The WAZIUP IoT platform:
build low-cost IoT devices and versatile IoT gateways

Ho chi Minh University of Technology
Computer Science Dept and IoT lab
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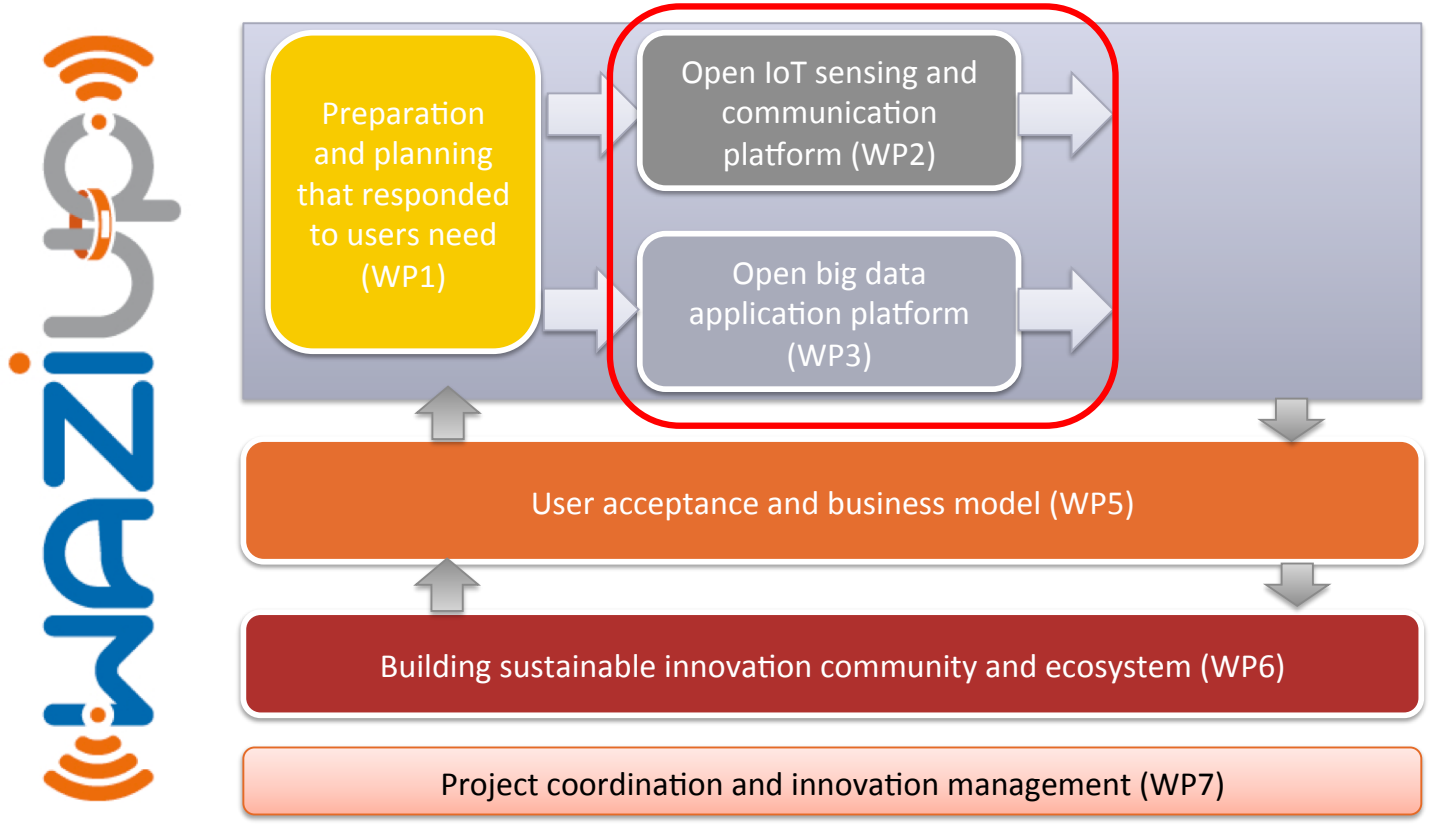
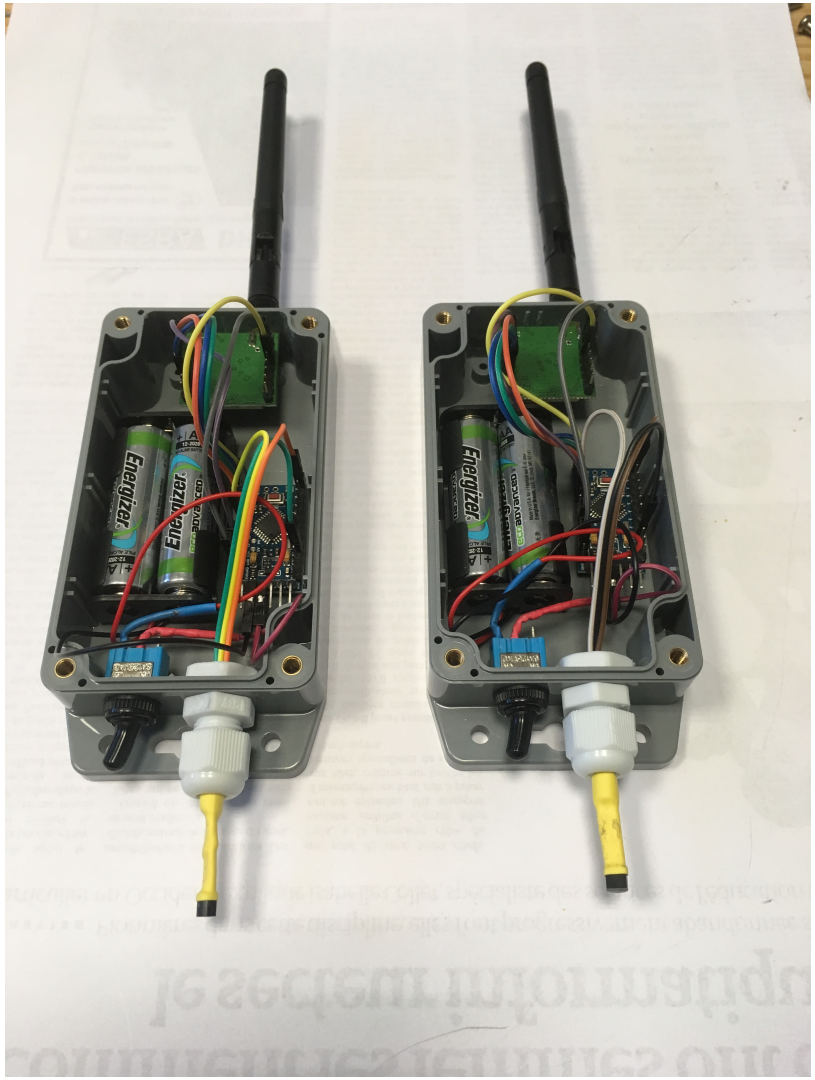
Université de Pau, France

IoT FOR RURAL APPLICATIONS IN DEVELOPPING COUNTRIES

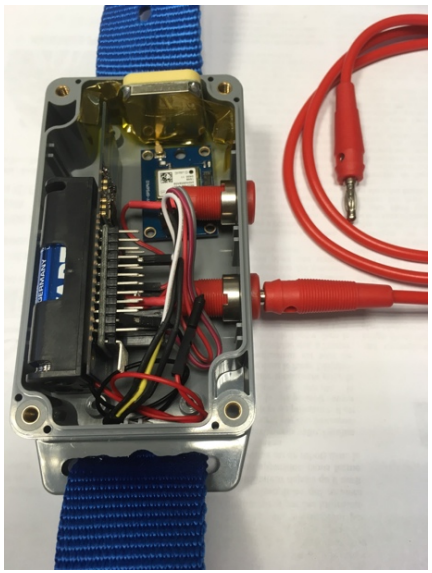
- WAZIUP is an EU H2020 project (2016-2019)
- contributes to long-range networks for rural applications with WP2 and big data with WP3



DO MORE with LESS

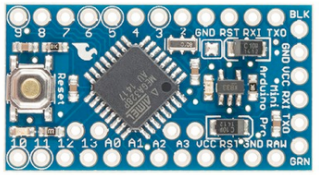

Energizer
Energizer

Low-cost IoT devices



LARGE ECOSYSTEM, STILL GROWING...

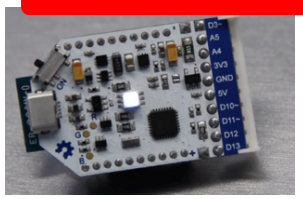
Arduino Pro Mini



LoPy

http://blog.atmel.com/2015/12/16/rewind-50-of-the-best-boards-from-2015/

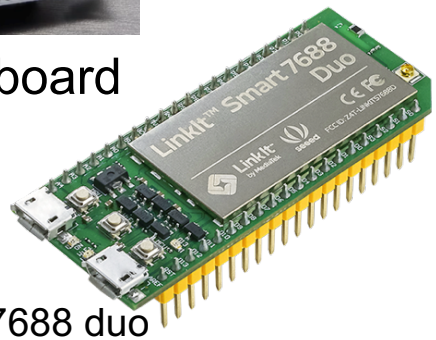
http://blog.atmel.com/2015/04/09/25-dev-boards-to-help-you-get-started-on-your-next-iot-project/



Theairboard

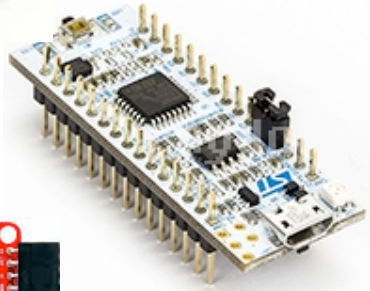
Teensy 3.2

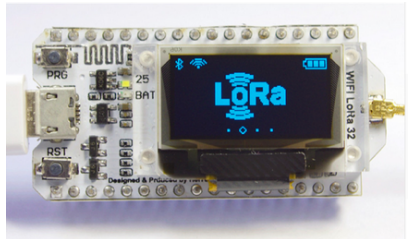
Expressif ESP32



LinkIt Smart7688 duo

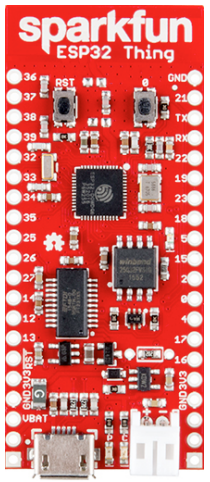
STM32 Nucleo-32





Heltec ESP32 + OLED

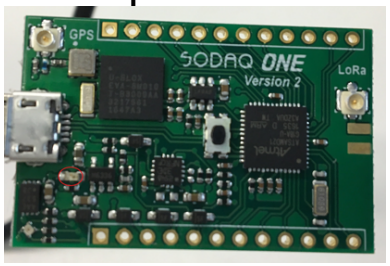
Adafruit Feather



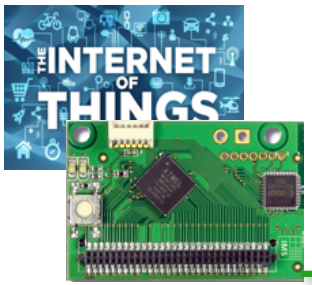
Sparkfun ESP32 Thing

Tessel

SodaqOnev2

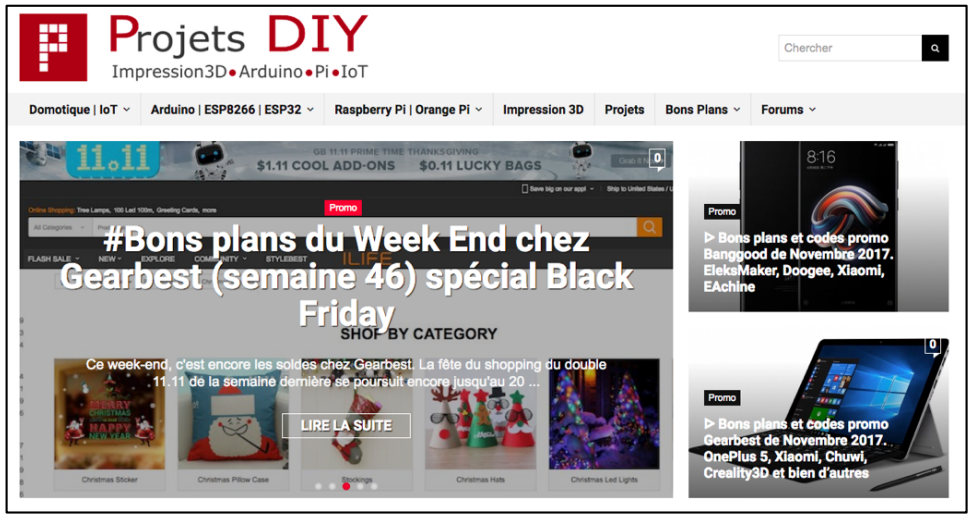


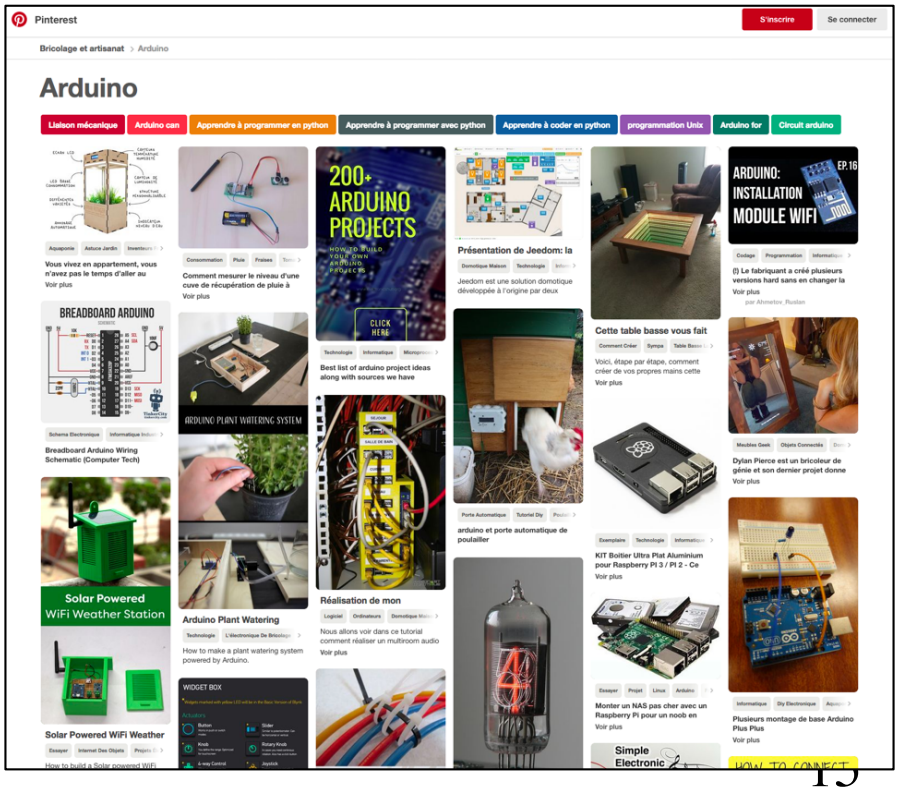
Tinyduino



... STIMULATING "DO-IT-YOURSELF" WORLDWIDE

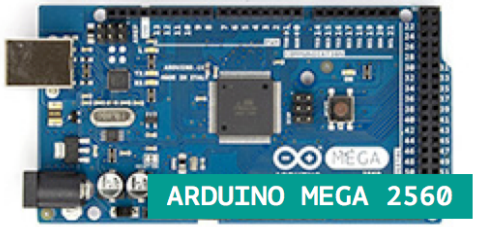
- DIY usually means
  - More open-source software from larger community
  - More flexibility

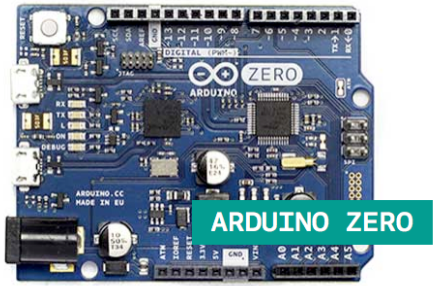


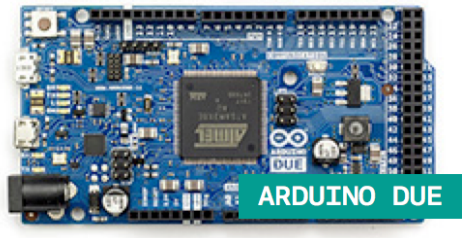


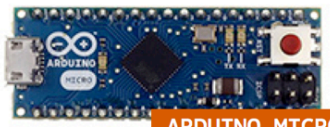
WAZIUP PROVIDES SW/HW BUILDING BLOCKS INTEGRATION


ARDUINO UNO

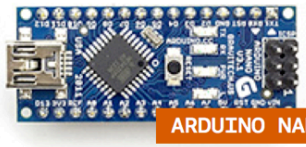

ARDUINO MEGA 2560

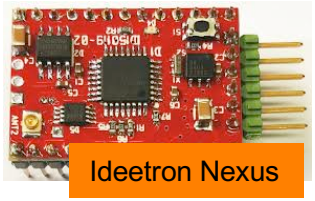

ARDUINO ZERO


ARDUINO DUE


ARDUINO MICRO


ARDUINO PRO MINI


ARDUINO NANO


Ideetron Nexus


TeensyLC/3.1/3.2

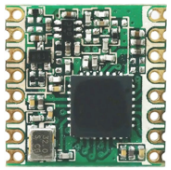

Adafruit Feather 32u4/M0


Expressif ESP8266/ESP32

More to come…

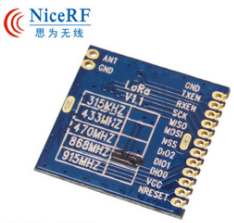
LoRa

LoRa radios that our library already supports


HopeRF RFM92W/95W


Libelium LoRa

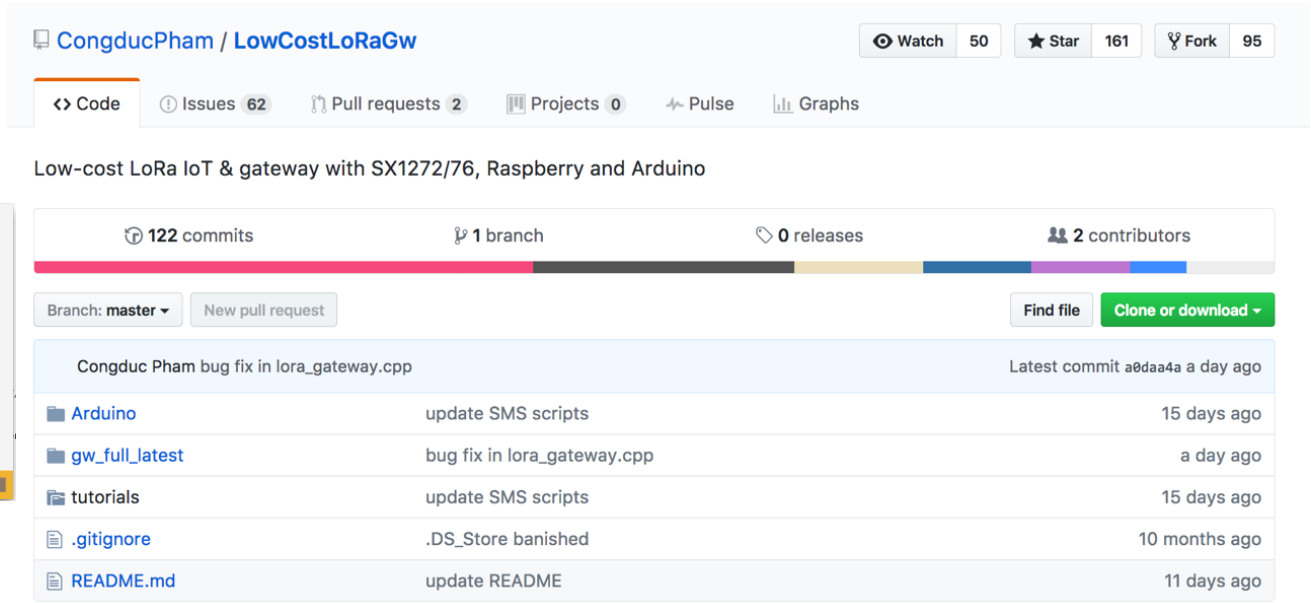

Modtronix inAir9/9B



NiceRF LoRa1276

Long-Range communication library

WAZIUP PROPOSES 100% OPEN-SOURCE SOFTWARE



LowCostLoRaGw github has latest general distribution:
https://github.com/CongducPham/LowCostLoRaGw
WAZIUP-specific configuration can be found on
https://github.com/Waziup/waziup-gateway

READY-TO-USE TEMPLATES

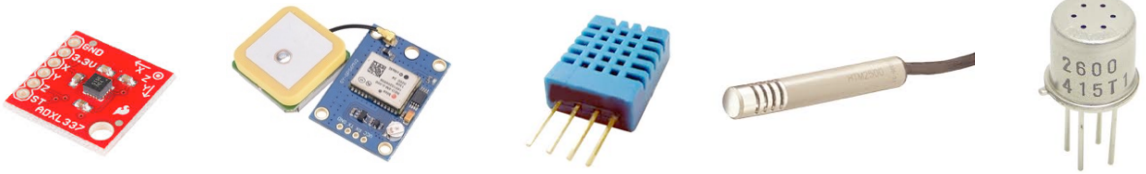
Moisture/
Temperature of
storage areas

10-15kms

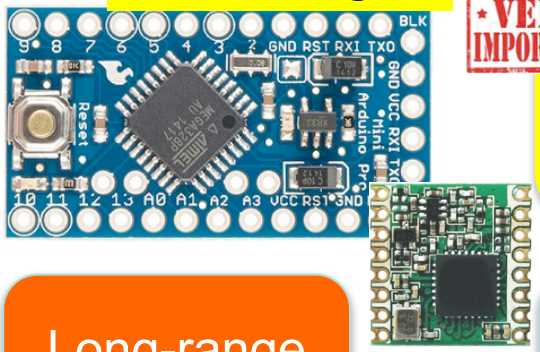
Physical sensor

Physical sensor

Physical sensor



Arduino Pro Mini @3.3V



Physical sensor mgmt

VERY IMPORTANT

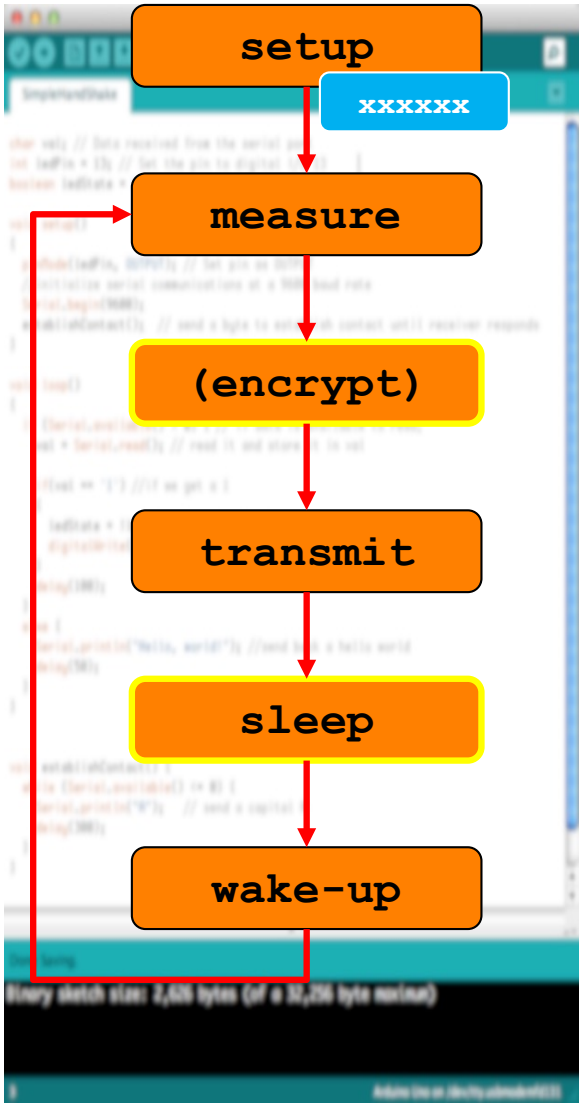
Activity duty-cycle, low power

VERY IMPORTANT

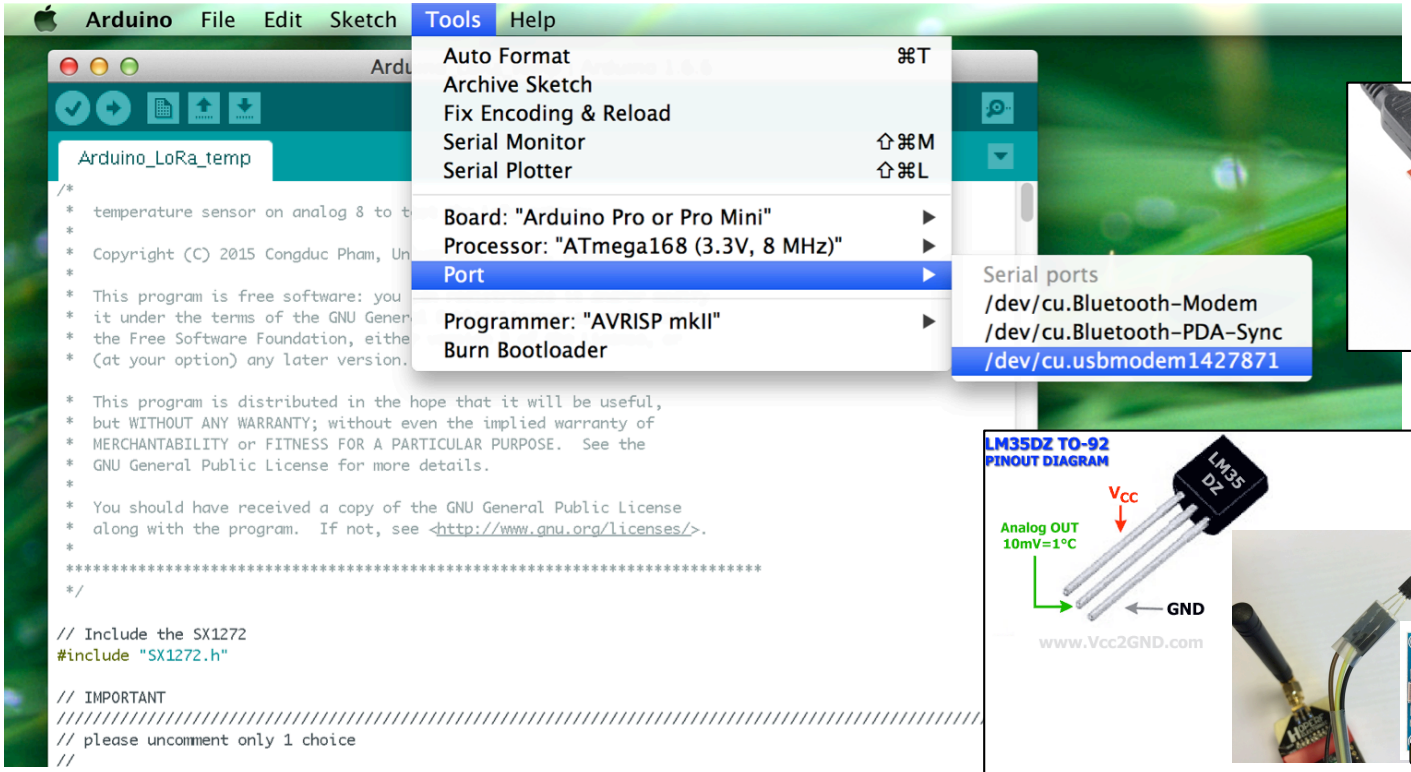
AES encryption

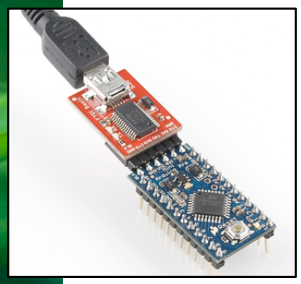
Long-range transmission

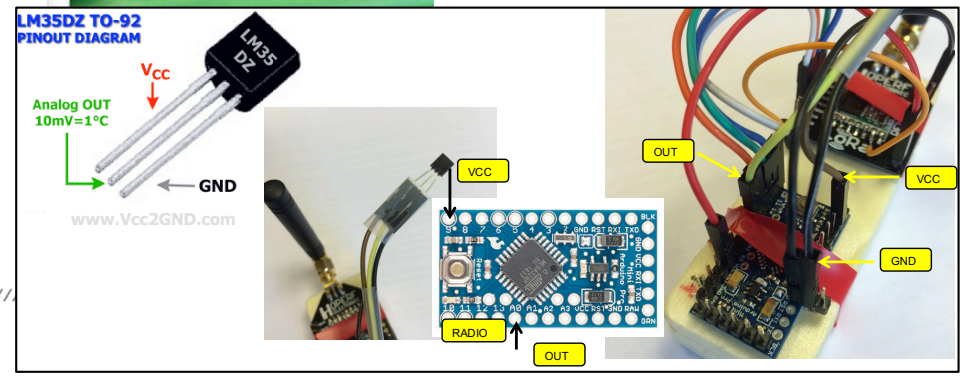
Logical sensor mgmt



Build your first LoRa IoT device

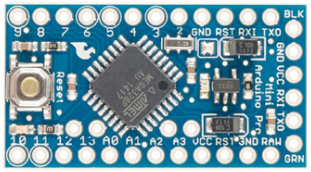






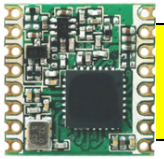
Connect the USB end to your computer and the USB port should be detected in the Arduino IDE. Select the serial port for your device. It may have another name than what is shown in the example. Then click on the « upload » button

LOW-COST INTEGRATION

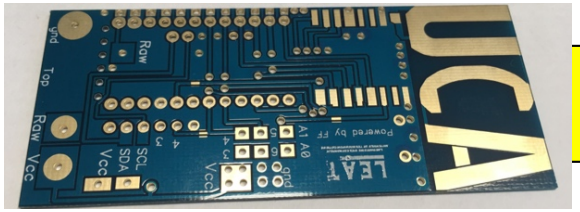


1.5€

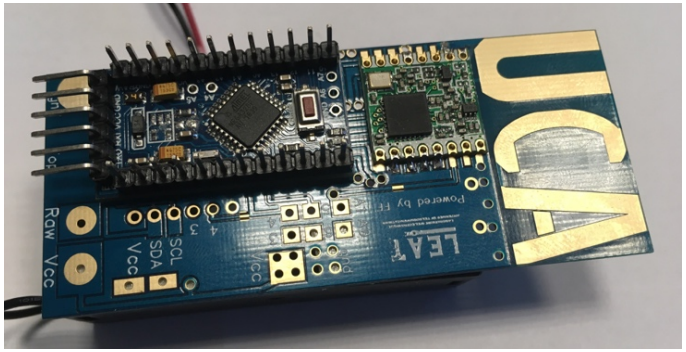
https://github.com/FabienFerrero/UCA_Board

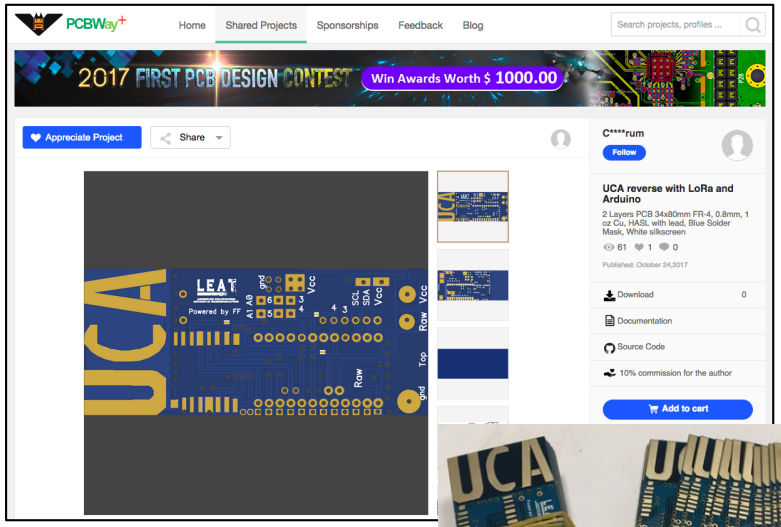


5€

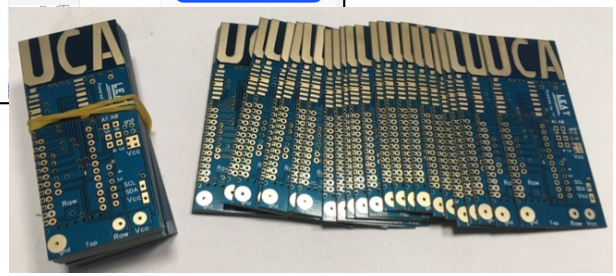


1€

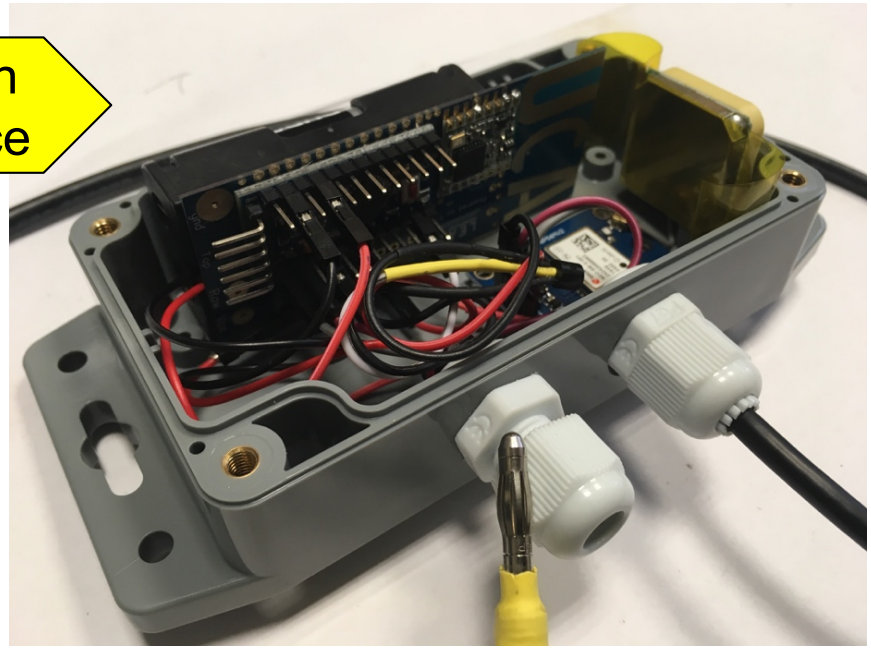




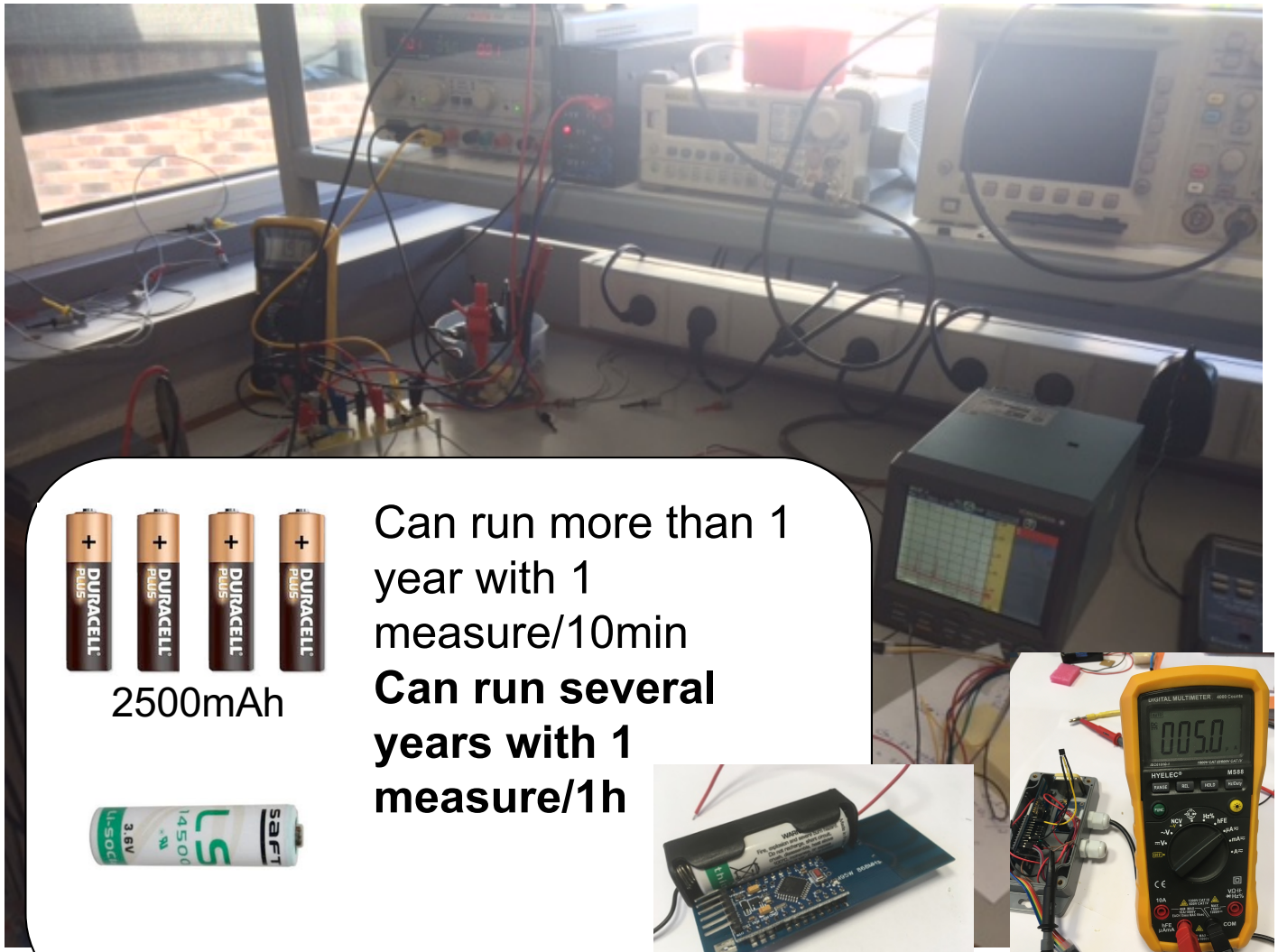
1-click order

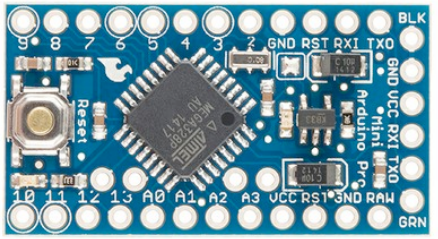


Less than 10€/device

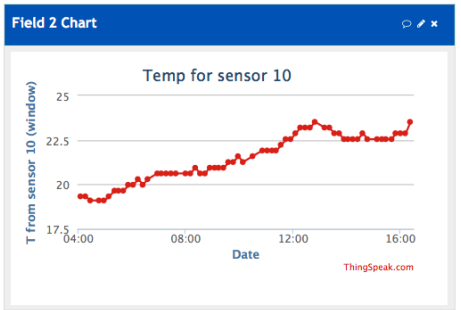


Low-power for longer lifetime!





Wakes-up every 10min, take a measure (temp) and send to GW



2500mAh

Can run more than 1 year with 1 measure/10min

Can run several years with 1 measure/1h

5µA in deep sleep mode, about 40mA when active and sending!

LARGE VARIETY OF EXAMPLES TO LEARN AND ADAPT

CongducPham / LowCostLoRaGw

Unwatch 49 | Unstar 216 | Fork 120

Code | Issues 96 | Pull requests 2 | Projects 0 | Wiki | Insights | Settings

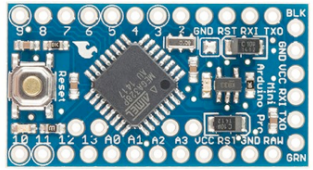
Branch: master ▾ | LowCostLoRaGw / Arduino / | Create new file | Upload files | Find file | History

Congduc Pham update README files, fix MD5 digest computation of gw id, always use ... | Latest commit aba3ed2 2 days ago

..		
Arduino_LoRa_GPS	update README	19 days ago
Arduino_LoRa_Gateway	update gateway related files and some sketch	4 months ago
Arduino_LoRa_Gateway_1_4	improve management of transmission power, add channels in 863-865	a year ago
Arduino_LoRa_Generic_Sensor	update Arduino examples	a month ago
Arduino_LoRa_InteractiveDevice	update Arduino examples	a month ago
Arduino_LoRa_Ping_Pong	update Arduino examples	a month ago
Arduino_LoRa_Simple_BeaconCol...	update Arduino example	23 days ago
Arduino_LoRa_Simple_SoilHum	update Arduino examples	a month ago
Arduino_LoRa_Simple_temp	update Arduino examples	a month ago
Arduino_LoRa_SoilHum	update Arduino examples	a month ago
Arduino_LoRa_temp	update Arduino examples	a month ago
Arduino_LoRa_ucamII	update image support	3 months ago
libraries	update README files, fix MD5 digest computation of gw id, always use ...	2 days ago
README.md	update README	19 days ago

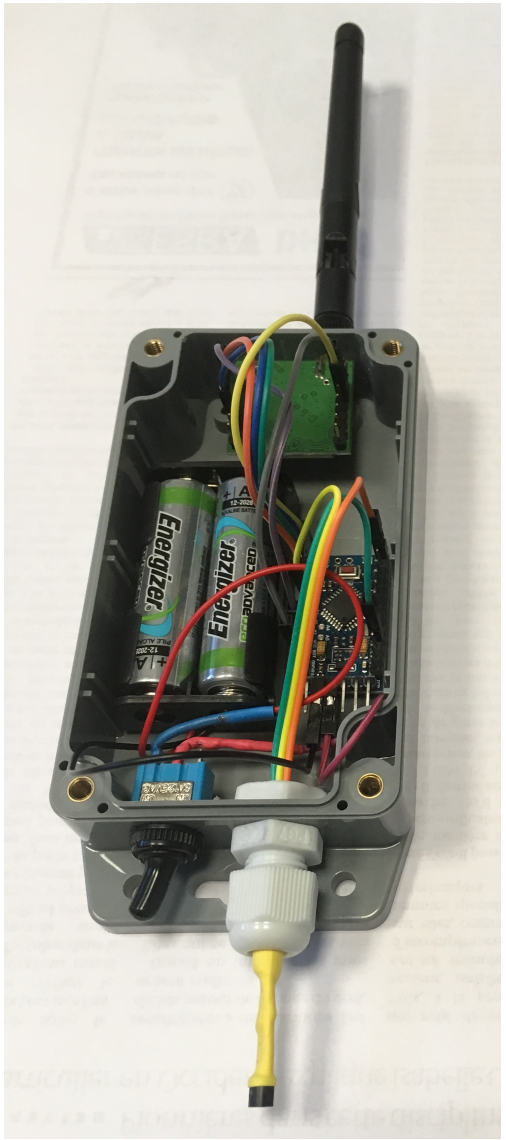
The simple temperature sensor example

Arduino Pro Mini @3.3V



Modtronix inAir9

TMP36



TUTORIALS AND VIDEOS

LOW-COST LORA IOT DEVICE: A STEP-BY-STEP TUTORIAL

PROF. CONGDUC PHAM
HTTP://WWW.UNIV-PAU.FR/~CPHAM
UNIVERSITÉ DE PAU, FRANCE

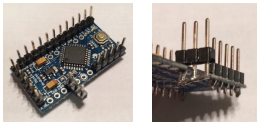
Congduc Pham, http://cpham.perso.univ-pau.fr

http://www.waziup.eu

The generic hardware platform

The Arduino Pro Mini

The Arduino Pro Mini is a compact form factor Arduino board based on the ATmega328P microcontroller
Use the **3.3v and 8MHz version** of the Arduino Pro Mini for lower power consumption



You can get the original board designed by Sparkfun or get one of the various clones available mainly from Chinese manufacturer. The last solution is very cost-effective as the Pro Mini board can be purchased for a bit more than 1€ a piece.

Depending on how many sensors you want to connect, the number of ground (GND) pins may be limited. You can extend a GND pin with a header pin where all pins are soldered together.

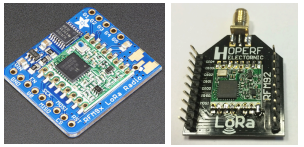
The LoRa radio module

There are various LoRa radio modules that are all based on the Semtech SX1272/1276 chips family

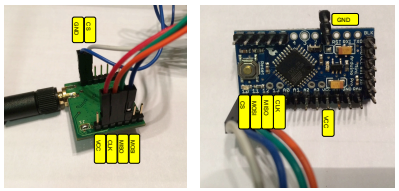
Fully tested LoRa radio modules | HopeRF RFM92W/95W | Libelium LoRa | Modtronix inAir4/9/9B | NiceRF LoRa1276

Most of SPI-based LoRa radio modules are supported. We recommend the Modtronix inAir model if you don't have delicate soldering experience as this module can come with header pins ready to be connected with Dupont wires.

The RFM95W can be found assembled (Adafruit) or an adapter can be purchased (from Ideetron for instance)



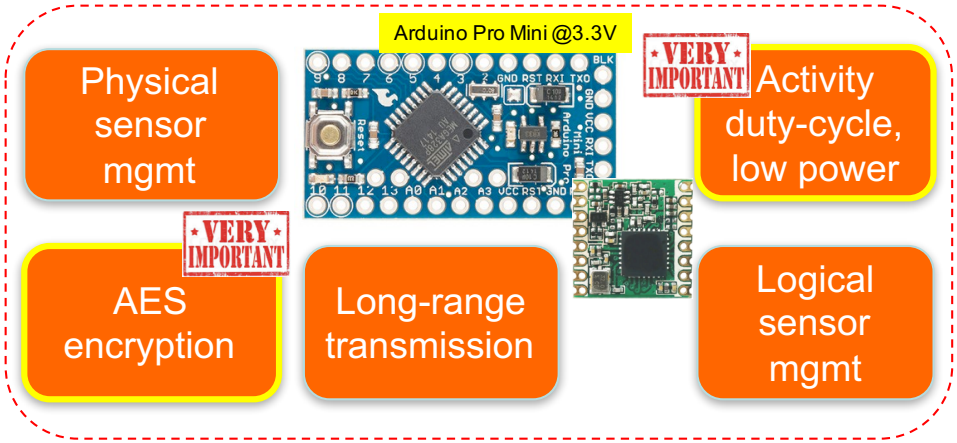
Connect the LoRa radio module

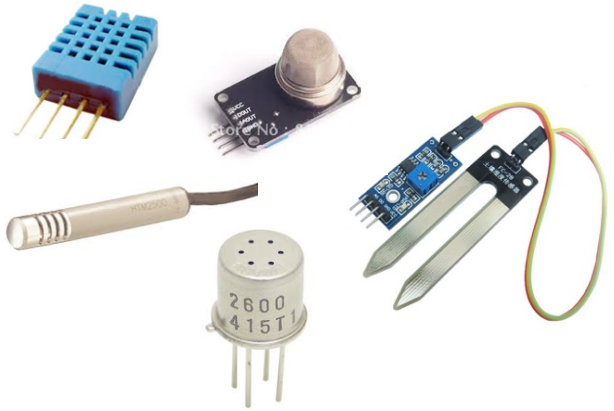


Connect the corresponding SPI pins of the radio module to the SPI pins on the Pro Mini board. MOSI (blue) is pin 11, MISO (green) is pin 12, CS (white) is pin 10 and CLK (orange) is pin 13 (right picture). Then connect also the VCC (red) and the GND (black) of the radio module to the VCC and the GND of the board (right picture). The VCC of the Pro Mini board gets 3.3v from the on-board voltage regulator.

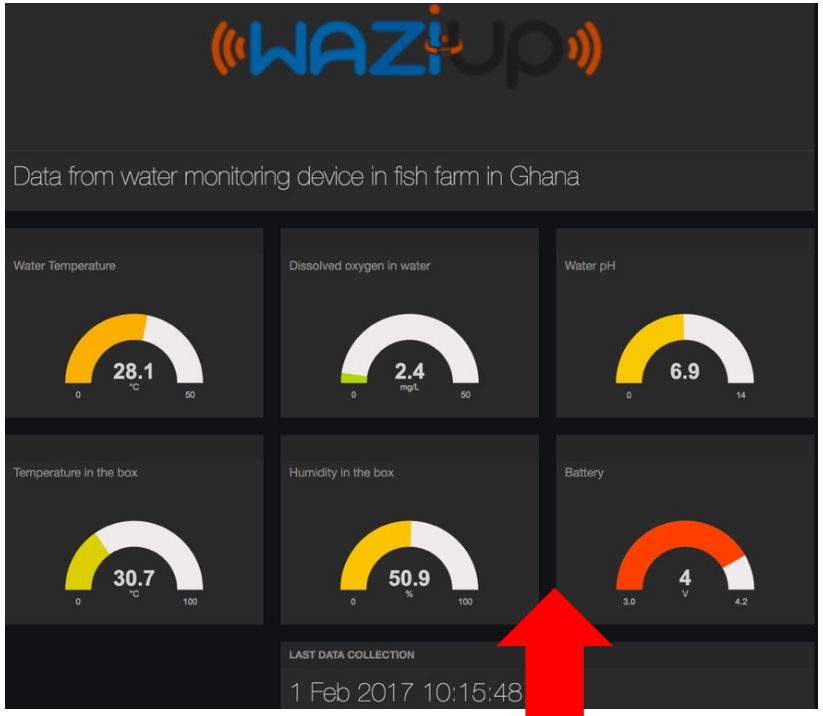
Generic sensing IoT device

- Build low-cost, low-power, Long-range enabled generic platform
- Methodology for low-cost platform design
- Technology transfers to user communities, economic actors, stakeholders,…





Low-cost buoy for fish farming MVP



WAZIUP

Physical sensor reading

WAZIUP

Physical sensor management

Activity duty-cycle, low power

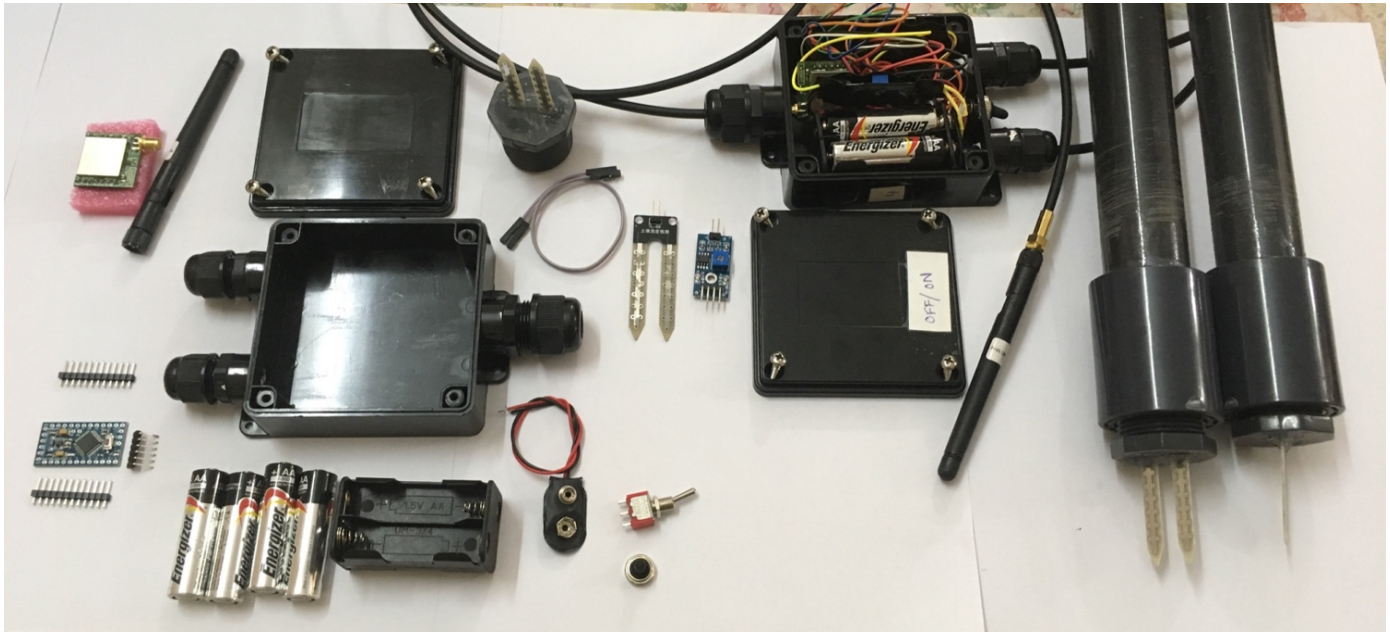
Security

Long-range transmission

Logical sensor management

Credit: EGM

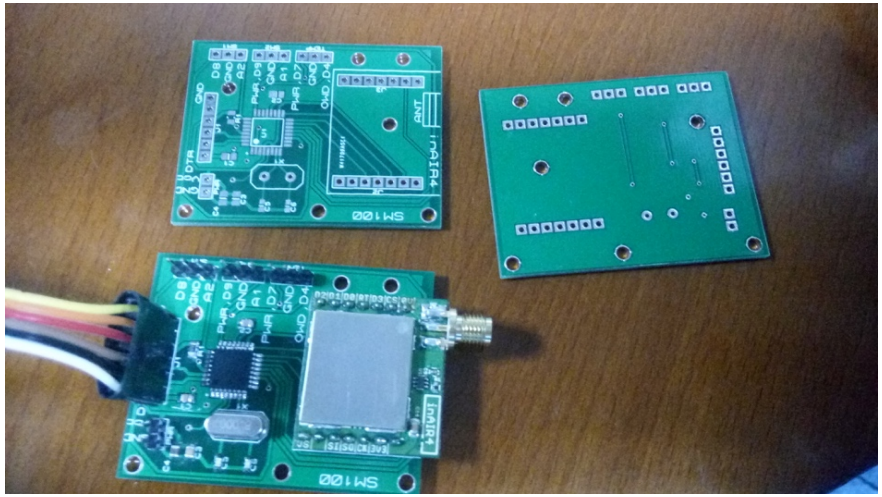
SOIL HUMIDITY SENSORS FOR AGRI MVP

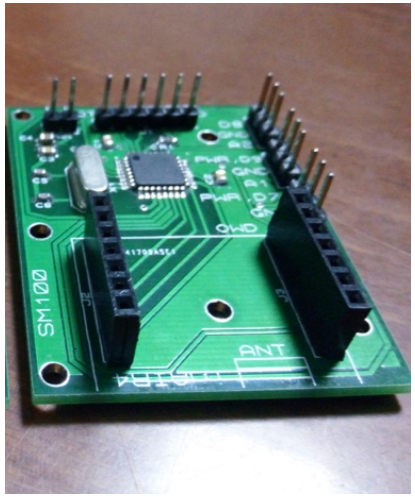


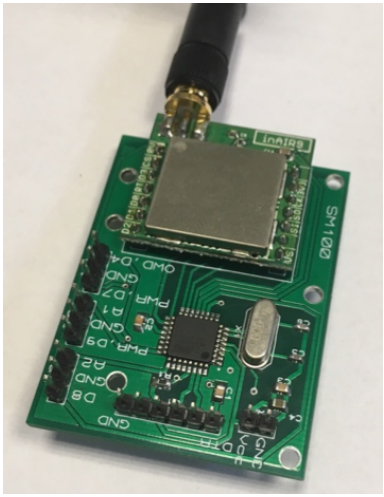
- Physical sensor management
- Activity duty-cycle, low power
- Security
- Long-range transmission
- Logical sensor management

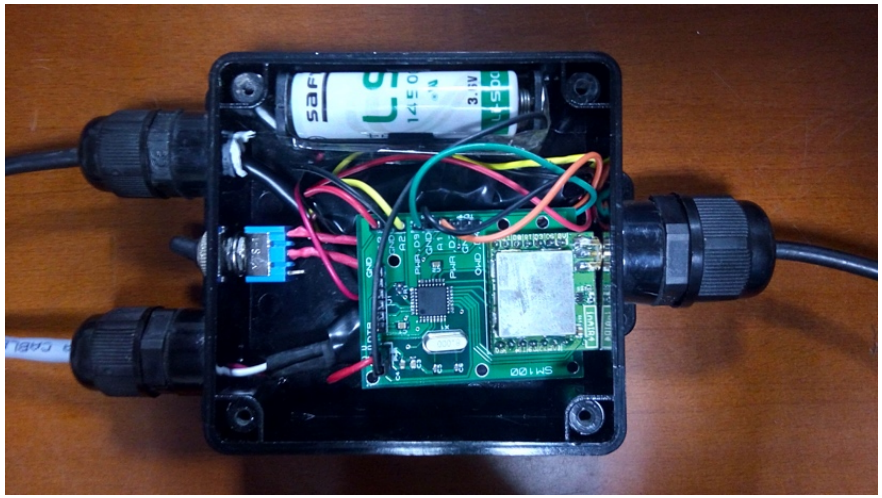
Deployment for Nestlé's WaterSense project

LOCAL INTEGRATION WITH TECHNOLOGY TRANSFER

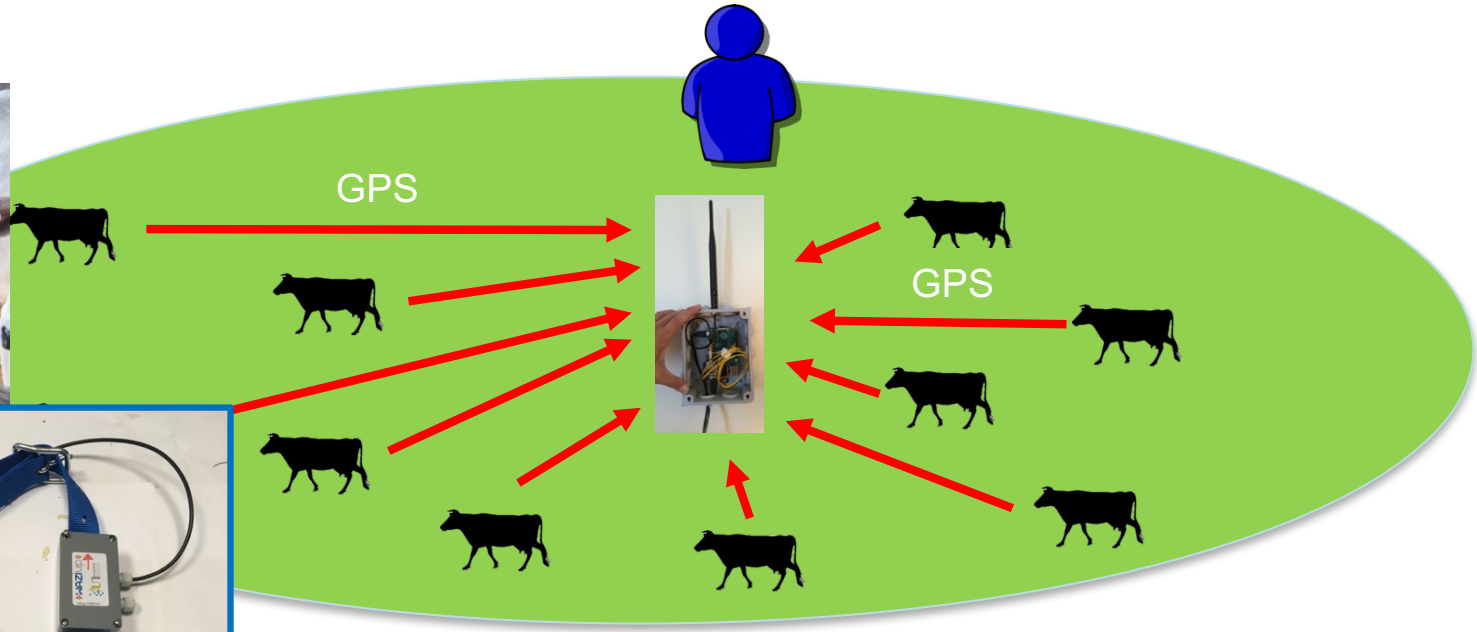








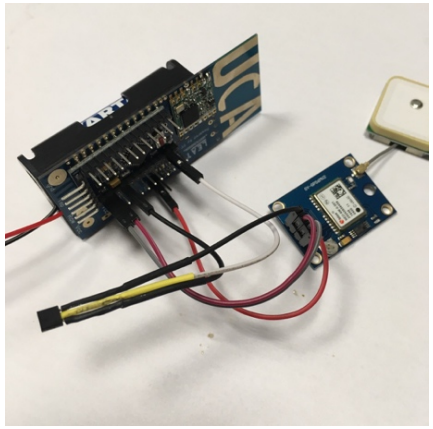
Collar for Cattle Rustling MVP

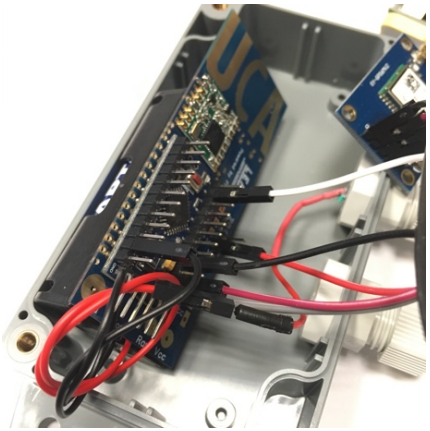


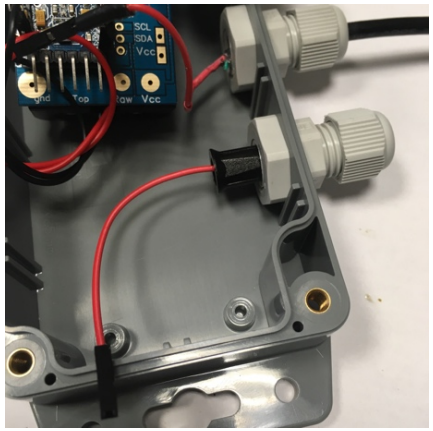
In Africa, the practice of animal husbandry has always been and still remain farmers' livelihood and incomes

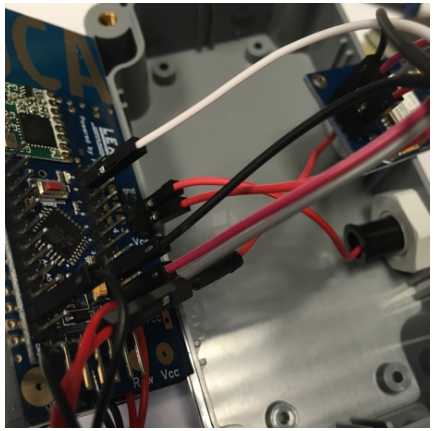
Their main problem in this activity remain the cattle rustling and some families are put in dramatic situation after a theft (reported 2 billions CFA losses)

Easy integration and customization

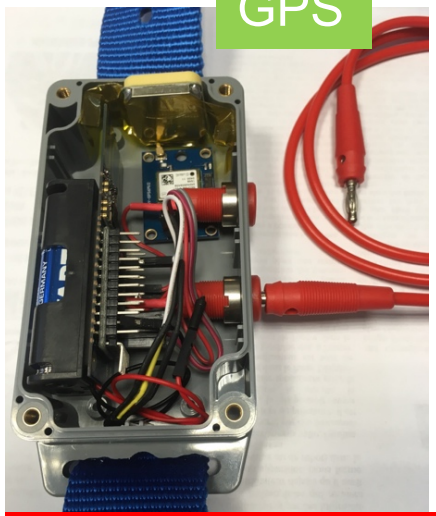


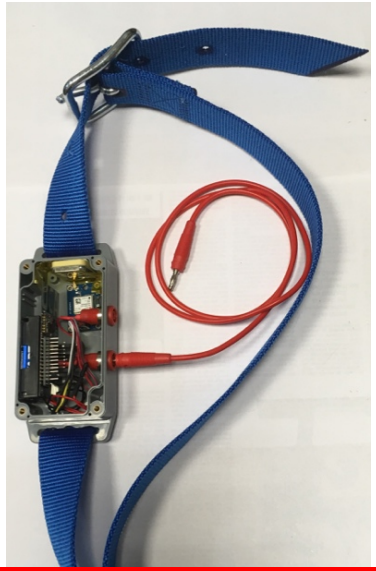




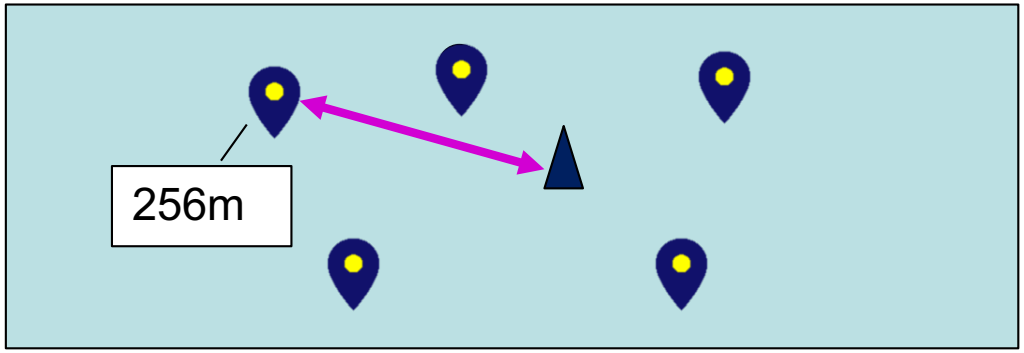


GPS





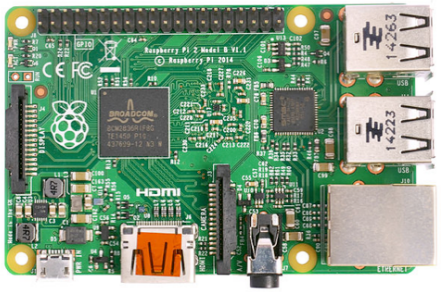
A web interface can be developped to display the position of the gateway and the position of the remote GPS devices

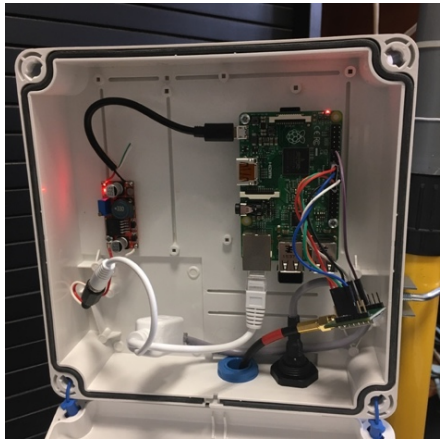


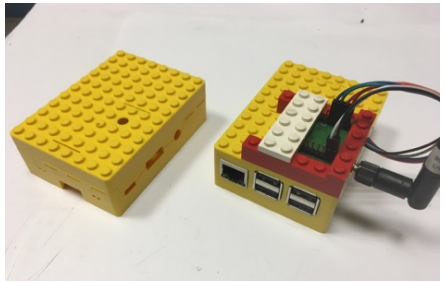
Dedicated tutorial on low-cost IoT collar w/GPS

https://github.com/CongducPham/tutorials/blob/master/Low-cost-LoRa-Collar.pdf

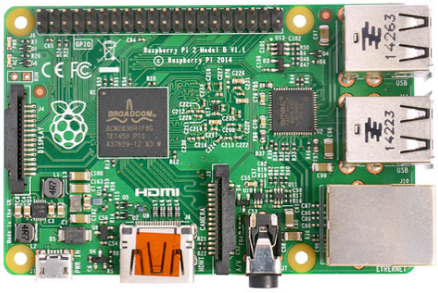
The versatile IoT gateway







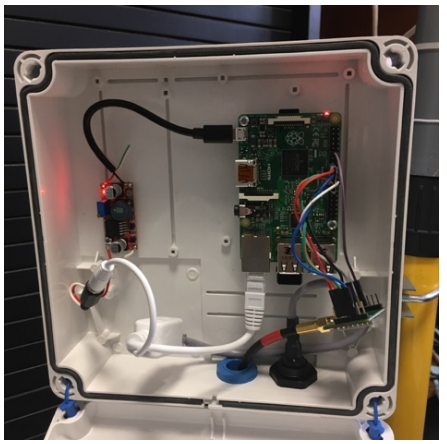
Raspberry-based low-cost LoRa gateway



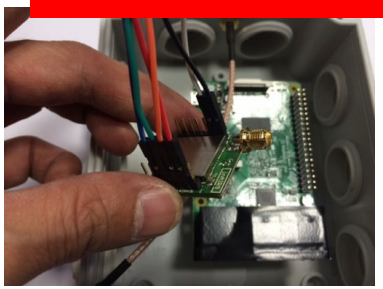
We can use all model of Raspberry. The most important usefull feature is the Ethernet interface for easy Internet connection. Then WiFi and Bluetooth can be added with USB dongles.
RPI3 provides built-in Ethernet, WiFi and Bluetooth!



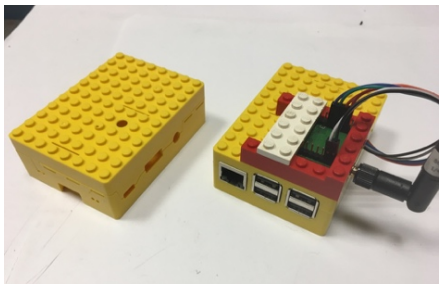




Less than 50€



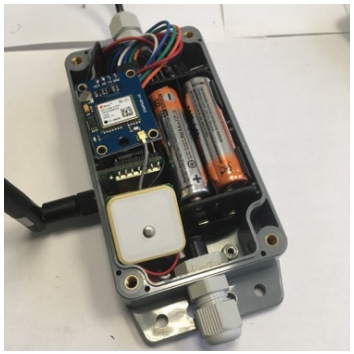


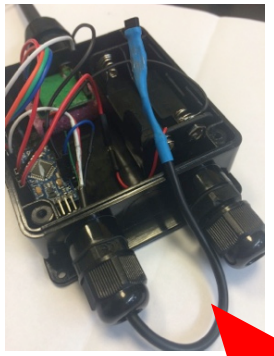


Get the ready-to-use SD card image

http://cpham.perso.univ-pau.fr/LORA/WAZIUP/raspberrypi-jessie-WAZIUP-demo.dmg.zip

100% DO-IT-YOURSELF !

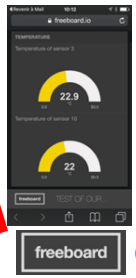


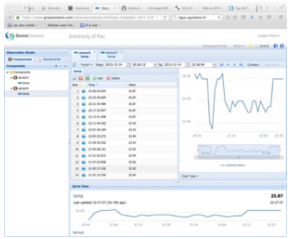


Step-by-step tutorial and source code available

Step-by-step tutorial and source code available

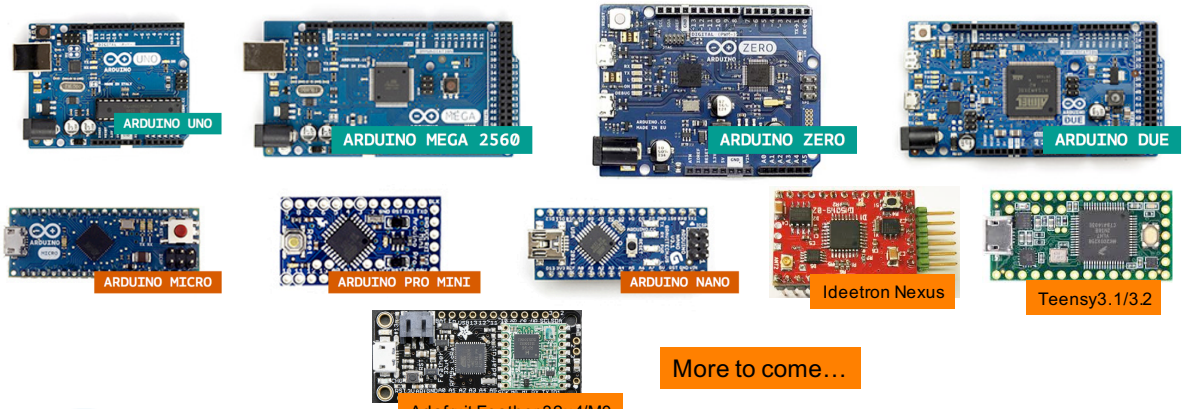
Python scripts available



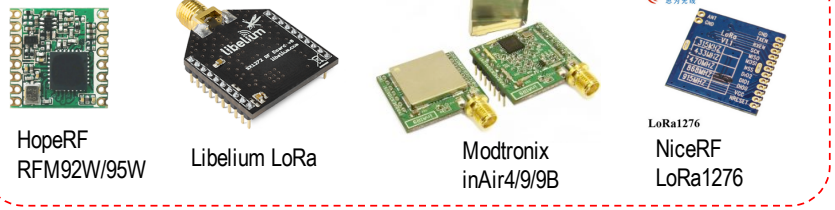


https://github.com/CongducPham/LowCostLoRaGw

SIMPLICITY!



LoRa radios that our library already supports

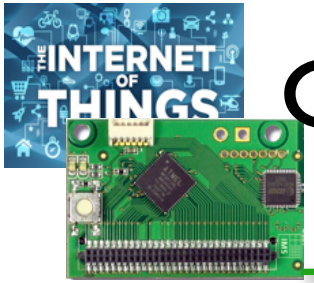


Long-Range communication library

```
sendPacketTimeout("TC/18.5");
// sends to gateway
// TC : temperature celcius
// 18.5 : value
```

1 send function!

Our Low-Cost gateway architecture



Kept as simple as possible

high-level lang. e.g. python

Most of user or application specific logics is done here!
We provide some basic features, up to you to enhance them

radio bridge program

stdout

post processing

stdout

stdin

mongoDB

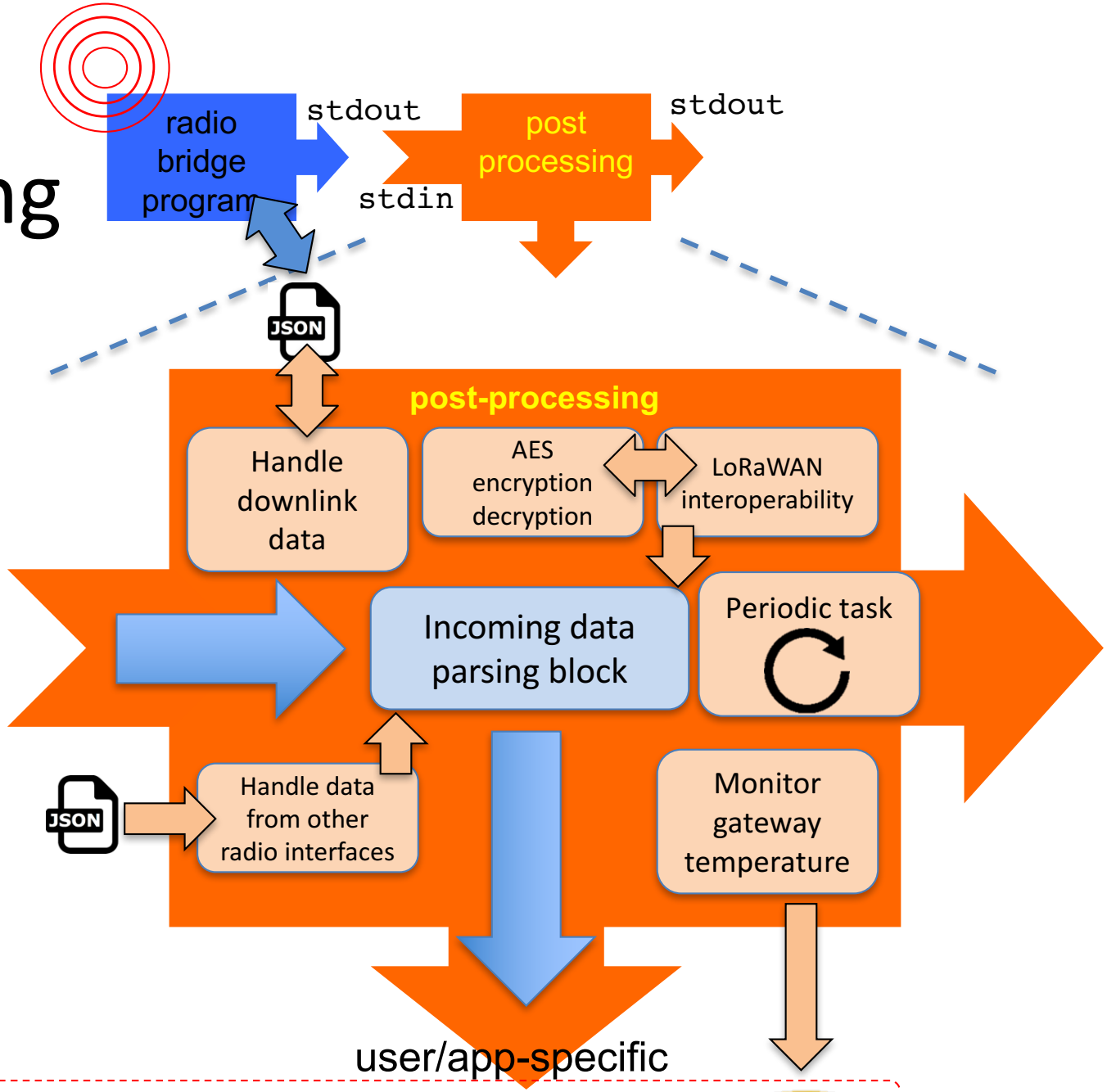
post-processing ⟷ user/app-specific

lora_gateway program

Long-range radio lib

Raspbian

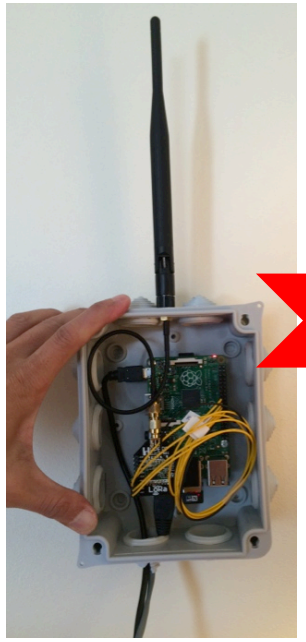
Post-processing stage

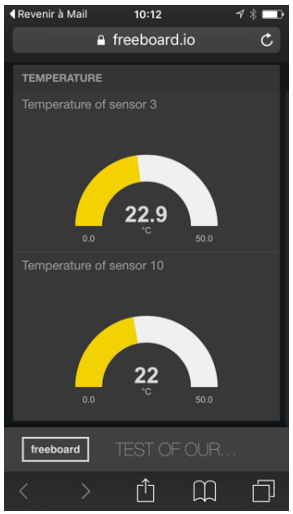


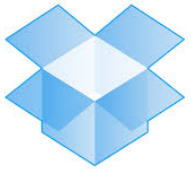
Cloud definition

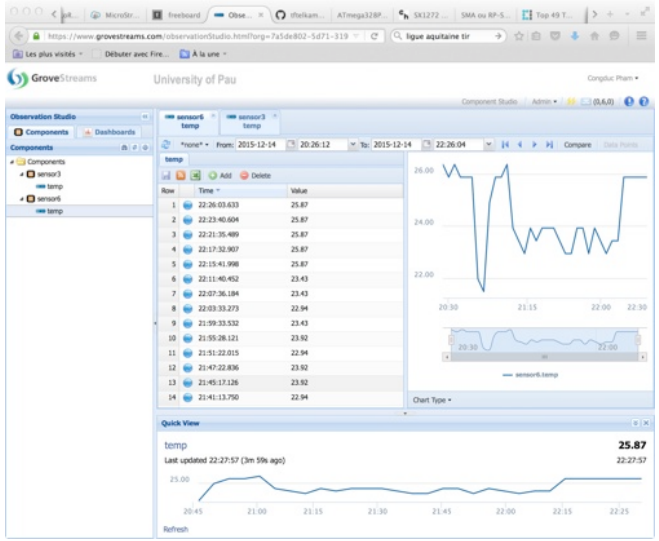
cloud_script_1 | cloud_script_2 | cloud_script_n | WAZIUP | local database

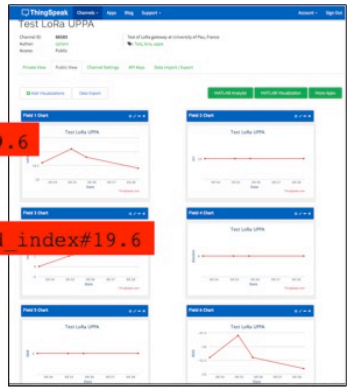
Templates for various clouds



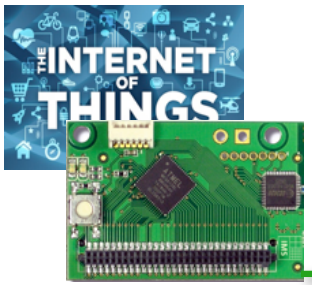








And much more: HTTP, FTP, MQTT, Node-Red…



CLOUDS.JSON


```
{
  "clouds": [
    {
      "notice": "do not remove the MongoDB cloud declaration",
      "name": "Local gateway MongoDB",
      "script": "python CloudMongoDB.py",
      "type": "database",
      "max_months_to_store": 2,
      "enabled": true
    },
    {
      "name": "WAZIUP Orion cloud",
      "script": "python CloudOrion.py",
      "type": "iotcloud",
      "write_key": "",
      "enabled": true
    },
    {
      "name": "ThingSpeak cloud",
      "script": "python CloudThingSpeak.py",
      "type": "iotcloud",
      "write_key": "",
      "enabled": true
    },
    {
      "name": "GroveStreams cloud",
      "script": "python CloudGroveStreams.py",
      "type": "iotcloud",
      "write_key": "",
      "enabled": false
    },
    {
      "name": "Firebase cloud",
      "script": "python CloudFireBase.py",
      "type": "jsoncloud",
      "write_key": "",
      "enabled": false
    },
```

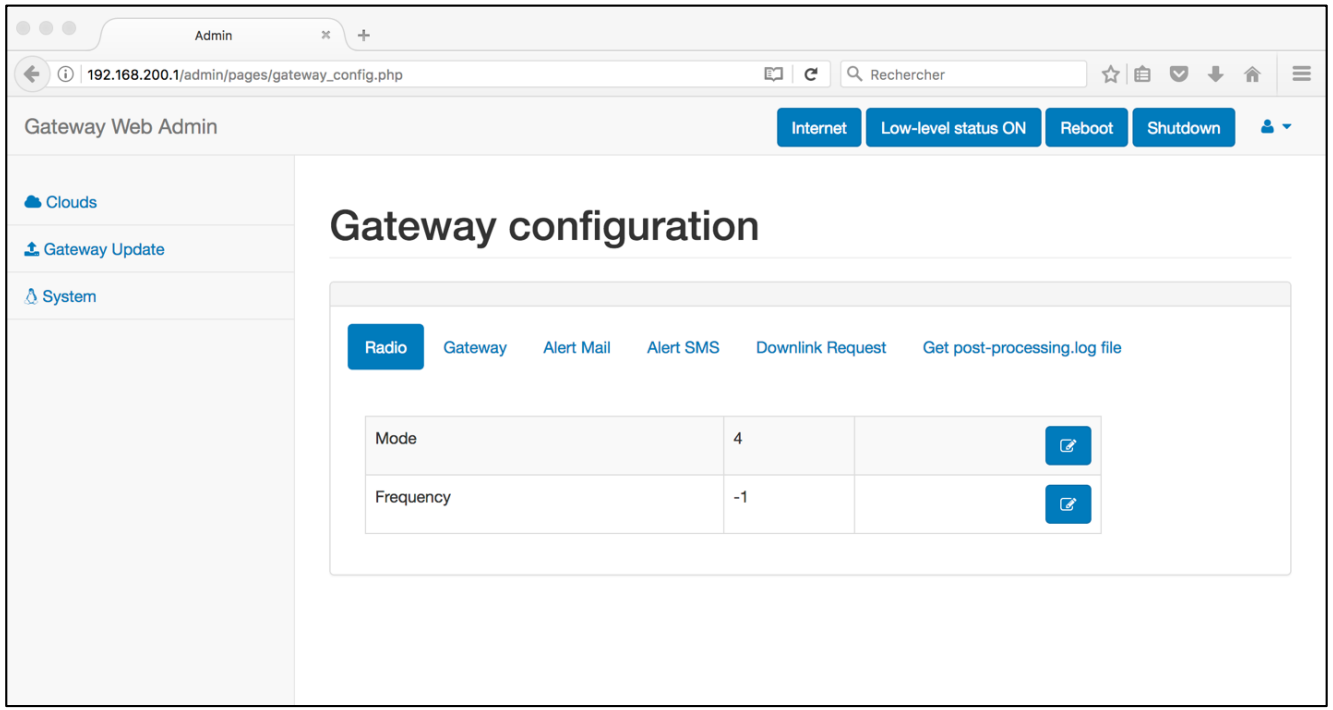

For each cloud, you have to provide a script and the launcher program (e.g. python)

Enabled clouds will be called by the post-processing stage

Each cloud script can incorporate parameters from a dedicated configuration file, e.g. key_ThinkSpeak.py for CloudThinkSpeak.py

Configure your gateway with the web interface

- http://192.168.200.1/admin
  - Login: admin
  - Password: loragateway



Working without Internet access

A

10-15kms

LoRa

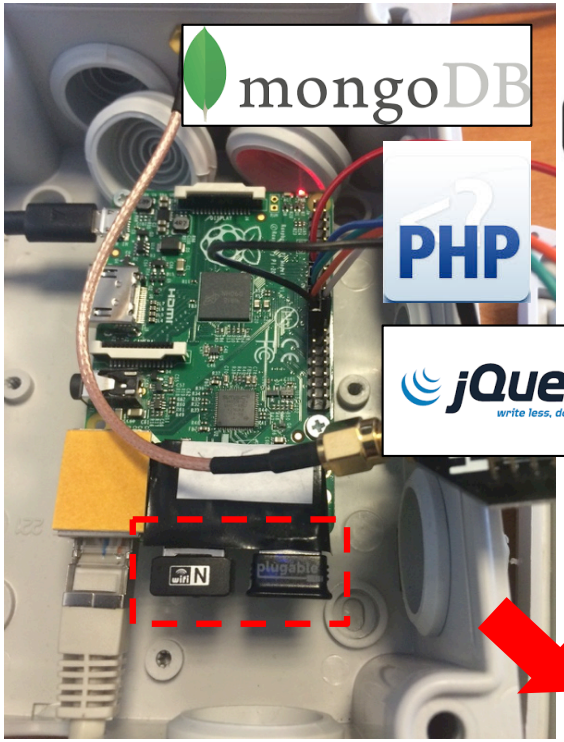
No subscription
Deploy own network
Low energy consumption

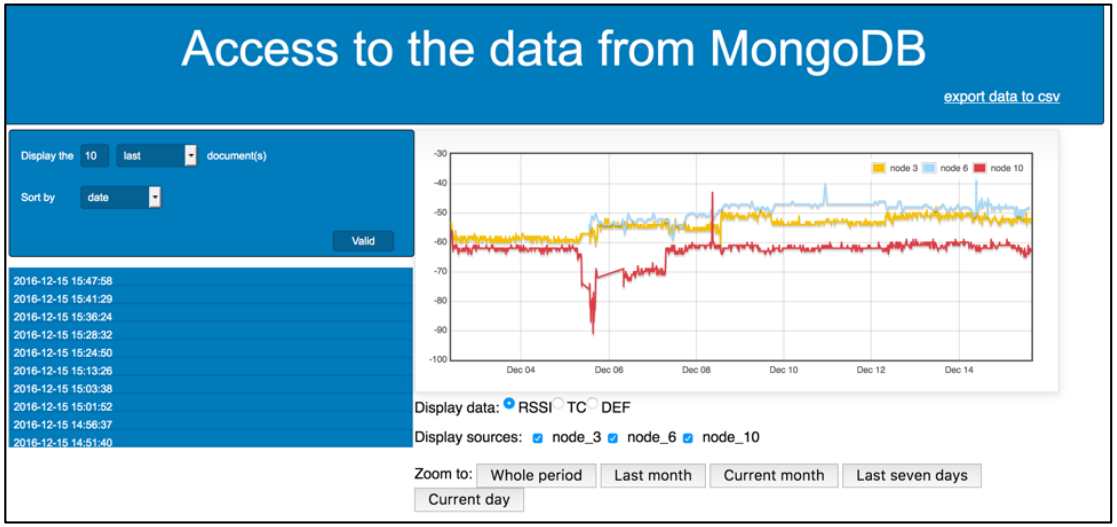
GSM
3G
Wi Fi
net
ccess

B

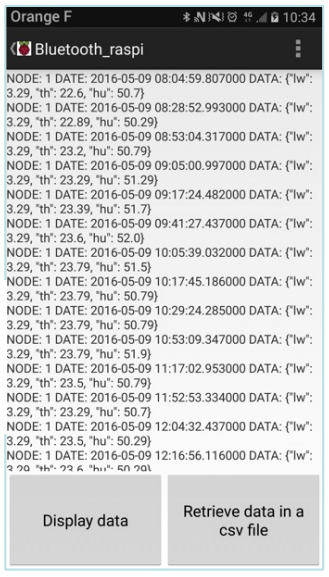
Wi Fi

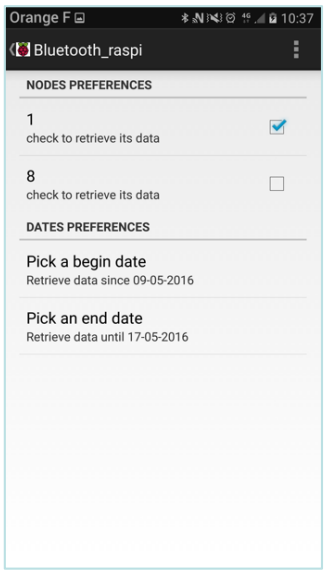
STANDALONE GATEWAY

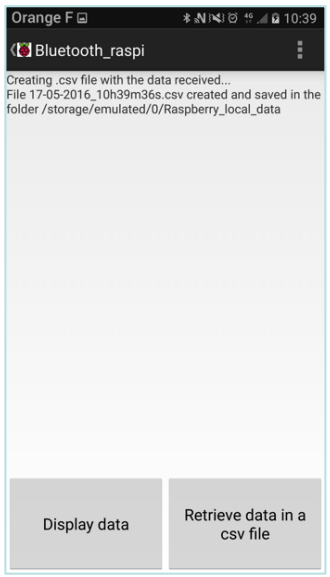


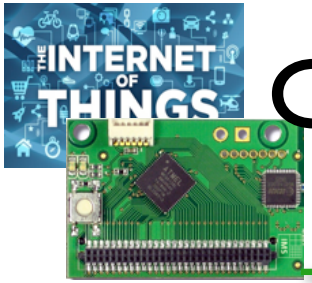


Isolated areas



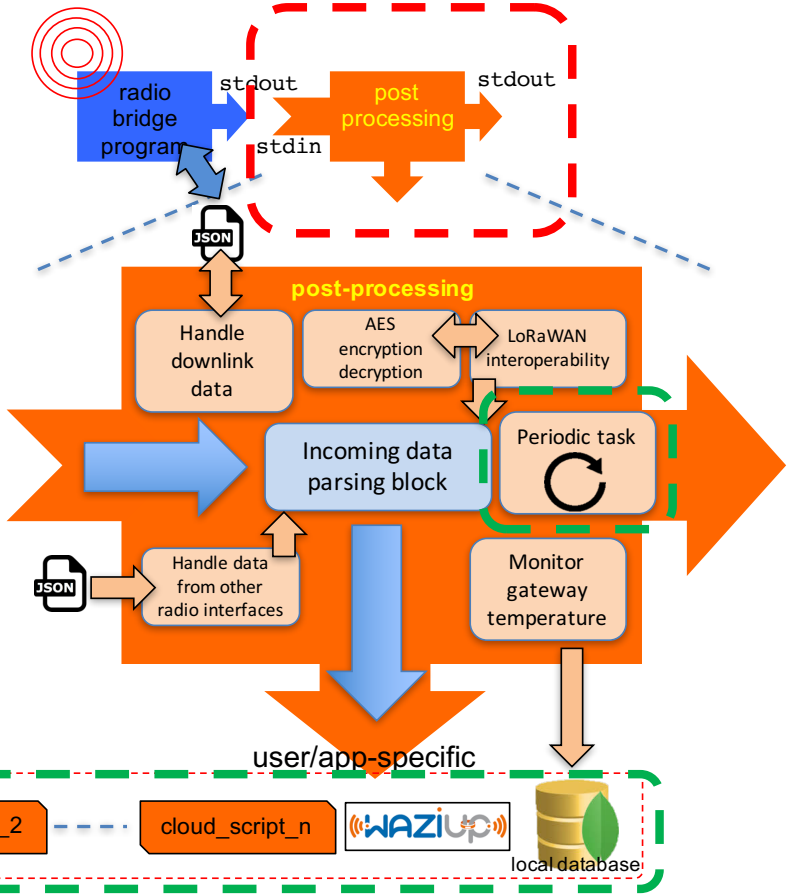


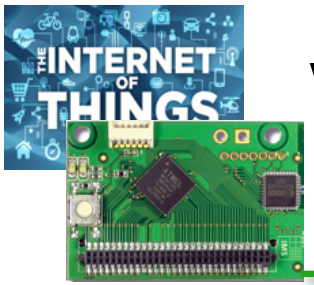




Customizing/Extending your gateway

- The flexible gateway architecture offers high versatility by customization
- There are 3 options for customization
- The geek way
  - Modify/extend post-processing script
- The "smarter" way
  - Add "cloud" scripts
    - On packet reception
  - Add periodic tasks
    - Independant from packet reception

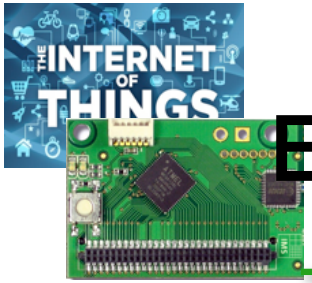




Write your own cloud script

- Use our templates to write your own cloud script
- A cloud script is called with 5 arguments
  - ldata: the received data
    - e.g. #4#TC/21.5 as 1st argument (sys.argv[1] in python)
  - pdata: packet information
    - e.g. "1,16,3,0,10,8,-45" as 2nd argument (sys.argv[2] in python)
    - interpreted as dst,ptype,src,seq,len,SNR,RSSI for the last received packet
  - rdata: the LoRa radio information
    - e.g. "500,5,12" as 3rd argument (sys.argv[3] in python)
    - interpreted as bw,cr,sf for the last received packet
  - tdata: the timestamp information
    - e.g. "2016-10-04T02:03:28.783385" as 4th argument (sys.argv[4] in python)
  - gwid: the gateway id
    - e.g. 00000027EBBEDA21 as 5th argument (sys.argv[5] in python)

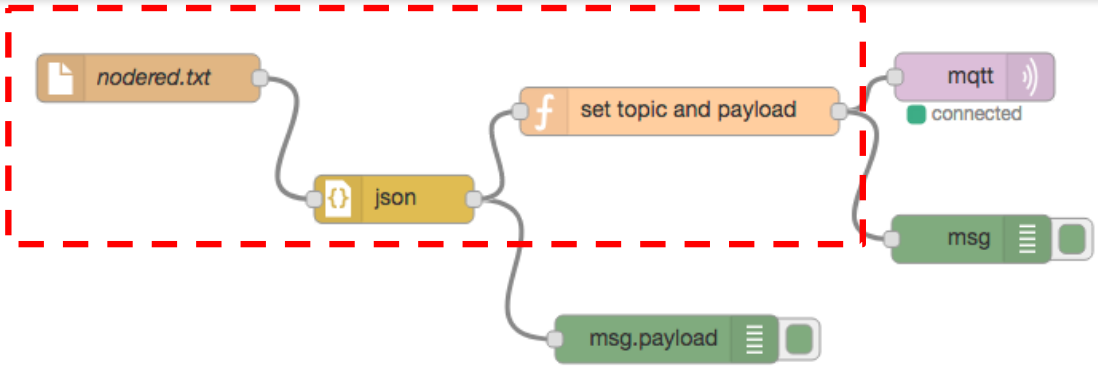
These parameters are passed to the script. It is up to the cloud script to use these parameters or not.



Example with Node-Red

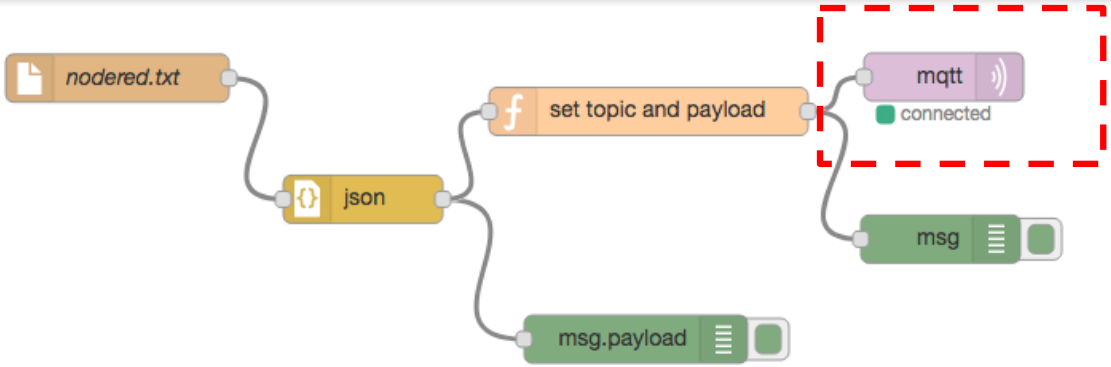
- `CloudNodeRed.py` shows how interface with Node-Red can be simply implemented to benefit from the facility offered by Node-Red
- We use `key_NodeRed.py` to define 3 variables that will be used by `CloudNodeRed.py`
  - `project_name="waziup"`
  - `organization_name="UPPA"`
  - `sensor_name="Sensor"`
- when a device which address is 2 sends "TC/22.5/HU/85" to the gateway, `CloudNodeRed.py` will generate the following json entries in `nodered/nodered.txt` file
  - `{"source":"waziup_UPPA_Sensor2","measure":"TC","value":22.5}`
  - `{"source":"waziup_UPPA_Sensor2","measure":"HU","value":85}`

Node-Red flow (1)

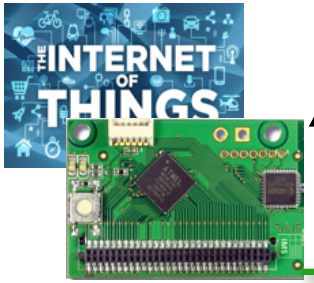


- The Node-Red flow is composed of a tail node that follows the `nodered/nodered.txt` file for new entries. Each entry will be converted into a json object with a json node. A function node will use the json entry to build a message as follows
  - `msg.topic=msg.payload.source+'/'+msg.payload.measure`
  - `msg.payload=msg.payload.value`
  - `return msg;`

Node-Red flow (2)



- An MQTT node using the `test.mosquitto.org` broker will receive the messages with the topic defined as `waziup_UPPA_Sensor2/TC` and `waziup_UPPA_Sensor2/HU`
- It will then respectively publish 22.5 and 85 under these topics
- More information on:
  - `https://github.com/CongducPham/LowCostLoRaGw/blob/master/gw_full_latest/README-NodeRed.md`

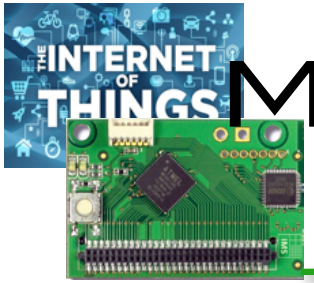


Another example with CloudGpsFile.py

- `CloudGpsFile.py` is a dedicated "cloud" module that will search in incoming messages a valid 'LAT' and 'LGT' field such as in "BC/9/LAT/43.31402/LGT/-0.36370/FXT/4180"
- You can enable `CloudGpsFile.py` in `clouds.json`. When a message with valid GPS coordinates is received, `CloudGpsFile.py` will write an entry in `gps/gps.txt` file containing relevant packet and GPS information, including the distance (in km) between the gateway and the GPS device

```
src waziup_UPPA_Sensor15 seq 188 bc 9 snr 5 rssi -90 time 2017-11-20T14:18:54 gw
00000027EB5171F7 fxt 4180 lat 43.31402 lgt -0.36370 distance 0.0224
```

- For distance calculation, the gateway position MUST be provided in the `gateway_conf.json` file (see Annex)
- For range test campaign, you can import (or copy/paste) this file in an Excel sheet to plot distance against SNR/RSSI

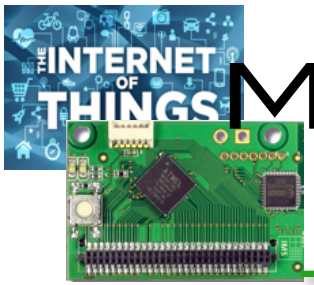


Maintaining a list of GPS devices (1)

- `CloudGpsFile.py` also maintains a list of GPS devices in `gps/gps.json`

```
{
    "devices": [
        {
            "gw": "00000027EB5171F7",
            "src": "waziup_UPPA_Sensor15",
            "seq": 188,
            "distance": 0.0224,
            "fxt": 4180,
            "bc": 9,
            "lat": 43.31402,
            "snr": 8,
            "time": "2017-11-20T14:18:54",
            "active": "yes",
            "rssi": -45,
            "lgt": -0.3637
        }
    ]
}
```

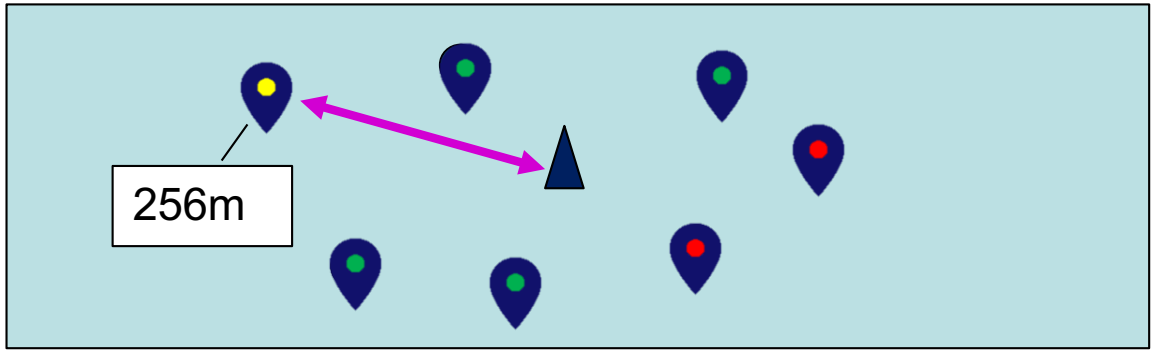
- New devices (from `src` field) will be added, while existing devices will be updated



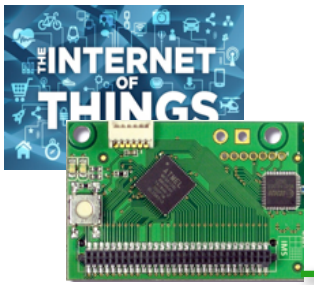
Maintaining a list of GPS devices (2)

- `CloudGpsFile.py` also extract from the list of GPS devices those that have sent GPS information in during the last time window
- `key_GpsFile.py` defines
  - `active_interval_minutes=20`
  - For instance, devices that have sent GPS info in the last 20 minutes will be indicated as active
- Those active devices are further maintained in `gps/active_gps.json`
- Further versions can also create kml or gpx file or any combination that would allow more complex visualization features

A WEB INTERFACE FOR TRACKING GPS DEVICES



- A web interface could use `gps/gps.json` and `gps/active_gps.json` to show:
  - the last updated GPS device
  - active devices (in the last time window)
  - inactive devices that have not been updated in the last time window
- This feature is especially usefull in mobility scenario



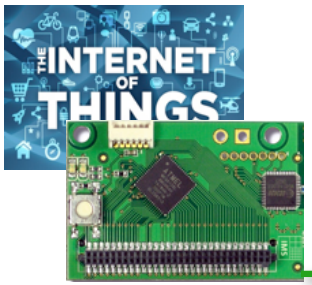
Extending by adding a new periodic task

- Illustration with dynamic gateway GPS position
- The gateway's coordinates are stored in `gateway_conf.json`

```
"gateway_conf" : {
        "gateway_ID" : "000000XXXXXXXXXX",
        "ref_latitude" : "43.31416",
        "ref_longitude" : "-0.36430",
```

- In a mobility scenario, the position of the gateway can be updated dynamically by plugging a USB GPS module to the gateway
- `gateway_conf.json` has a `status_conf` section where `dynamic_gps` can be enabled

```
"status_conf" : {
        "dynamic_gps" : true,
        "gps_port" : "/dev/ttyACM0"
},
```



When enabling dynamic_gps

- Enabling `dynamic_gps` in `gateway_conf.json` activates the following tasks
  - `post_status_processing_gw.py` which is periodically called by `post_processing_gw.py` will try to get the position of the gateway using a connected GPS module. It uses `get_gps.py` in the `sensors_in_raspi` folder
  - `get_gps.py` produces a `gateway_gps.txt` file if a valid GPS fix is obtained. The file simply contains the coordinates in decimal degree: `43.31427,-0.36424`
  - If `post_status_processing_gw.py` finds a `gateway_gps.txt` file, it will update in `gateway_conf.json` the GPS coordinate fields used by `CloudGpsFile.py`

TUTORIALS/RESOURCES

https://github.com/CongducPham/tutorials

WAZIUP

EU H2020 grant agreement number 687607

Low-cost LoRa IoT devices and gateway FAQ

1) **What is Internet-of-Thing (IoT)?**

From IERC (European Research Cluster on the Internet of Thing)

The IERC definition states that IoT is "A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network."

From http://www.gartner.com/it-glossary/internet-of-things/

"The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment."

From http://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT

"The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction."

2) **What is WAZIUP?**

The EU H2020 WAZIUP project, namely the Open Innovation Platform for IoT-Big Data in Sub-Saharan Africa is a collaborative research project using cutting edge technology applying IoT and Big Data to improve the working conditions in the rural ecosystem of Sub-Saharan Africa. First, WAZIUP operates by involving farmers and breeders in order to define the platform specifications in focused validation cases. Second, while tackling challenges which are specific to the rural ecosystem, it also engages the flourishing ICT ecosystem in those countries by fostering new tools and good practices, entrepreneurship and start-ups. Aimed at boosting the ICT sector, WAZIUP proposes solutions aiming at long term sustainability.

WAZIUP will deliver a communication and big data application platform and generate locally the know how by training by use case and examples. The use of standards will help to create an interoperable platform, fully open source, oriented to radically new paradigms for innovative application/services delivery. WAZIUP is driven by the following visions:

1. Empower the African R… empower the African rur… of rapid urbanization an… support the necessary … breeding on a new scale

Author : Congduc Pham, University of Pa…
Last update : 07.09.2016

TUTORIAL ON HARDWARE & SOFTWARE FOR LOW-COST LONG-RANGE IOT

WAZIUP

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LOW-COST LORA IOT DEVICE: A STEP-BY-STEP TUTORIAL

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BUILDING AN IOT DEVICE FOR OUTDOOR USAGE: A STEP-BY-STEP TUTORIAL

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LOW-COST LORA IOT: USING THE WAZIUP DEMO KIT

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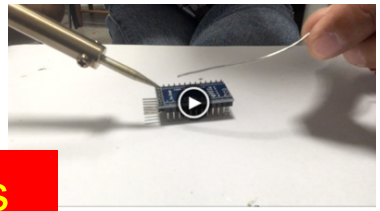
Low-cost IoT device

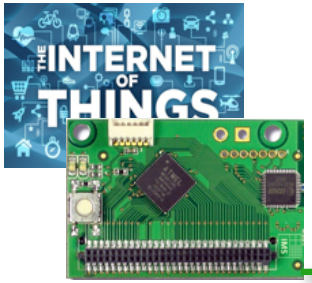


+43000 views

https://www.youtube.com/watch?v=YsKbJeeav_M

Low-cost IoT gateway

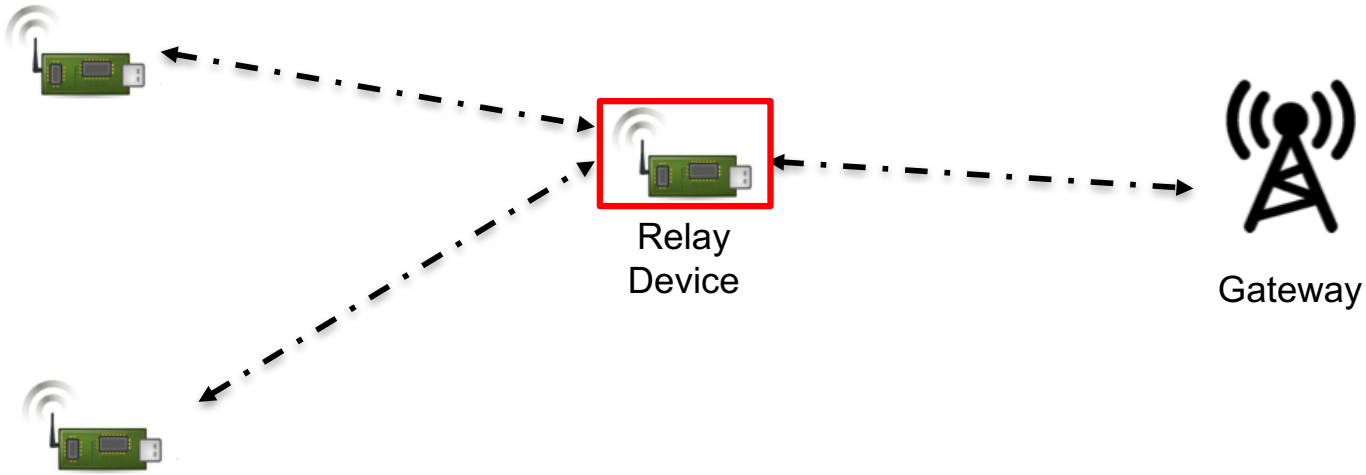
https://www.youtube.com/watch?v=mj8ItKA14PY



Conducting research with the WAZIUP IoT platform

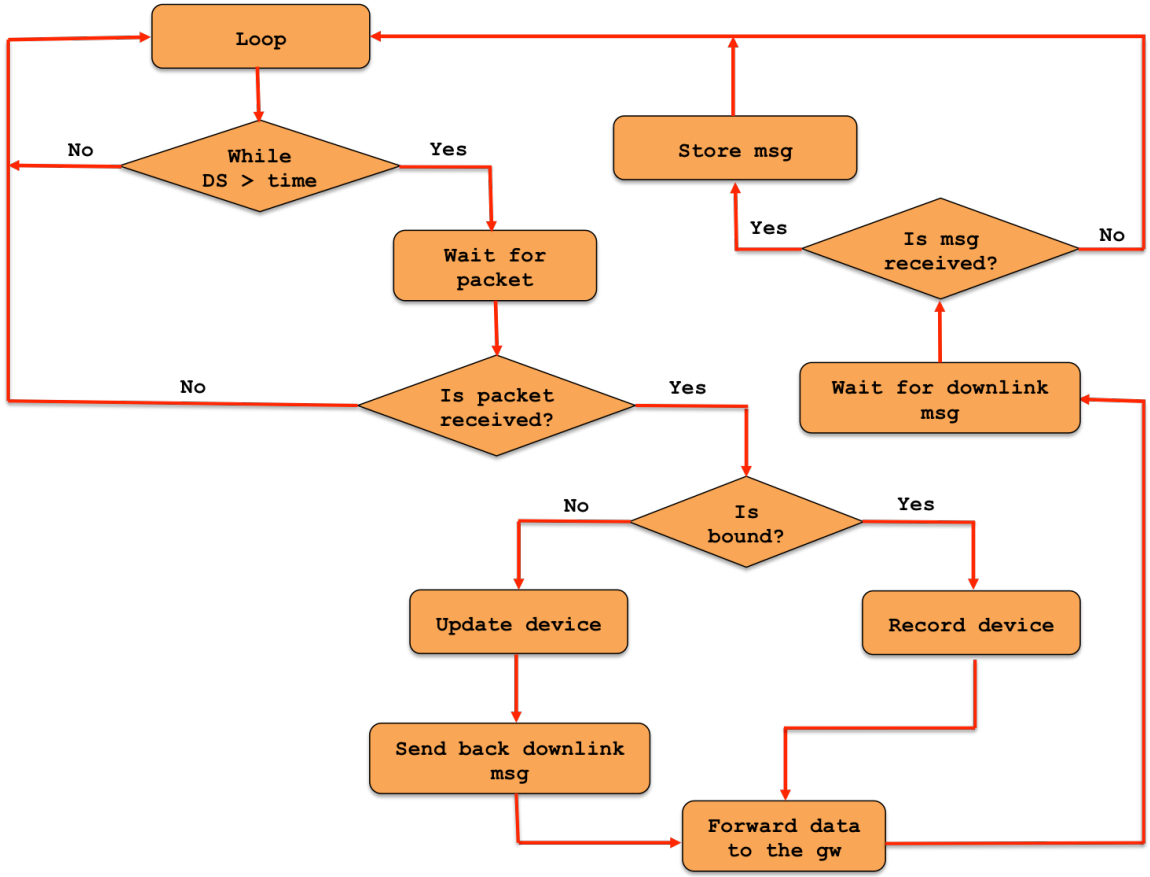
2-hop LoRa

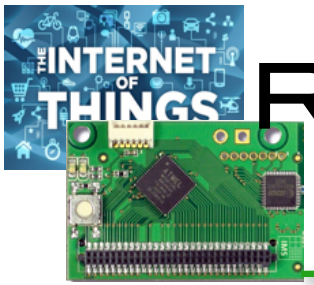
- Provides 2-hop LoRa to solve some connectivity issues in real-world deployment scenario
- Objective is to have a smart relay node that can be inserted at anytime between end-devices and gateway



Smart relay device learning on-the-fly

- On-the-fly learning of incoming traffic from end-devices: the observation phase

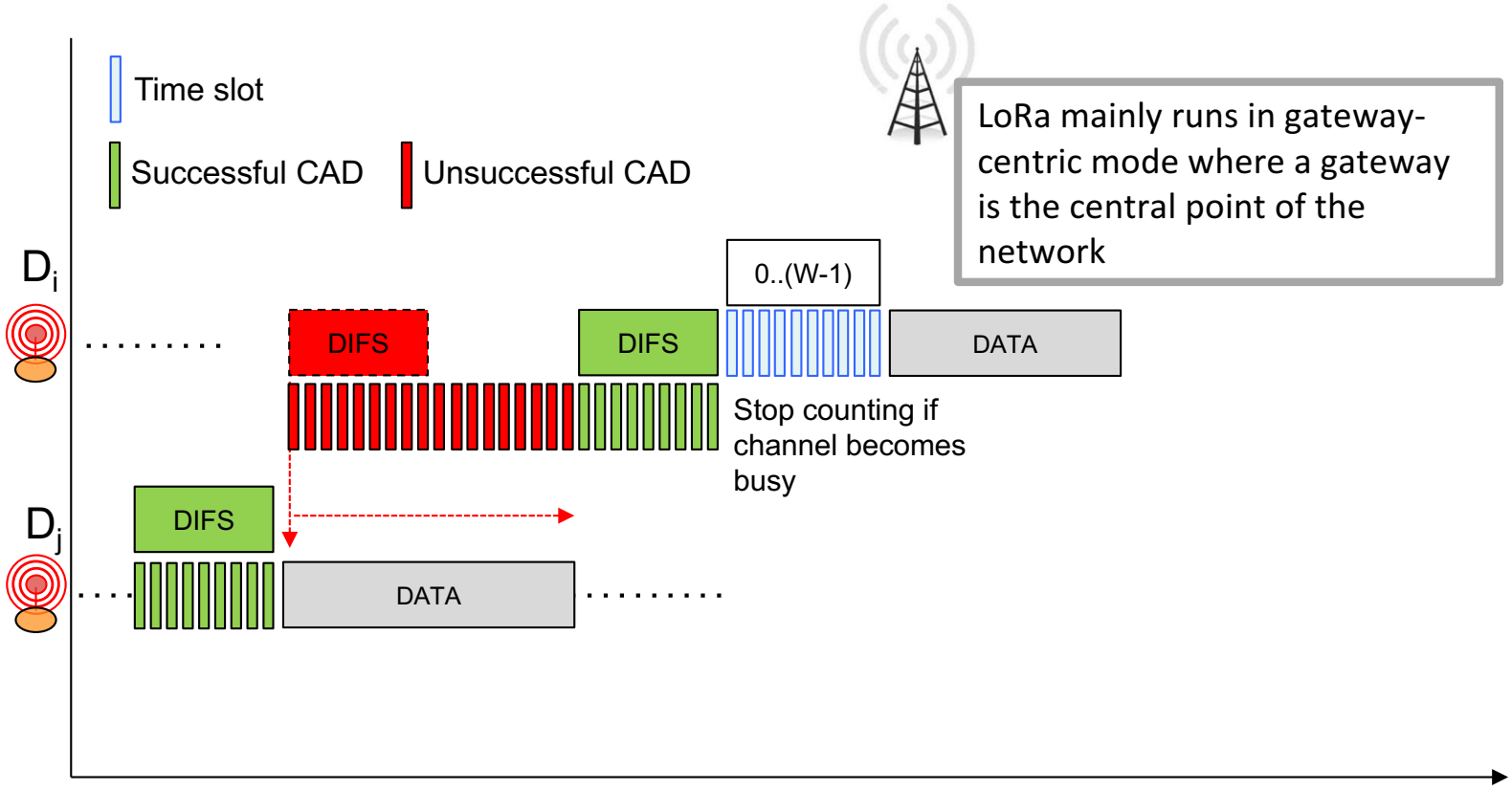




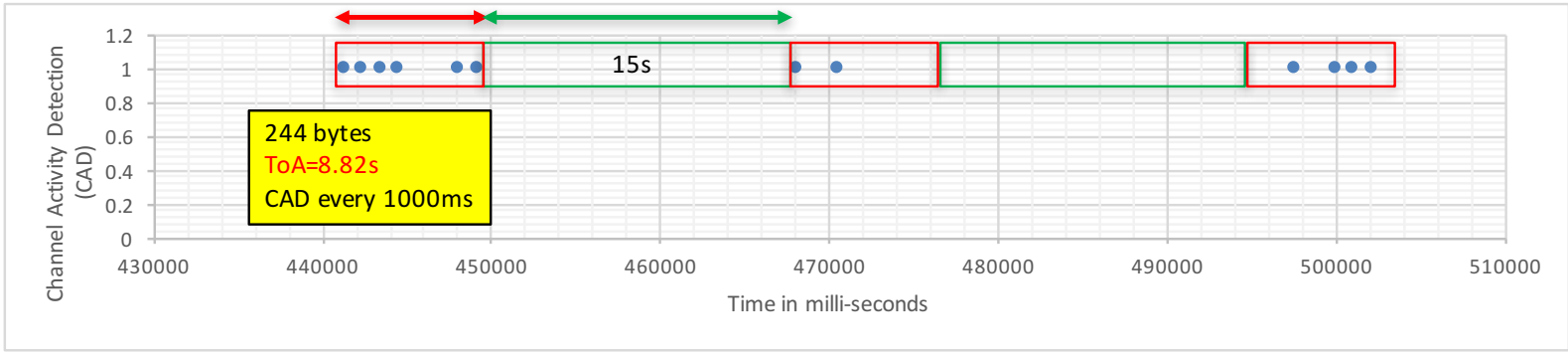
Robust channel access mechanisms

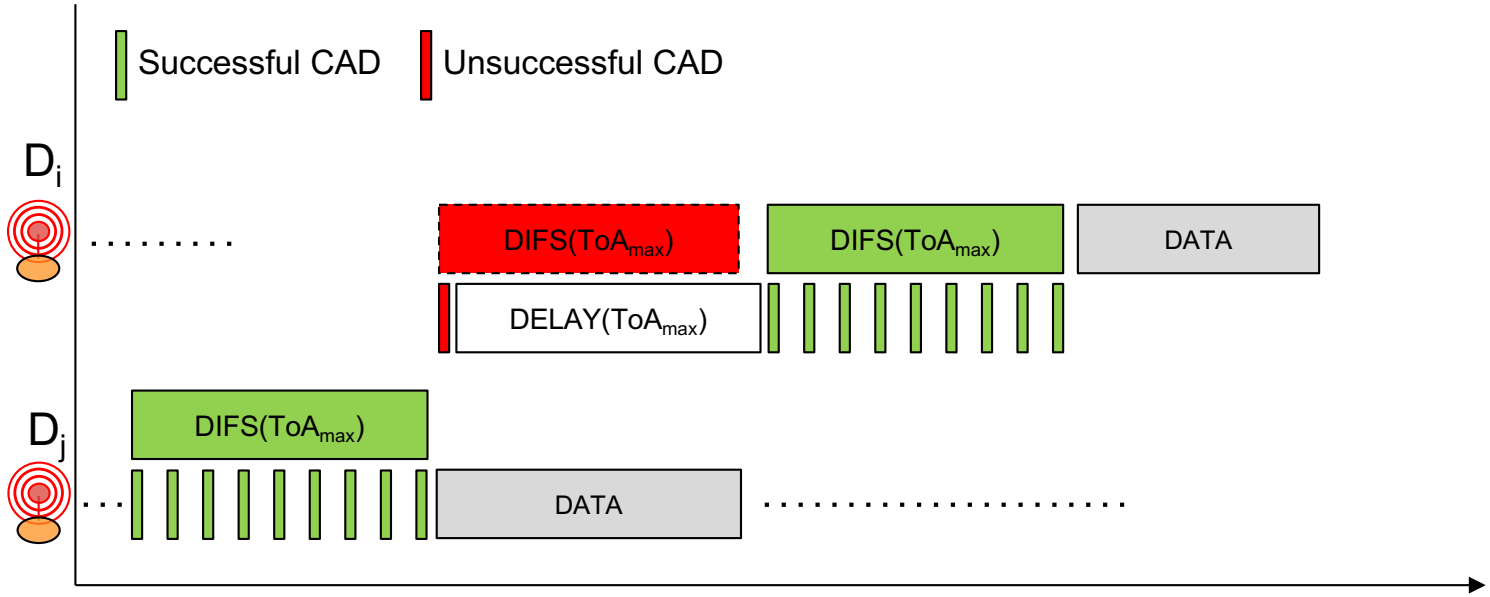
- With densier LoRa networks and more heterogeneous traffic (traditional+image sensors) it is necessary to provide a more robust channel access mechanism
- Objectives are to reduce packet collisions, thus reducing delivery latency, and reduce power consumption due to unsuccessfull transmissions

CSMA-BASED DERIVED FROM 802.11

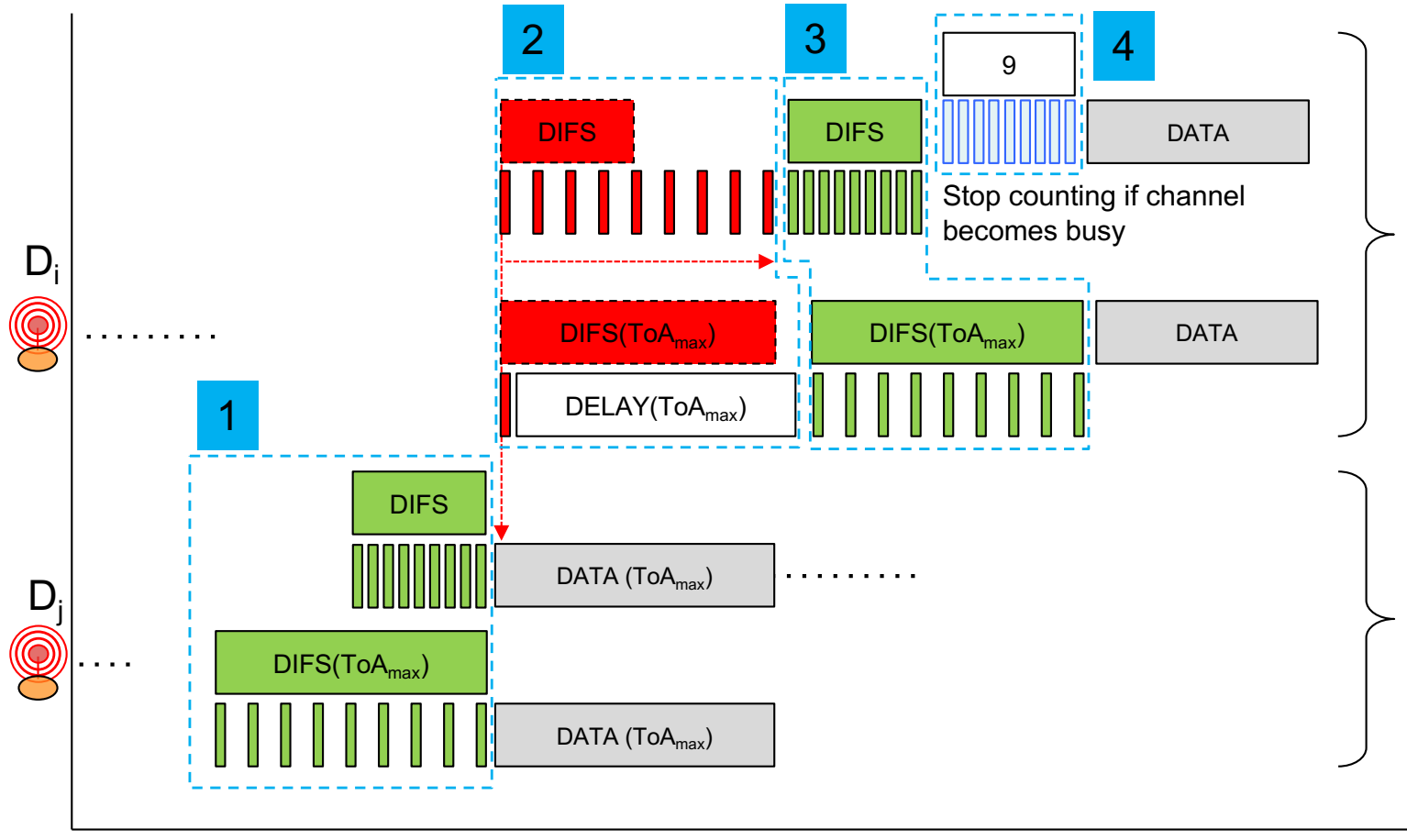


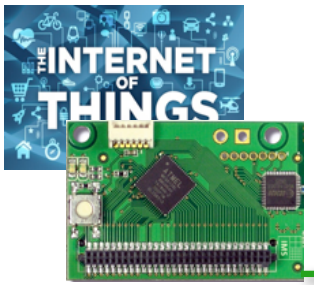
CSMA-BASED ADAPTED TO LONGER MSG





CSMA ALTERNATIVES & COMPARISON

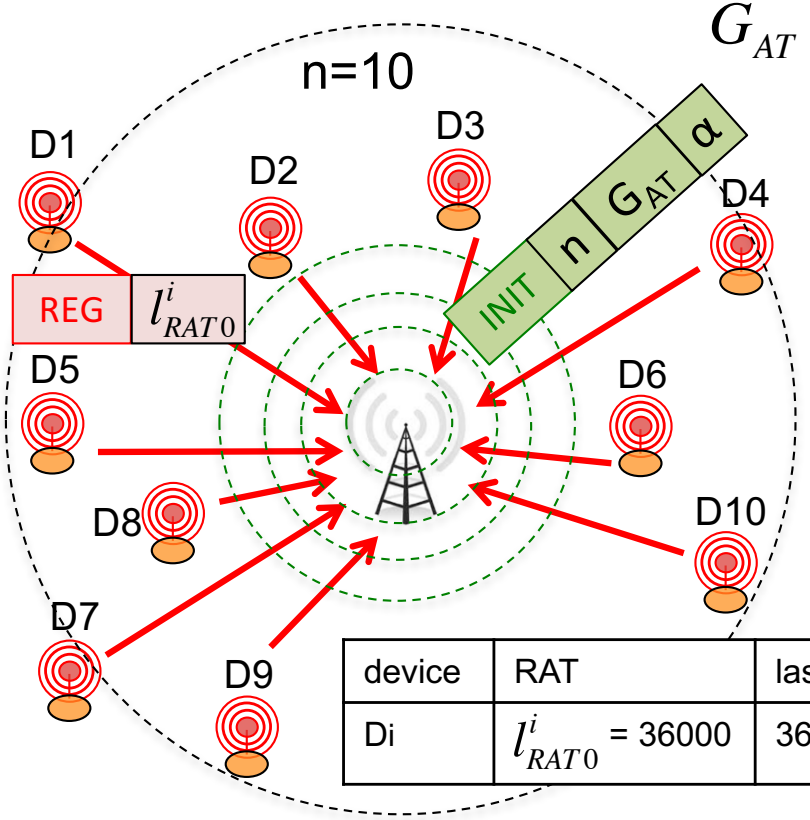




Quality of Service

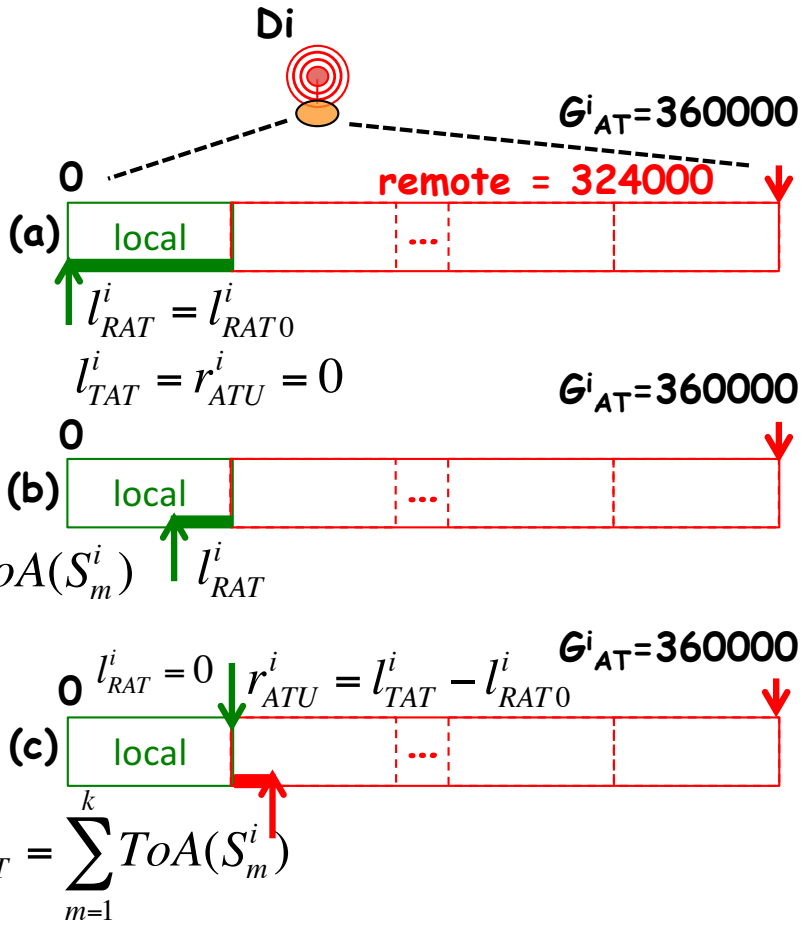
- Regulations stipulate that radio activity duty-cycle should be enforced at devices.
- LoRaWAN specification from LoRa Alliance is a first attempt to standardize LoRa networks but no issues on quality of service.
- Proposition of a Long-range Activity Sharing (LAS) mechanism when running under duty-cycle regulations
- Allow a device to be able to send critical data without having to wait for the next cycle

Long-range Activity Sharing (LAS)



device	RAT	lastRAT
Di	l^i_{RAT0} = 36000	36000

$$G_{AT} = \sum_{i=1}^{n} l^i_{RAT0}$$

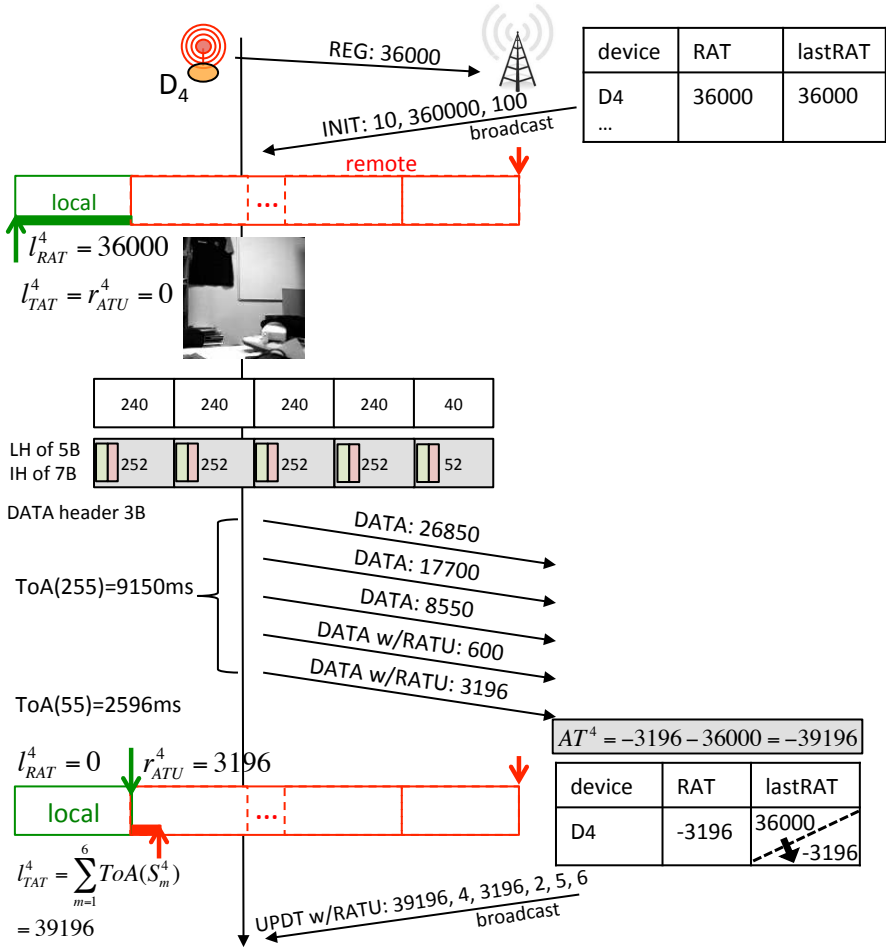


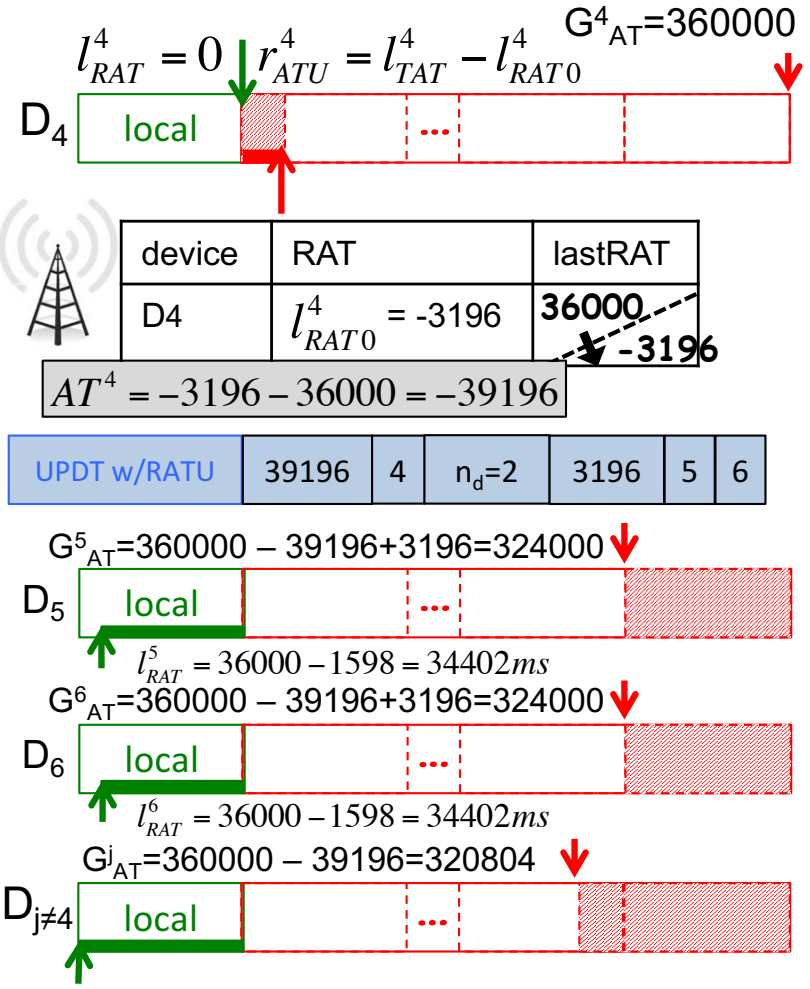
$$l^i_{TAT} = \sum_{m=1}^{k} ToA(S^i_m)$$

$$l^i_{TAT} = \sum_{m=1}^{k} ToA(S^i_m)$$

A device can transmit more if needed, provided that other devices will decrease their radio activity time accordingly.

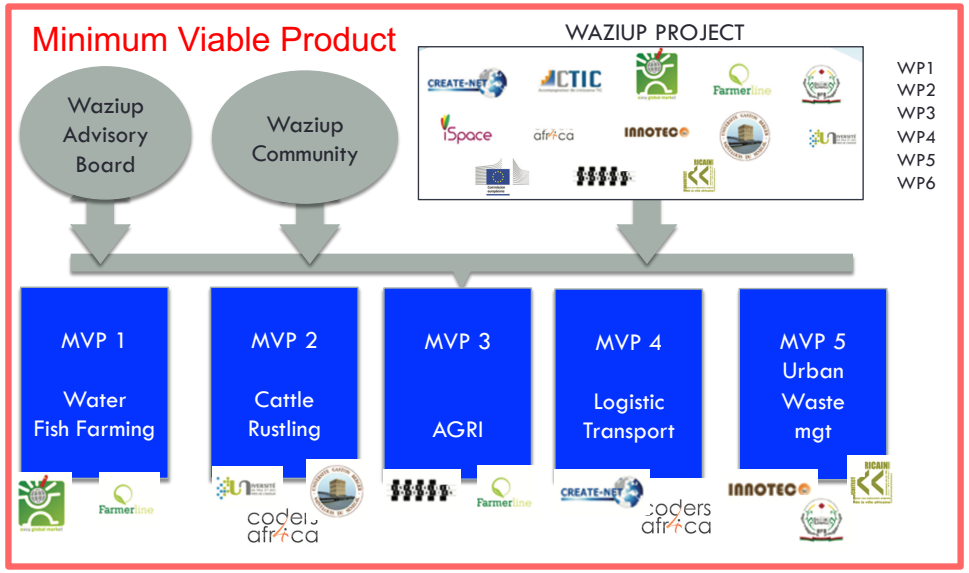
Distributing Remote Activity Time Usage





AND MUCH MORE!

- The WAZIUP IoT platform can be adapted/tailored/extended for specific vertical IoT domains in a production/business context



- The flexibility of the IoT platform allows for easy prototyping and fast integration of innovative research propositions

Thanks.

Let's keep in touch

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