DEPLOYMENT OF AD-HOC LORA SOLUTIONS FOR RURAL APPLICATIONS IN AFRICA: FEEDBACKS FROM H2020 WAZIUP & WAZIHUB

LPWAN scientific days
July 11-12, 2019, INSA Lyon, Lyon

Presented by Ehsan Muhammad (senior researcher in WAZIHUB)

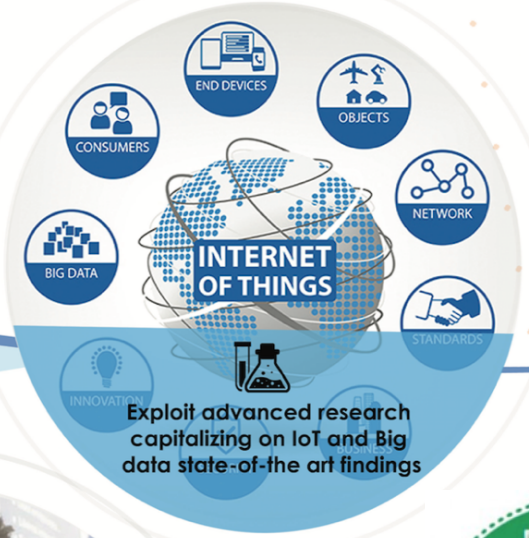
Prof. Congduc Pham
http://www.univ-pau.fr/~cpham
Université de Pau, France

IoT – from idea to reality

WAZIUP Open IoT and Big data platform for Africans, by Africans

HORIZON 2020

Affordable technologies to empower rural economics



Exploit advanced research capitalizing on IoT and Big data state-of-the art findings

Develop IoT solutions and applications meeting African needs

DO MORE with LESS

www.waziup.eu

Waziup IoT

Waziup IoT

Waziup

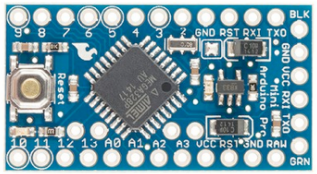
Waziup

CREATE-NET · CTIC · Farmerline · iSpace · coders africa · INNOTEC

waziup.community@create-net.org

Low-cost IoT

Arduino Pro Mini

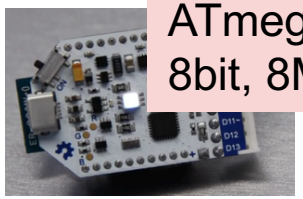


LoPy

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/

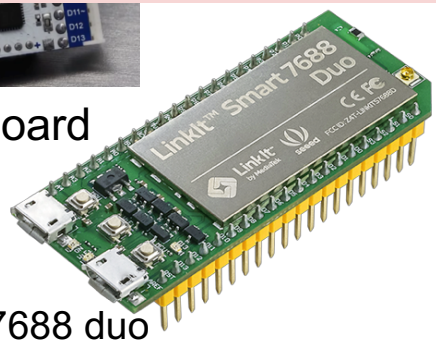
ATmega328P 3.3v
8bit, 8MHz, 32K flash, 2K RAM



Theairboard

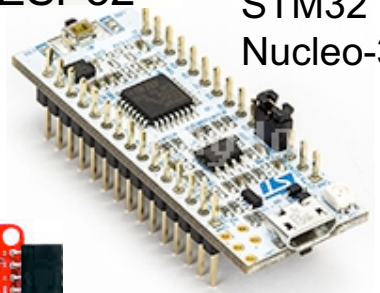
Teensy 3.2

Expressif ESP32



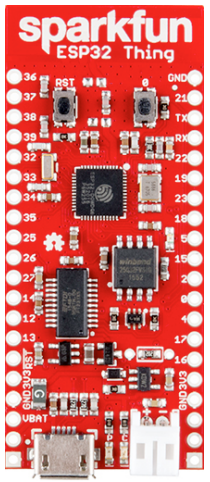
LinkIt
Smart7688 duo

STM32
Nucleo-32



Heltec ESP32 + OLED

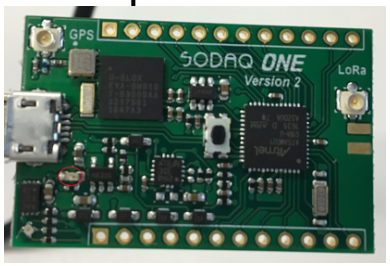
Adafruit Feather



Sparkfun ESP32
Thing

Tessel

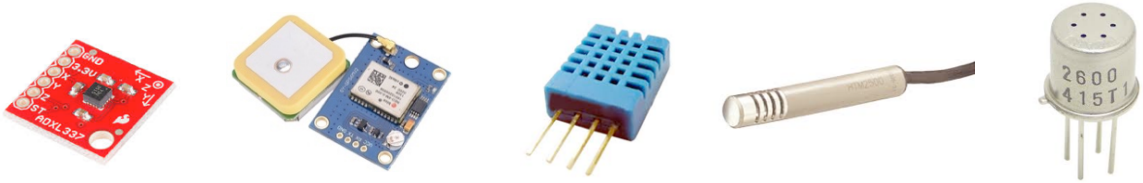
SodaqOnev2



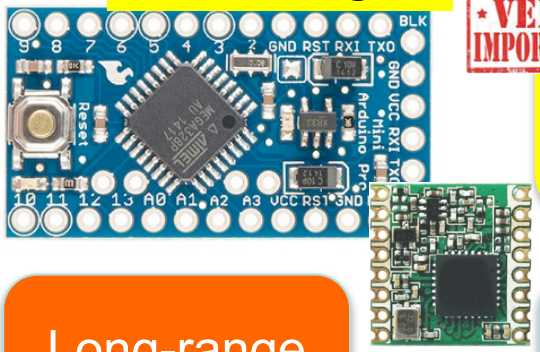
Tinyduino

Reduce development cost & time

Physical sensor | Physical sensor | Physical sensor



Arduino Pro Mini @3.3V



Physical sensor mgmt

VERY IMPORTANT

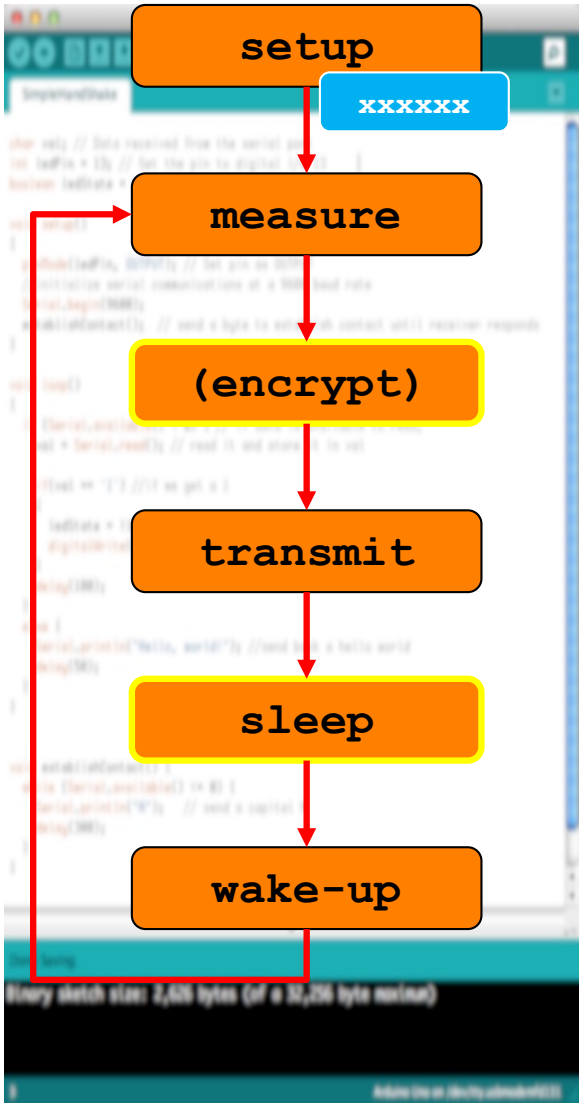
Activity duty-cycle, low power

VERY IMPORTANT

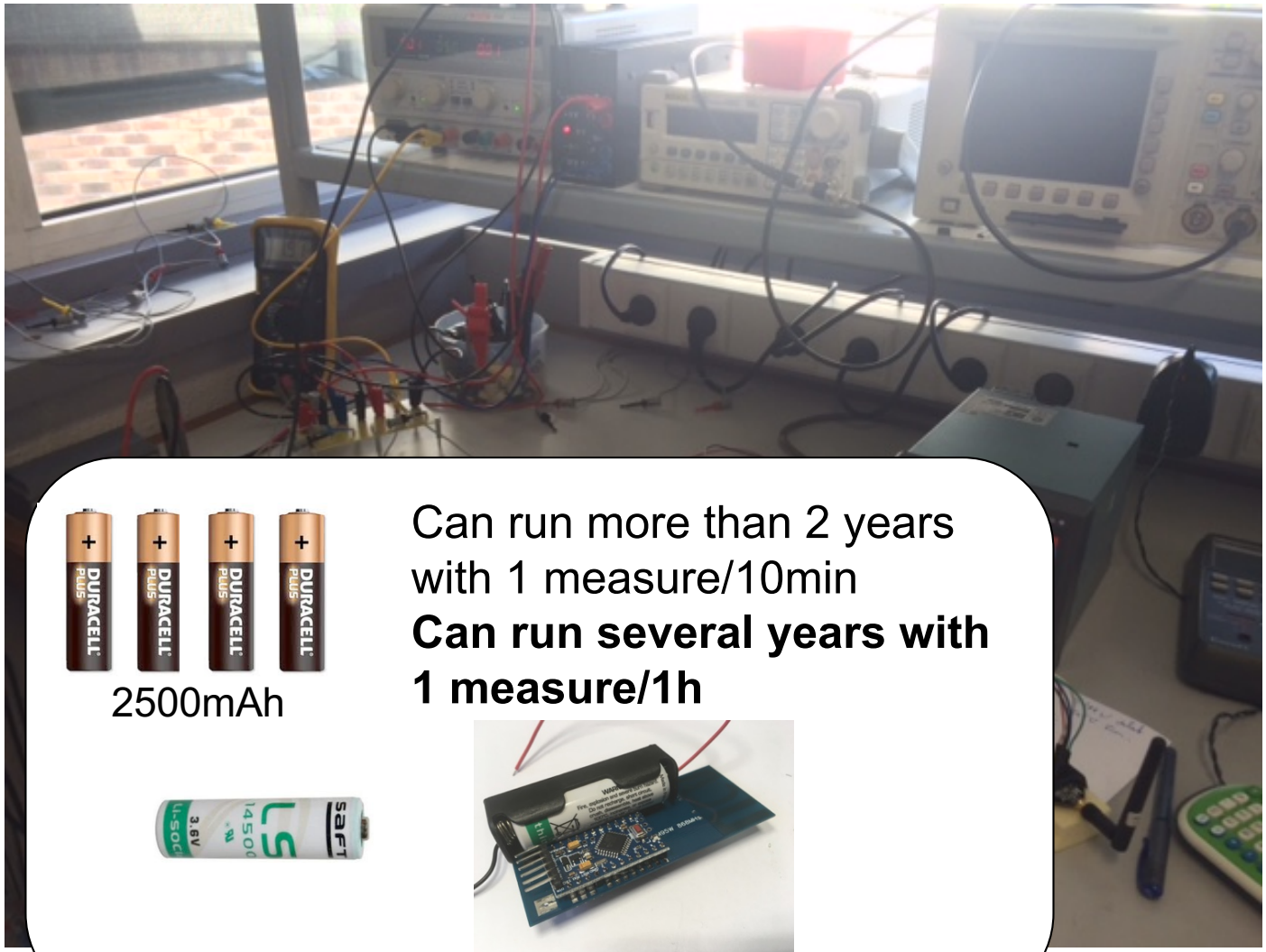
AES encryption

Long-range transmission

Logical sensor mgmt

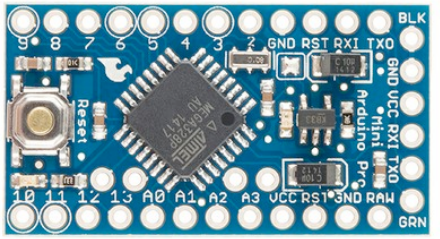


Low-power for longer lifetime!

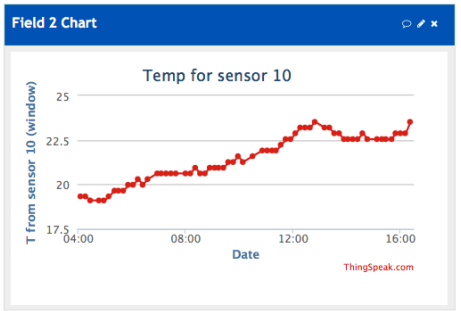


2500mAh

Can run more than 2 years with 1 measure/10min
Can run several years with 1 measure/1h



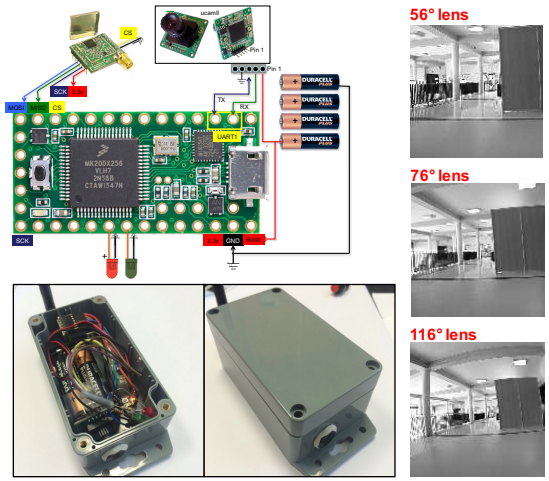
wakes-up every 10min, take a measure and send to GW

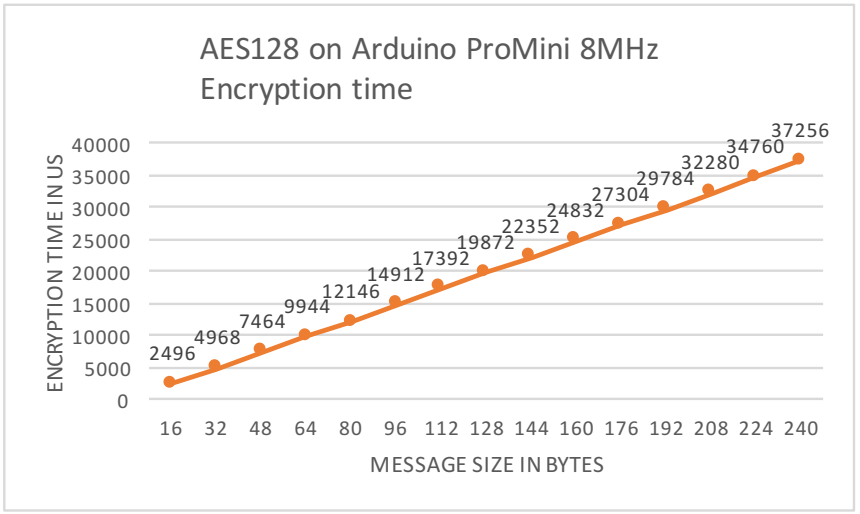


5µA in deep sleep mode, about 40mA when active and sending!

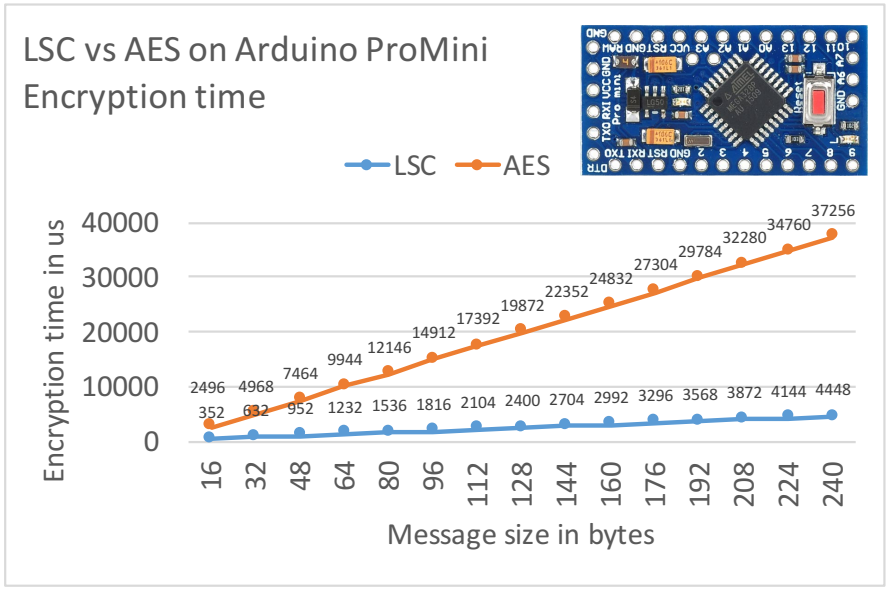
Cost of data encryption

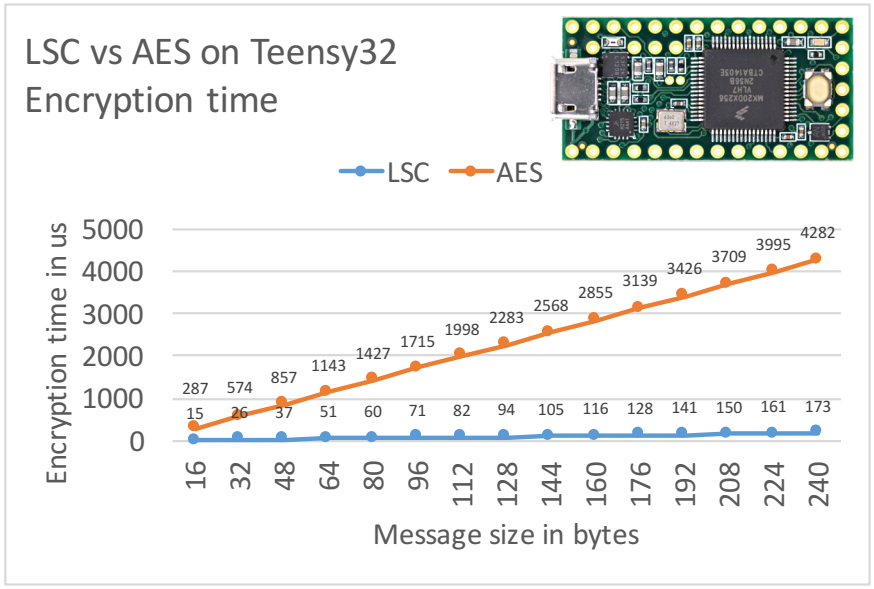
- AES128





- Lightweight Stream Cipher (LSC)

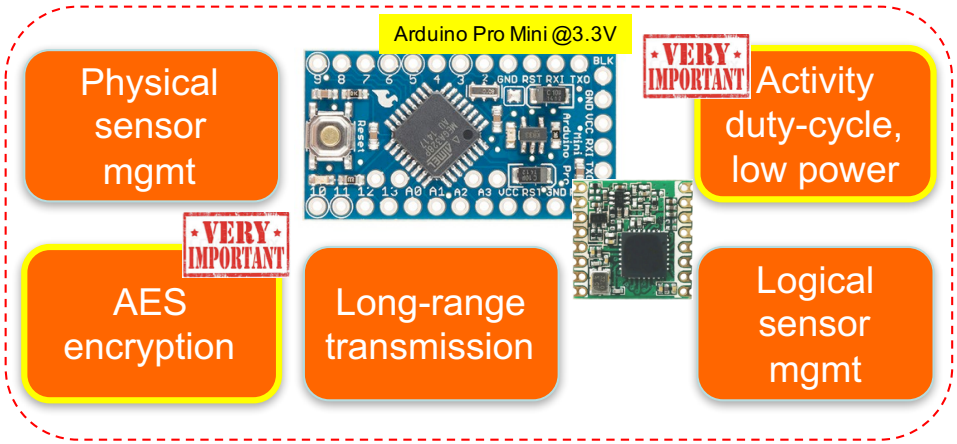


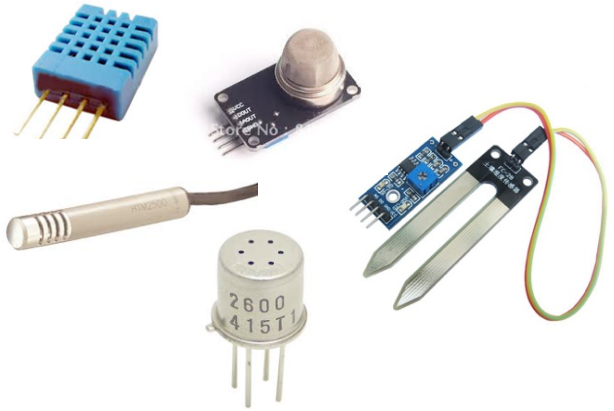


Work in collaboration with R. Couturier (Univ. Franche Comté) and Hassan Noura (American University of Beirut)

Generic sensing IoT device v.s. Highly specialized

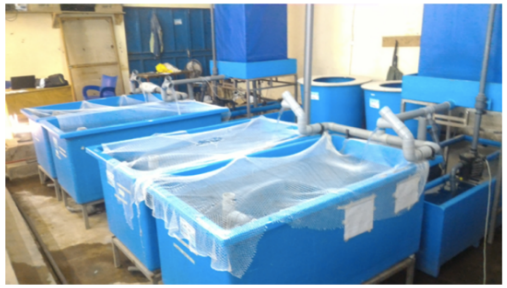
- Build low-cost, low-power, **long-range** enabled generic platform
- Methodology for low-cost platform design
- Technology transfers to user communities, economic actors, stakeholders,…

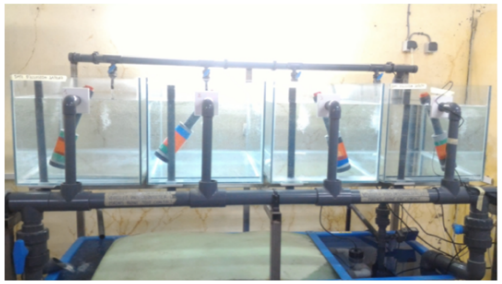




Hatchery experiment, Burkina Faso

- Laboratory named Laboratoire d'Études des Ressources Naturelles et des Sciences de l'Environnement (LERNSE)
- NAZI BONI University in a small village of Bobo-Dioulasso city
- Sensors are placed in a hatchery and the box is placed outside of the building





Low-cost buoy for fish farming

In Sub-Saharian Africa, the volume of natural captured fish doesn't meet half of the population demand

Increasing production of aquaculture will help reduce the quantity of imported fishes in Africa

The aim is to monitor in real-time different parameters to control water quality and prevent some diseases that could affect fish in order to improve the quality and quantity of the production

Kumah farm, Ghana

- The Kwame Nkrumah University of Science and Technology (KNUST)
- Located on the campus of the Kwame Nkrumah University of Science and Technology in Kumasi, Ghana.
- The farm comprises 30 constructed fish ponds, a farm house, a recirculating aquaculture system (RAS) laboratory and store houses.

Sanar farm, Senegal

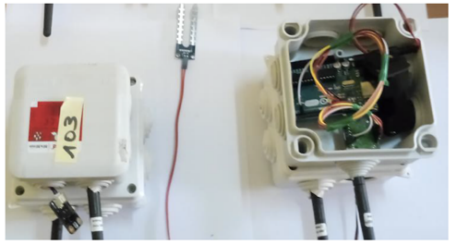
- Farm located at less than 2 km from UGB.
- One pond is dedicated for the Waziup application : 50x25m, average depth of 0.5 meters, populated by 4000 individuals of saltwater tilapia.
- The basin is irrigated via a water supply system fed by a river in proximity.
- The water in the pond is changed every 10 days

UBG farm, Senegal





Soil humidity sensor for agriculture



Monitoring soil moisture and other parameters to provide insightful recommendations and notifications to farmers, and advisors


Nasso site, Burkina Faso


Bananas field

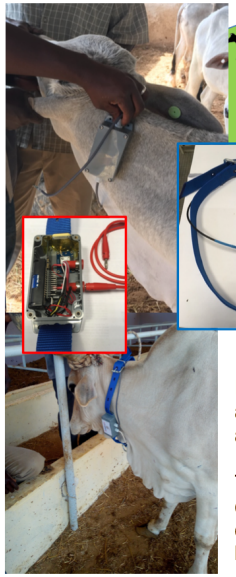

Papayas solos field

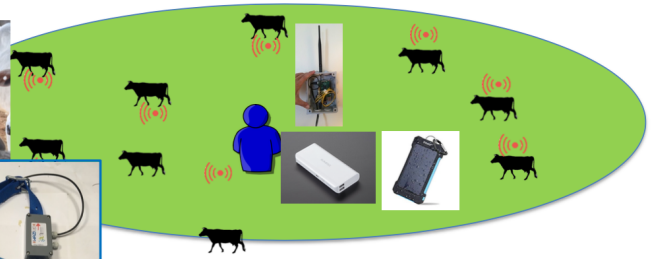

Banana plant


Papaya tree

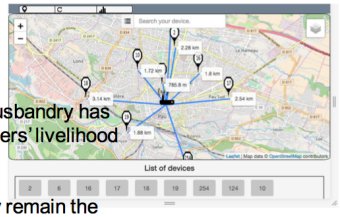
Urbannatic gardens, Togo


LOW-COST COLLAR FOR CATTLE RUTLING: CIMEL FARM, SENEGAL





A web interface displays the position of the gateway those of the remote GPS devices



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)

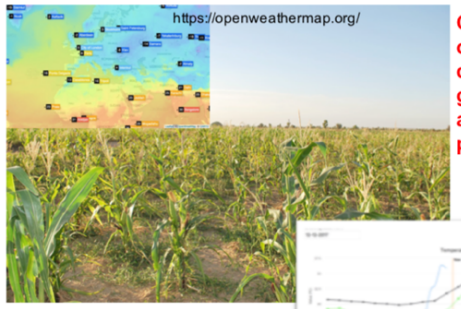
LOCAL WEATHER STATION FOR AGRICULTURE

In agriculture, different factors can be monitored. Having the ability to control those factors is the key to increase the productivity.

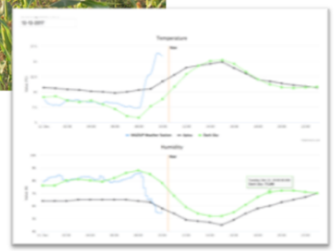
Agriculture MVP requirements:

Obtain and produce weather related information which will be used to advise the farmers!

Get local weather measurements

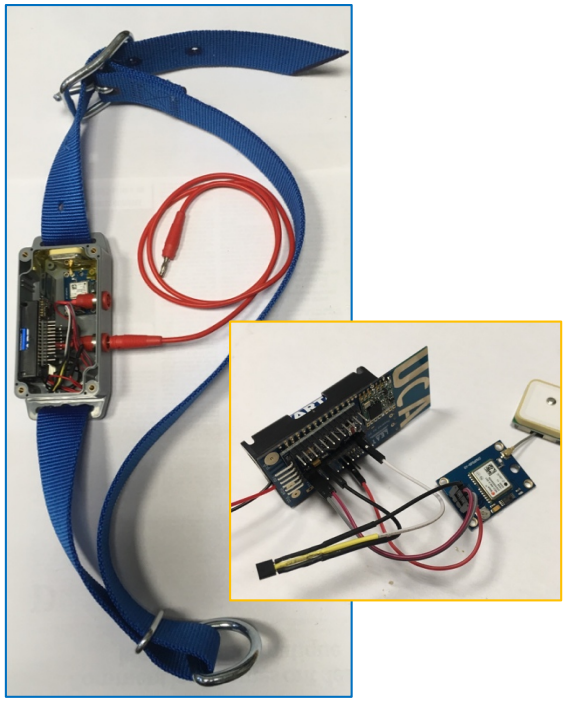


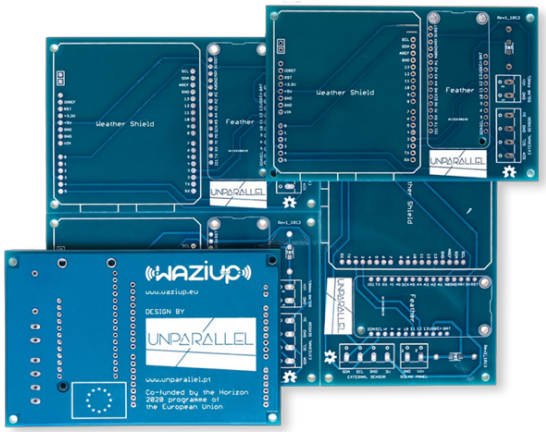
Combine with open weather data to get more accurate predictions



Weather Web App

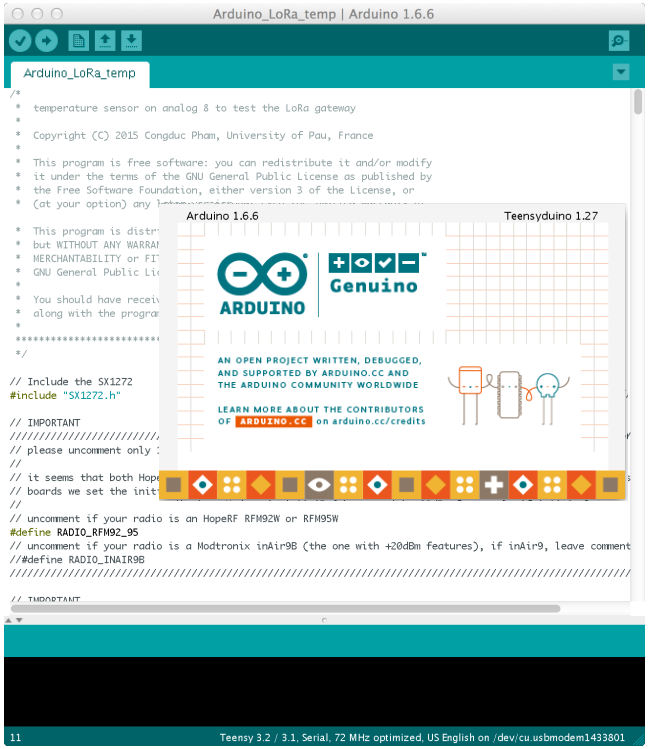
Pilot sites: Senegal, Togo, Ghana, Burkina Faso

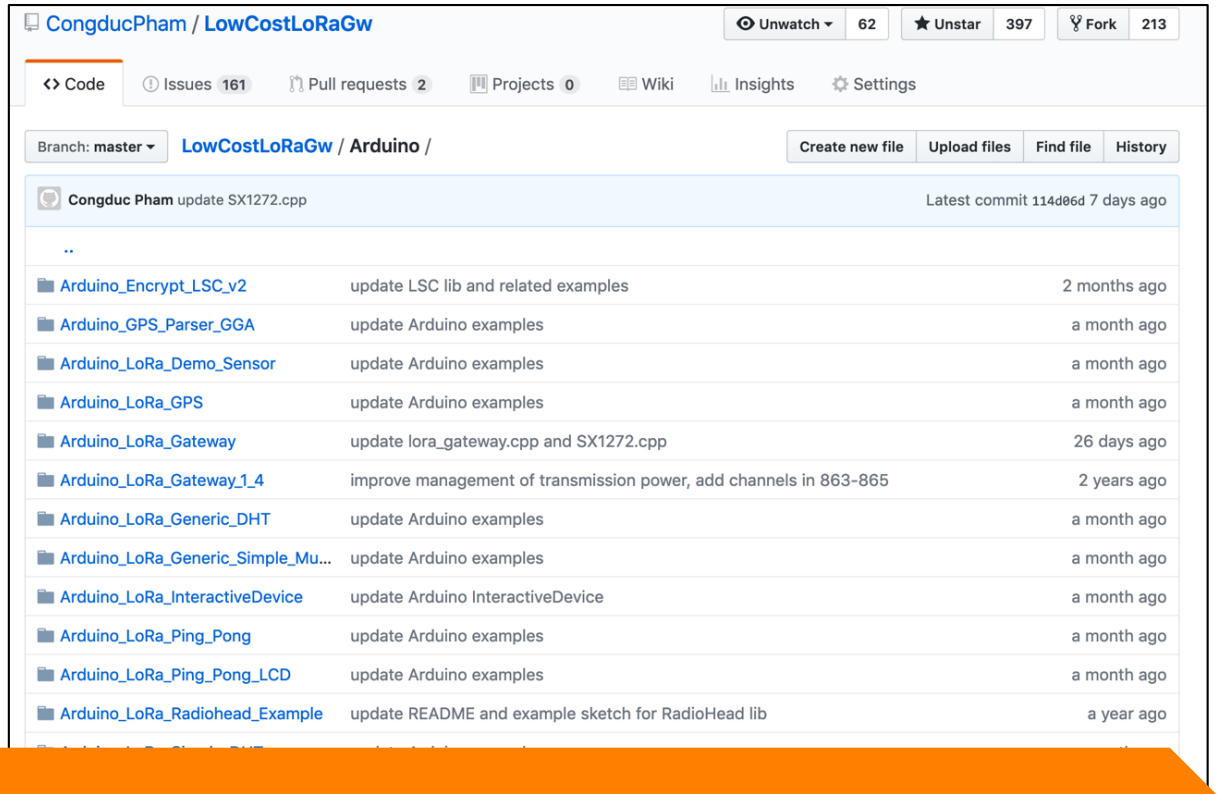




From Unparallel for WAZIUP

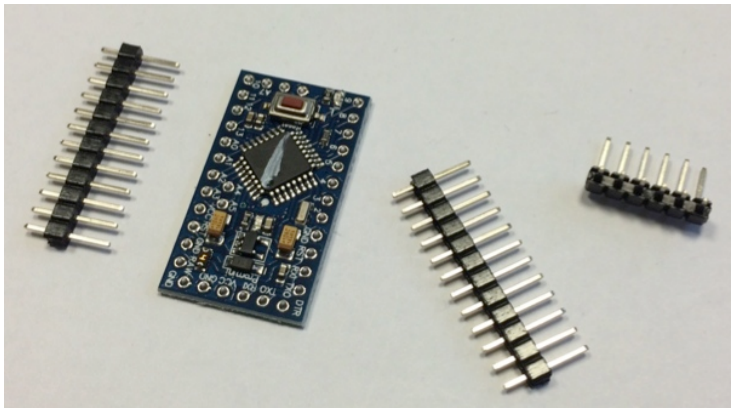
100% open-source code templates

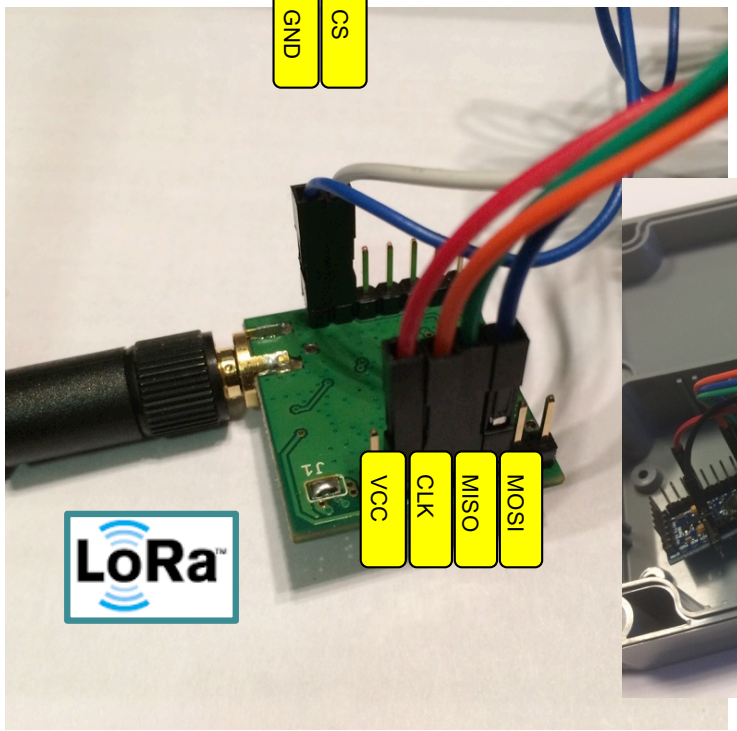


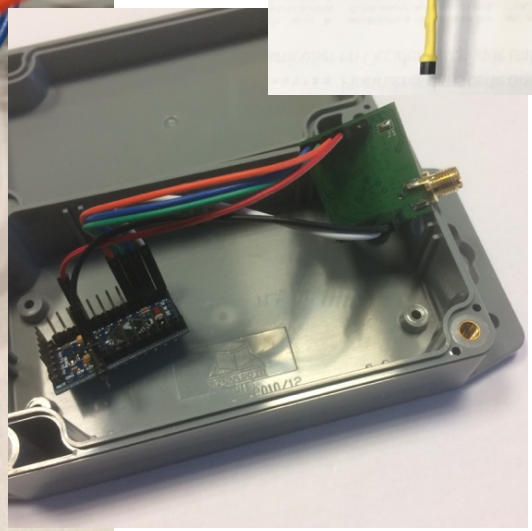


LowCostLoRaGw github has latest general distribution:
https://github.com/CongducPham/LowCostLoRaGw
Many examples using various temp/hum sensors
https://github.com/CongducPham/LowCostLoRaGw/tree/master/Arduino

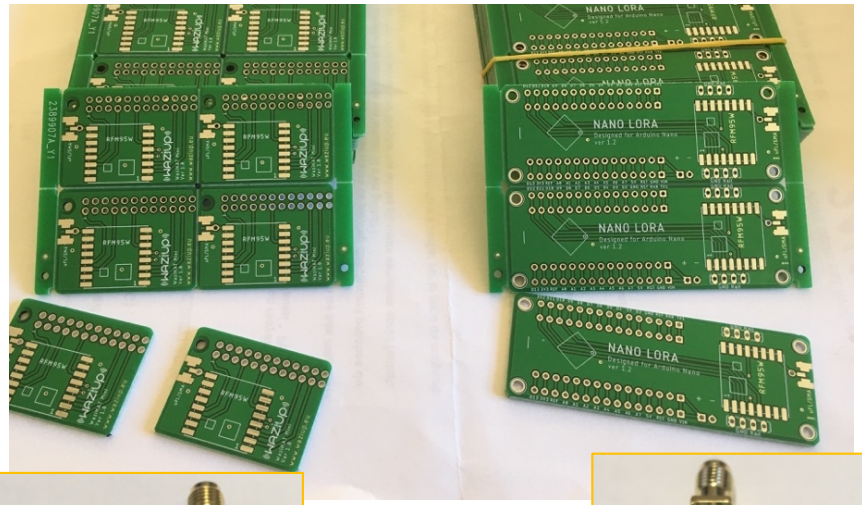
From full Do-It-Yourself approach

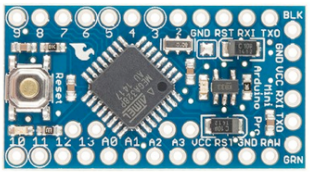






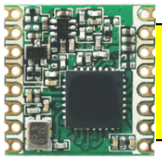
…to simple PCB for easy integration



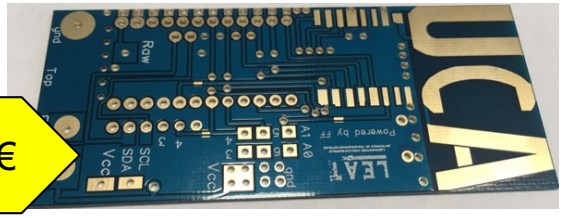


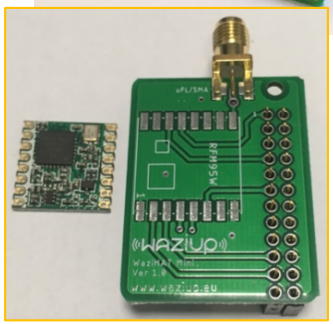
1.5€

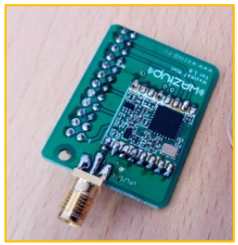
https://github.com/FabienFerrero/UCA_Board

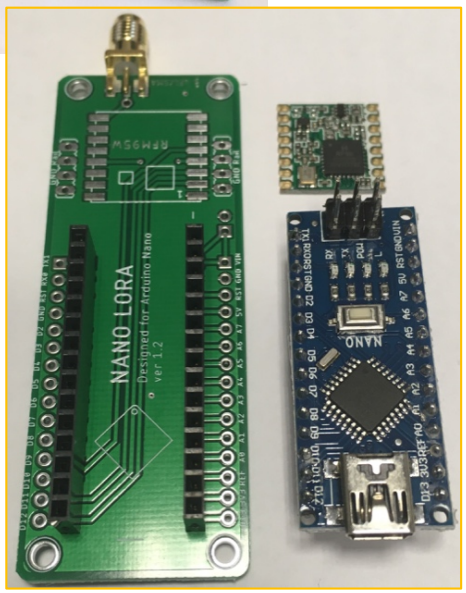


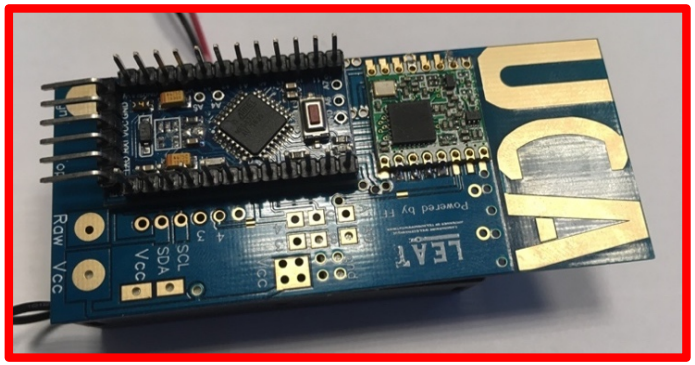
5€

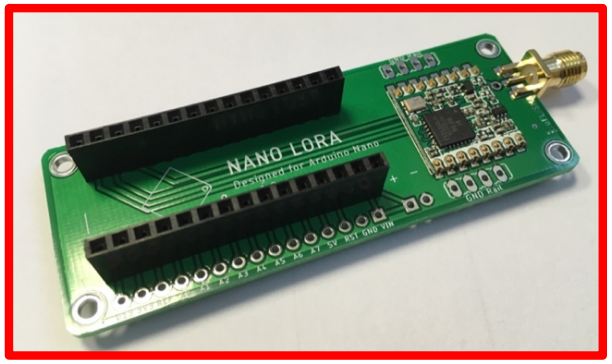


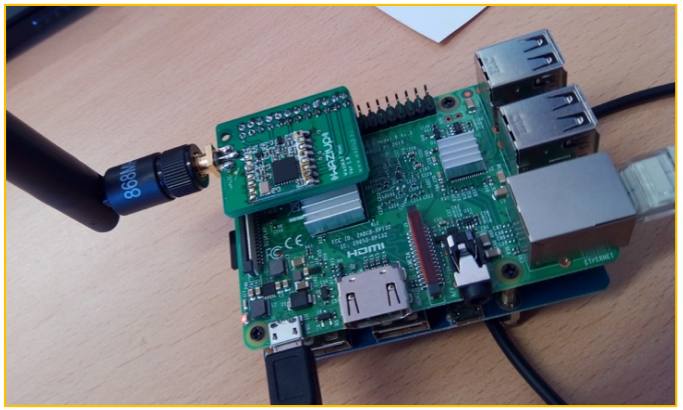




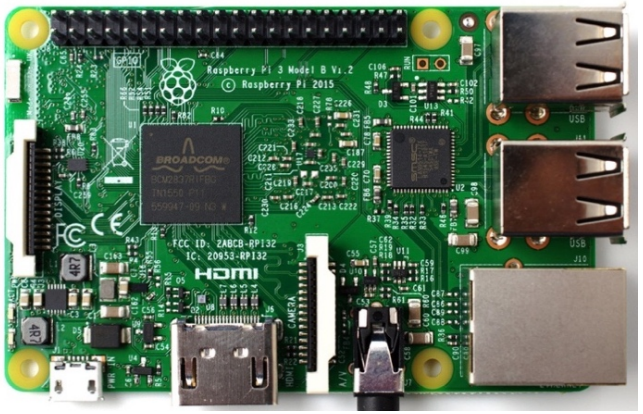


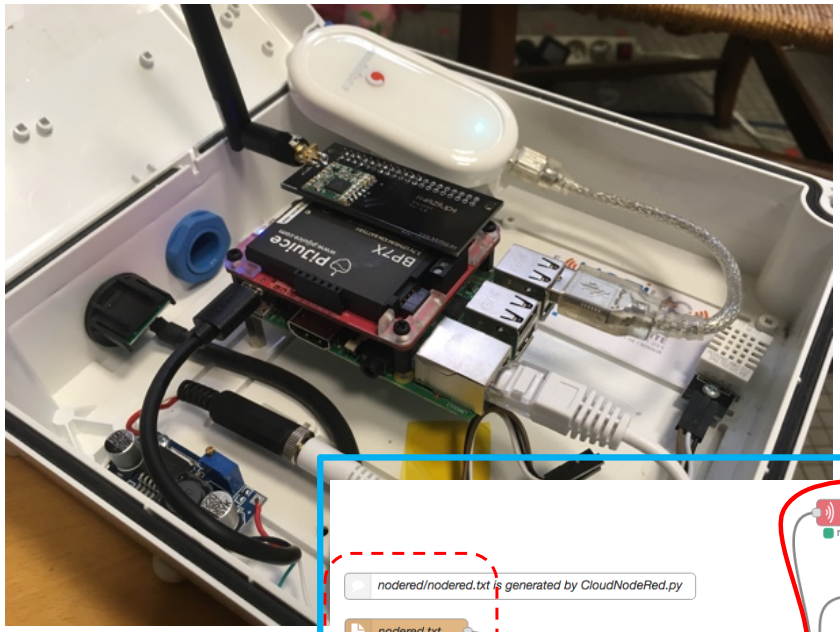




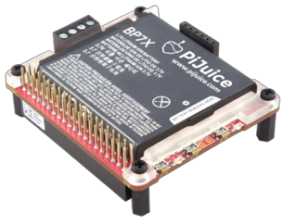


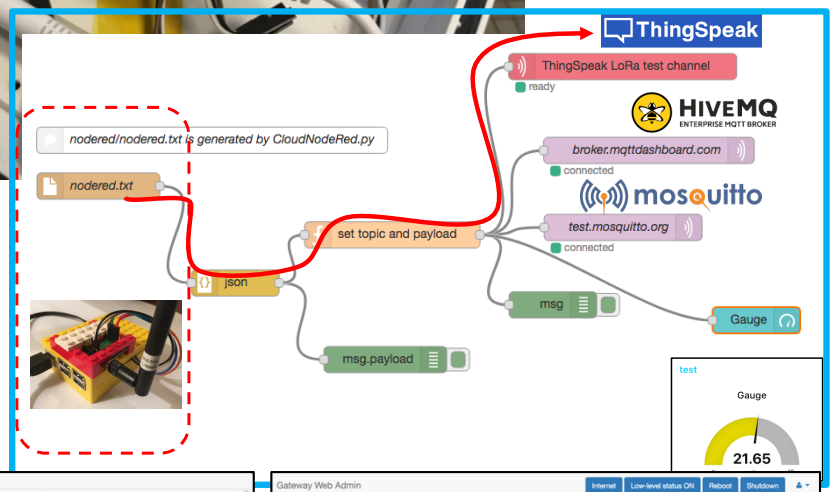
Open, versatile IoT gateway

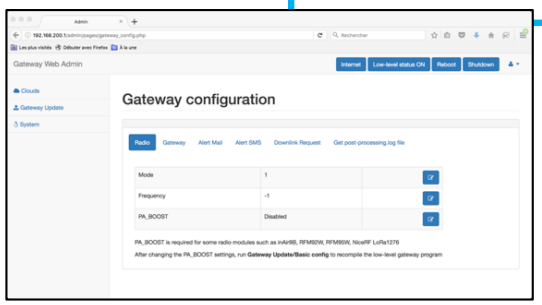


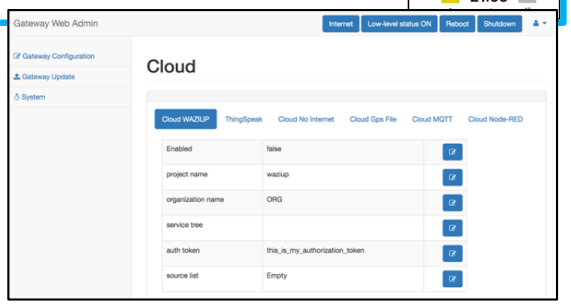


Raspberry PI: lots of libraries, lots of software, lots of hardware, lots of shields,…





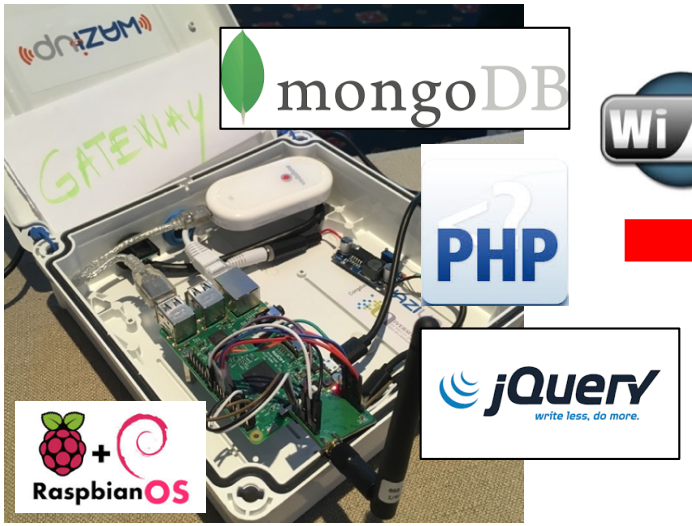


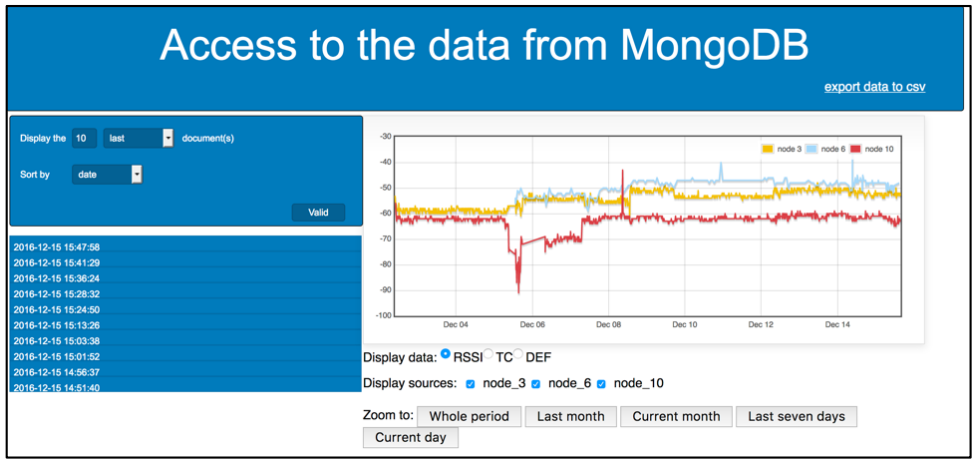


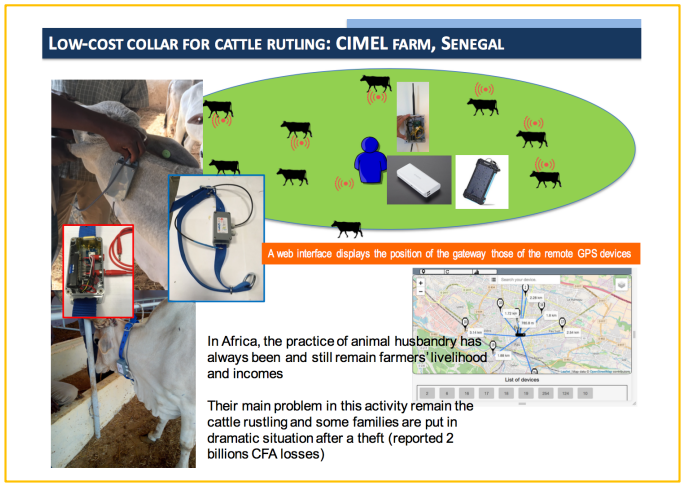
Deployment in rural areas
no Internet ☹

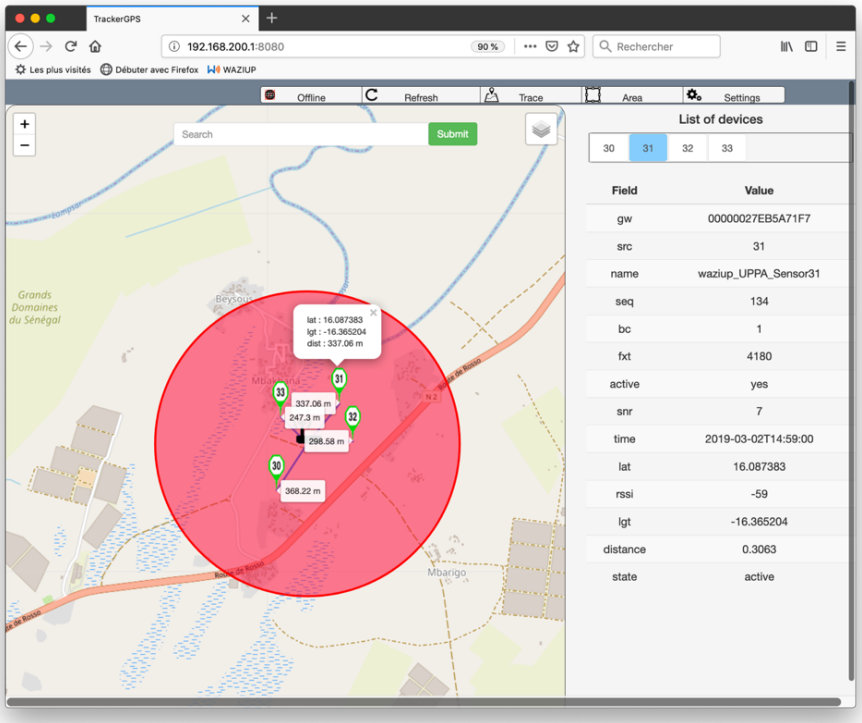
- deploying IoT in very isolated areas…
- … where internet and electricity are not stable!

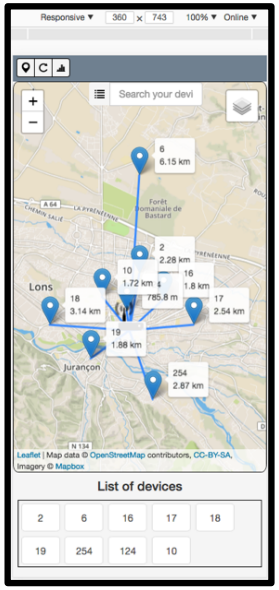
Autonomous gateway











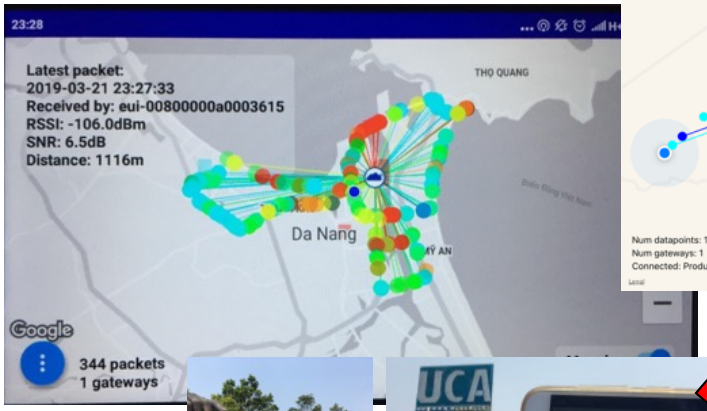
Link to a short demo video of the collar web interface: https://youtu.be/meFDav1SLPI

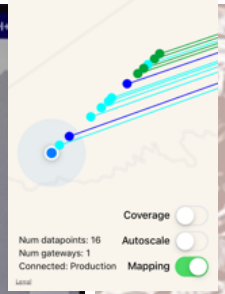
City environment
high building=large coverage

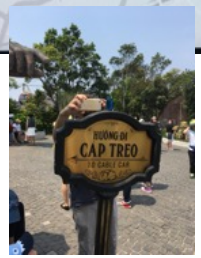
- LoRaWAN gateway on top of DSP building by F. Ferrero (U. Nice), U. Danang and DSP team. Congrats Fabien!

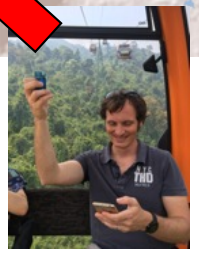






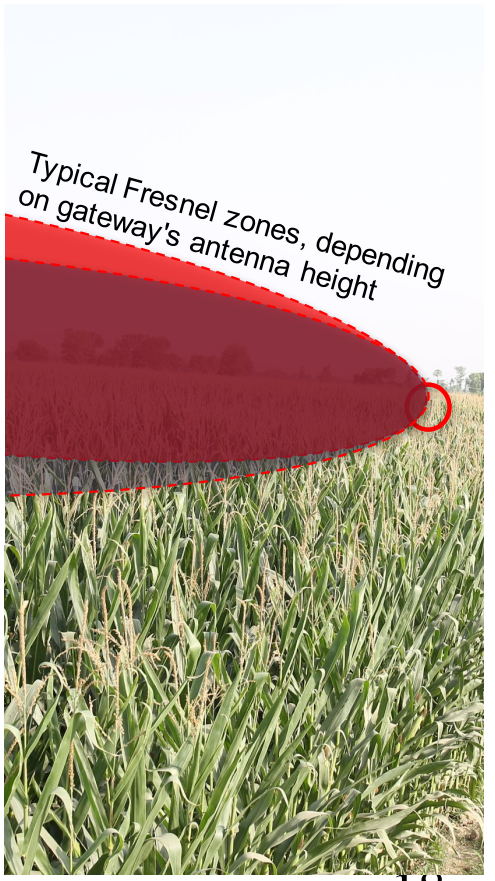


See TTN Mapper
https://ttnmapper.org/

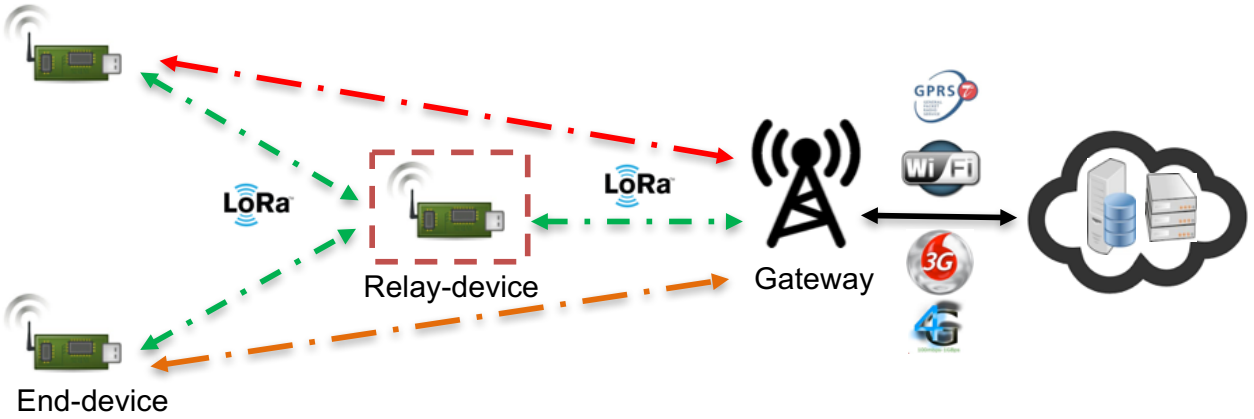
Deployment in rural areas
no high building ☹

- Expected range: about 2-4kms
- 1-hop connectivity to gateway is difficult to achieve in real-world, remote, rural scenarios



2-hop long-range approach

- **smart, transparent** relay node should be able to be inserted at anytime between end-devices and gateway to increase range

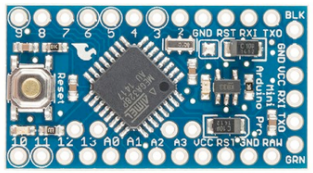


- **2 possible approaches**
  - Use periodic & short Channel Activity Detection (CAD) to detect uplink messages (recent draft from Semtech)
  - Use an observation phase (full receive mode) to determine device's schedule

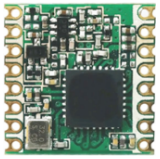
Our relay's design choices

- Observation phase + data forwarding phase
  - CAD reliability decreases as distance increases
  - A CAD returning false does not mean that there is no activity!
- On-the-fly learning of incoming traffic from end-devices: **observation phase**
- Just-in-time wake up in **data forwarding phase**
- Deep sleep between 2 wake up
- No additional hardware ➔ low-cost sensor nodes can be recycled as relay node

Arduino Pro Mini @3.3V



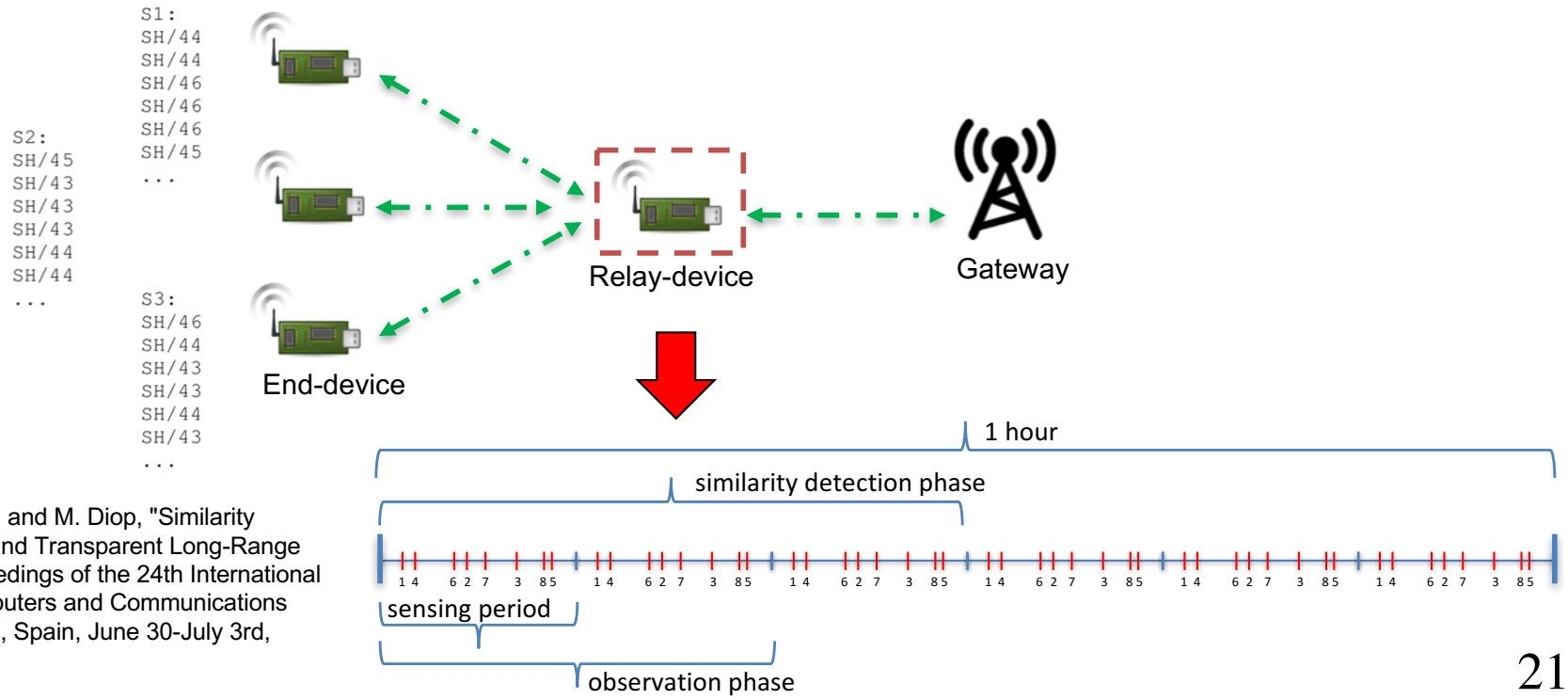
RFM95W



M. Diop and C. Pham, "Increased flexibility in long-range IoT deployments with transparent and light-weight 2-hop LoRa approach", 11th Wireless Days conference, Manchester, UK, April 23-25, 2019.

Extending with similarity detection

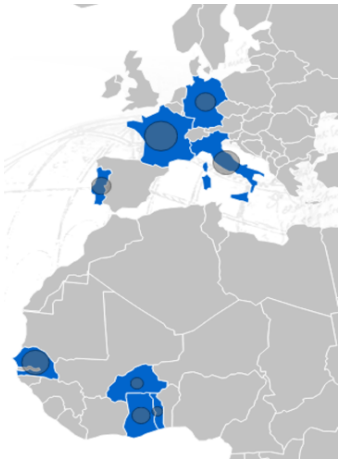
- Find similarities between measures to avoid both waking-up and transmission to gateway
- Reduce energy consumption + help enforcing duty-cycle



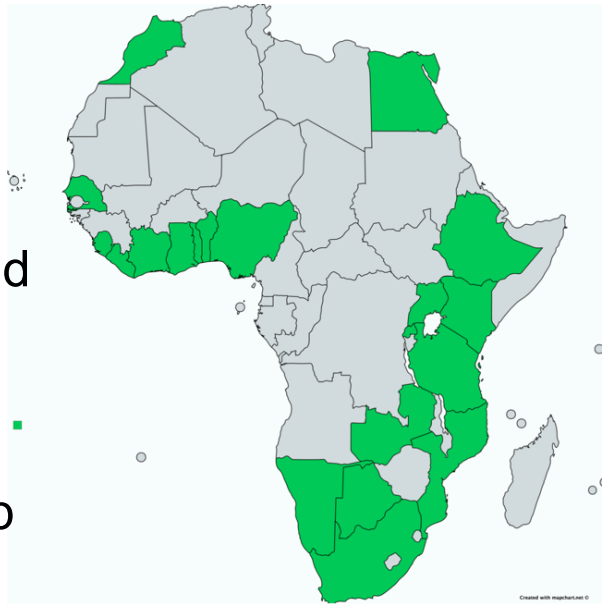
C. Pham, A. Makhoul and M. Diop, "Similarity Detection for Smart and Transparent Long-Range IoT Relaying", Proceedings of the 24th International Symposium on Computers and Communications (ISCC'19), Barcelona, Spain, June 30-July 3rd, 2019.

Scaling up!

Feb 2016 - 2019



May 2018 - 2021



WAZIUP has been developing the open, low-cost IoT technologies/frameworks and use-cases

WAZIHUB will focus on dissemination, community building and entrepreneurship