WAZIUP: deploying low-cost IoT in Developing countries

Seminar at LIG, Grenoble, France
April 24th, 2018

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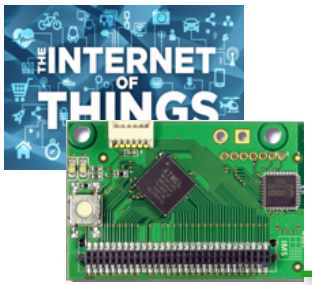
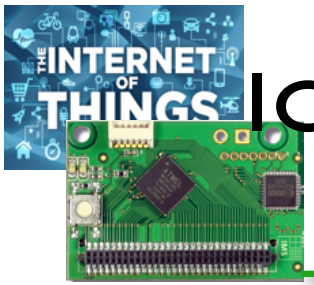
Université de Pau, France



WAZIUP: LOW-COST IOT

ABOUT » TECHNOLOGIES » COMMUNITY NEWS & EVENT » DOWNLOADS DEV KIT FAQ CONTACT

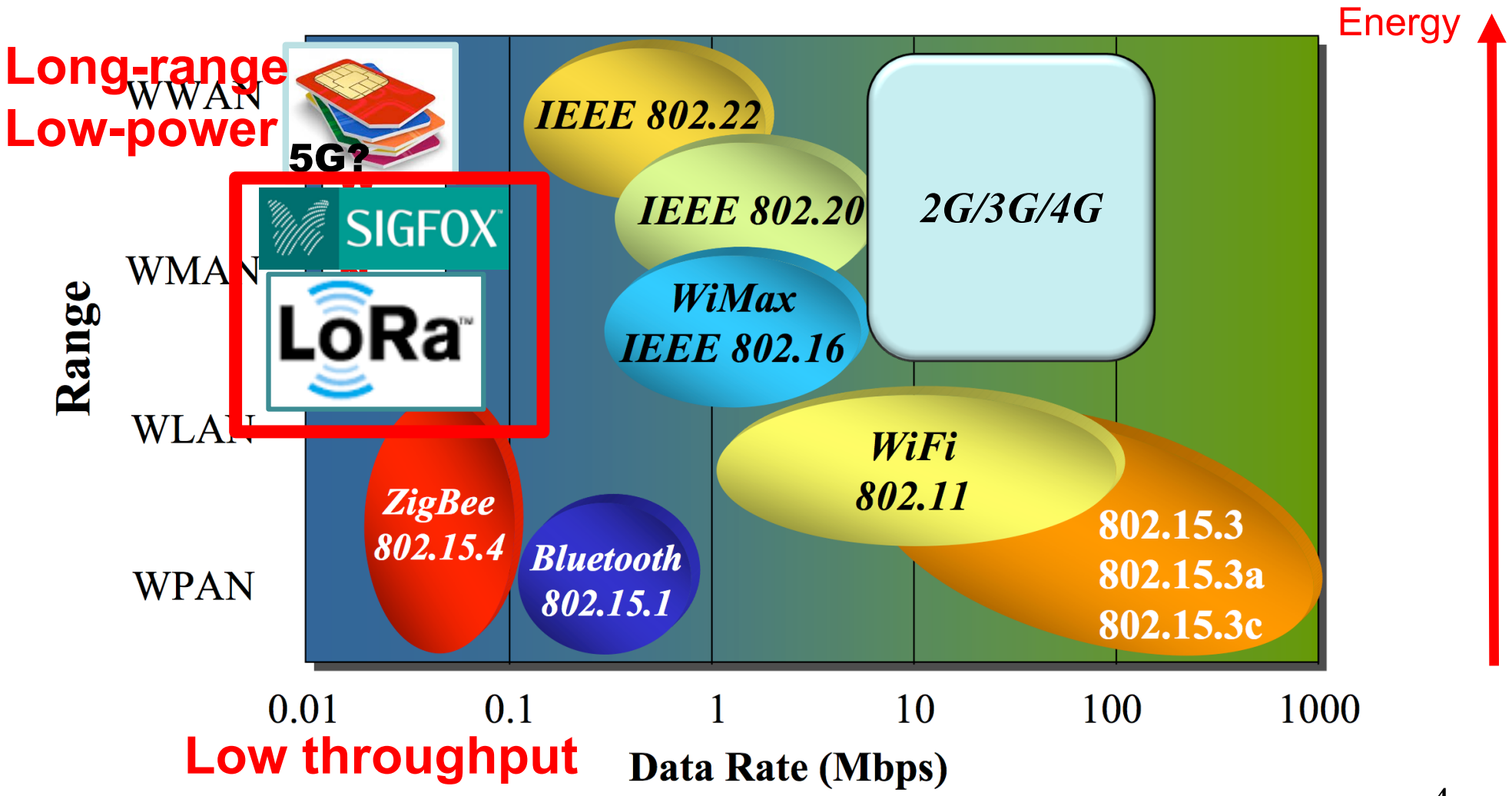


IoT IN DEVELOPING COUNTRIES AND RURAL AREAS

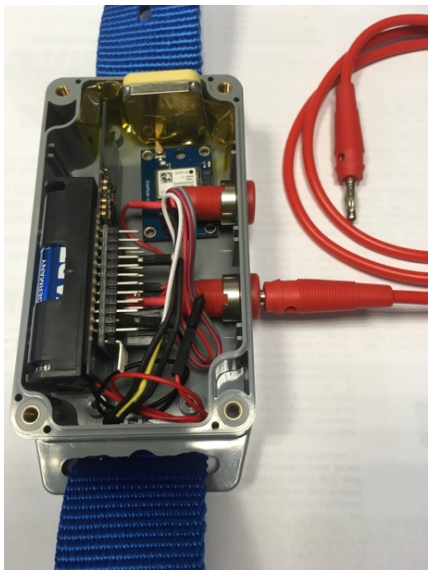
- Developing countries/rural areas are still far from being ready to enjoy the smallest benefit of IoT
  - lack of infrastructure
  - high cost of hardware
  - complexity in deployment
  - lack of technological eco-system and background
- **to deploy IoT in developing countries, it is necessary to target three major issues**
  - **reduce cost of infrastructures, hardware and services**
  - **limit dependancy to proprietary infrastructures and provide local interaction models**
  - **target technology appropriation, push for local business models**

LOW-POWER & LONG-RANGE RADIO TECHNOLOGIES

Energy-Range dilemma

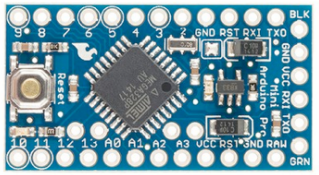


Low-cost IoT devices



LARGE ECOSYSTEM, STILL GROWING...

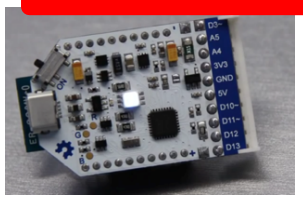
Arduino Pro Mini



LoPy

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

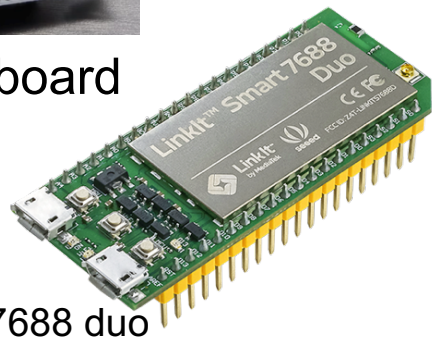
http://blog.atmel.com/2015/04/09/25-dev-boards-to-help-you-get-started-on-your-next-iot-project/



Theairboard

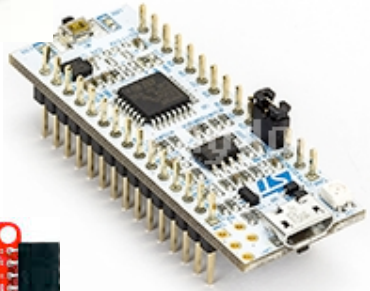
Teensy 3.2

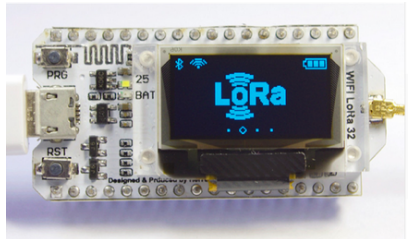
Expressif ESP32



LinkIt Smart7688 duo

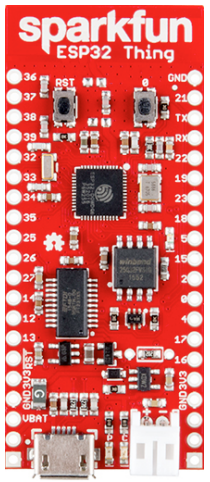
STM32 Nucleo-32





Heltec ESP32 + OLED

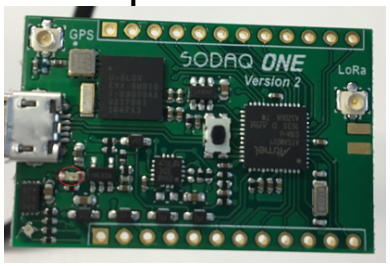
Adafruit Feather



Sparkfun ESP32 Thing

Tessel

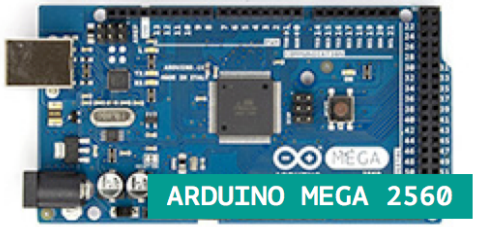
SodaqOnev2

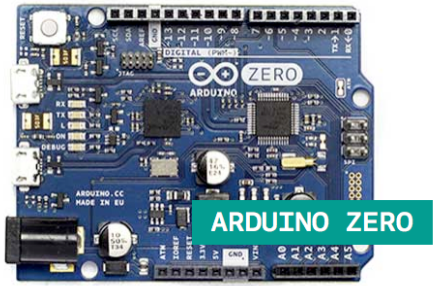


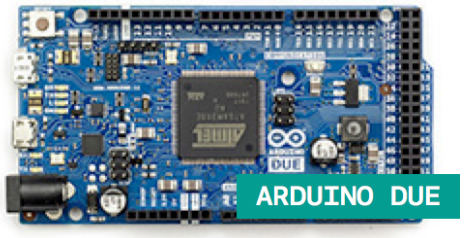
Tinyduino

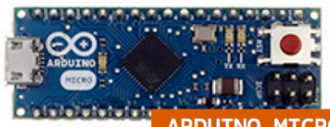
WAZIUP PROVIDES SW/HW BUILDING BLOCKS INTEGRATION


ARDUINO UNO

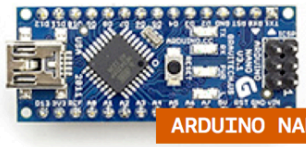

ARDUINO MEGA 2560

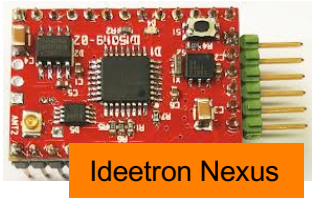

ARDUINO ZERO


ARDUINO DUE


ARDUINO MICRO


ARDUINO PRO MINI


ARDUINO NANO


Ideetron Nexus


TeensyLC/3.1/3.2

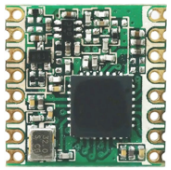

Adafruit Feather 32u4/M0

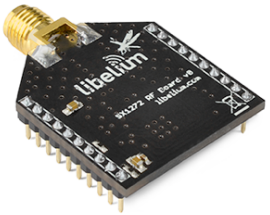

Expressif ESP8266/ESP32

More to come…

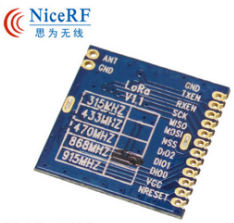
LoRa

LoRa radios that our library already supports


HopeRF RFM92W/95W


Libelium LoRa


Modtronix inAir9/9B



NiceRF LoRa1276

Long-Range communication library

READY-TO-USE TEMPLATES

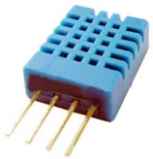
Moisture/
Temperature of
storage areas

10-15kms

Physical sensor

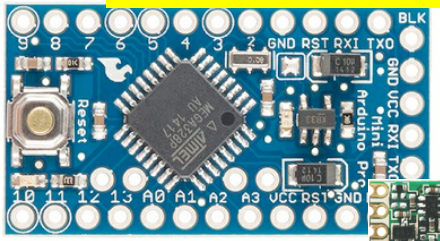
Physical sensor

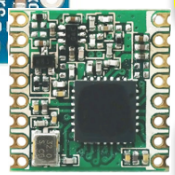
Physical sensor



Physical sensor mgmt

Arduino Pro Mini @3.3V





VERY IMPORTANT

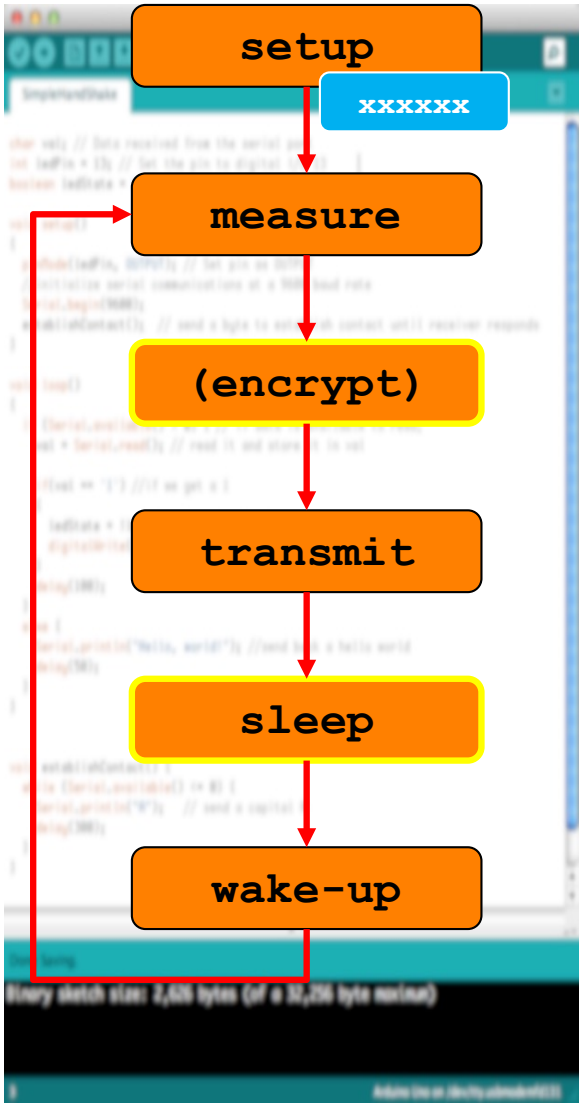
Activity duty-cycle, low power

VERY IMPORTANT

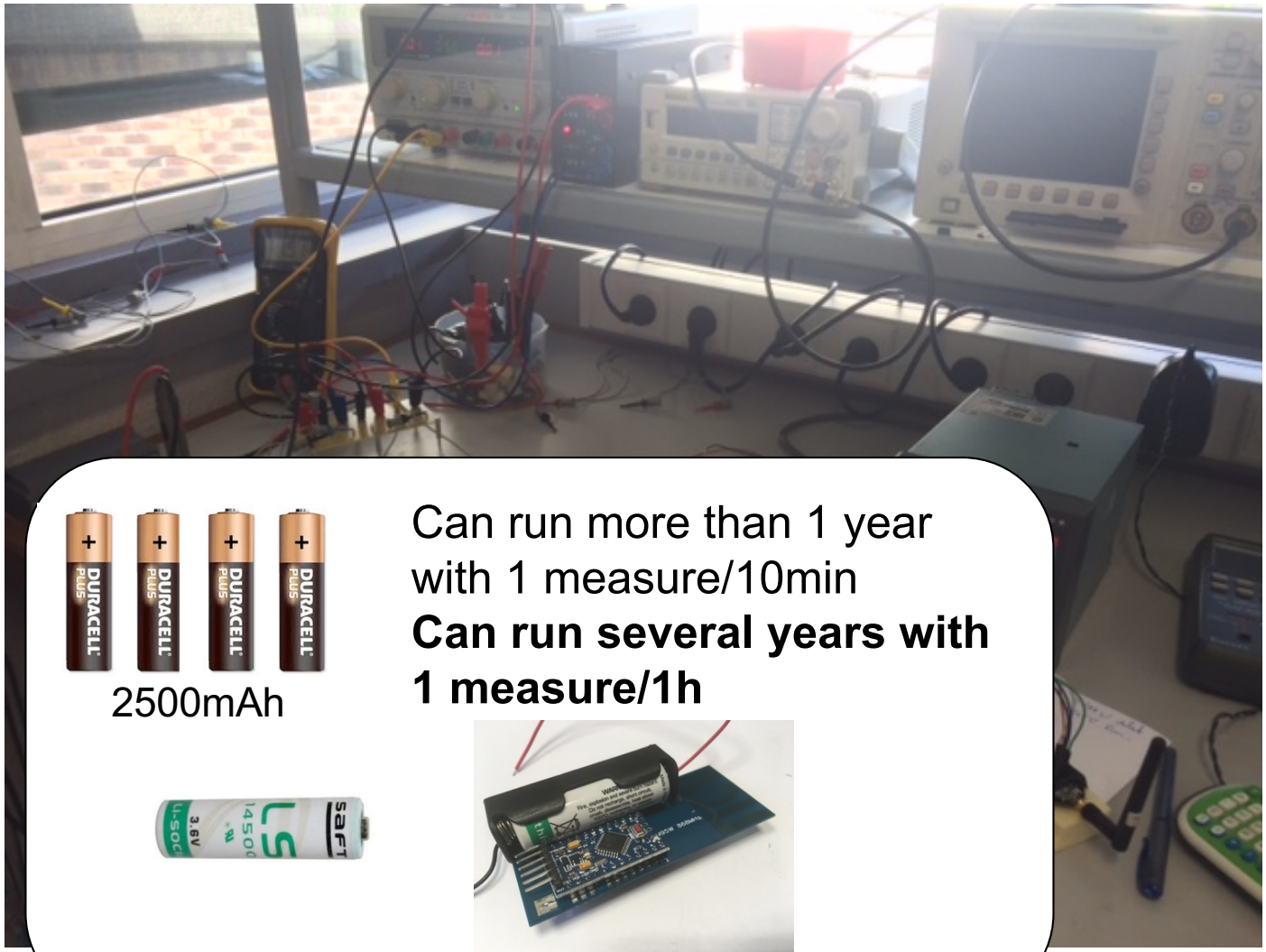
AES encryption

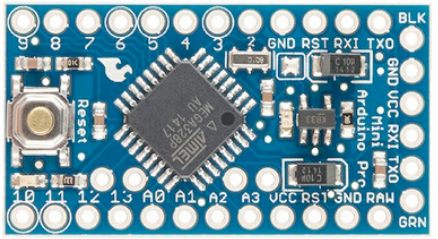
Long-range transmission

Logical sensor mgmt

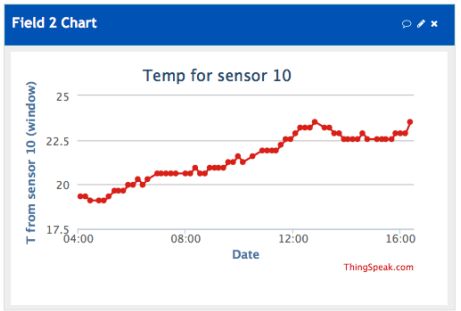


Low-power for longer lifetime!





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



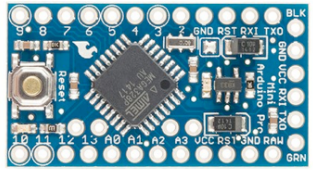
2500mAh

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!

A SIMPLE TEMPERATURE SENSOR EXAMPLE

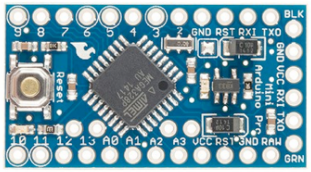
Arduino Pro Mini @3.3V



Modtronix inAir9

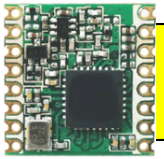
TMP36

LOW-COST INTEGRATION

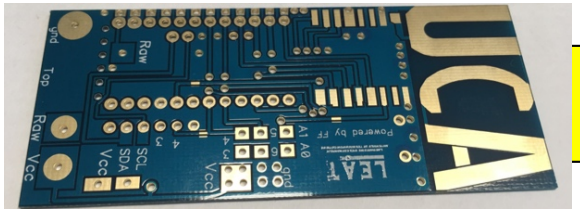


1.5€

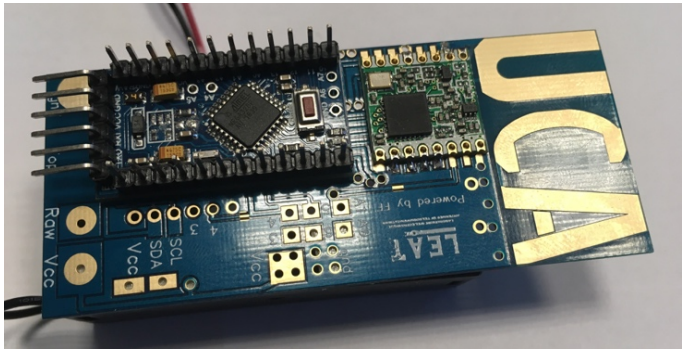
https://github.com/FabienFerrero/UCA_Board

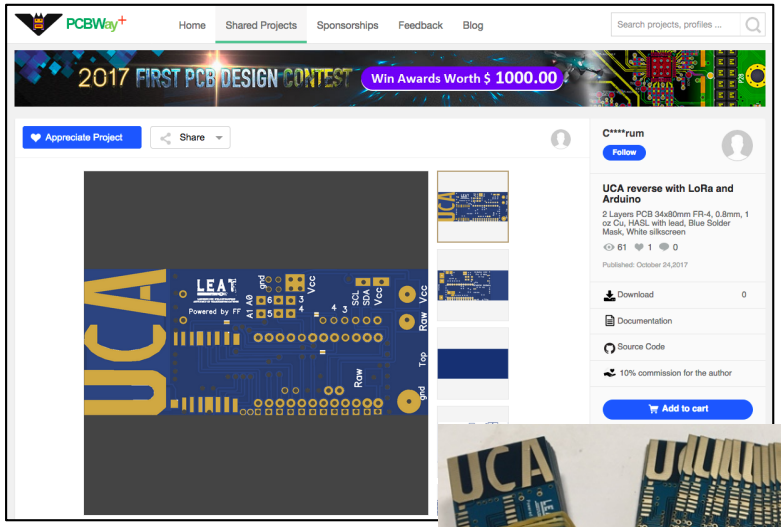


5€

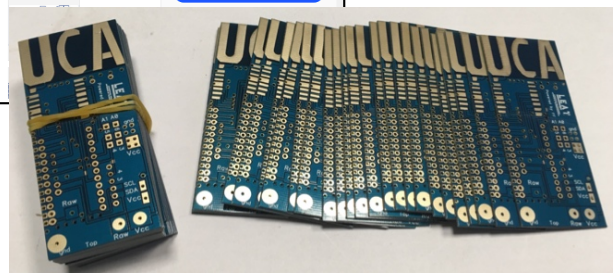


1€

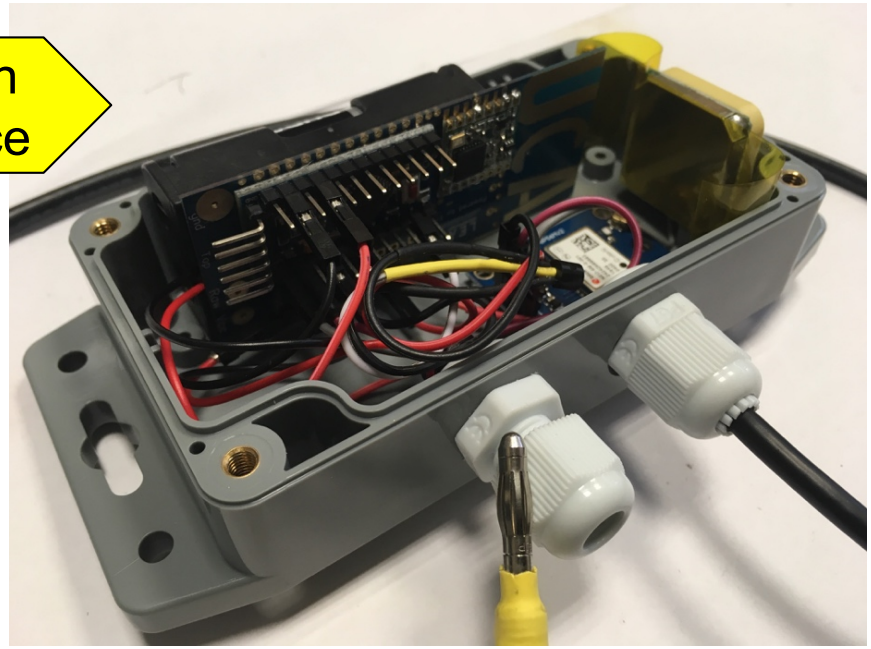




1-click order

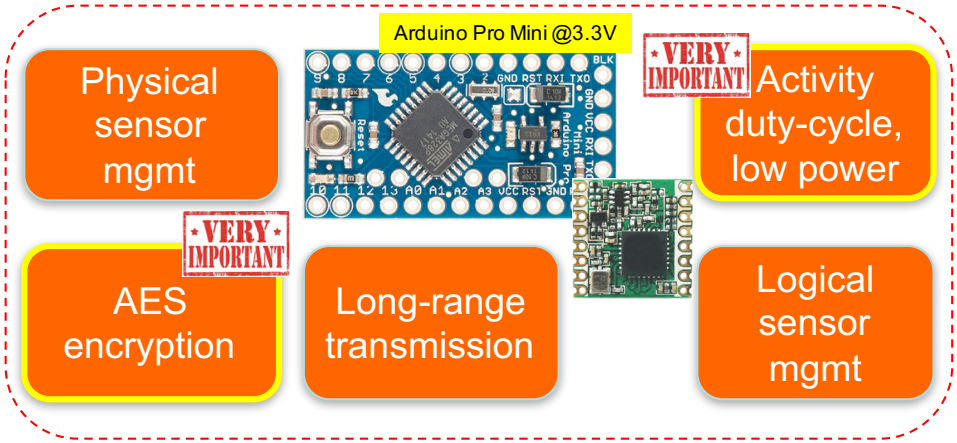


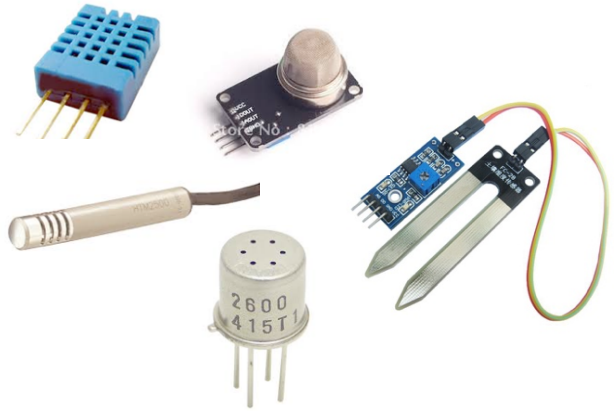
Less than 10€/device



Generic sensing IoT device vs Highly specialized

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





Generic sensing IoT device vs Highly specialized

- Build low-cost, low-power, **long-range** enabled generic platform
- Me
- Tec
  ecc

Minimum Viable Product

Waziup Advisory Board

Waziup Community

WAZIUP PROJECT

WP1
WP2
WP3
WP4
WP5
WP6

Physical sensor mgmt

VERY IMPORTANT

AES encryption

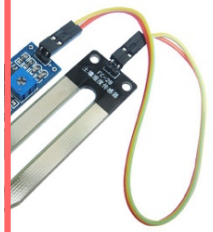
MVP 1 Water Fish Farming

MVP 2 Cattle Rustling

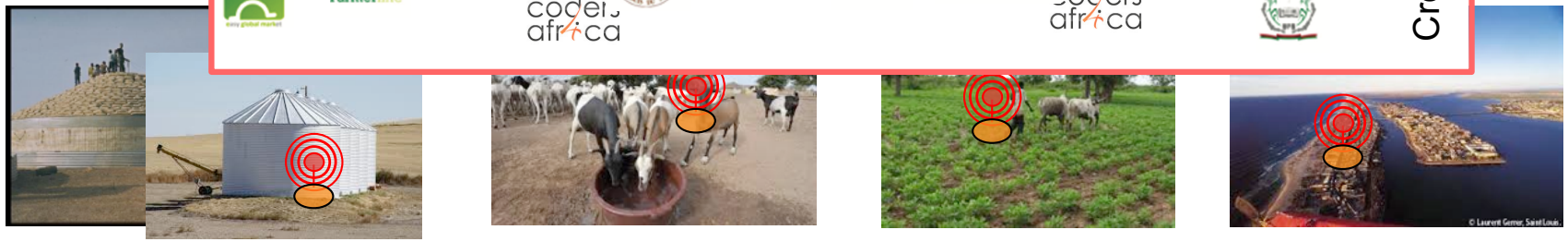
MVP 3 AGRI

MVP 4 Logistic Transport

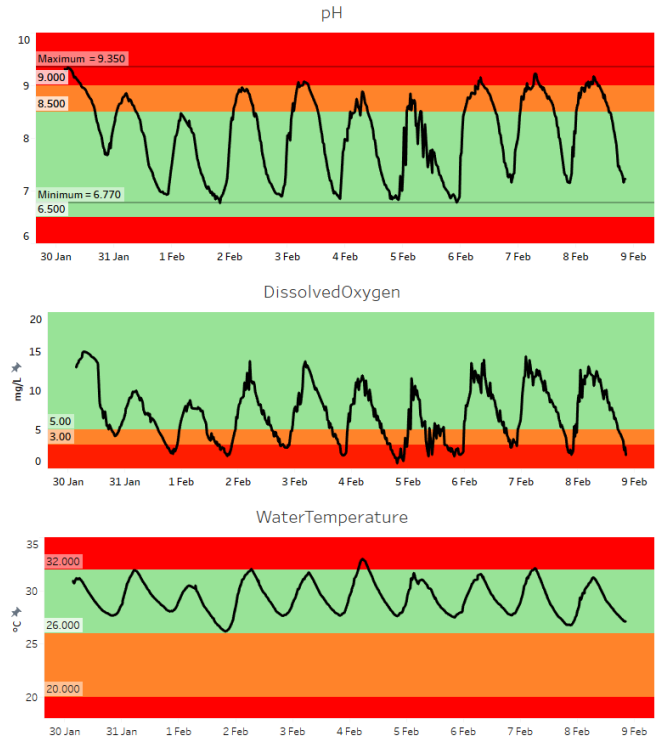
MVP 5 Urban Waste mgt



Credit: P. Cousin, EGM



Low-cost buoy for fish farming MVP



Physical sensor reading

Credit: EGM

Physical sensor management

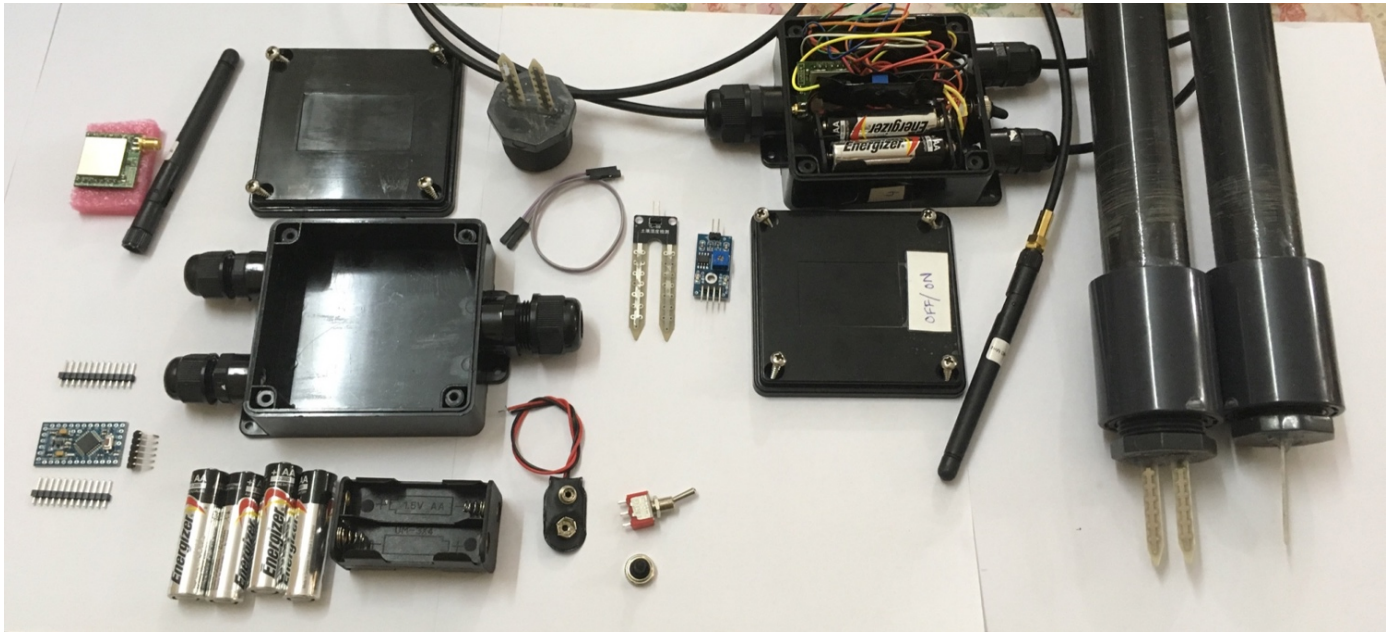
Activity duty-cycle, low power

Security

Long-range transmission

Logical sensor management

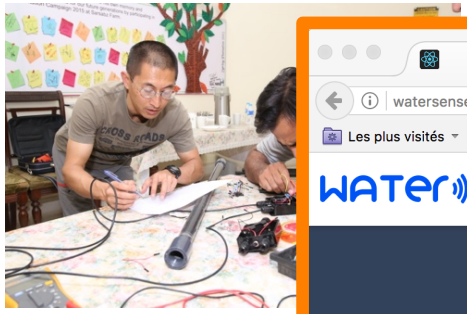
SOIL HUMIDITY SENSORS FOR AGRI MVP

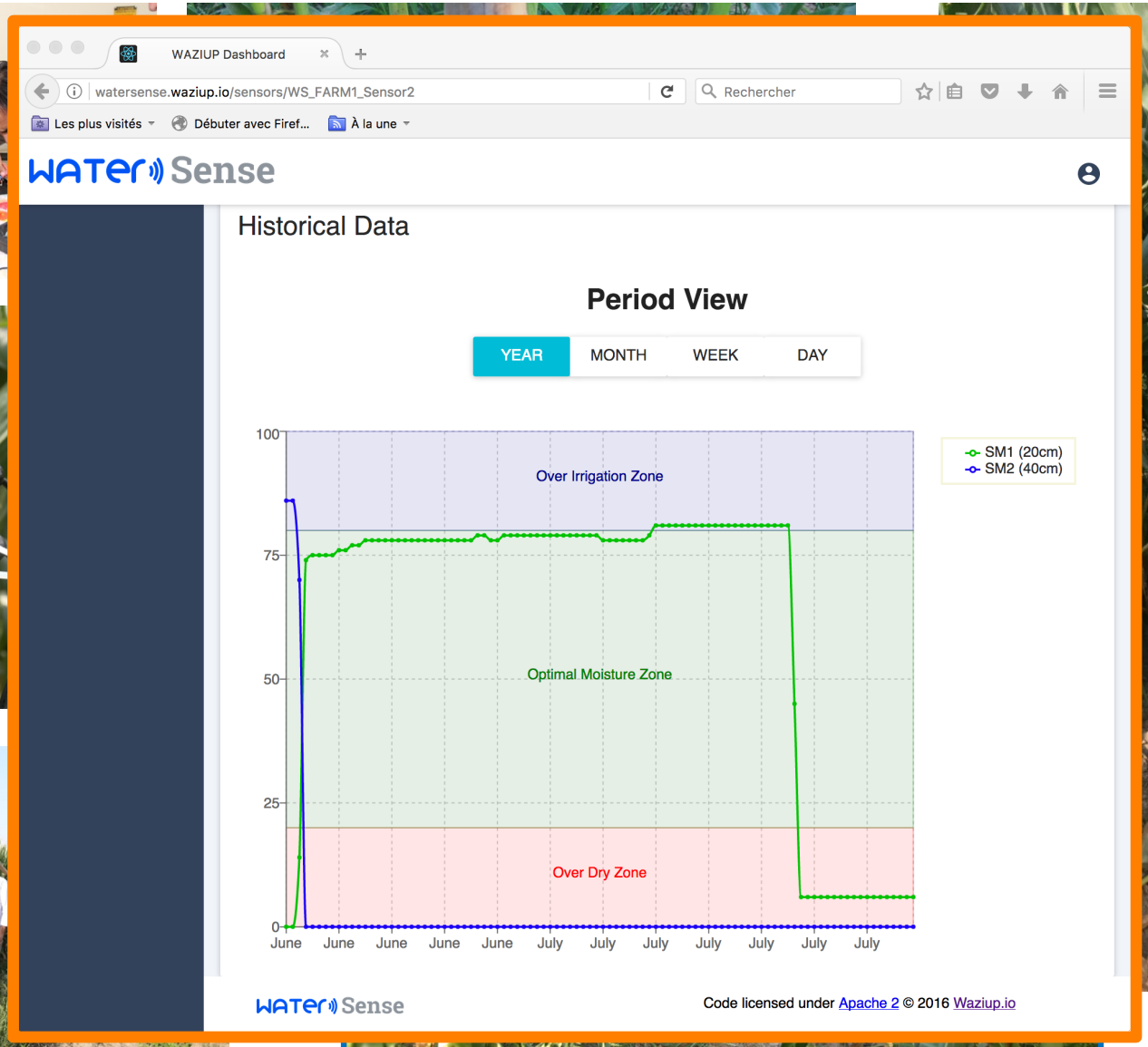


- Physical sensor management
- Activity duty-cycle, low power
- Security
- Long-range transmission
- Logical sensor management

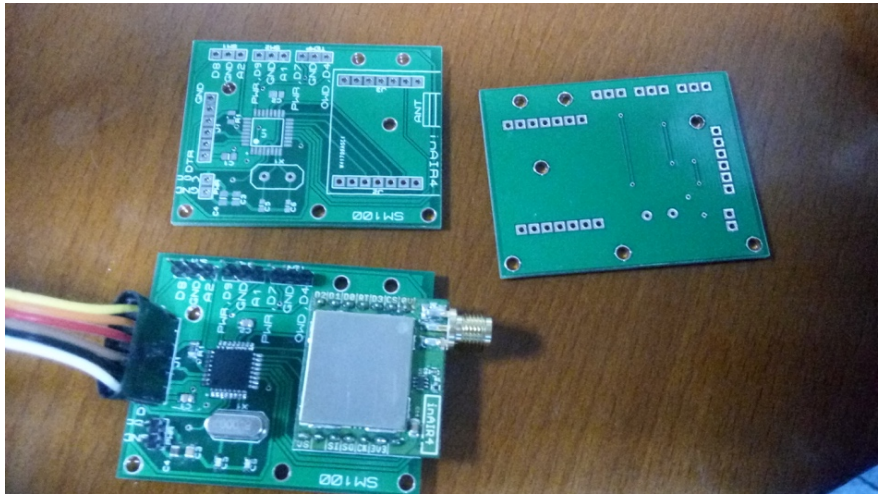
Deployment for Nestlé's WaterSense project

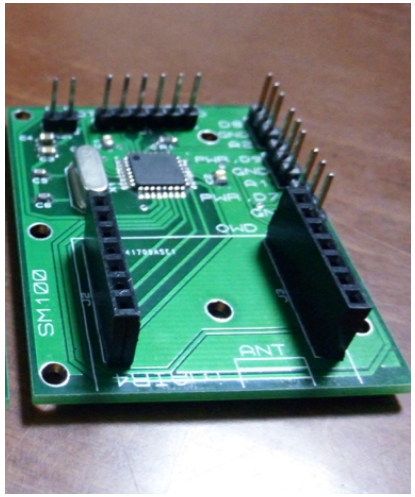
Deployment for Nestlé's WaterSense project

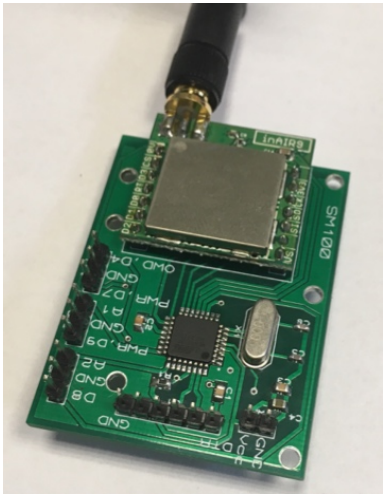


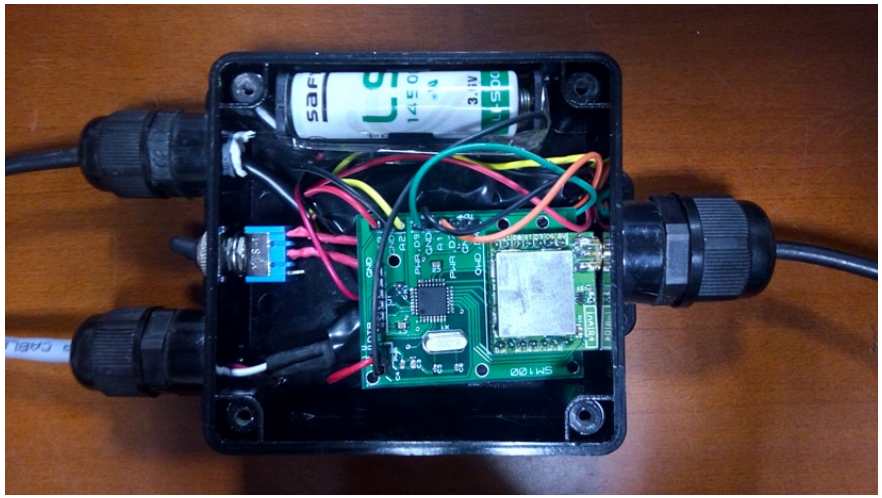


LOCAL INTEGRATION WITH TECHNOLOGY TRANSFER

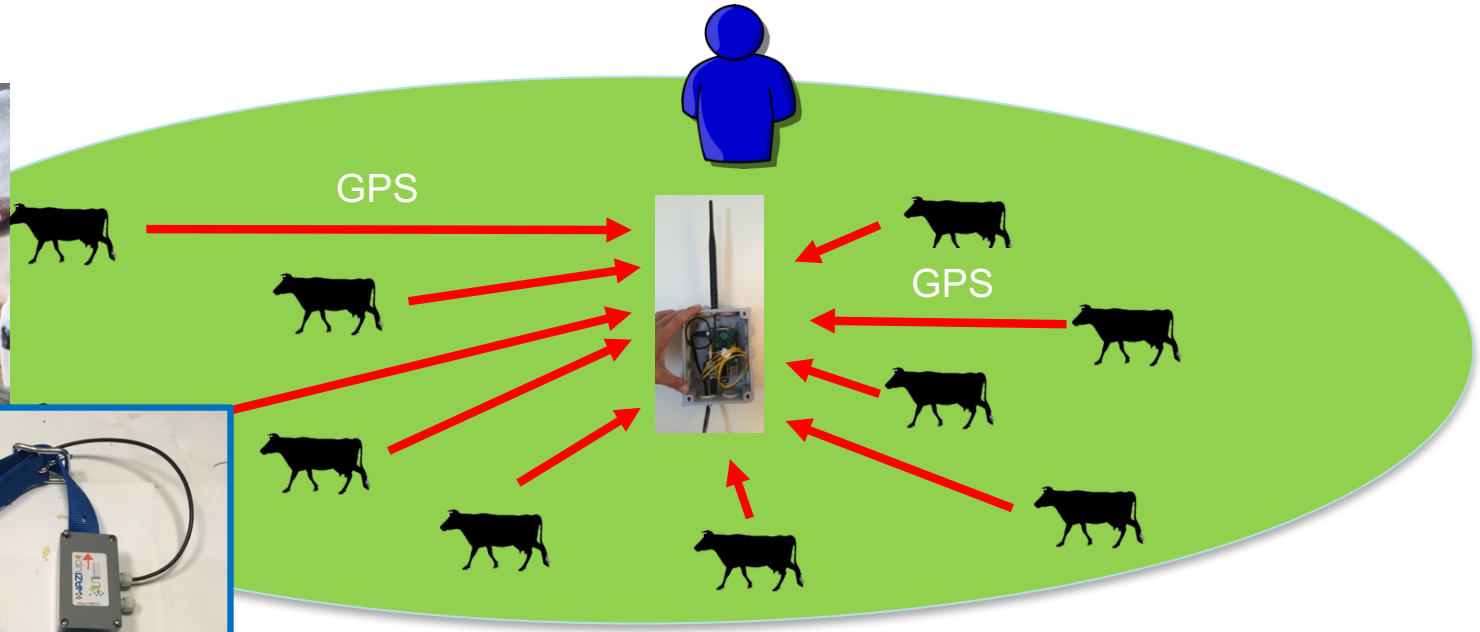








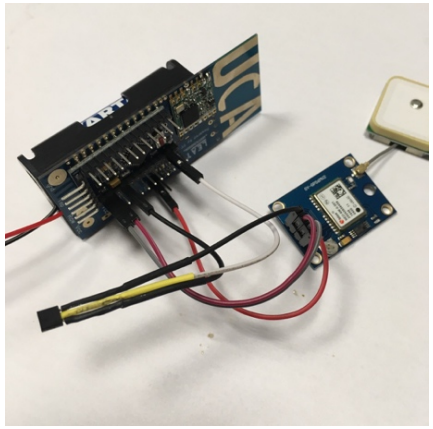
Collar for Cattle Rustling MVP

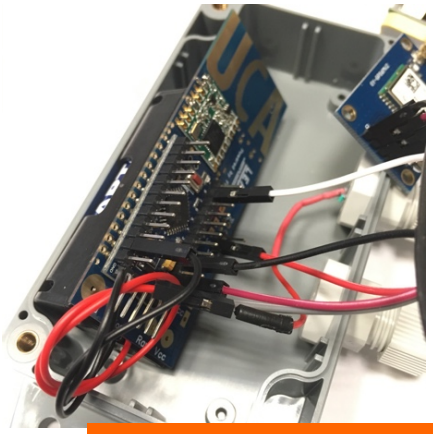


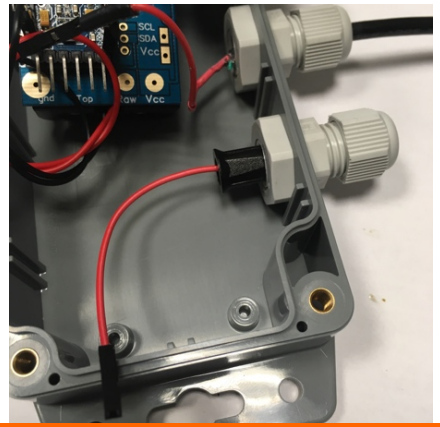
In Africa, the practice of animal husbandry has always been and still remain farmers' livelihood and incomes

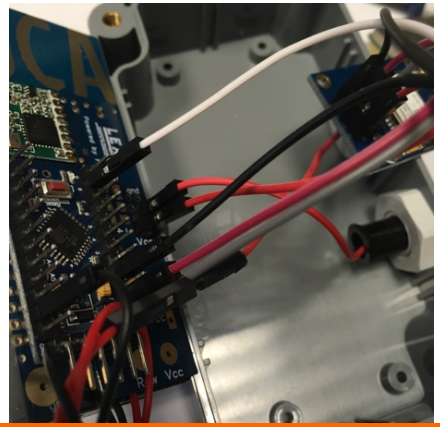
Their main problem in this activity remain the cattle rustling and some families are put in dramatic situation after a theft (reported 2 billions CFA losses)

Easy integration and customization

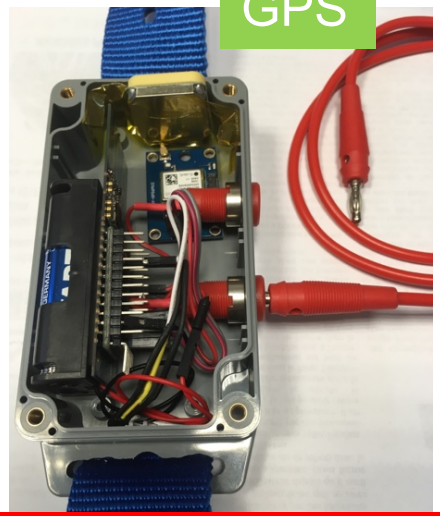


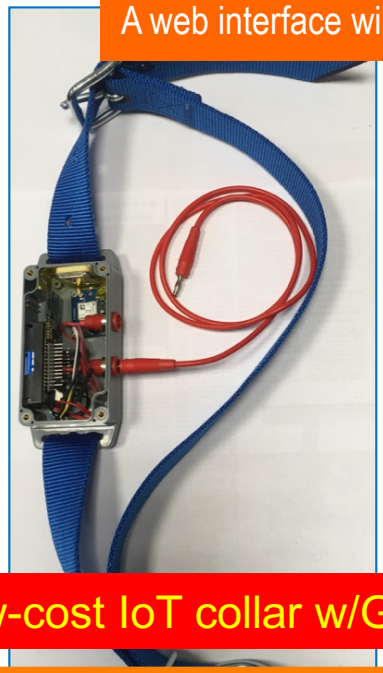






GPS



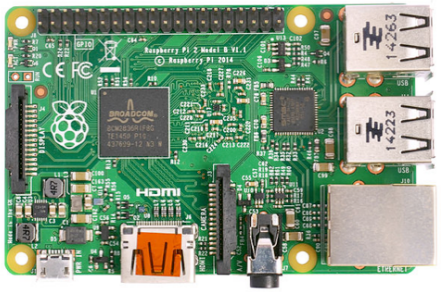


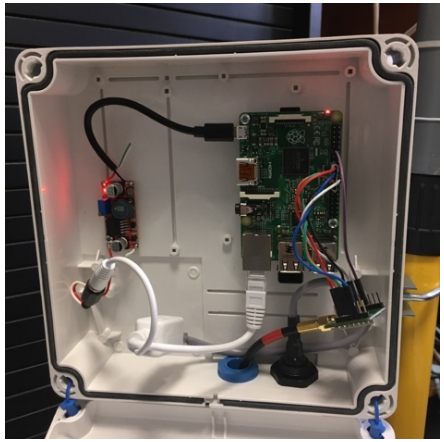
A web interface will display the position of the gateway and those of the remote GPS devices

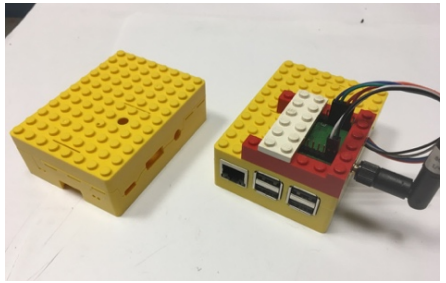
Dedicated tutorial on low-cost IoT collar w/GPS

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

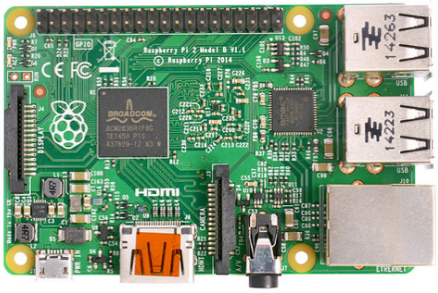
The versatile IoT gateway







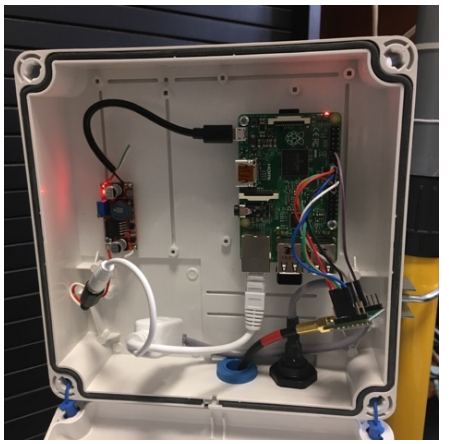
Raspberry-based low-cost LoRa gateway



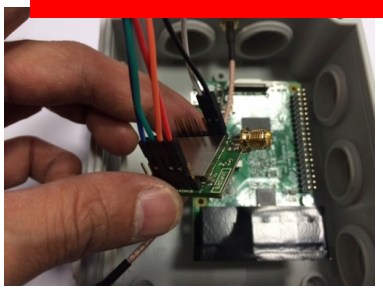
We can use all model of Raspberry. The most important usefull feature is the Ethernet interface for easy Internet connection. Then WiFi and Bluetooth can be added with USB dongles.
RPI3 provides built-in Ethernet, WiFi and Bluetooth!



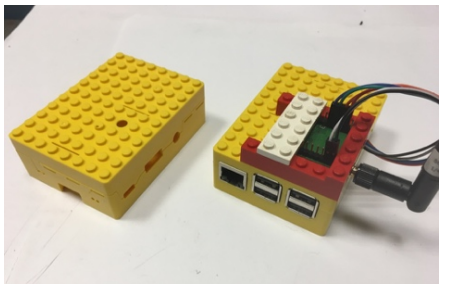




Less than 50€



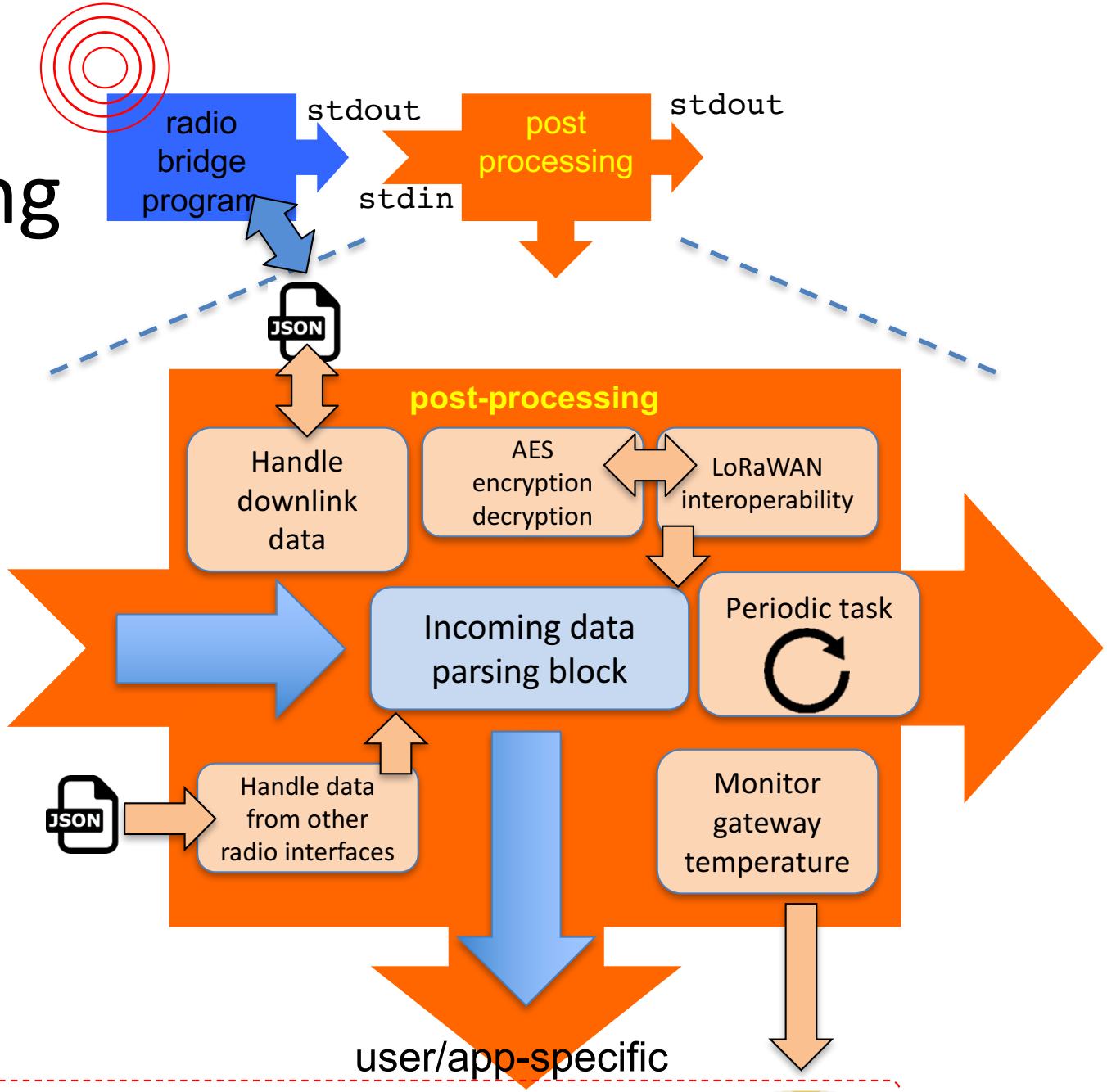




Get the ready-to-use SD card image

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

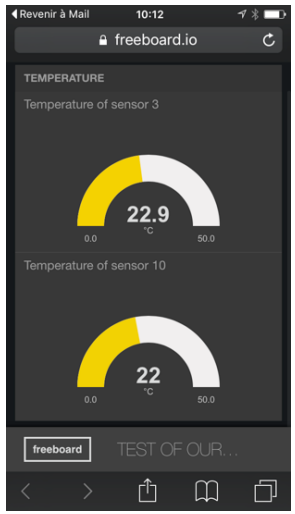
Post-processing stage



Cloud definition

cloud_script_1 | cloud_script_2 | cloud_script_n | WAZIUP | local database

Templates for various clouds



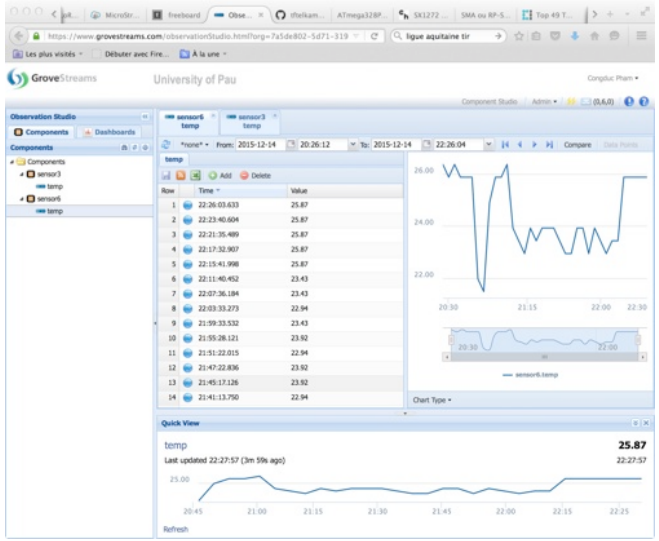
Dropbox

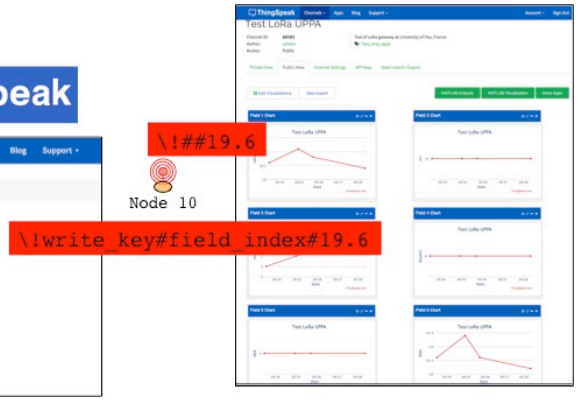
Firebase

SensorCloud™

freeboard

FIWARE





\!##19.6

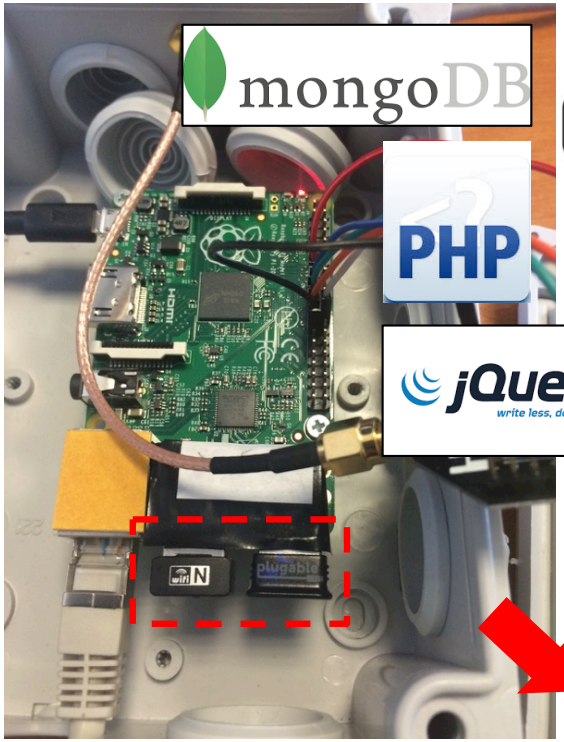
Node 10

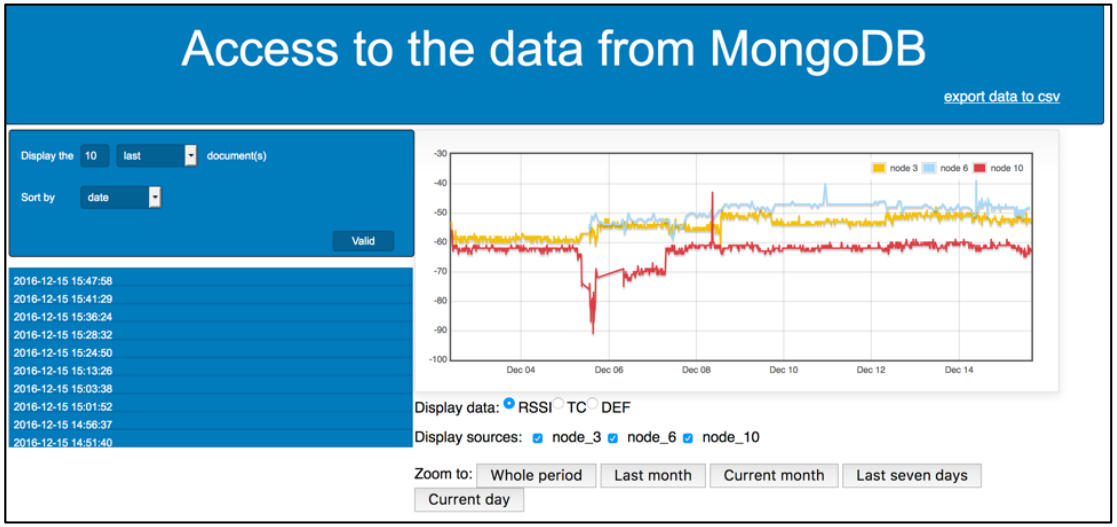
\!write_key#field_index#19.6

GroveStreams

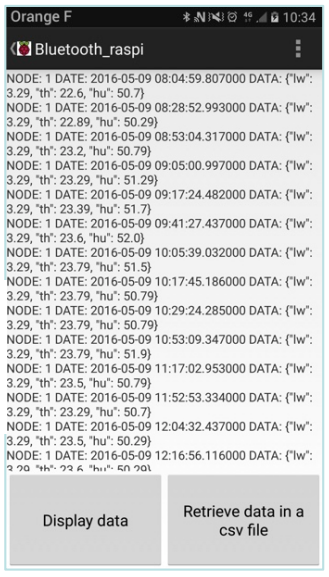
And much more: HTTP, FTP, MQTT, Node-Red…

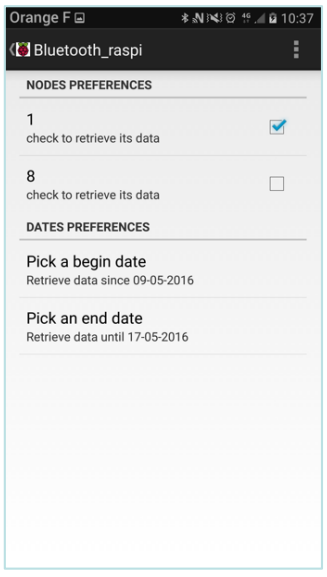
STANDALONE GATEWAY

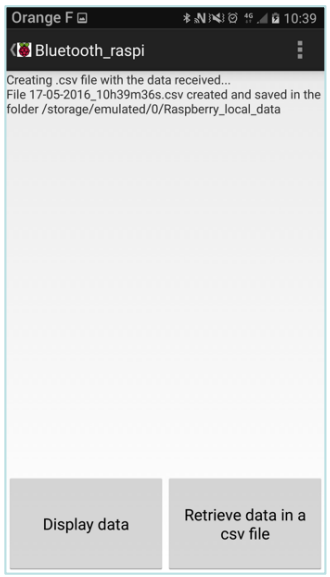


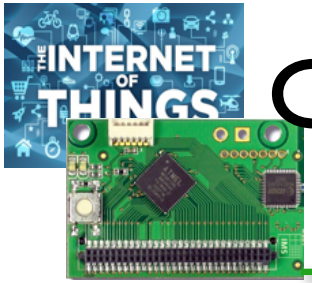


Isolated areas



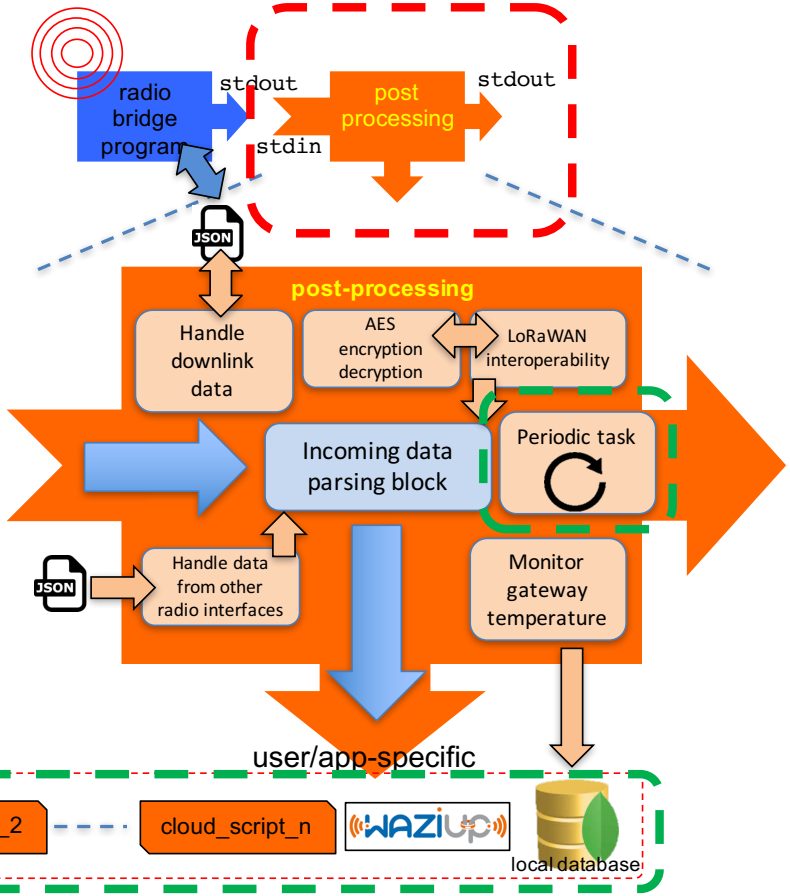






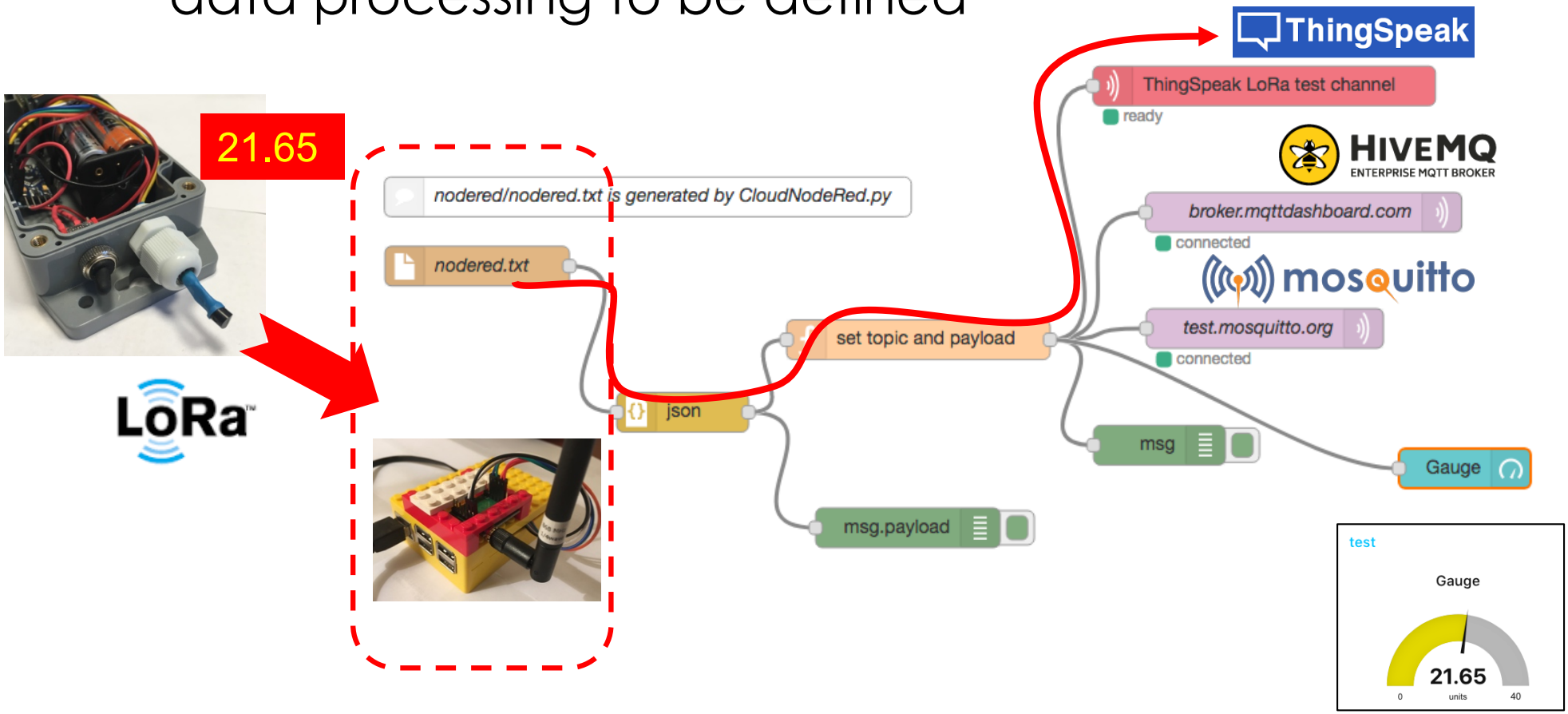
Customizing/Extending your gateway

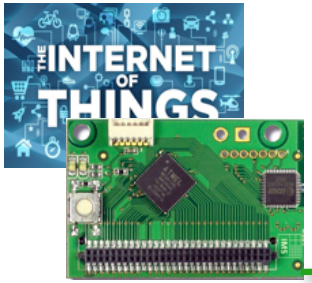
- The flexible gateway architecture offers high versatility by customization
- There are 3 options for customization
- The geek way
  - Modify/extend post-processing script
- The "smarter" way
  - Add "cloud" scripts
    - On packet reception
  - Add periodic tasks
    - Independant from packet reception



The Node-RED enabled gateway

- Messages received on the gateway can be injected into a Node-Red flow, allowing complex data processing to be defined

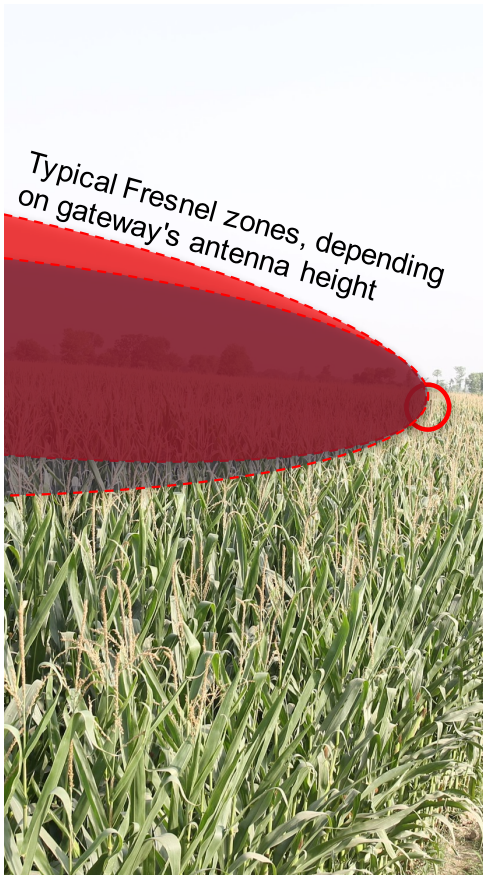




Research activities

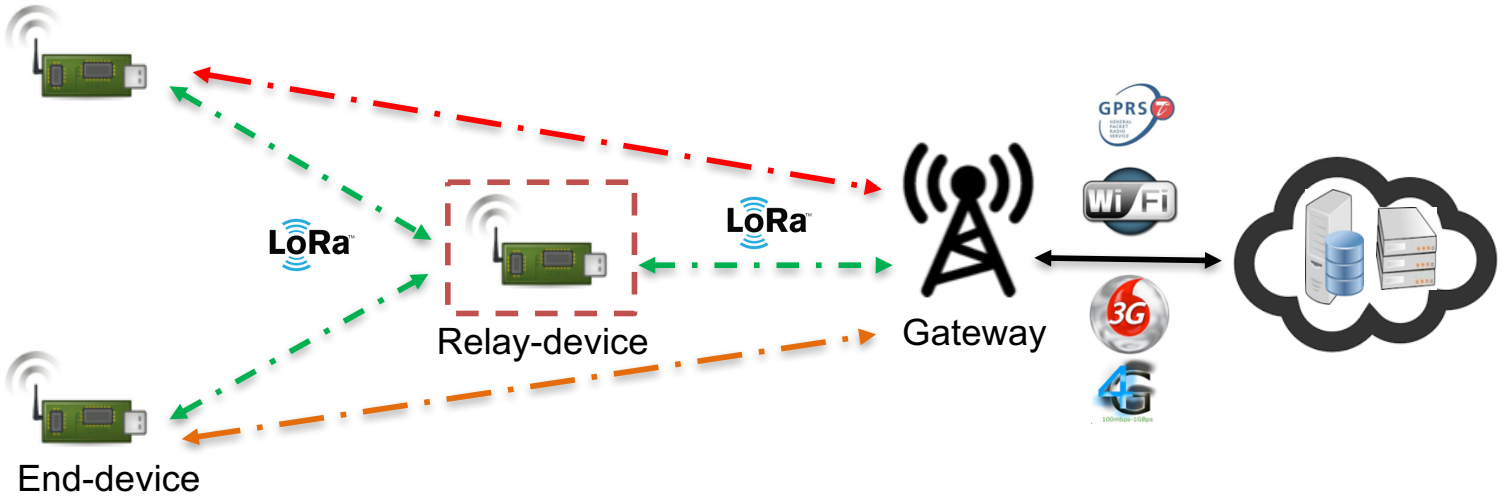
2-hop LoRa

- Provides 2-hop LoRa to solve some connectivity issues in real-world deployment scenario



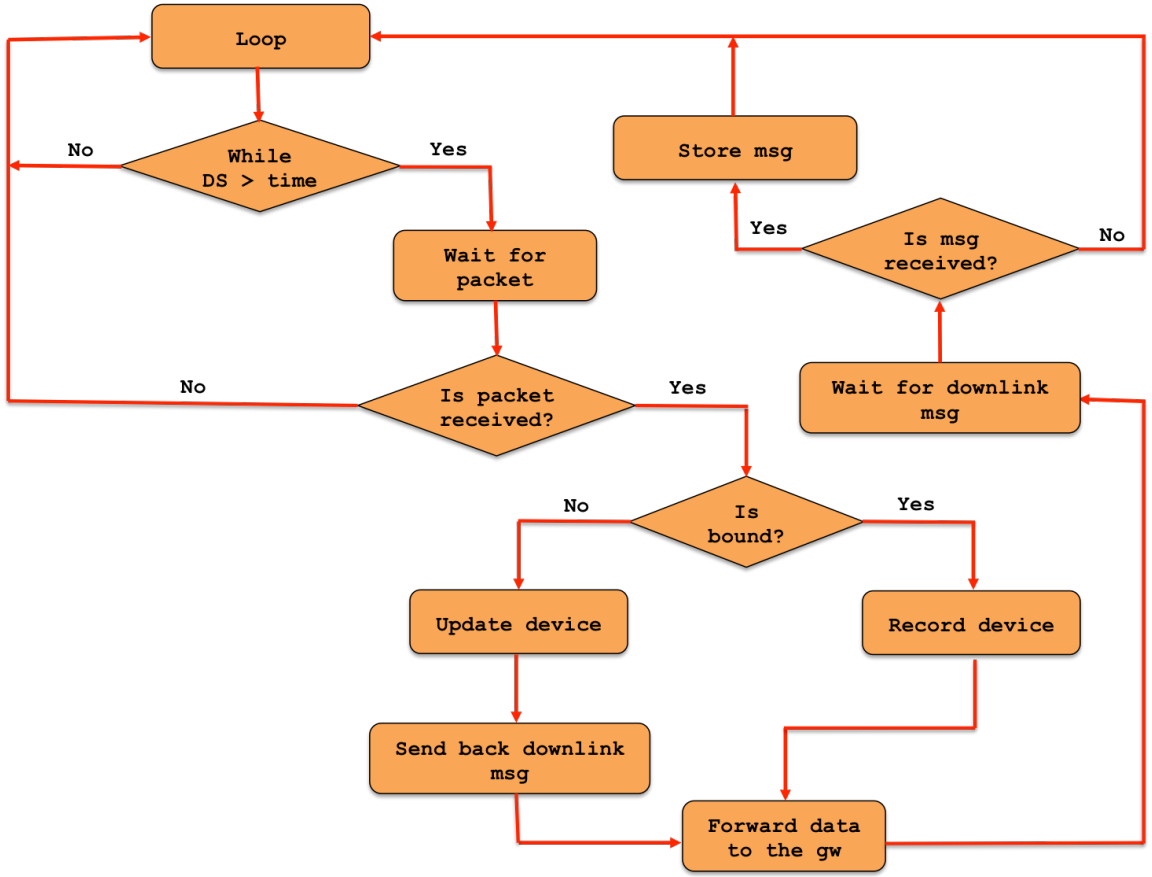
2-hop LoRA approach

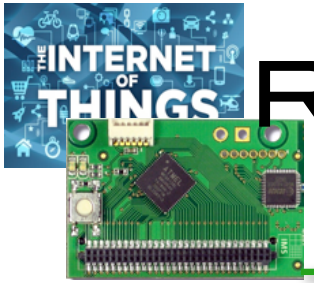
- Objective is to have a **smart, transparent** relay node that can be inserted at anytime between end-devices and gateway



Smart relay device learning on-the-fly

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





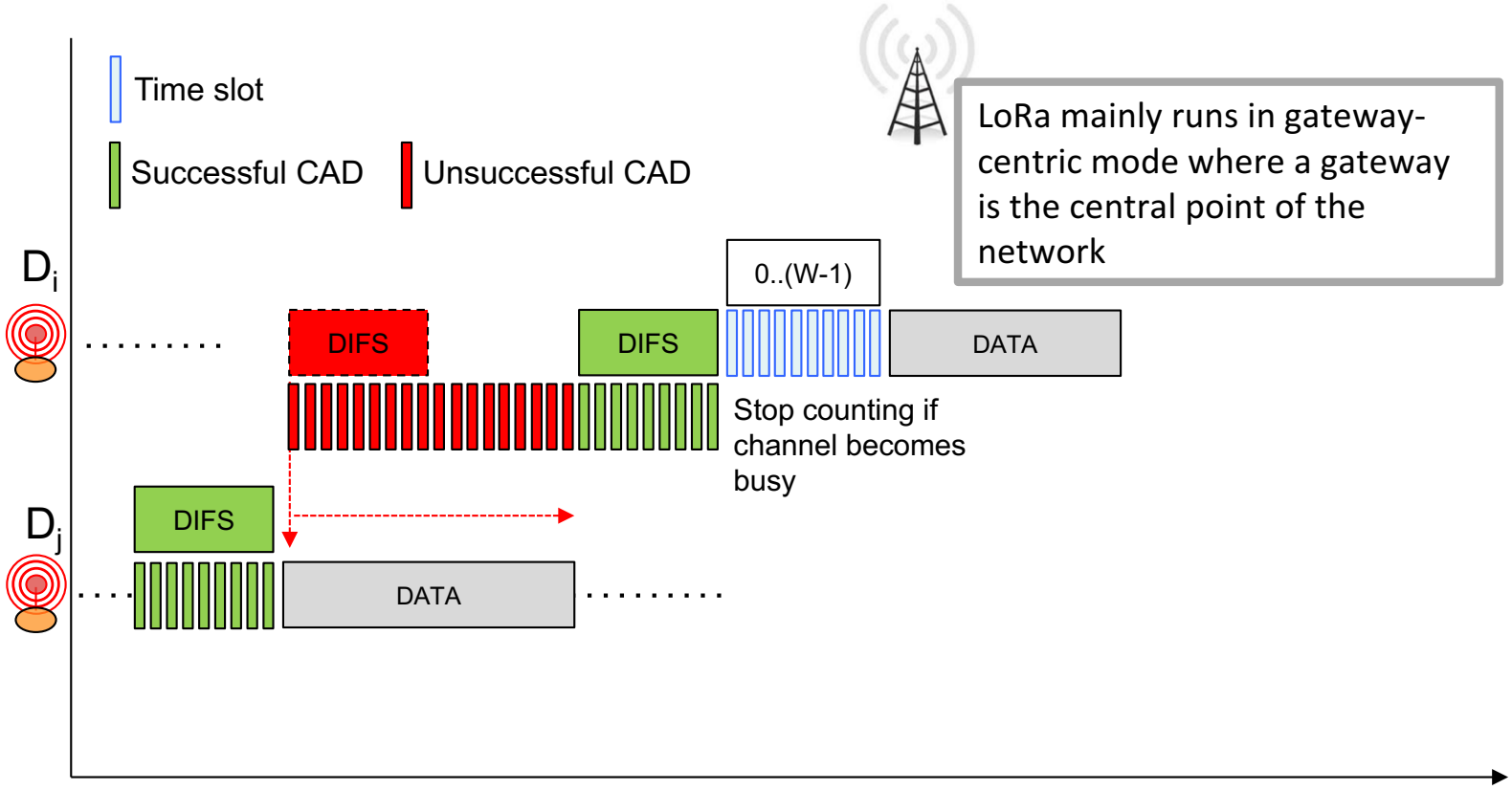
Robust channel access mechanisms

- 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

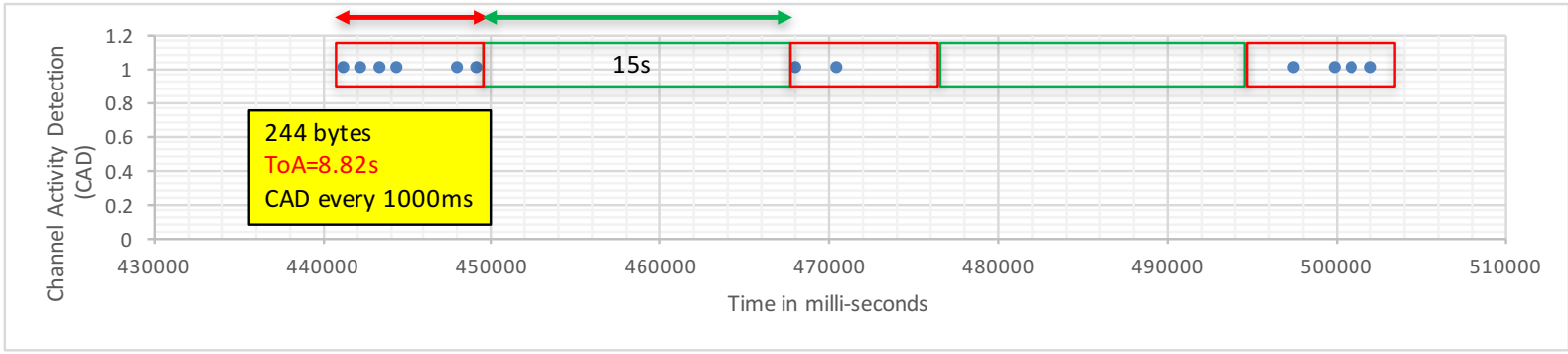
C. Pham, "Investigating and Experimenting CSMA Channel Access Mechanisms for LoRa IoT Networks", IEEE WCNC'2018.

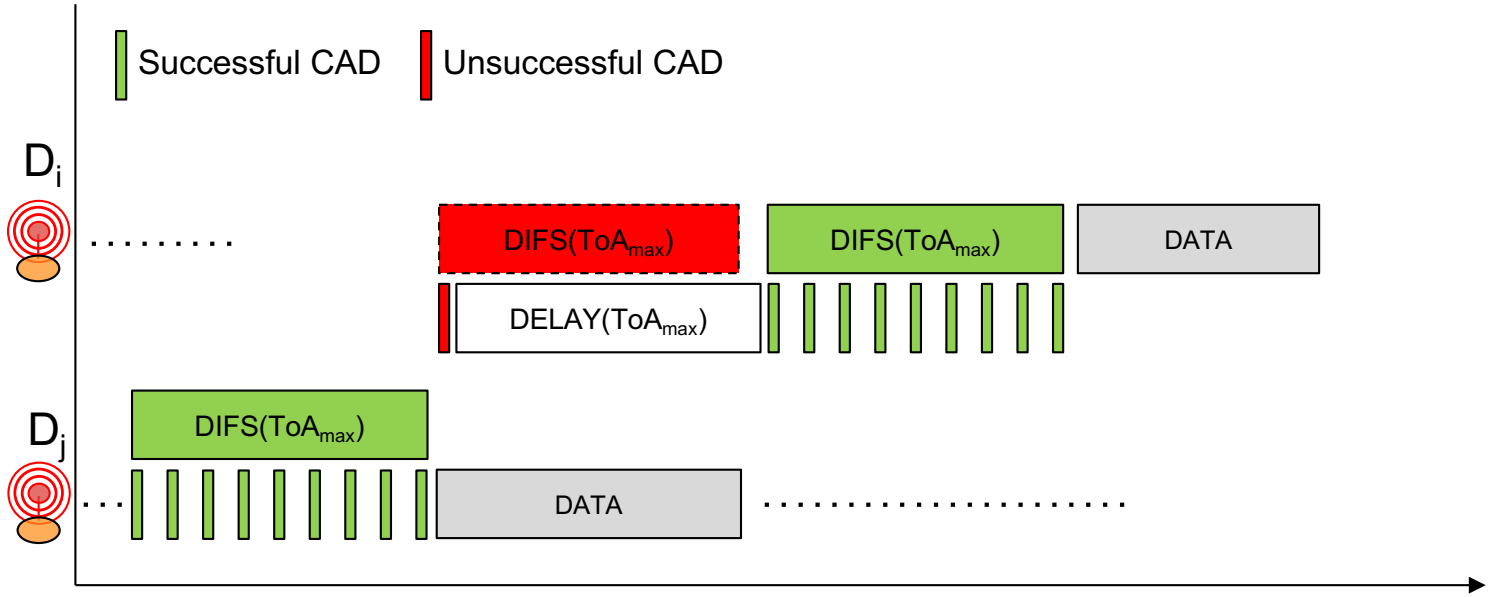
C. Pham, "Robust CSMA for Long-Range LoRa Transmissions with Image Sensing Devices", IEEE WD'2018.

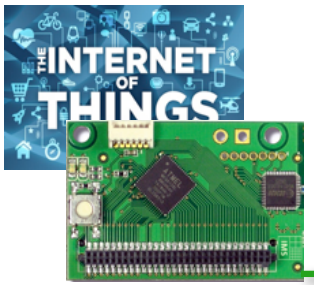
CSMA-BASED DERIVED FROM 802.11



CSMA-BASED ADAPTED TO LONGER MSG







Quality of Service

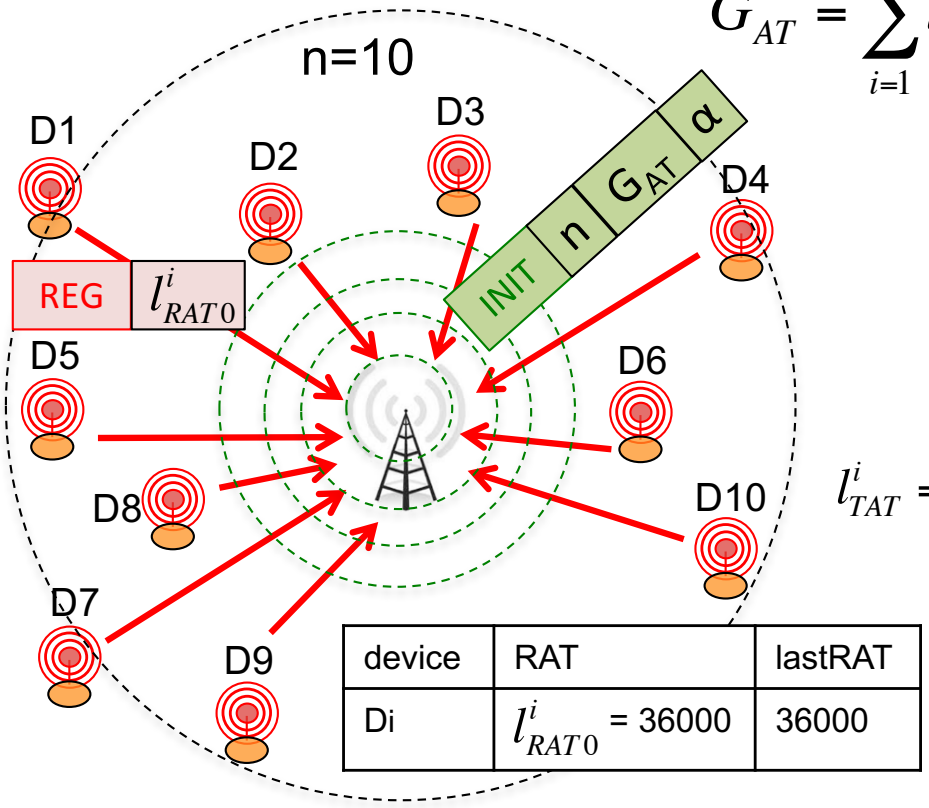
- Regulations stipulate that radio activity duty-cycle should be enforced at devices.
- LoRaWAN specification from LoRa Alliance is a first attempt to standardize LoRa networks but no issues on quality of service.
- Proposition of a Long-range Activity Sharing (LAS) mechanism when running under duty-cycle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

C. Pham, "Deploying a Pool of Long-Range Wireless Image Sensor with Shared Activity Time". Proceedings of the 11th IEEE WiMob'2015, October 19-21, 2015, Abu Dhabi, UAE.

C. Pham, "Towards Quality of Service for Long-range IoT in Unlicensed Radio Spectrum". IEEE Wireless Days (WD'2016), Toulouse, France, March 2016.

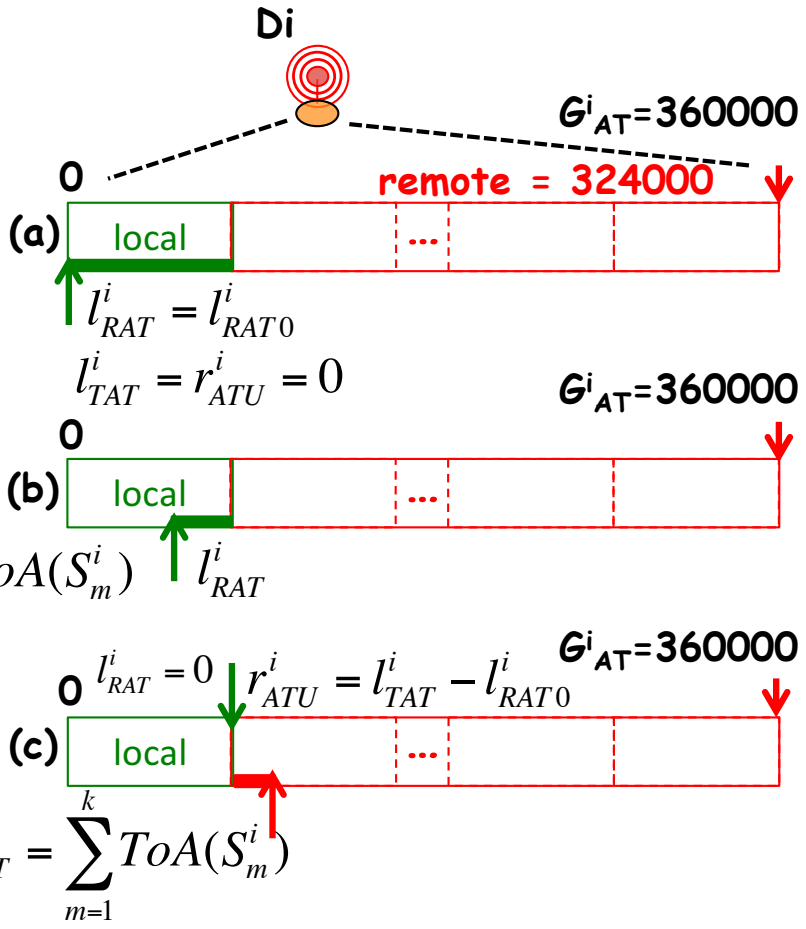
C. Pham, "QoS for Long-Range Wireless Sensors under Duty-Cycle Regulations with Shared Activity Time Usage". ACM Transactions on Sensor Networks, Vol. 12(4), 2016.

Long-range Activity Sharing (LAS)



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

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

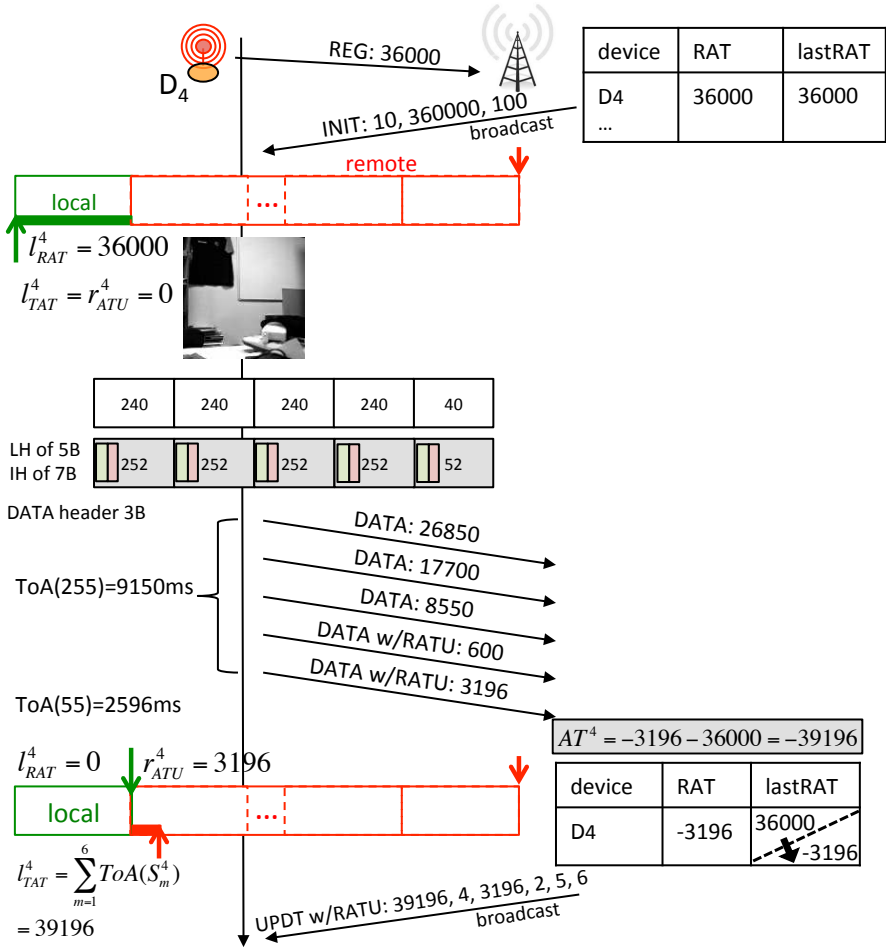


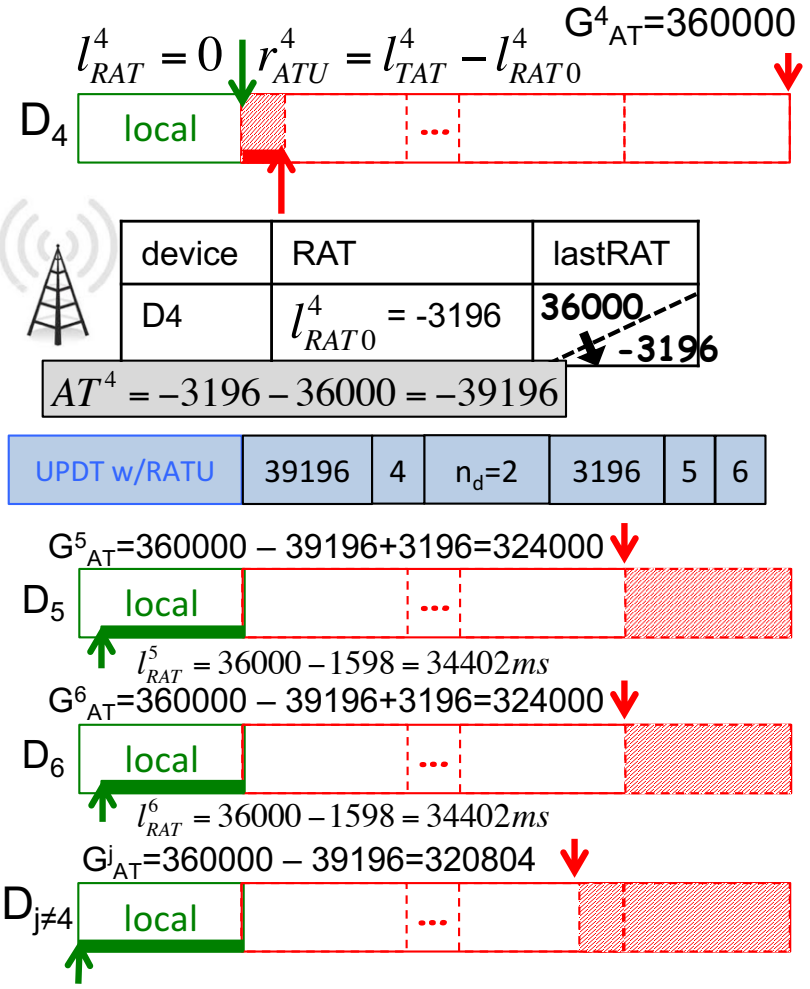
$$l^i_{TAT} = \sum_{m=1}^{k} ToA(S^i_m)$$

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

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

Distributing Remote Activity Time Usage





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

LIUPPA T2i team

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

UNIVERSITÉ DE PAU ET DES PAYS DE L'ADOUR

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 DEVICE: SUPPORTED PHYSICAL SENSORS

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LOW-COST LORA GATEWAY: A STEP-BY-STEP TUTORIAL

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LOW-COST LORA IOT: USING THE WAZIUP DEMO KIT

WAZIUP

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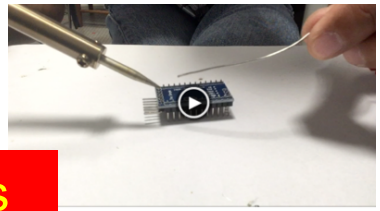
Low-cost IoT device



+43000 views

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

Low-cost IoT gateway

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