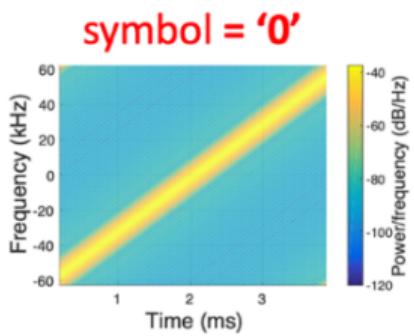
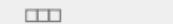
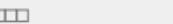
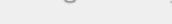
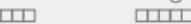
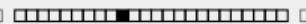
Then the data transmission begins, which has a series of "symbols" that function much like M-ARY FSK symbols, but instead happen on a chirp.

Chirp Spread Spectrum (CSS) is a spread spectrum technique that uses wideband linear frequency modulated chirp pulses to encode information.

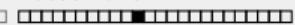
Data-carrying chirps are chirps that are cyclically-shifted, and this cyclical shift carries the information.



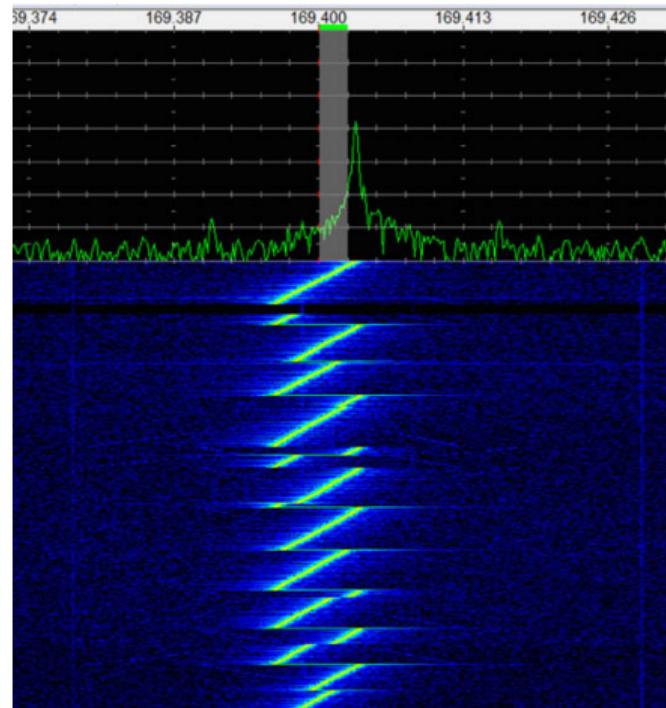
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Links : https://courses.engr.illinois.edu/ece463/fa2018/Lab/ECE463_Fall2018_Lab10.pdf

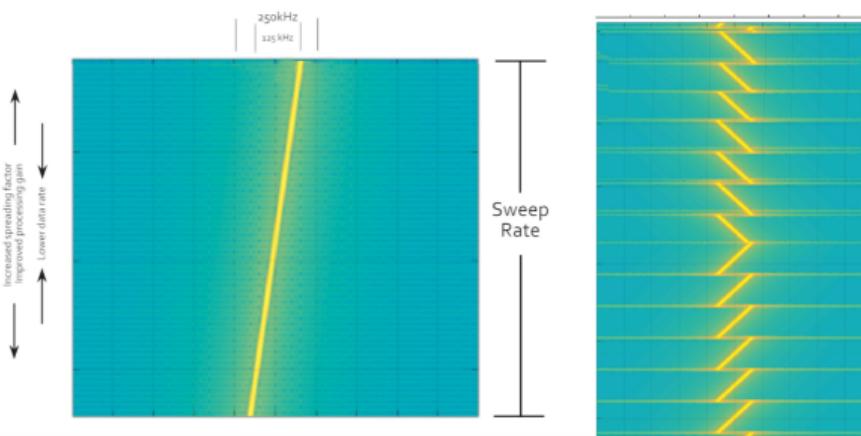


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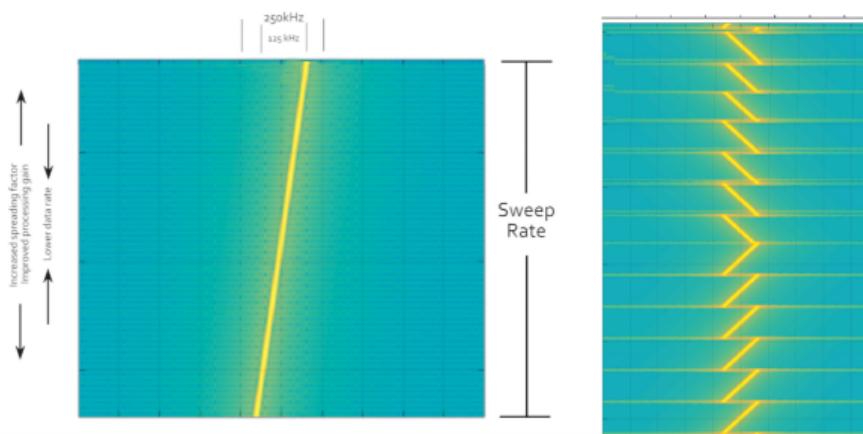


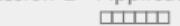
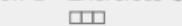
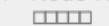
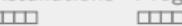
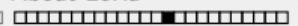
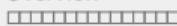
Video on the computer





YouTube Video

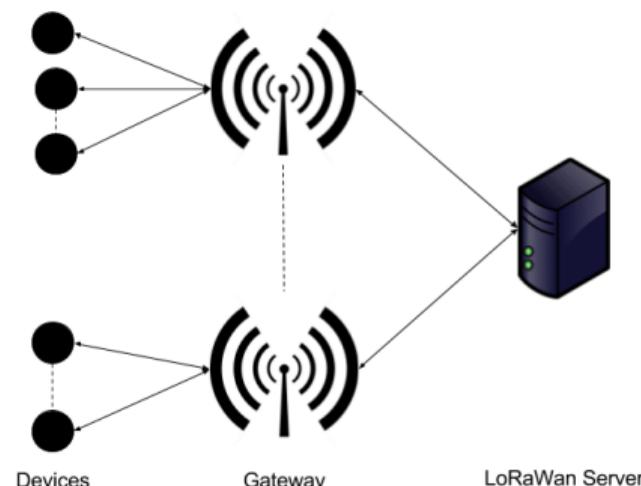




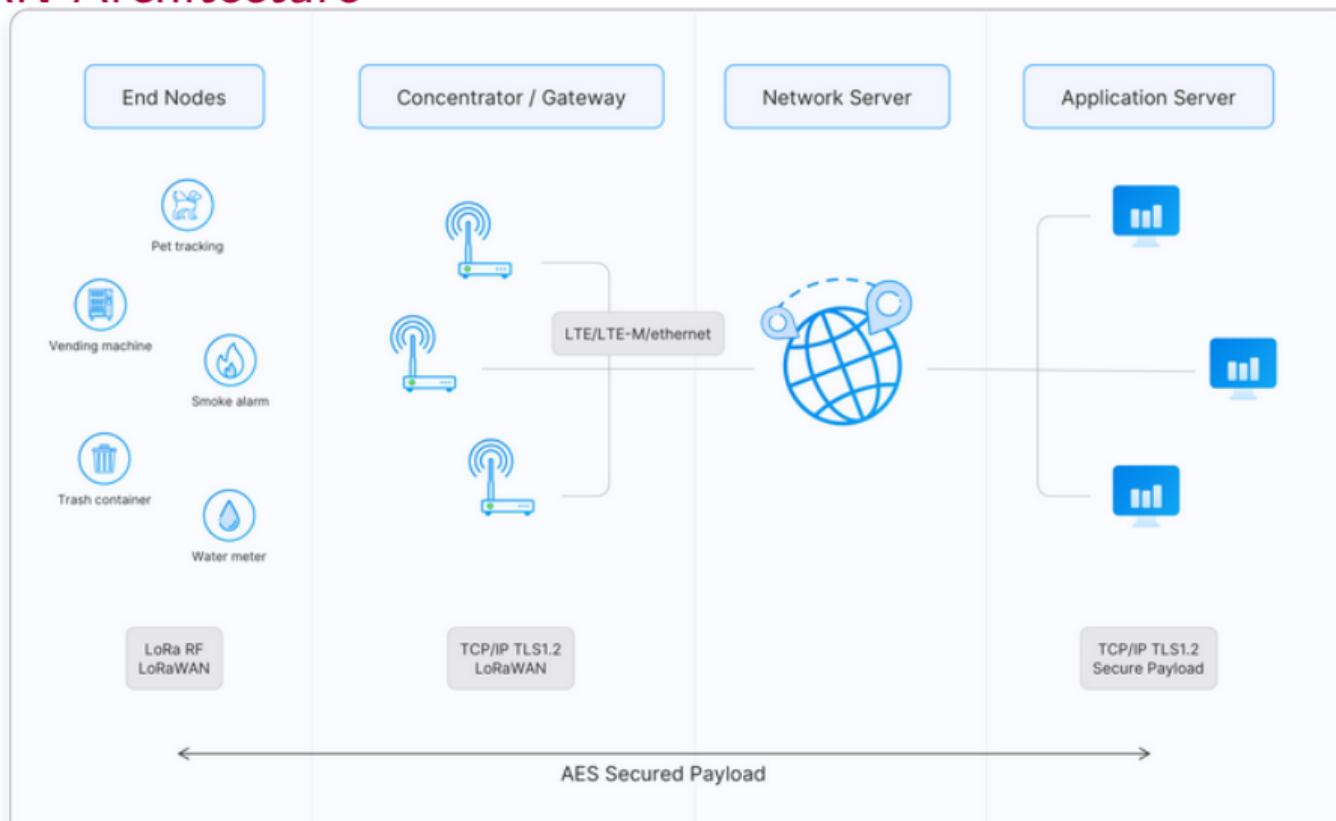
LoRaWAN network

For communication, this network uses a star network,a topology where a central device (here the gateway) act as a conduit to transmit messages.

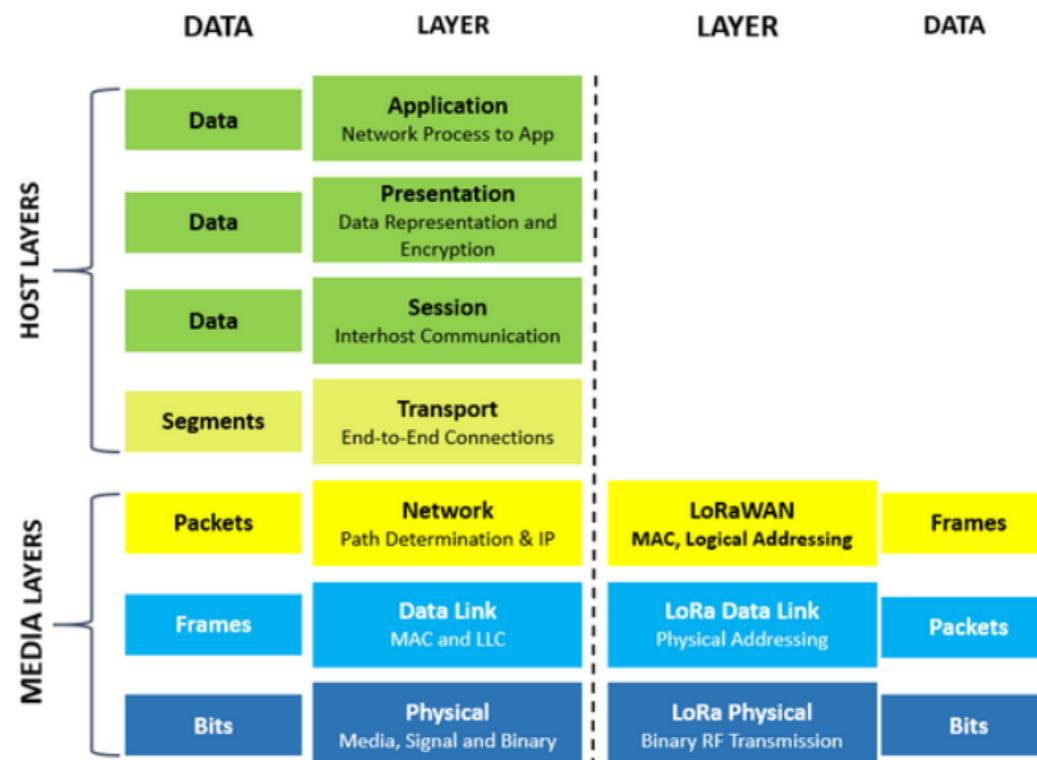
For this kind of network, all the devices communicate to a Gateway using the LoRa technology. The Gateway, which has an internet connection, will forward the data received from the devices to the server and vice-versa.

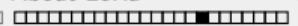
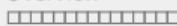


LoRaWAN Architecture



LoRaWAN in the 7 layer OSI model

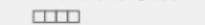
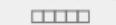
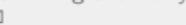
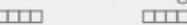
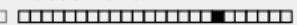
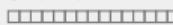




LoRaWAN Classes

The specifications define 3 different modes that can be used within a LoRaWan network :

- Classe A : The communication can be initiated only by the end device. When the end device has a message to send, it will send it and listen for a response during a short time. To do that, it will listen on the same frequency it used to send the message (Rx1) and then it will listen on a specific frequency known by the devices and gateways (Rx2).
- Class B : This mode is like the Class A but the device will also open short regularly reception windows (Rx2).
- Class C : In this mode, the device can send a message whenever it wants, and it will listen for an incoming message at all time (Rx2).

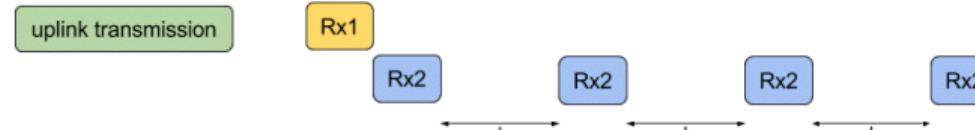


LoRaWAN Classes

Class A

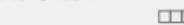
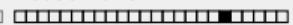


Class B



Class C





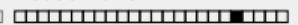
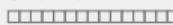
Duty cycle and time-on-air

Duty cycle and time-on-air (dwell time) restrictions

- Both end devices and gateways must respect them
- In different regions:
 - may or may not apply
 - may have different limits
- Imposed by the local authorities
 - make sure to check your local government regulations!
 - see LoRaWAN Regional Parameters

Frequency plan	EU	US
Duty cycle	0.1%-10%	No limit
Dwell time	No limit	400ms for channels 0-63

Image source: "RP002 - 1.0.2. LoRaWAN Regional Parameters", specification by LoRa Alliance (lora-alliance.org)



Spreading factor

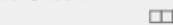
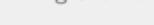
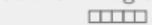
Another powerful feature of LoRa is the ability to demodulate several orthogonal or simultaneous signals at the same frequency, assuming they have different chirp rates. In the datasheet, LoRa chirp rates are called "spreading factors", with higher spreading factors denoting slower chirps.

Spreading factors call FSK (Frequency-shift keying). These spreading factors are used to adjust the radio signal speed depending on the distance.

In short, the spreading factor indicates the number of databits per second. The higher the factor, the slower the communication is. Increasing the spreading factor increases the time it takes to send a message, consumption increase then also.

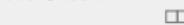
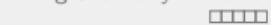
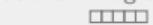
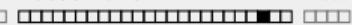
Lower SF → shorter range → less time on air → lower energy consumption → higher data rate

It is a trade off to make.

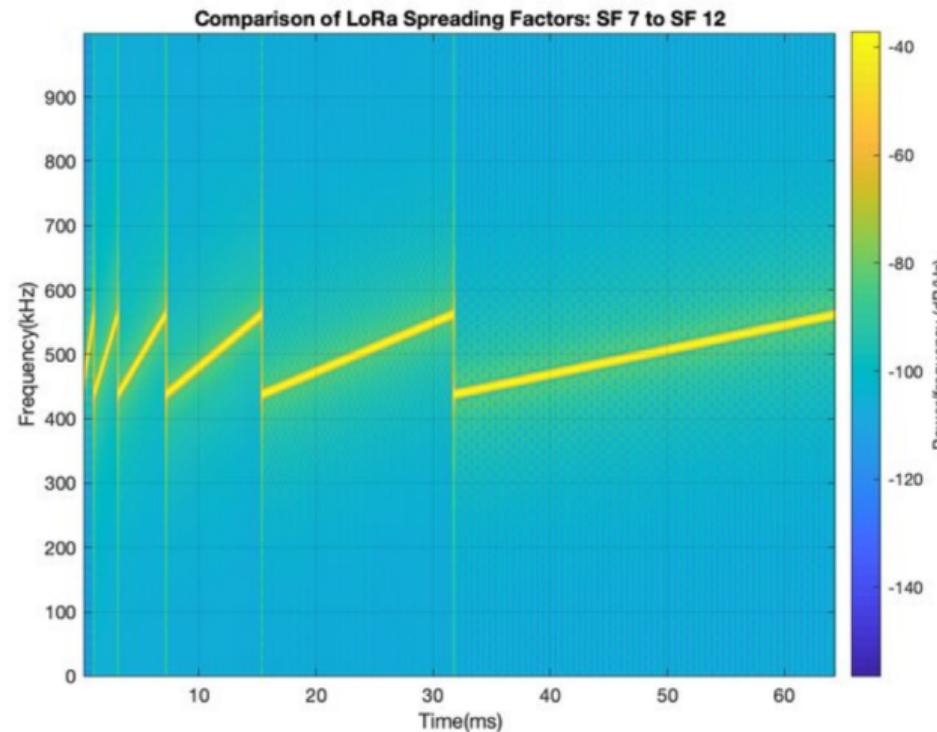


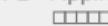
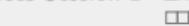
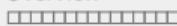
Spreading factor

DataRate	Configuration	Indicative physical bit rate [bit/s]
0	LoRa: SF12 / 125 kHz	250
1	LoRa: SF11 / 125 kHz	440
2	LoRa: SF10 / 125 kHz	980
3	LoRa: SF9 / 125 kHz	1760
4	LoRa: SF8 / 125 kHz	3125
5	LoRa: SF7 / 125 kHz	5470
6	LoRa: SF7 / 250 kHz	11000
7	FSK: 50 kbps	50000
8..15	RFU	



Spreading factor





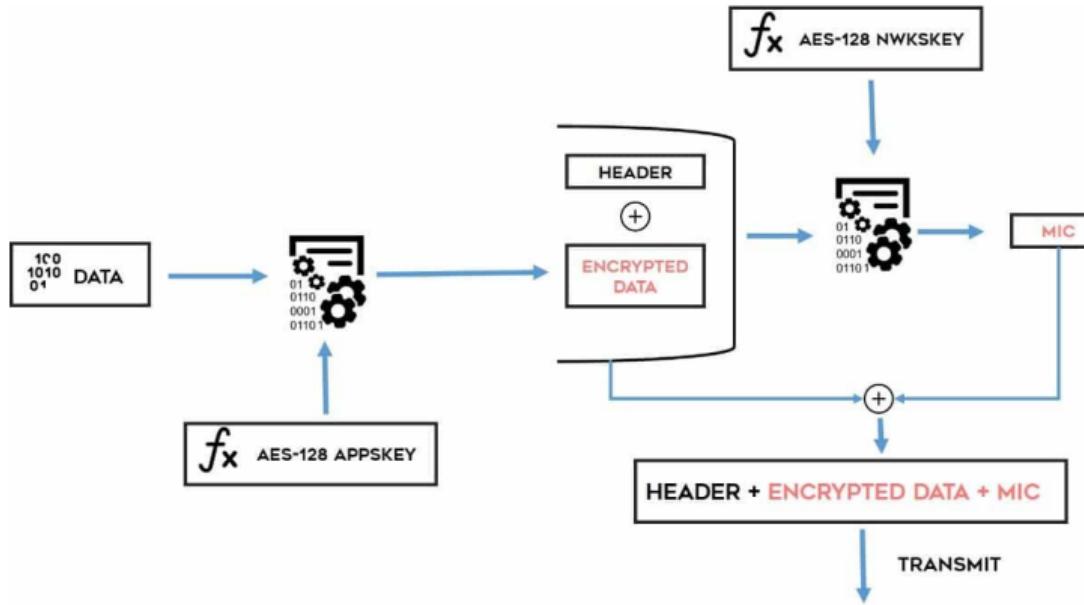
Data encryption

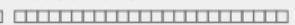
Key1 is the AppSKey (Application Session Key) that is shared between the application owner and the LoRa device. This key is used to encrypt the message payload and is unique per Application.

Key2 is the NwkSKey (Network Session Key) shared between the LoRaWan network provider and the LoRa device. This key is used to calculate a message integrity code from the previous encrypted payload and a network header added to the message. It is unique per Network.

The message composed with a header, the payload and the Message Integrity Code (MIC) is then sent to the LoRaWan network provider that will verify the message integrity to the MIC and NwkSKey. Whether the MIC is good, the LoRaWan network provider will then send the message to the application that will be able to read the payload to the AppSKey.

Data encryption





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1 Overview

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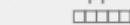
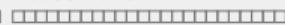
4 Programming the LoPy4

5 Node-Red

6 Exercices Session 1

7 Exercices Session 2

8 Application example : Umons



Installs

Install Atom :

<https://atom.io/>

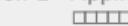
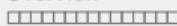
Open installer in atom and search for pymakr, install pymakr from pycom
or use : <https://atom.io/packages/pymakr>

If needed, install additional drivers :

<https://docs.pycom.io/gettingstarted/software/drivers/>

More detailed infos here :

<https://docs.pycom.io/gettingstarted/software/atom/>



Installs

Install Node Red docs : <https://nodered.org/docs/getting-started/local>

In short :

- install Node.js and npm : <https://nodejs.org/en/download/>
- install Node-red : npm install -g –unsafe-perm node-red

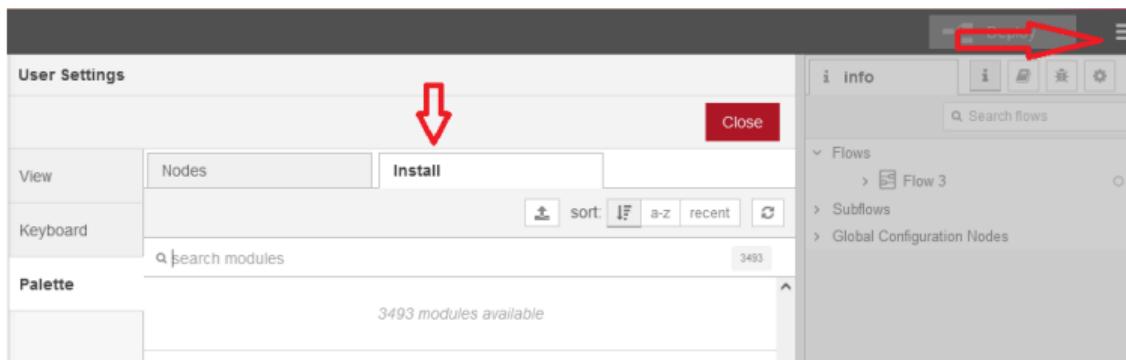
Open Node-Red :

- type "node-red" in cmd
- in your browser go to : localhost:1880
- later for interfacing : localhost:1880/ui



Installs

In your browser on the right go to settings ...

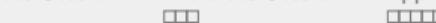


Then palette on the left and select install, then add :

node-red-dashboard

and :

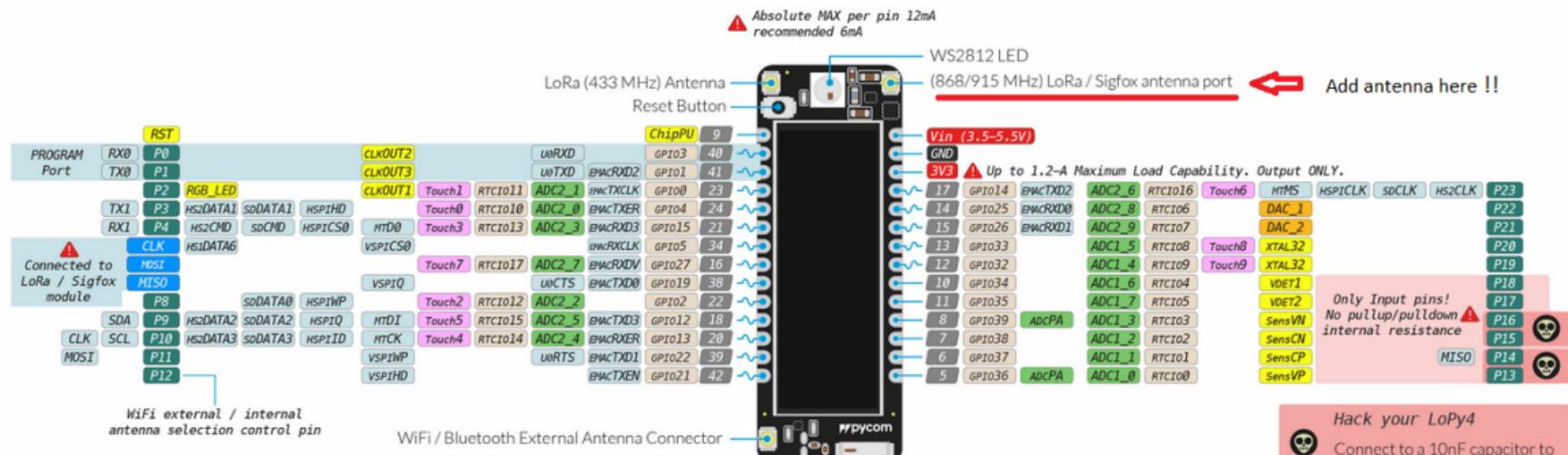
node-red-contrib-aedes (if you want to create a localhost broker at home)



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The LoPy4



Power

GND

Serial Pin

Analog Pin

Control

Physical Pin

Port Pin

Touch Pin

DAC Pin

DMM Pin

Low Level Bootloader

P2 + GND

Boot modes and safe boot

P12 + 3V3

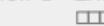
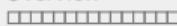
1-3 sec Safe boot, latest firmware is selected

4-6 sec Safe boot, previous user update selected

7-9 sec Safe boot, the factory firmware is selected

Internal Functions

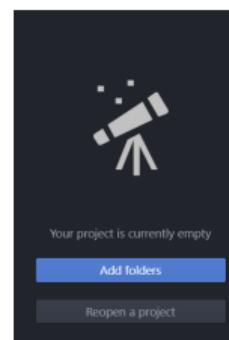
36	GPIO23	vSPIID	HSI STROBE	LoRa / Sigfox Interrupt
27	GPIO18	DMC0180	uTXD	HSI DATA5 LoRa / Sigfox Select



Programming the LoPy4

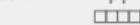
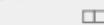
First connect the Lopy4 to you computer (using the expansion board and the usb A to micro B cord, add antenna also)

Open the Atom software, the device should be detected automatically



Create a projects folder (name it projects).

Inside this folder create another folder and name it first_exchange



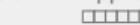
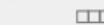
Programming the LoPy4

Add 2 files into the folder (you can also use the atom file tree on the left)

Name them boot.py and main.py, they are saved as python files (.py).

And/Or use codes on github :

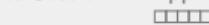
https://github.com/verogeorl/CREACTIF_IOTLAB/tree/main/IoT_LoRa



Programming the LoPy4

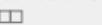
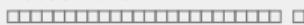
Additional informations :

- <https://docs.pycom.io/gettingstarted/>
- <https://www.codecademy.com/articles/f1-text-editors>
- <https://pycom.io/wp-content/uploads/2020/04/Lesson-2-Setting-up-Pymakr-LoPy4.pdf>

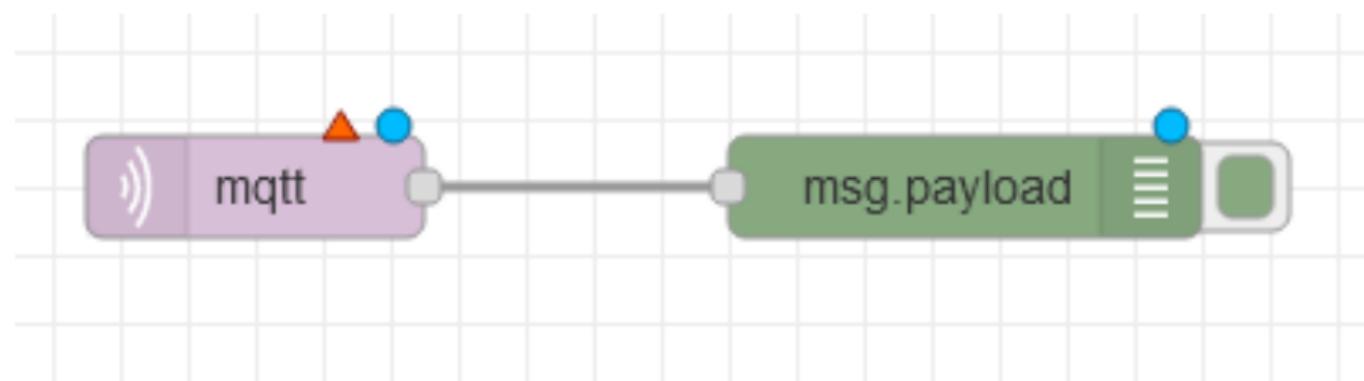


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- 7 Exercices Session 2
- 8 Application example : UMons

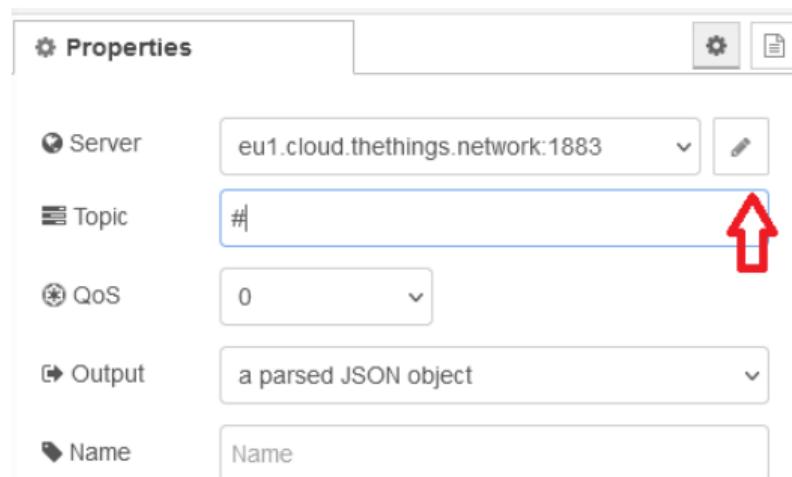


MQTT-first steps



Add the MQTT in node as well as a debug node.

MQTT-first steps

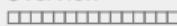


Write # in topic, this will send you every info available.

Select a Quality of service (QoS) of 0.

The output should be a parsed JSON object.

Then select the pen to edit the server (see red arrow).



MQTT-first steps

Properties

Name: Name

Connection **Security** **Messages**

Server: eu1.cloud.thethings.network **Port**: 1883
 Use TLS

Protocol: MQTT V3.1.1

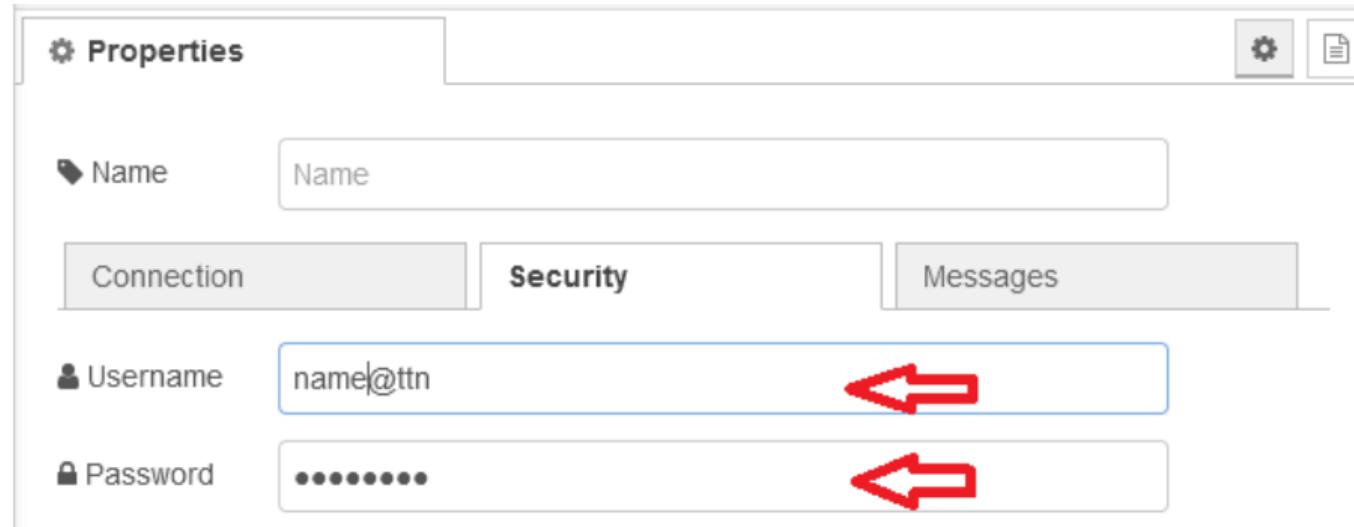
Client ID: Leave blank for auto generated

Keep Alive: 60

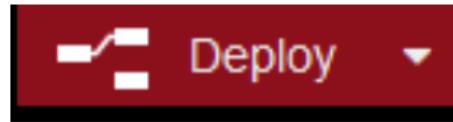
Session: Use clean session

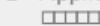
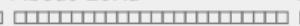
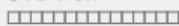
As server use : eu1.cloud.thethings.network
and Port : 1883

MQTT-first steps



Input the username and password given to you. Finally, deploy the system.





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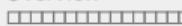
4 Programming the LoPy4

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Connection test

After installation connect the Lopy4 to the computer and try to run the 'Blink' example.

Try to change the color of the led.

Enable/Disable heartbeat.



Dev_EUI

Adding a device to the ttn server.

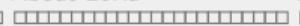
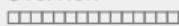
Try the `find_DevEUI` code



Send a message to the TTN server

Use the 'first_exchange' code and send your group number to The Things Network server.

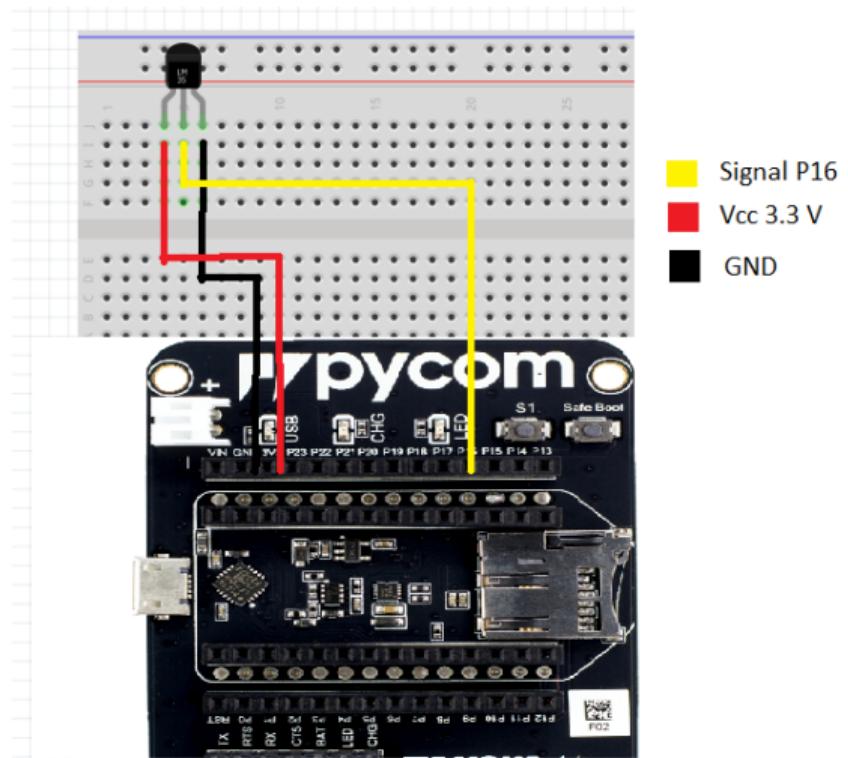
For example group 2 sends 222 in bytes, you will see the message on the TTN Live data.

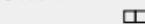
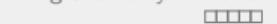
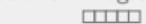


Outline

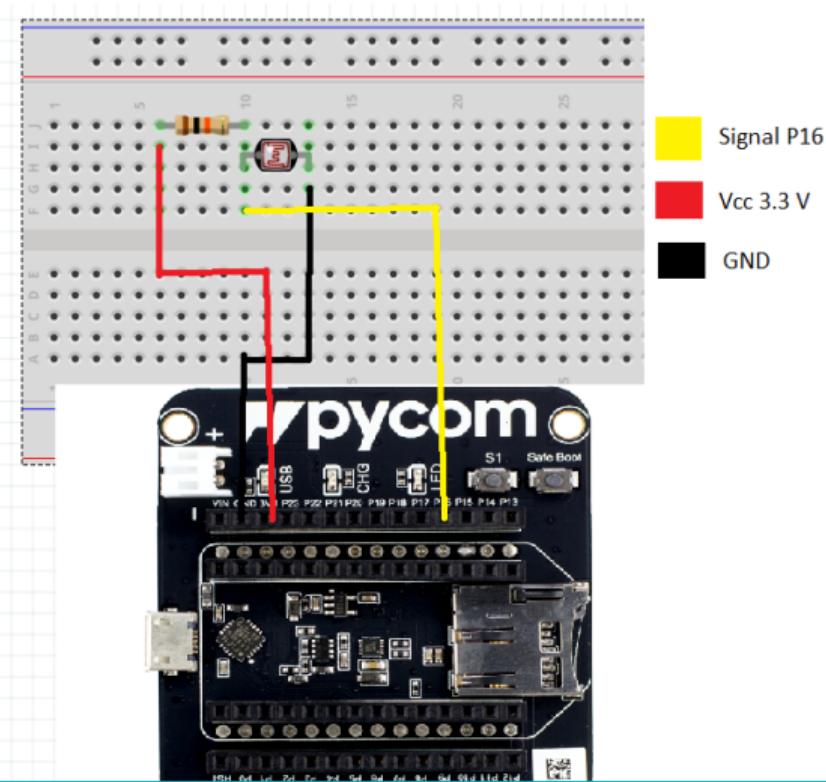
- 1** Overview
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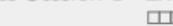
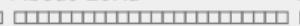
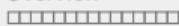
Temperature sensor





LDR sensor





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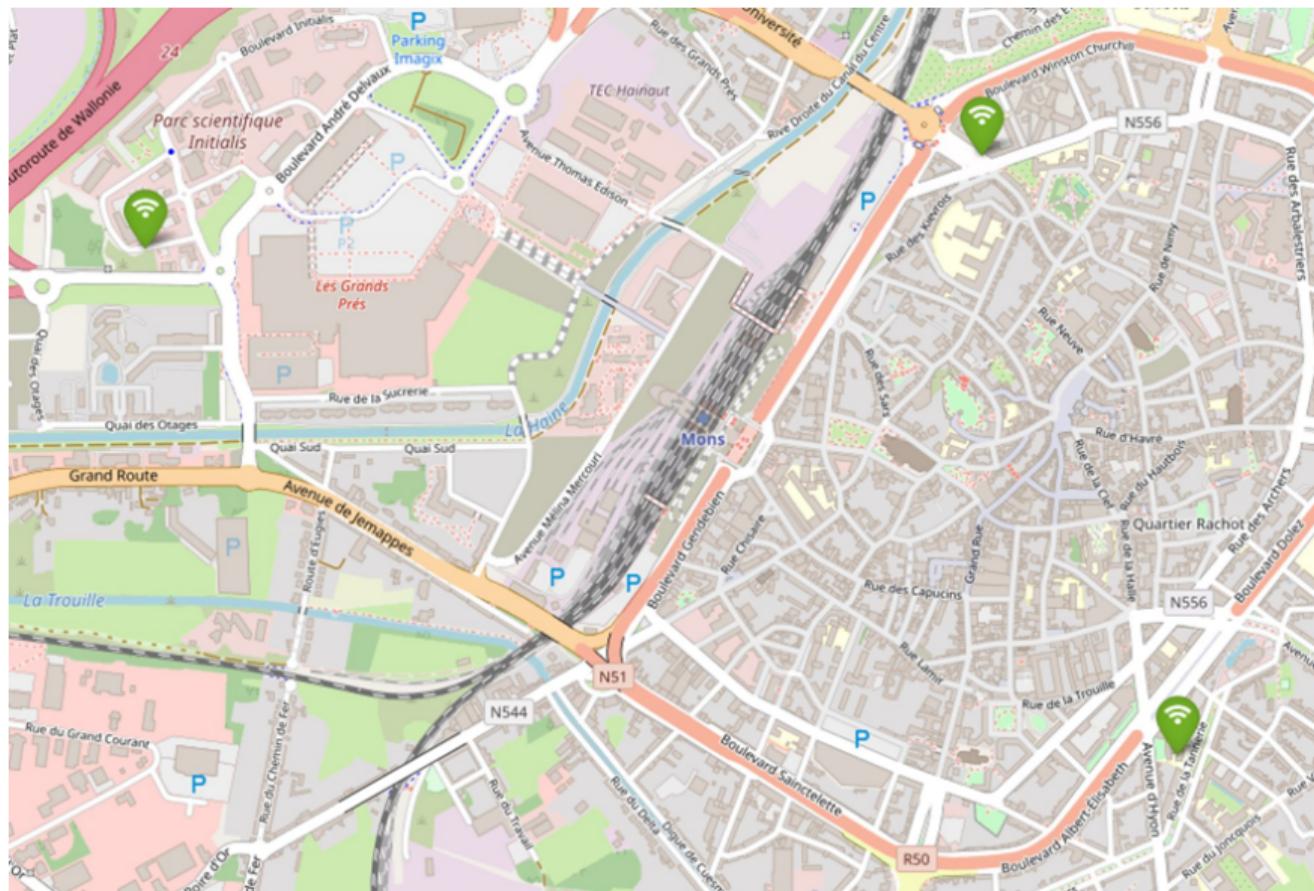
8 Application example : UMons



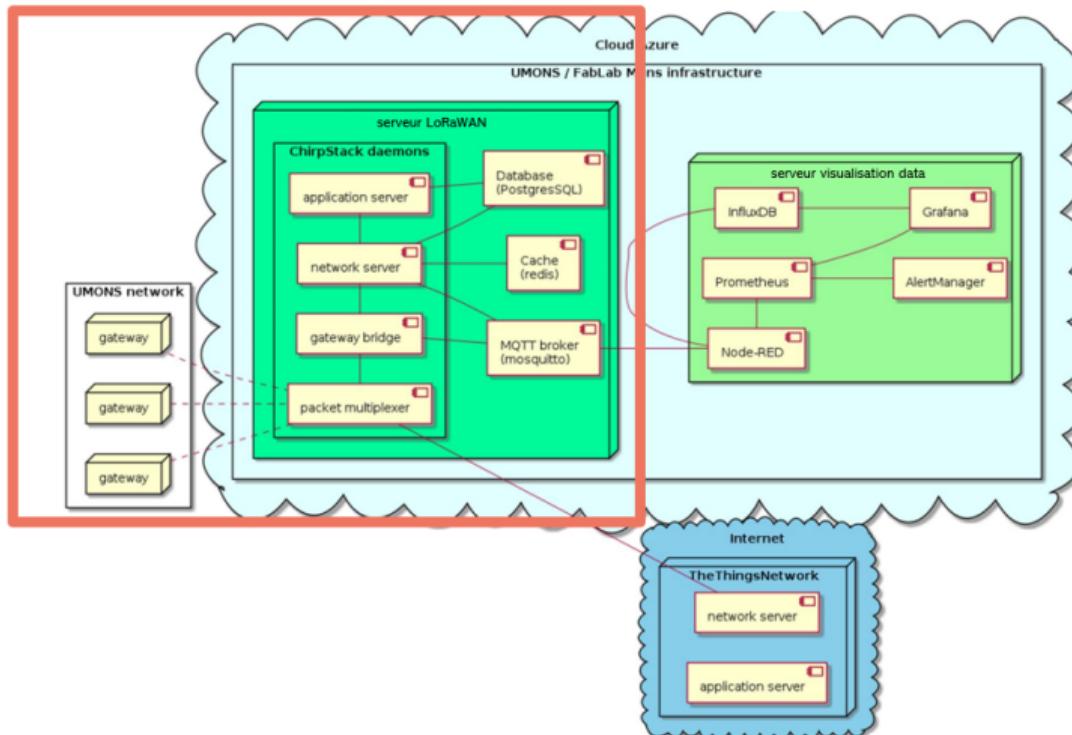
Sensors



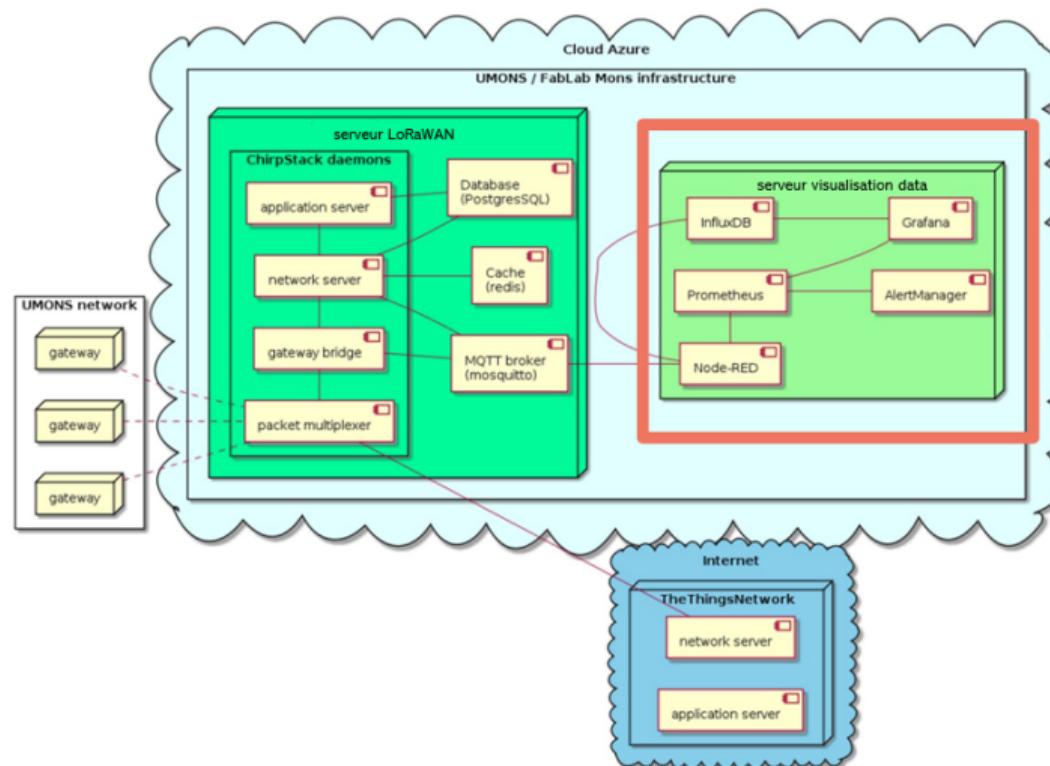
CO2 and water consumption sensors.



Infrastructure réseau



Infrastructure de traitement



Ateliers Creactifs - IoT

Connection d'un objet réel au monde de l'internet

Ir. Alexander GROS

Electromagnetism and Telecommunication Department
Faculty of Engineering
University of Mons

alexander.gros@umons.ac.be

UMONS
Université de Mons



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