IOT ONLINE COURSE

Fundamentals of IoT

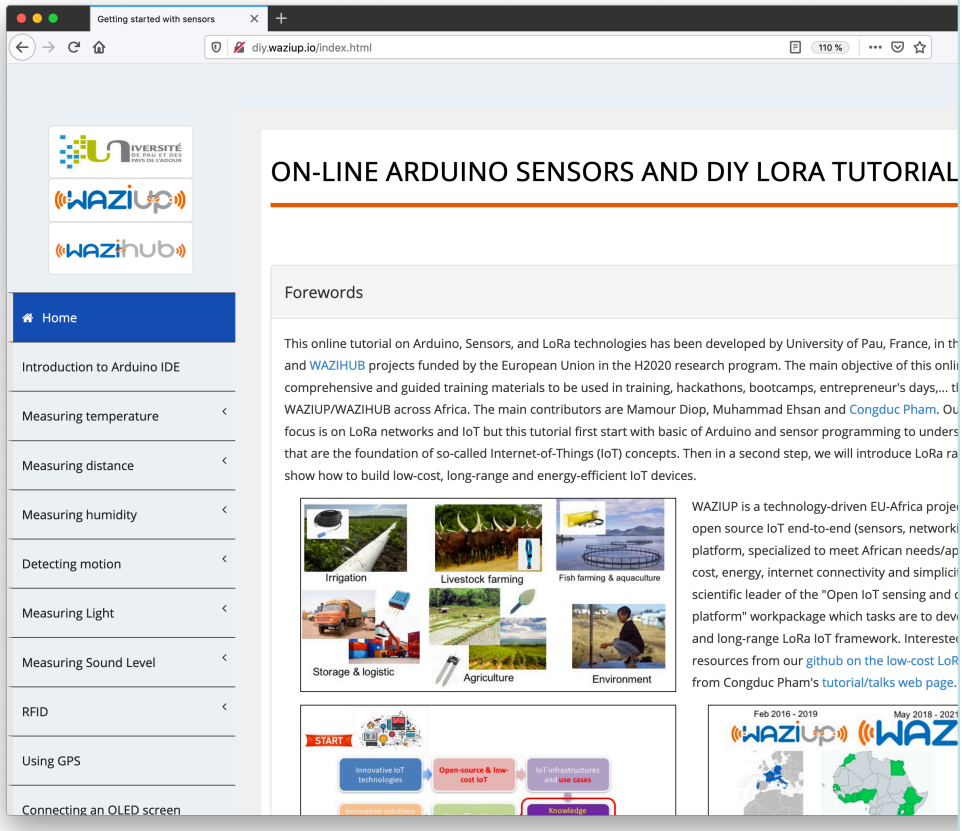
F-IOT-4: Low-cost & Open-source IoT Technologies

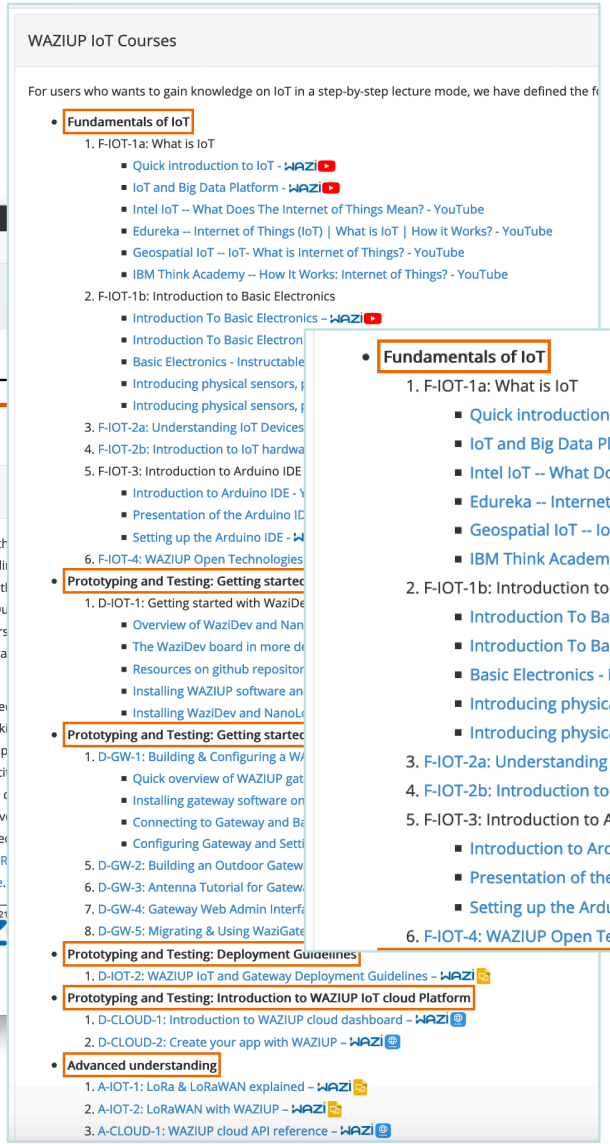
Prof. Congduc Pham
http://www.univ-pau.fr/~cpham
Université de Pau, France

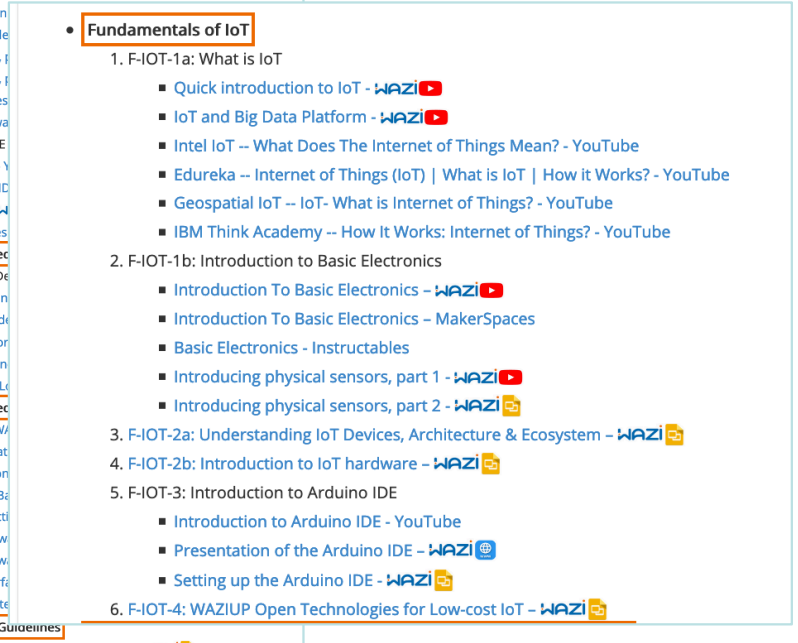
IoT – from idea to reality

IoT Online Course

- http://diy.waziup.io







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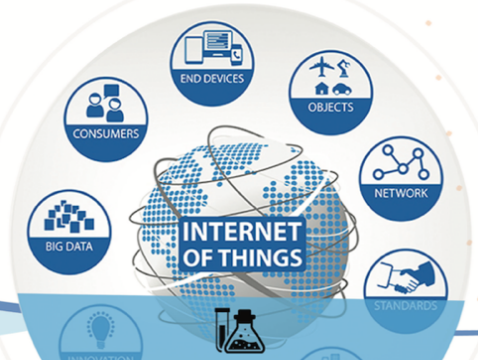
WAZIUP Open IoT and Big data platform for Africans, by Africans

Feb2016-Jan2019

HORIZON 2020



DO MORE with LESS

www.waziup.eu

Waziup IoT

Waziup IoT

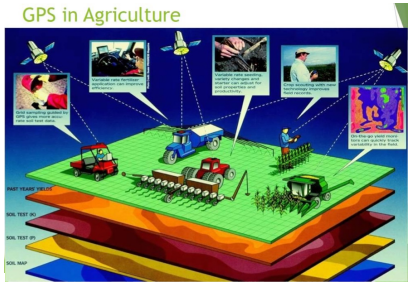
Waziup

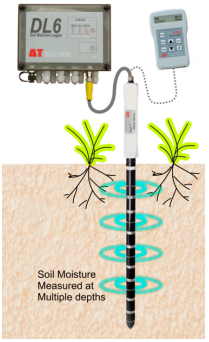
Waziup

CREATE-NET CTIC Farmerline iSpace coders africa INNOTECH

waziup.community@create-net.org

Most of existing system are not adapted for small holders





SMALLHOLDERS AND FAMILY FARMERS

DID YOU KNOW?

ENVIRONMENT

Eighty percent of the farmland in sub-Saharan Africa and Asia is managed by smallholders (working on up to 10 hectares). While 75 percent of the world's food is generated from only 12 plants and 5 animal species, making the global food system highly vulnerable to shocks, biodiversity is key to smallholder systems who keep many rustic and climate-resilient varieties and breeds alive.

ECONOMY

Out of the 2.5 billion people in poor countries living directly from the food and agriculture sector, 1.5 billion people live in smallholder households. Many of those households are extremely poor: overall, the highest incidence of workers living with their families below the poverty line is associated with employment in agriculture.

SOCIAL

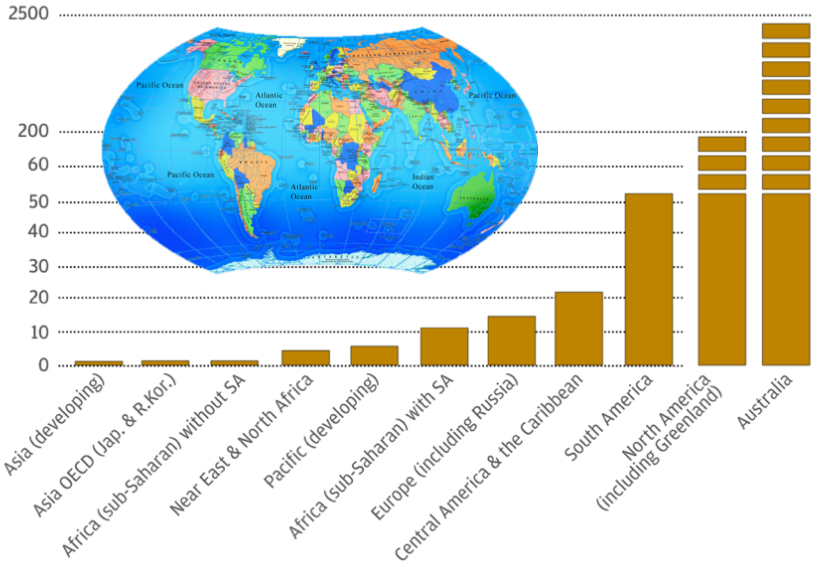
Women comprise an average of 43 percent of the agricultural labour force of developing countries up to almost 50 percent in Eastern and Southeastern Asia and sub-Saharan Africa. Should women farmers have the same access to productive resources as men, they could increase yields on their farms by 20-30 percent, lifting 100-150 million people out of hunger. Women are the quiet drivers of change towards more sustainable production systems and a more varied and healthier diet.

GOVERNANCE

Smallholders provide up to 80 percent of the food supply in Asian and sub-Saharan Africa. Their economic viability and contributions to diversified landscape and culture is threatened by competitive pressure from globalization and integration into common economic areas; their fate is either to disappear and become purely self-subsistence producers, or to grow into larger units that can compete with large industrialized farms.

Smallholders are small-scale farmers, pastoralists, forest keepers, fishers who manage areas varying from less than one hectare to 10 hectares. Smallholders are characterized by family-focused motives such as favouring the stability of the farm household system, using mainly family labour for production and using part of the produce for family consumption.

AVERAGE SIZE OF AGRICULTURAL HOLDINGS (ha)



Food and Agriculture Organization of the United Nations

Making IoT happening!

Innovative IoT technologies

"IoT for All" paradigm

IoT infrastructures and use cases

Knowledge dissemination & training

Users/Developers engagement

Innovative solutions adapted to local needs

Exploitation plan and innovation hubs

Communication & community building

Sustainable & long-term innovation

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Community building for sustainable innovation

International Events
+ 20 organized & attended

Launch event (Senegal, CTIC Dakar)

Launch event (Ghana, iSpace)

Workshop at the European Conference on Networks & Cmmunications (Greece, CNET)

IoTWeek2016 (Belgrade, EGM)

IoTBigData2016 (Italy, EGM)

IoTCareConference (Budapest, CNET)

WAZIUP Workshop on IoT (Togo, l'Africaine d'Architecture)

Credit: C. Vavasseur, CTIC Dakar

Workshop at the RESSACS 2016 (France, UPPA)

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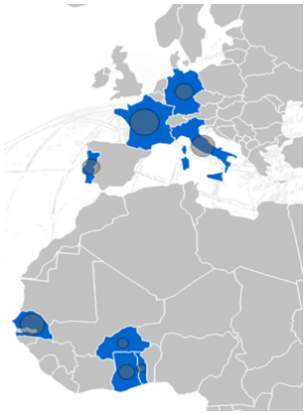
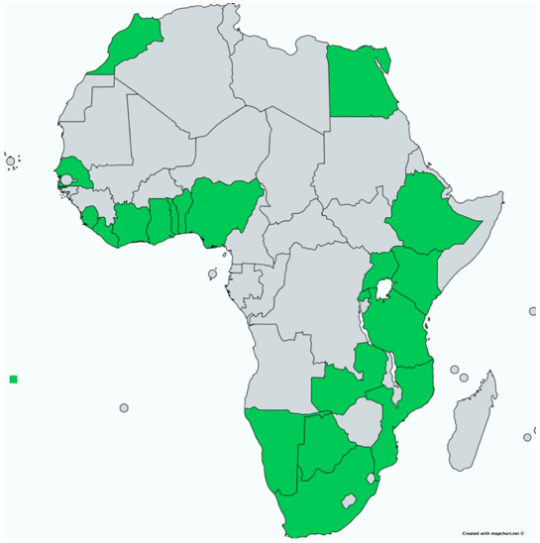
Scaling up!

Feb 2016 - 2019



May 2018 - 2021



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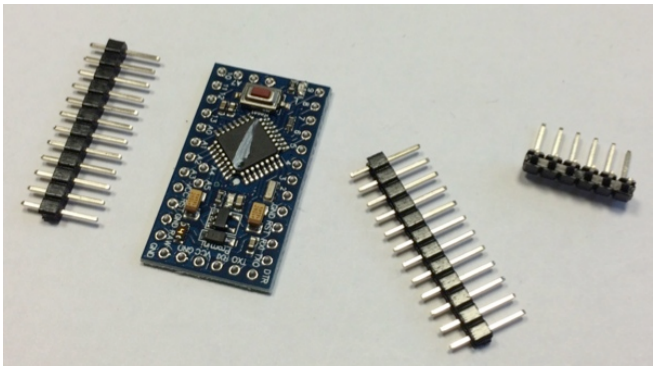
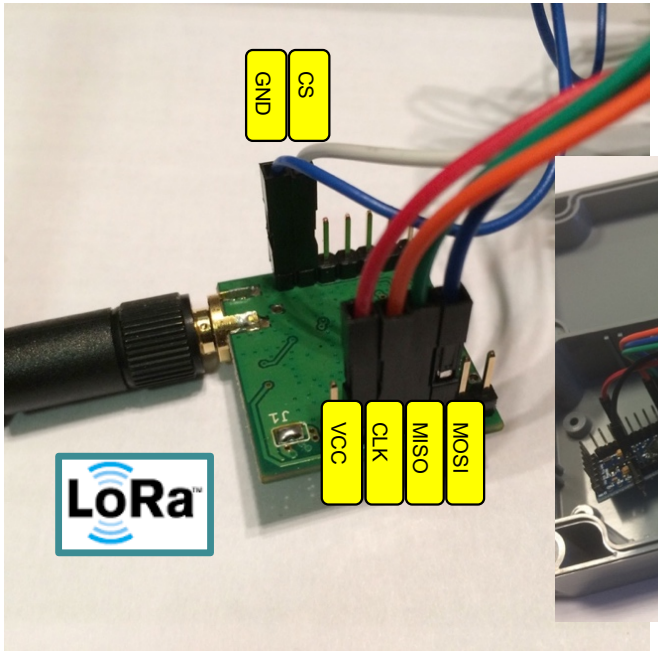
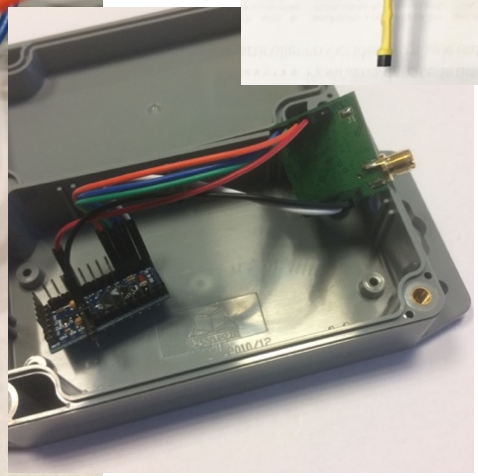
DIY approach

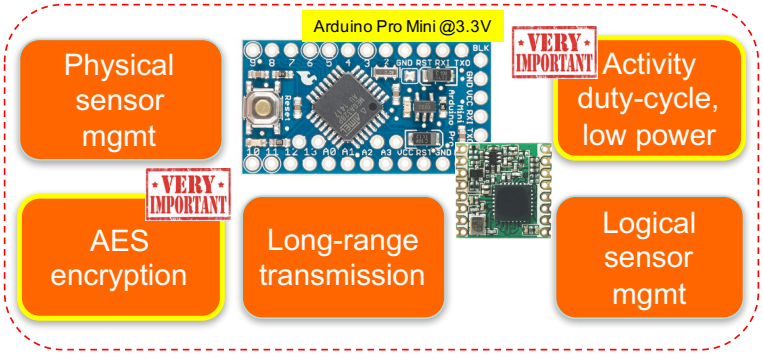


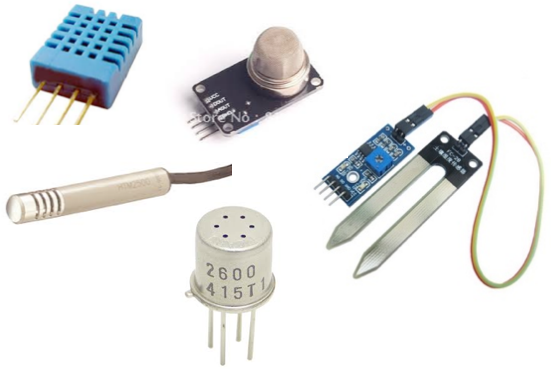




Generic IoT v.s. highly specialized

- Build low-cost, low-power, generic IoT platform
- Methodology for low-cost platform design
- Technology transfers to user communities, economic actors, stakeholders,...





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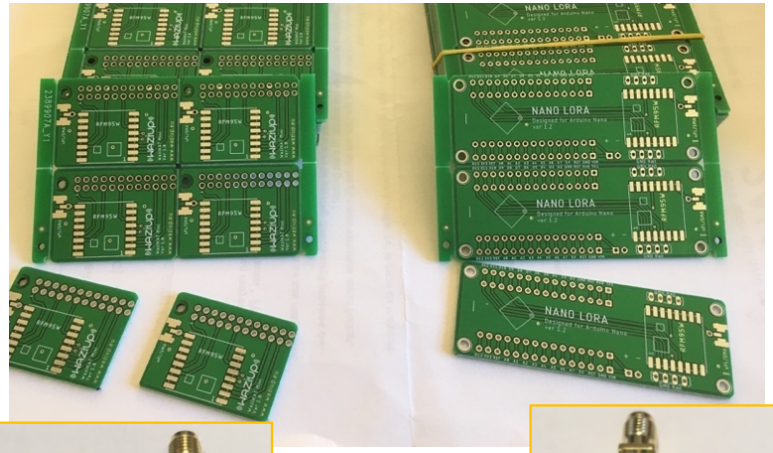
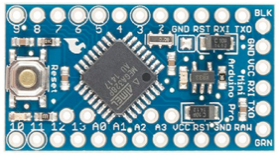
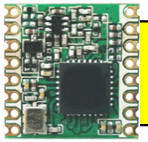
Simple PCBs ease the DIY approach



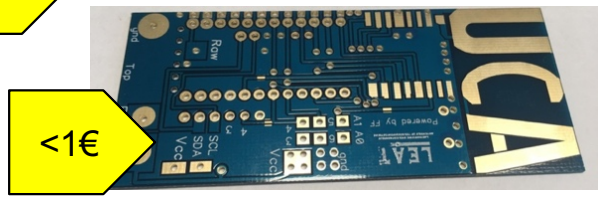


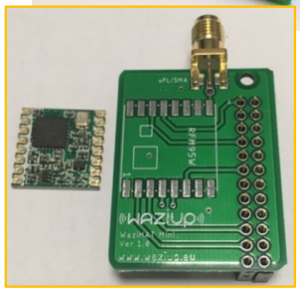
1.5€

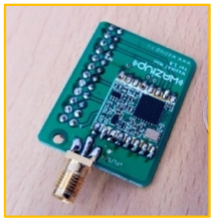
https://github.com/FabienFerrero/UCA_Board

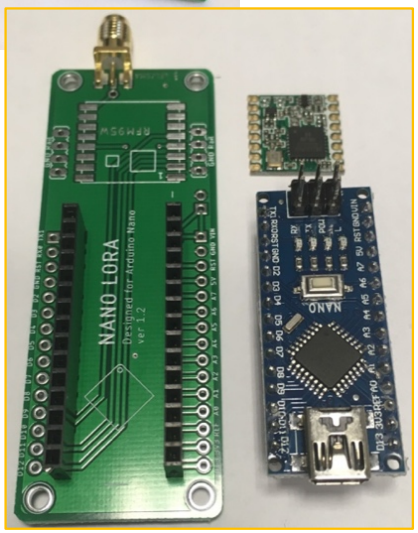


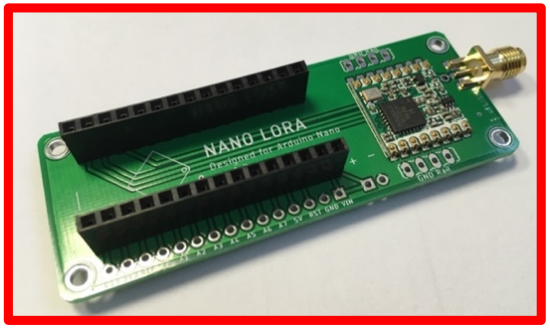
5€

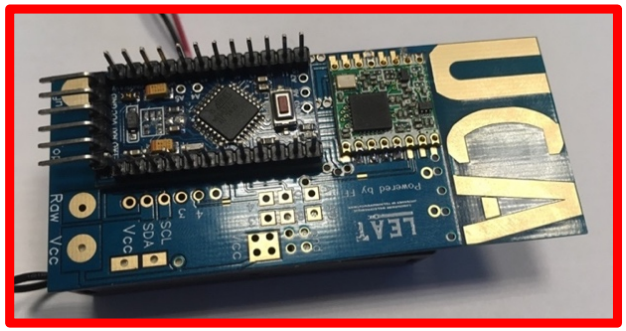






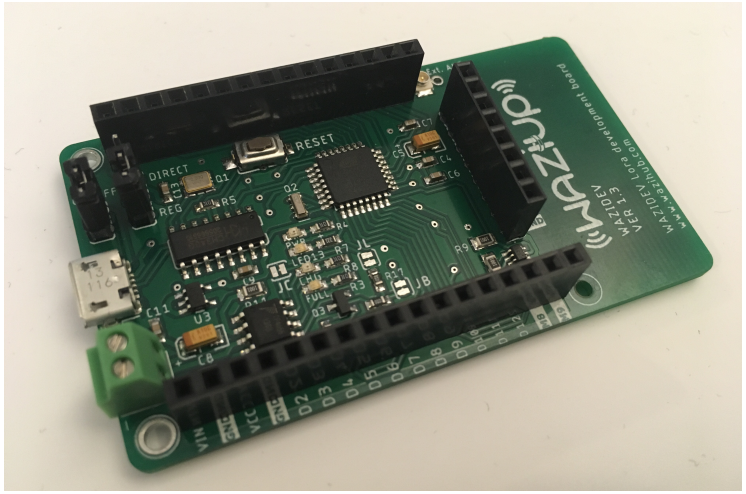


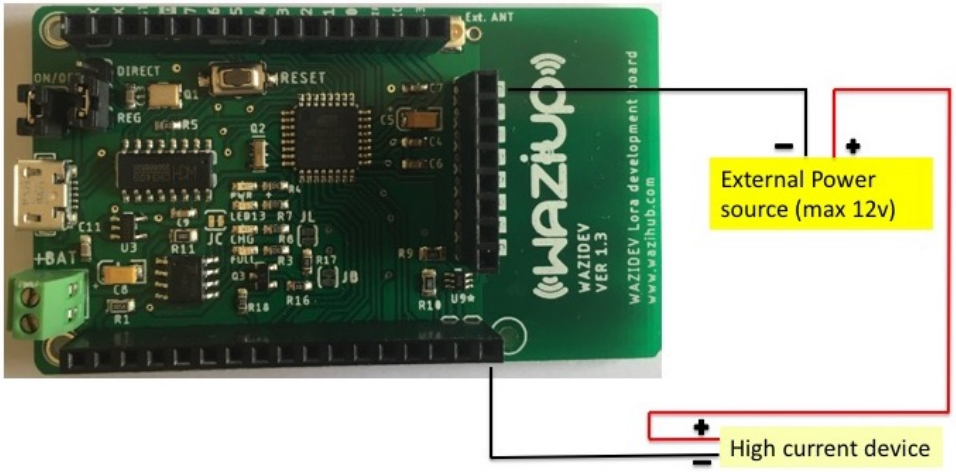




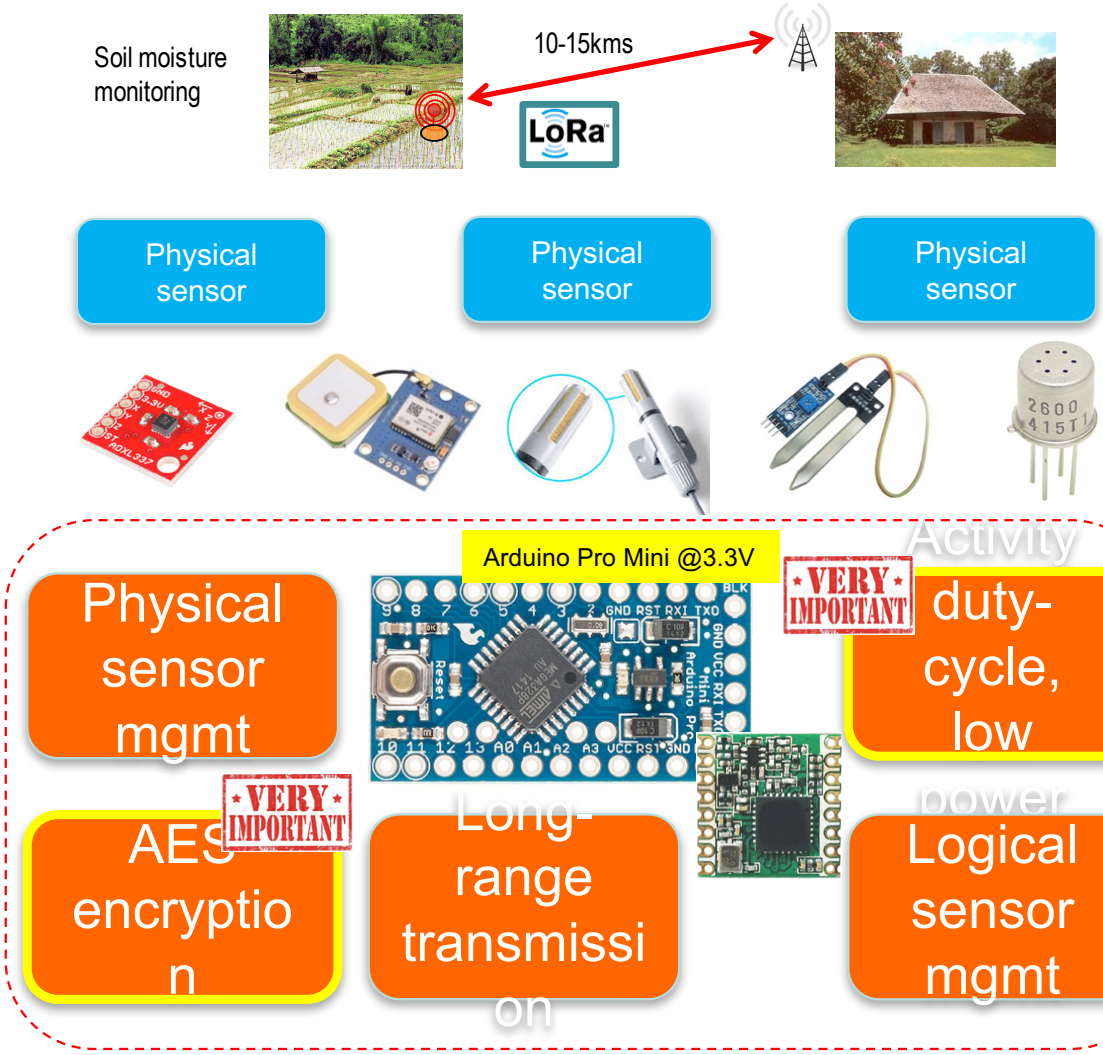
WaziDev board

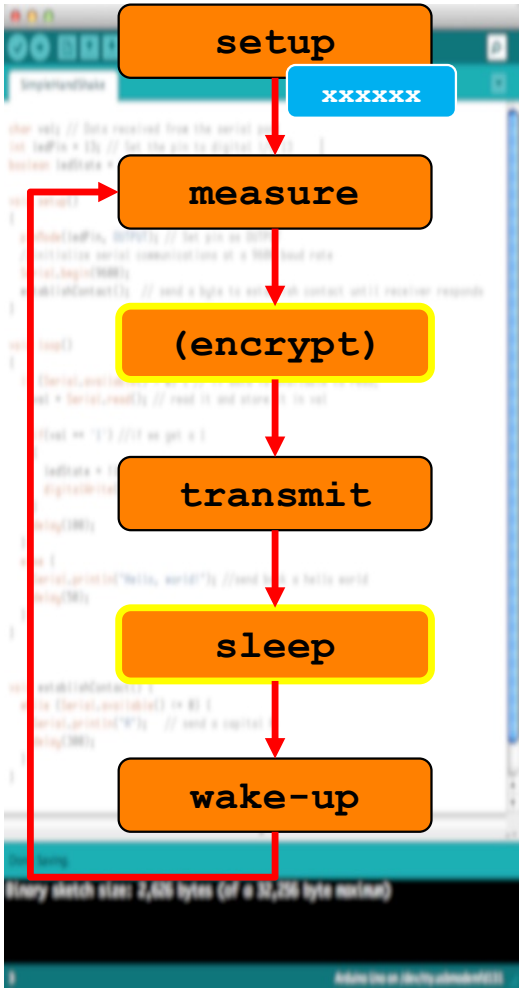
- Fully integrated development board: WAZIDev
  - Integrated MCU (ATMega328P, 3.3V & 8MHz)
  - On-board FTDI chip
- Features
  - All pins of MCU will be exposed
  - 2 MOSFET transistors to control energy-consuming sensors (e.g. GPS)





Simple development cycle





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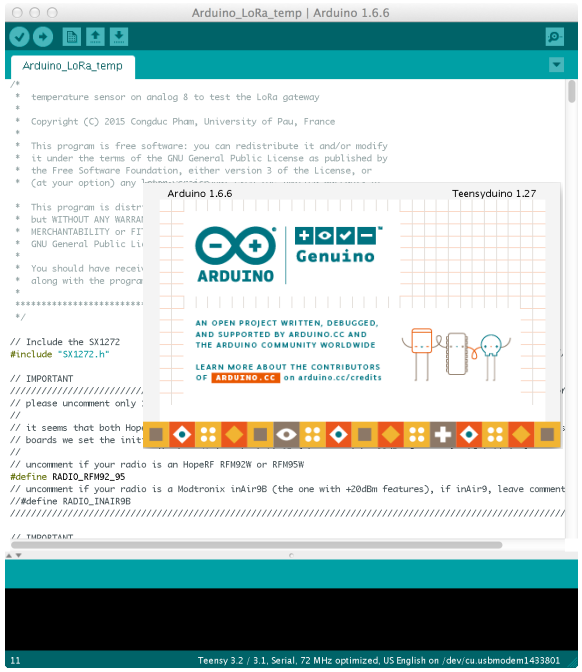
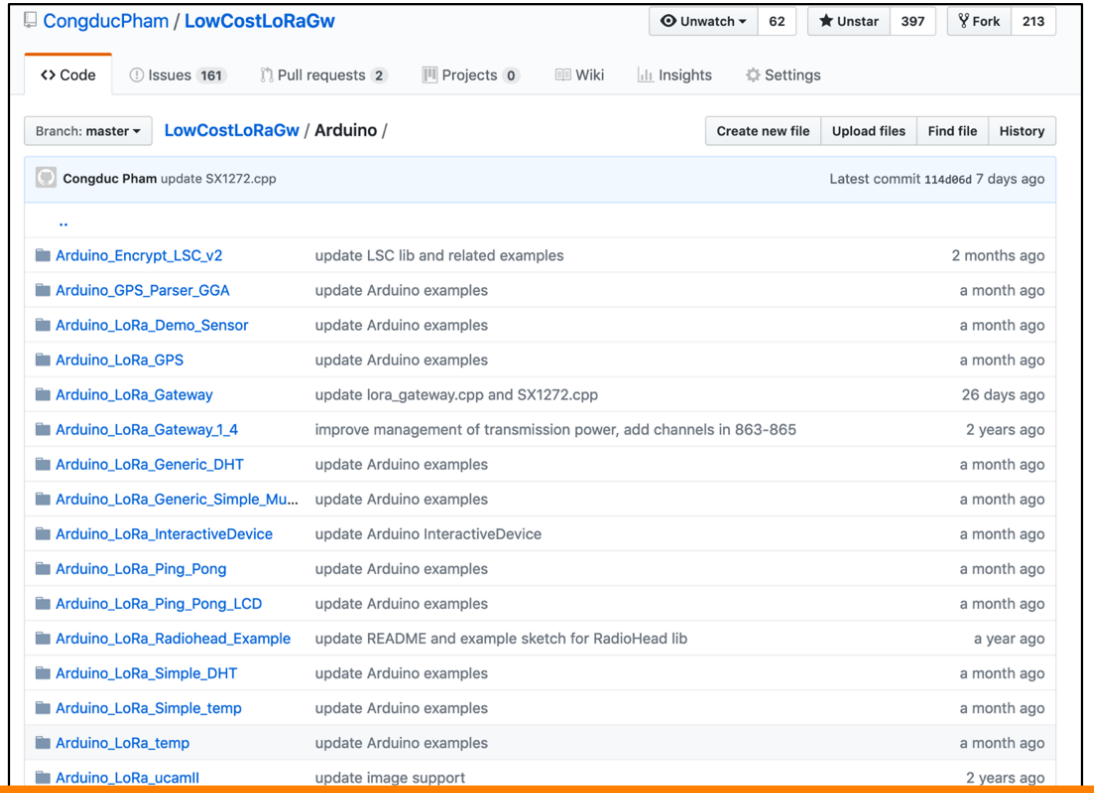
100% open-source code templates





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

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http://www.univ-pau.fr/~cpham

Large variety of examples to learn and adapt

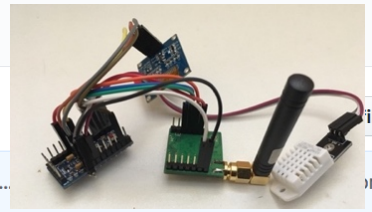
CongducPham / LowCostLoRaGw

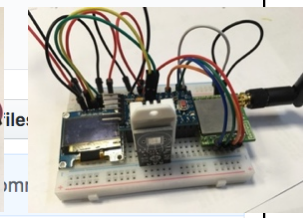
Unwatch 49 | Unstar 216 | Fork 120

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

Branch: master ▾ LowCostLoRaGw / Arduino /

Congduc Pham update README files, fix MD5 digest computation of gw id, always use ...





..	
Arduino_LoRa_GPS	update README
Arduino_LoRa_Gateway	update gateway related files and some ske
Arduino_LoRa_Gateway_1_4	improve management of transmission pow
Arduino_LoRa_Generic_Sensor	update Arduino examples
Arduino_LoRa_InteractiveDevice	update Arduino examples
Arduino_LoRa_Ping_Pong	update Arduino examples
Arduino_LoRa_Simple_BeaconCol...	update Arduino example
Arduino_LoRa_Simple_SoilHum	update Arduino examples
Arduino_LoRa_Simple_temp	update Arduino examples
Arduino_LoRa_SoilHum	update Arduino examples
Arduino_LoRa_temp	update Arduino examples
Arduino_LoRa_ucamII	update image support
libraries	update README files, fix MD5 digest comp
README.md	update README 19 days ago

`Arduino_LoRa_Demo_Sensor` is a very simple demo sketch for training purpose. The main program, i.e. `Arduino_LoRa_Demo_Sensor` can be left unchanged by the students. They just have to add/modify code in `my_demo_sensor_code.h` and `my_demo_sensor_code.cpp` to adapt the code for a given physical sensor. The provided example reads from either an LM35DZ or a TMP36 analog temperature sensor. The sensor is connected on pin A0 and is powered with digital pin 9.

`Arduino_LoRa_Simple_temp` uses the same simple structure than `Arduino_LoRa_Demo_Sensor` where `my_temp_sensor_code.cpp` contains the code to read values from the physical sensor (which is still either an LM35DZ or a TMP36 analog temperature sensor). Additionally, this example illustrates how to implement periodic sensing with low-power mode to run on battery for years. The sensor is connected on pin A0 and is powered with digital pin 9.

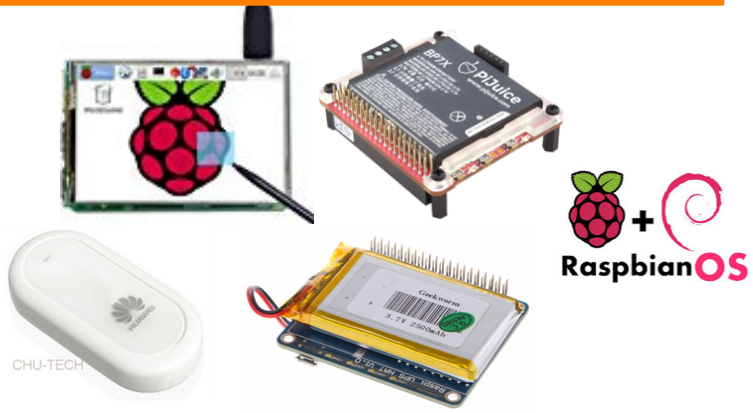
`Arduino_LoRa_Simple_DHT` shows how a more elaborated digital sensor such as the DHT22 (also known as AM2302) can be used. Code for DHT sensor is provided by the DHT library by Adafruit. This example therefore shows how you can use libraries provided by third-parties which is most likely the approach that you will use if you need to support a new physical sensor. Note that the DHT code can also be used for the AM2305 sensor. One advantage of the AM2305 is that it usually comes in an outdoor casing which make it suitable for outdoor and real-world deployment scenarios. Note that as it is a very simple example, only one physical measure is provided. In the example, it is the temperature even if the DHT22 sensor can provide both temperature and humidity. The sensor is connected on pin A0 and is powered with digital pin 9.

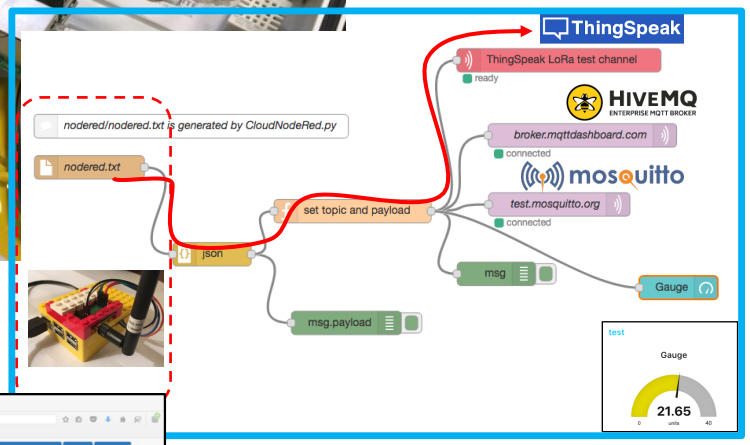
`Arduino_LoRa_temp` ends the simple temperature example serie. It illustrates a more complex example with AES encryption and the possibility to send LoRaWAN packet. It can also open a receive window after every transmission to wait for downlink message coming from the gateway (to do so, uncomment `#define WTH_RCVW`). The template shows for instance how an '/@Ax#' command from the gateway can be parsed to set the node's address to 'x'. It can serve as a template for a more complex LoRa IoT device with actuation capability on downlink packets from the gateway. The sensor is connected on pin A0 and is powered with digital pin 9.

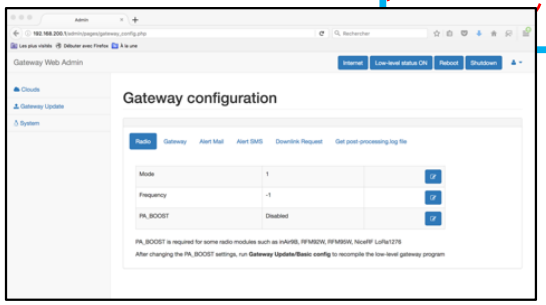
Open, versatile IoT gateway

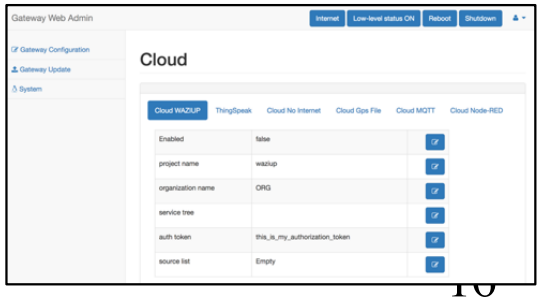
Latest distribution
https://github.com/CongducPham/LowCostLoRaGw

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









THE THINGS NETWORK

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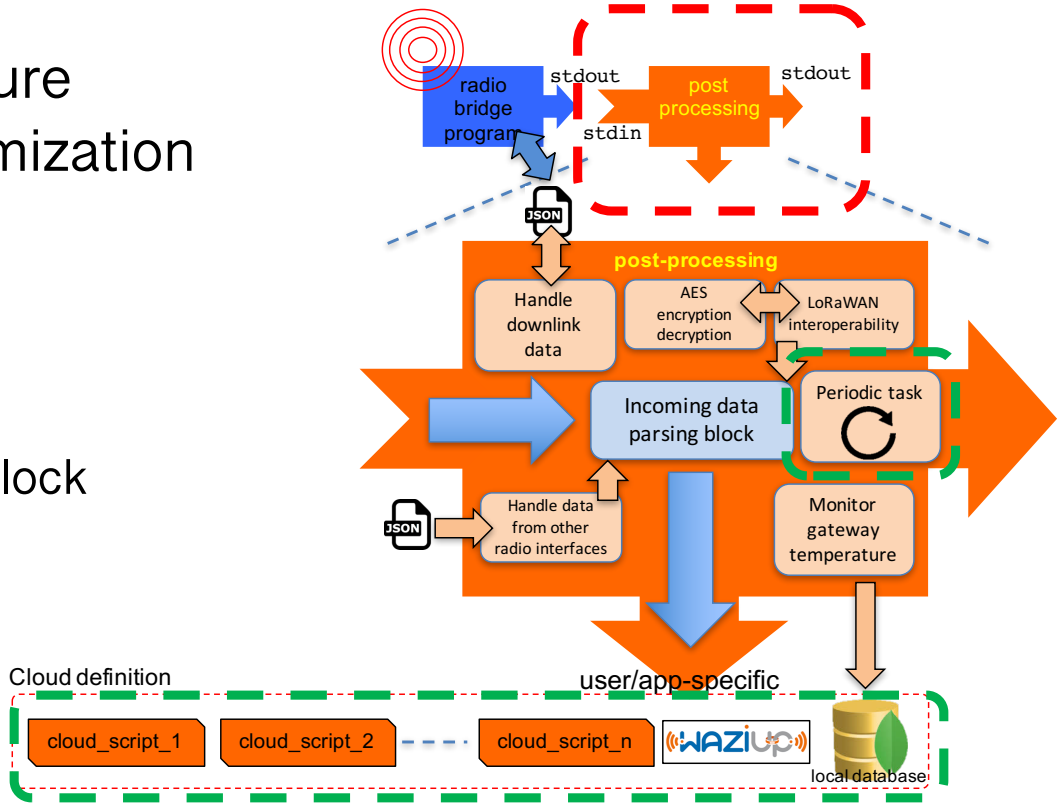
Large customization possibilities

- The flexible gateway architecture offers high versatility by customization
- There are 4 alternatives for customization
- The geek way
  - Modify/extend post-processing block
- The "smarter" way
  - Add "cloud" scripts
    - On packet reception
  - Add low rate periodic tasks
    - Independant from packet reception
  - Add fast rate statistic-oriented tasks



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Deployment in rural areas no Internet ☹

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

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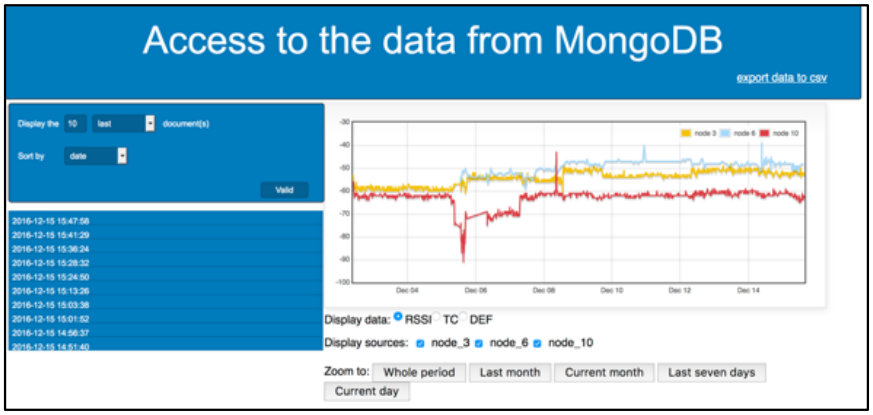
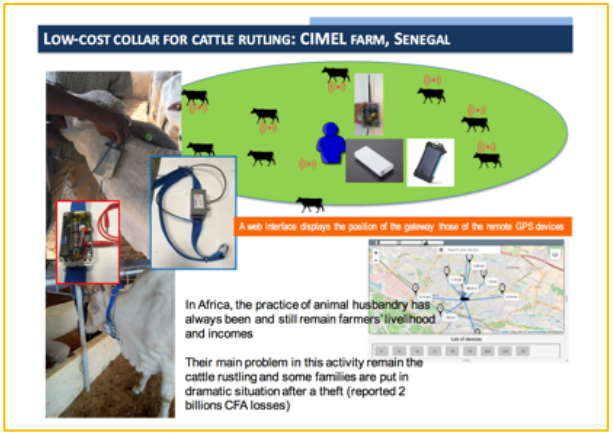
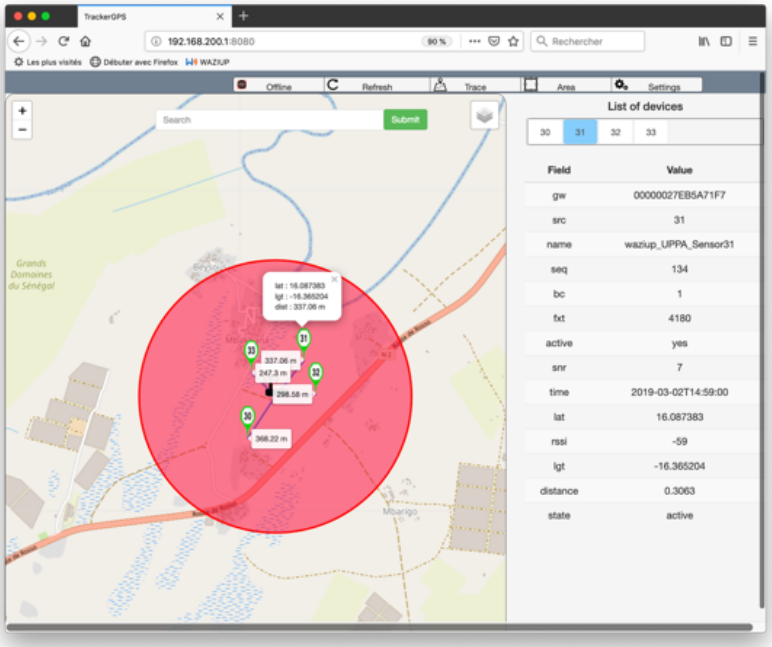
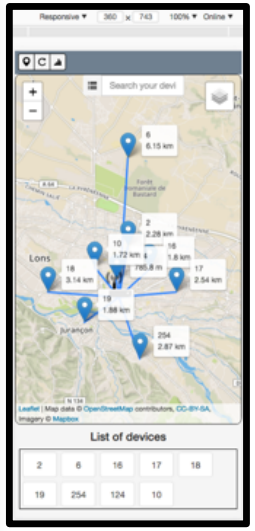
Deploying IoT in Africa

Autonomous gateway – no Internet scenario





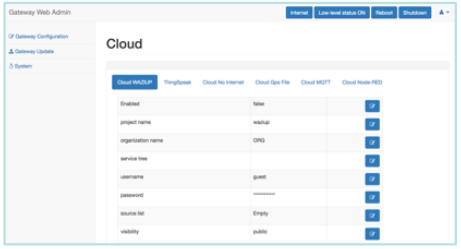




Link to a short demo video of the collar web interface: https://youtu.be/meFDav1SLPI

"Branding" your IoT gateway

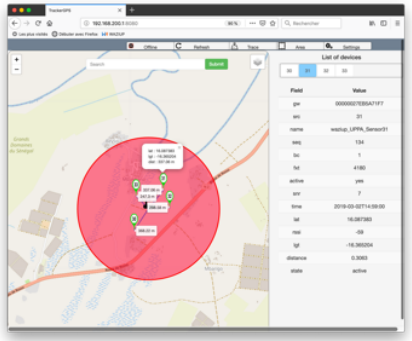
- Develop/Add project/company specific features on top of the general distribution

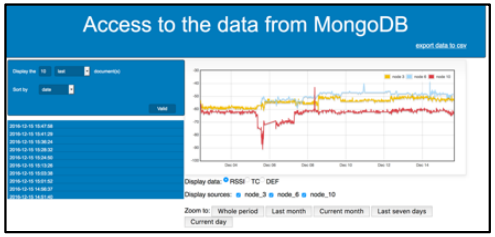


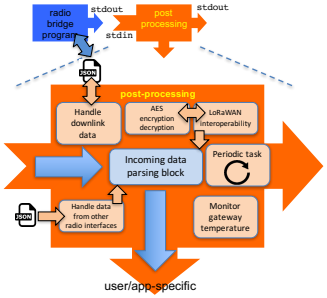
ADDITIONAL FEATURES SET 2

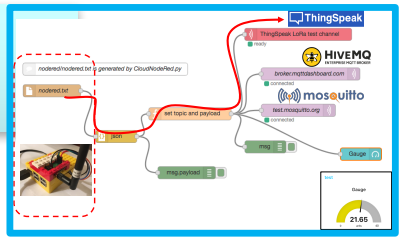
ADDITIONAL FEATURES SET 1

GENERAL DISTRIBUTION









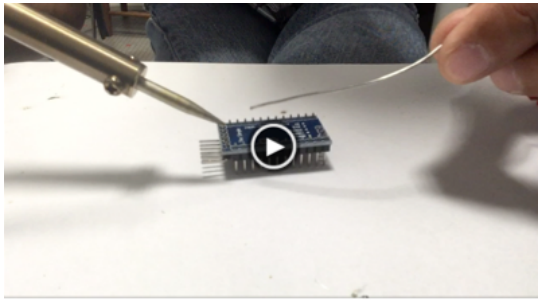
Tutorials/resources

https://github.com/CongducPham/tutorials

Prof. Congduc Pham
http://www.univ-pau.fr/~cpham

YouTube videos

Low-cost LoRa IoT device



+87000 views

Apr2020

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

Low-cost LoRa IoT gateway

+19000 views

Apr2020

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

Extreme low-power LoRa IoT

+8000 views

Apr2020

https://www.youtube.com/watch?v=2_VQpcCwdd8

Setting up a gateway in 5mins

+3500 views

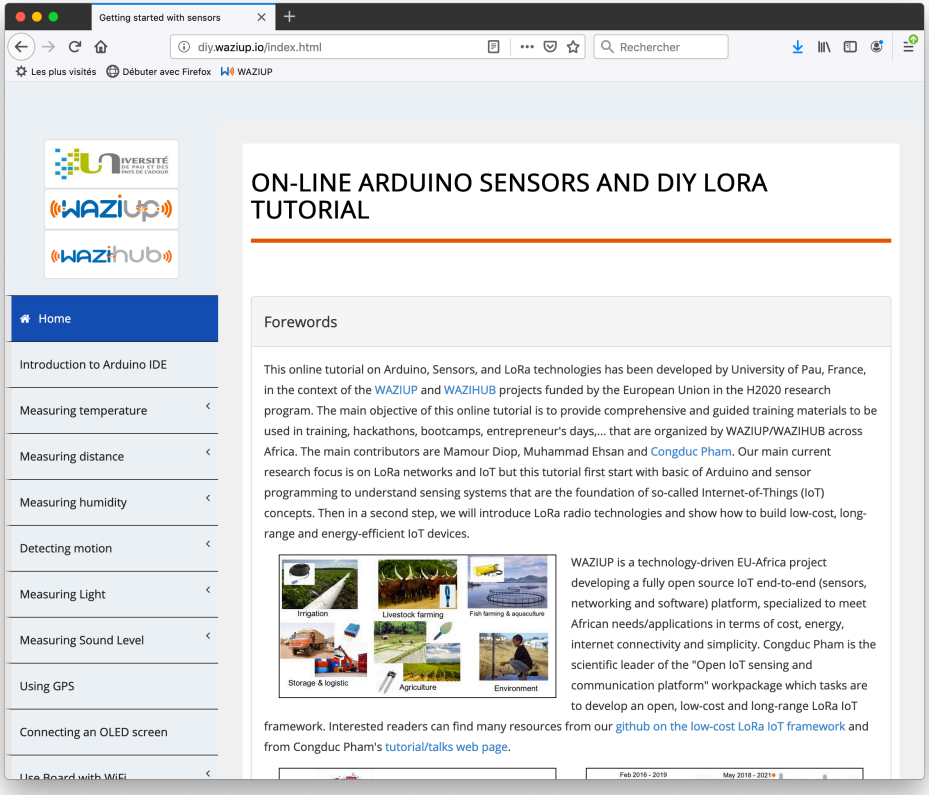
Apr2020

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

Prof. Congduc Pham
http://www.univ-pau.fr/~cpham

Training & hackathons

- Technical training sessions
- Hackathons, ...



Online Arduino & IoT step-by-step tutorial
https://diy.waziup.io

Prof. Congduc Pham
http://www.univ-pau.fr/~cpham

Building domain-specific sensors

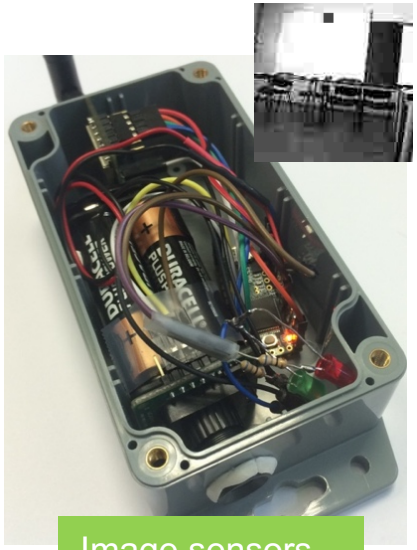
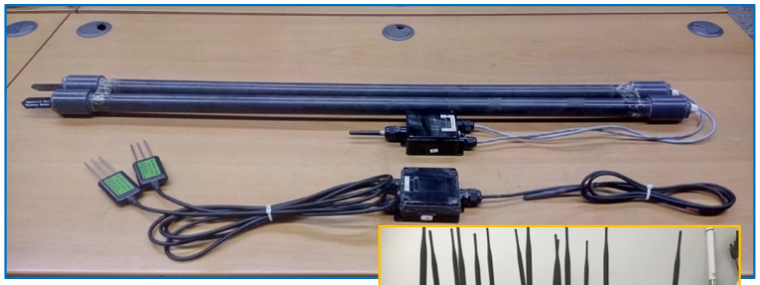


Image sensors

GPS collar



Soil Moisture

Photo from Unparallel

Photo from EGM

Buoy for water quality

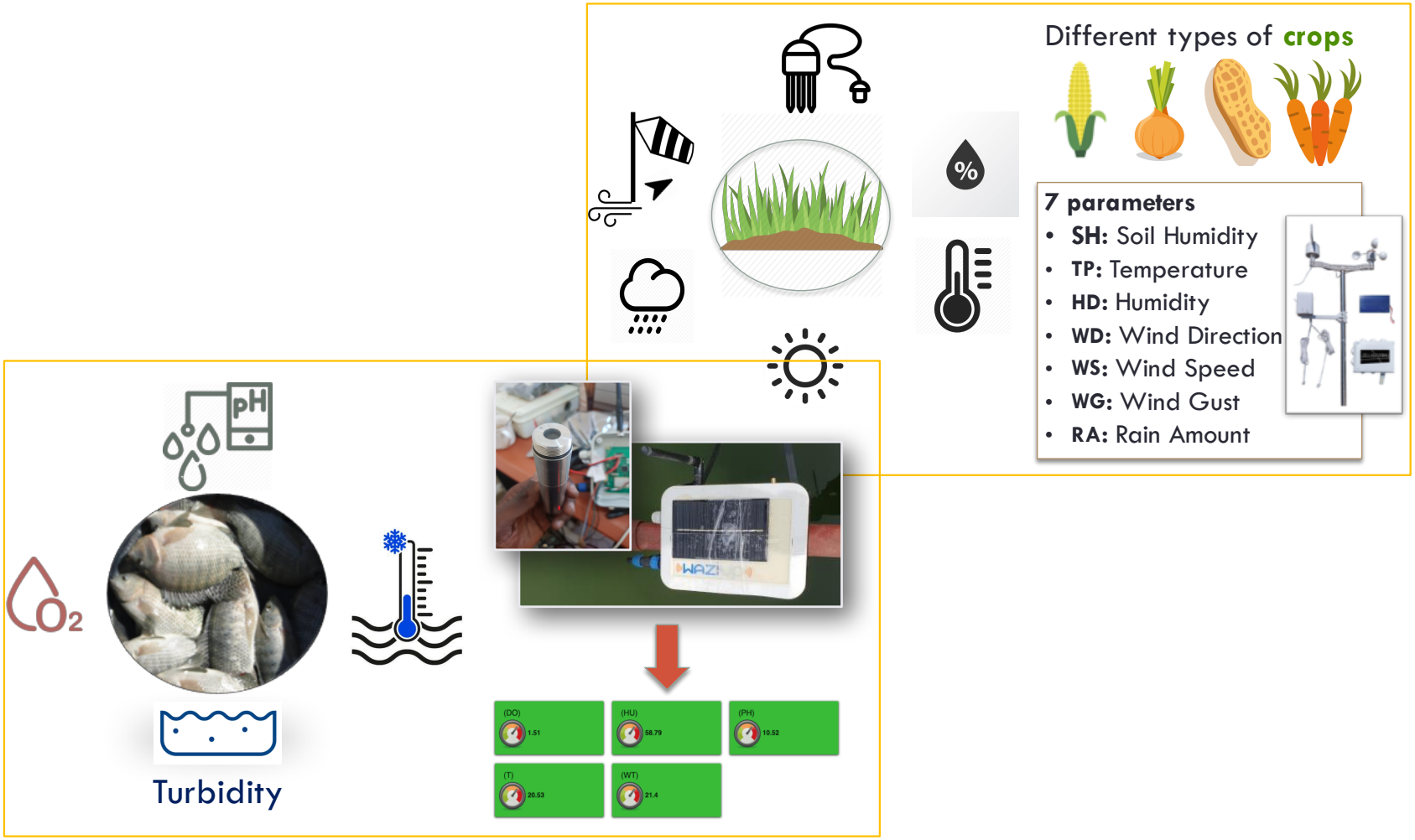
Weather Station

Bin presented at Woelab

Waste Mngt

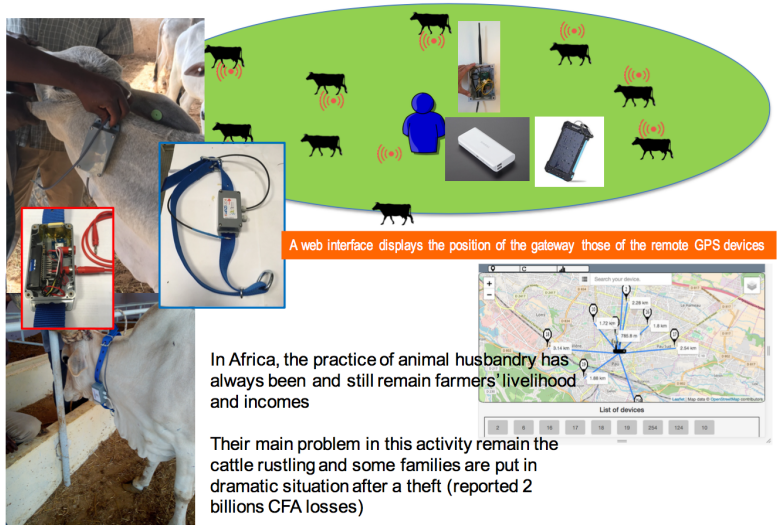
Prof. Congduc Pham
http://www.univ-pau.fr/~cpham

...to capture specific parameters



Prof. Congduc Pham
http://www.univ-pau.fr/~cpham

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)

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

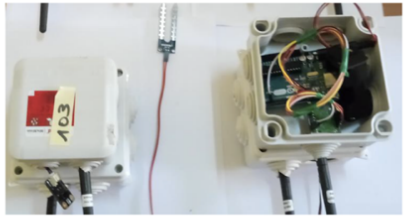
- The Kwame Nkrumah University of Science and Technology (KNUST)
- Located on the campus of the Kwame Nkrumah University of Science and Technology in Kumasi, Ghana.
- The farm comprises 30 constructed fish ponds, a farm house, a recirculating aquaculture system (RAS) laboratory and store houses.

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

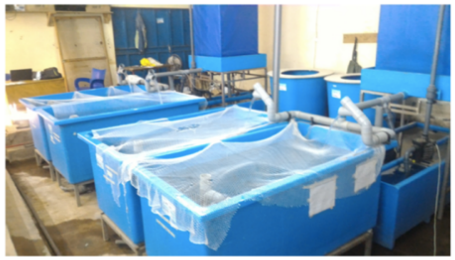
Banana plant

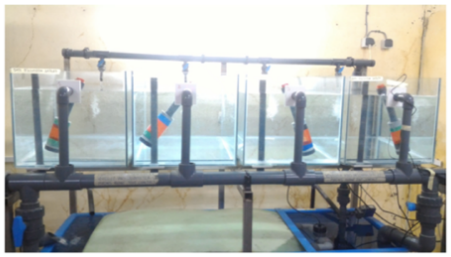
Papaya tree

Urbannatic gardens, Togo

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





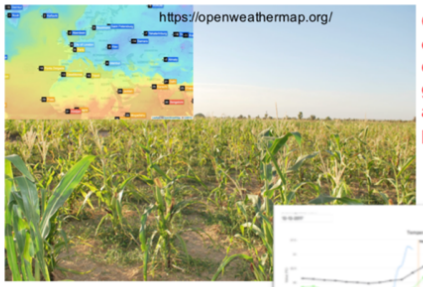
LOCAL WEATHER STATION FOR AGRICULTURE

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

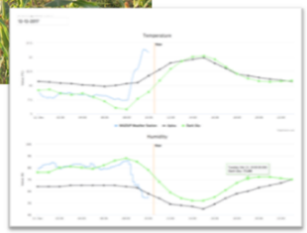
Agriculture MVP requirements:

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

Get local weather measurements

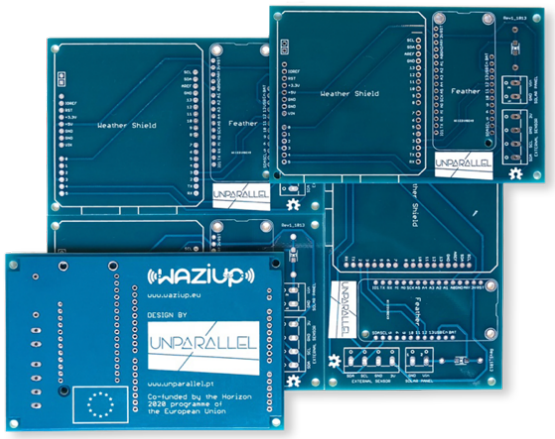


Combine with open weather data to get more accurate predictions



Weather Web App

Pilot sites: Senegal, Togo, Ghana, Burkina Faso



From Unparallel for WAZIUP

IOT ONLINE COURSE

Fundamentals of IoT

Continue with
A-IOT-1: LoRa & LoRaWAN explained

WAZIUP
IoT – from idea to reality
WAZIHUB