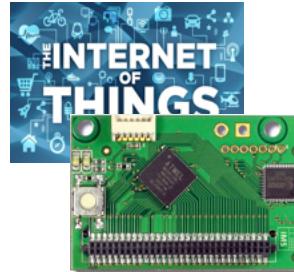


DEPLOYING LOW-COST AND LONG-RANGE INTERNET OF THINGS IN DEVELOPING COUNTRIES



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





IoT FOR DEVELOPMENT



Irrigation



Livestock farming



Fish farming & aquaculture



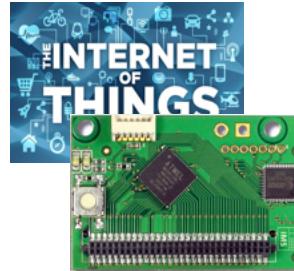
Storage & logistic



Agriculture



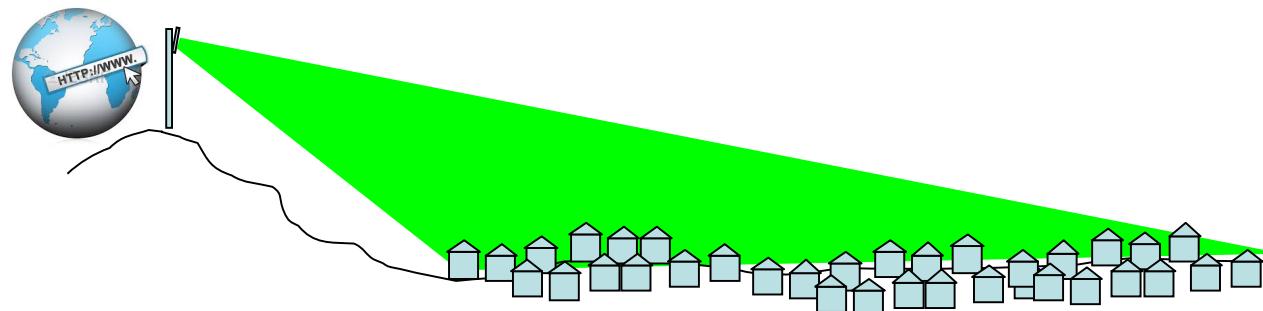
Fresh water



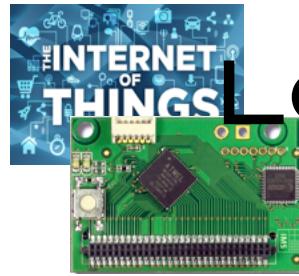
LONG-RANGE SENSING



Moisture/
Temperature of
storage areas



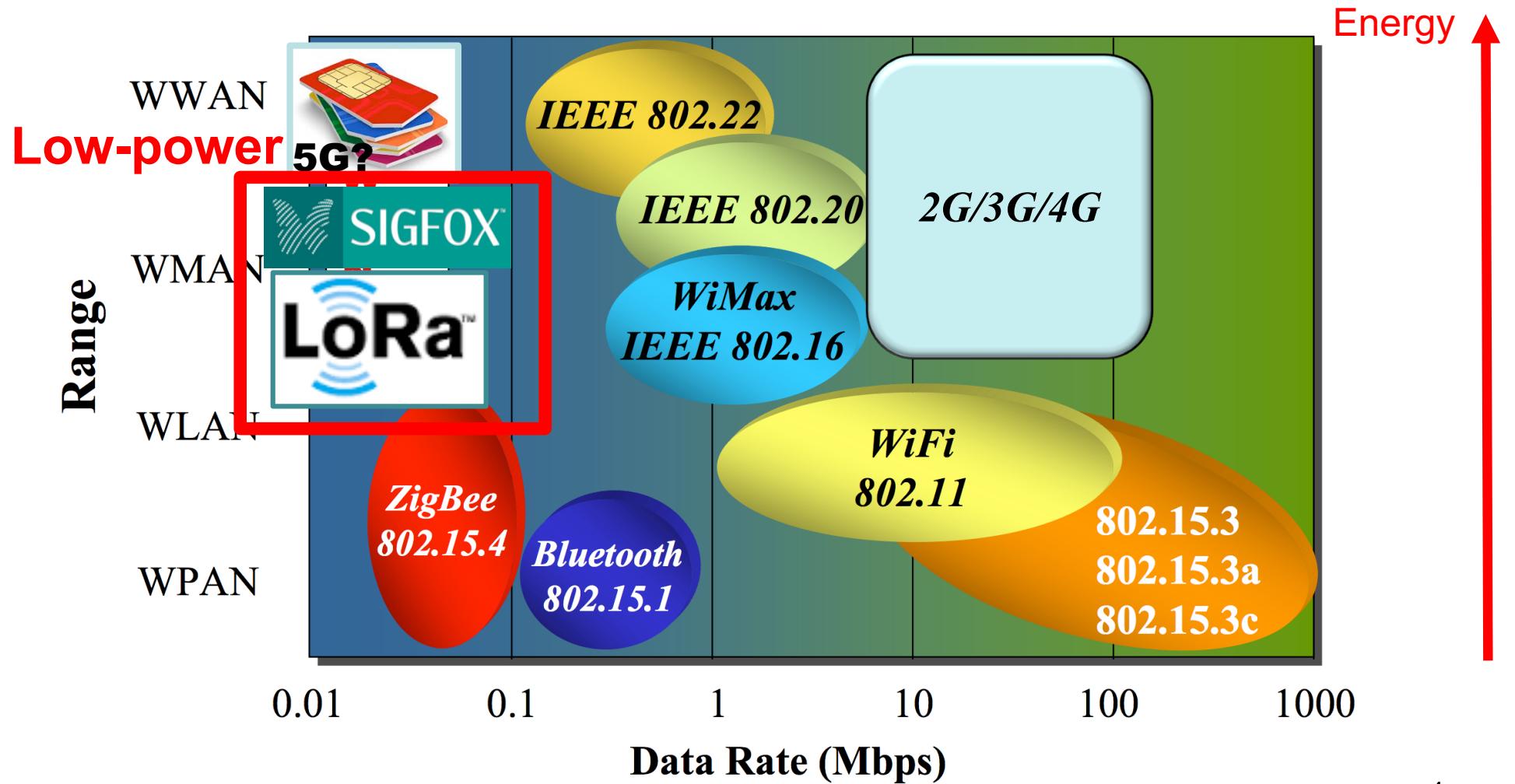
Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200-500mA	500-1000mA	100-300mA
Standby current	2.3mA	3.5mA	NC

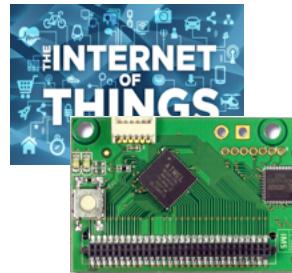


LOW-POWER & LONG-RANGE RADIO TECHNOLOGIES



Energy-Range dilemma





ENERGY CONSUMPTION COMPARAISON



Tables from Semtech

Technology	2G	3G	LAN	ZigBee	Lo Power WAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m	O: 90m I: 30m	Same as 2G/3G
Tx current consumption	200-500mA	500-1000mA	100-300mA	18mA	18mA
Standby current	2.3mA	3.5mA	NC	0.003mA	0.001mA
Energy harvesting (solar, other)	No	No	No	Possible	Possible
Battery 2000mAh (LR6 battery)	4-8 hours(com) 36 days(idle)	2-4 hours(com) X hours(idle)	50 hours(com) X hours(idle)	60hours (com)	120 hours(com) 10 year(idle)
Module Revenue Annually	12 \$	20 \$	4 \$	\$3	3 \$

Autonomy GSM with 2000mAh -



Autonomy LP WAN with 2000mAh -



Example for energy meter

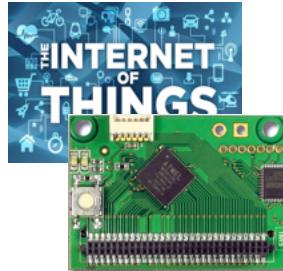
1 year

5 years

10 years

MATURATION OF THE IOT MARKET...





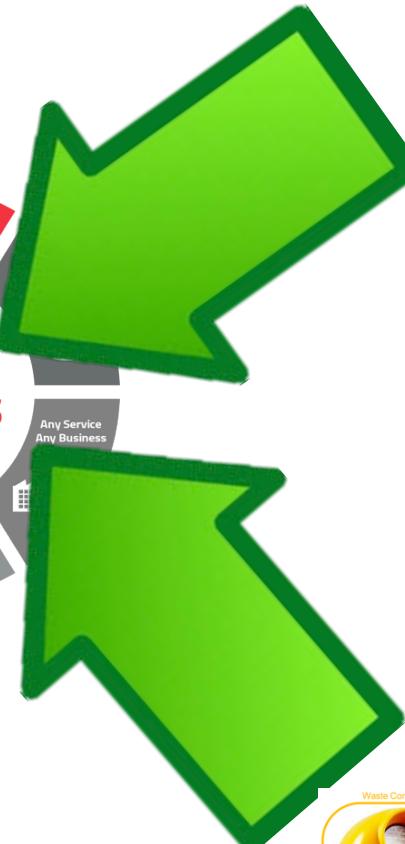
IOT BECOMES REALITY!

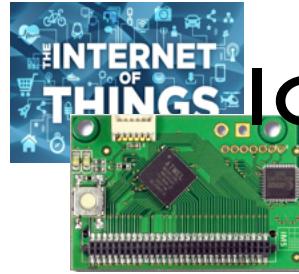


NB-LTE



nwave
LTE-M
NB-IOT
EC-GSM

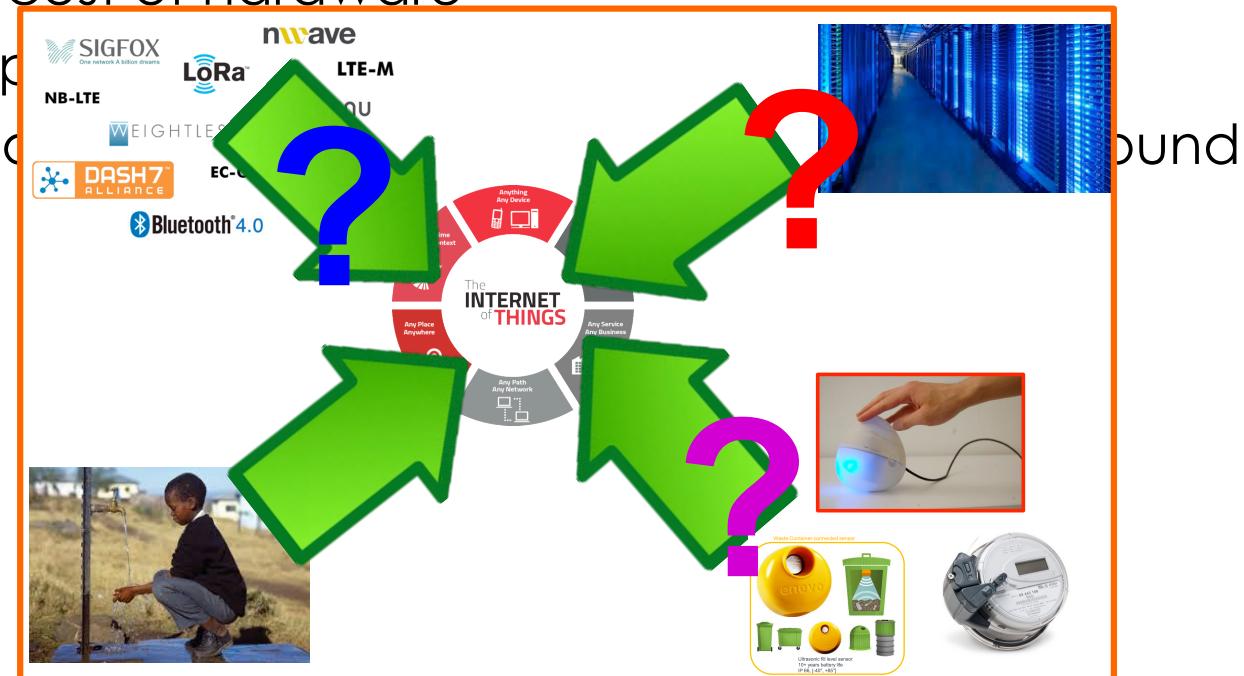




THE INTERNET OF THINGS IN DEVELOPING COUNTRIES OR RURAL AREAS?



- Developing countries/rural areas are still far from being ready to enjoy the smallest benefit of IoT
 - lack of infrastructure
 - high cost of hardware
 - competition
 - lack of skills

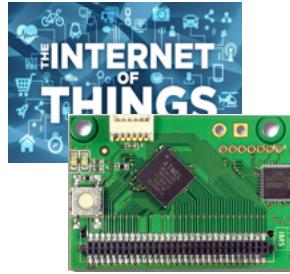


MATURATION OF THE IOT MARKET...

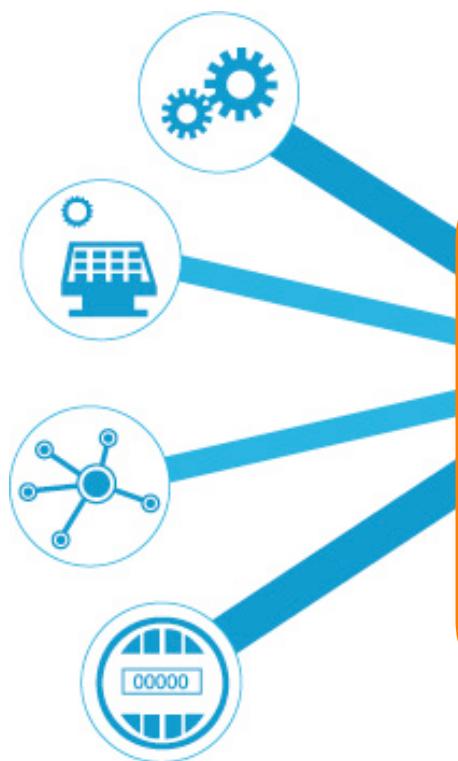


Too expensive
Too integrated
Highly specialized
Difficult to customize
Difficult to upgrade



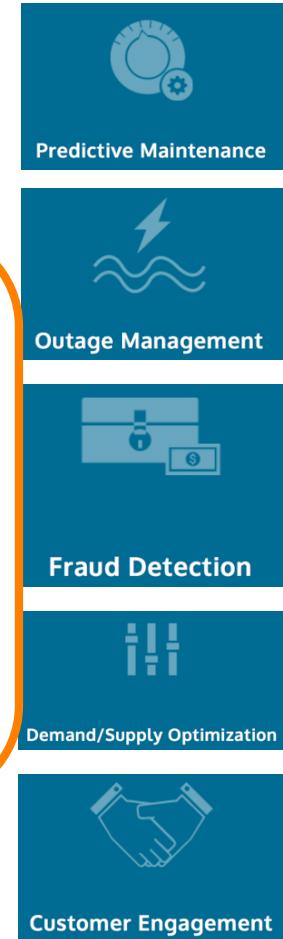


INTERNET, CLOUD & BIG DATA ANALYTICS

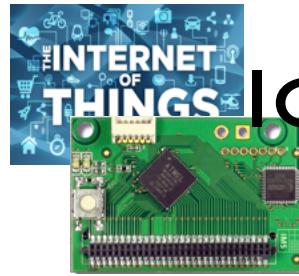


Internet connectivity is weak and expensive!

Nearly impossible in remote/rural areas



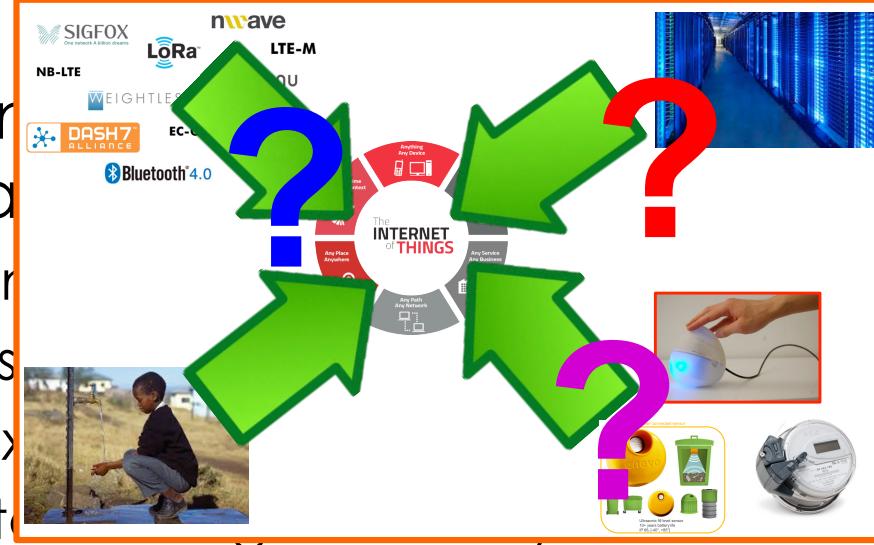
Graphics from <http://www.vitria.com/iot-analytics/>

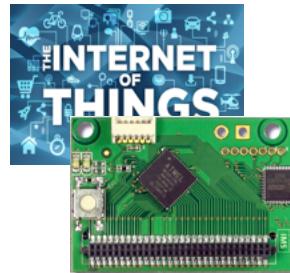


IoT IN DEVELOPING COUNTRIES AND RURAL AREAS



- Developing countries being ready
 - lack of infrastructure
 - high costs
 - complex regulations
 - lack of technical background
- still far from benefit of IoT
- **to deploy IoT in developing countries, it is necessary to target three major issues**
 - reduce cost of infrastructures, hardware and services
 - limit dependency to proprietary infrastructures and provide local interaction models
 - target technology appropriation, push for local business models



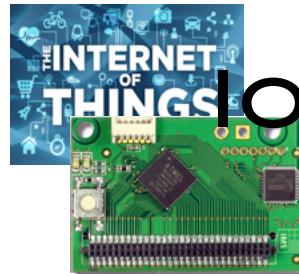


WAZIUP: LOW-COST IoT



[ABOUT »](#) [TECHNOLOGIES »](#) [COMMUNITY](#) [NEWS & EVENT »](#) [DOWNLOADS](#) [DEV KIT](#) [FAQ](#) [CONTACT](#)

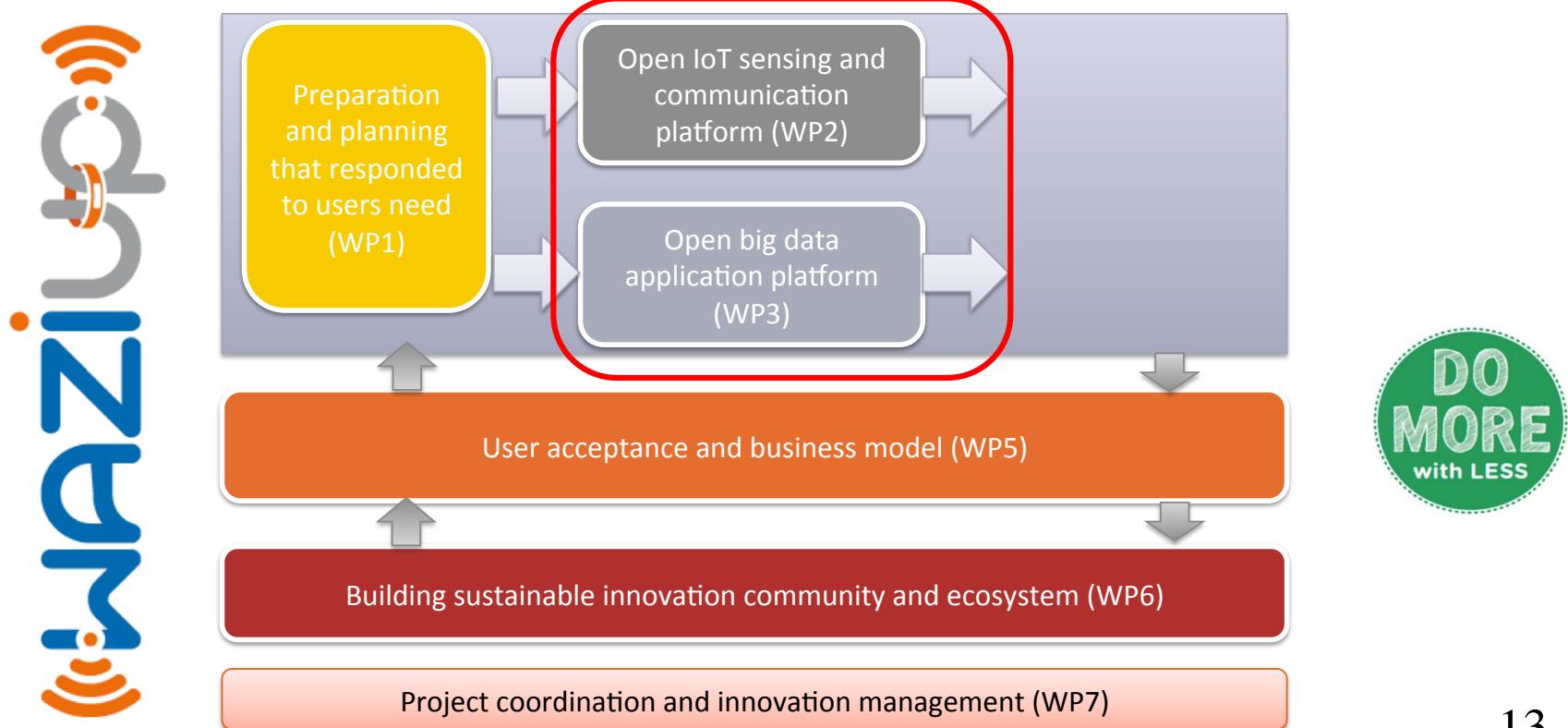


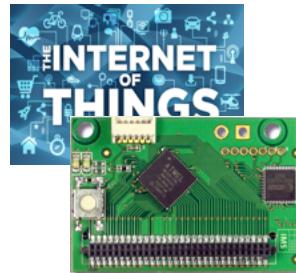


IoT FOR RURAL APPLICATIONS IN DEVELOPPING COUNTRIES



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





LOW-COST HARDWARE



WHAT IS ARDUINO?

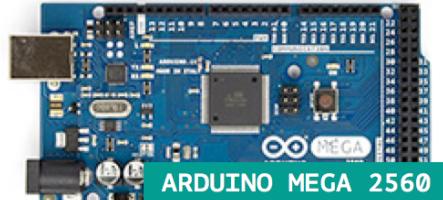
Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects.

ARDUINO BOARD

Arduino senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators.



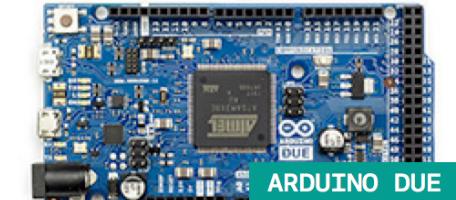
ARDUINO UNO



ARDUINO MEGA 2560



ARDUINO ZERO



ARDUINO DUE



ARDUINO MICRO



ARDUINO PRO MINI

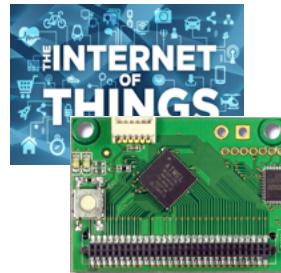


ARDUINO NANO

```
void setup() {  
}  
  
void loop() {  
}
```

ARDUINO SOFTWARE

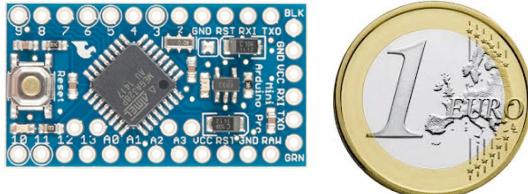
You can tell your Arduino what to do by writing code in the Arduino programming language and using the Arduino development environment.



LARGE ECOSYSTEM, STILL GROWING!



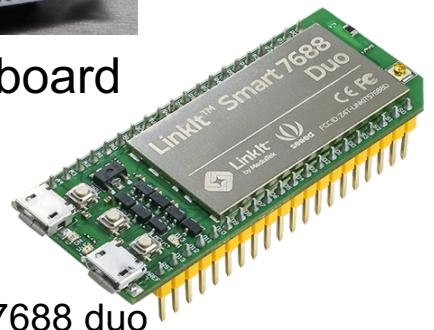
Arduino Pro Mini



LoPy



Theairboard



LinkIt
Smart7688 duo



Expressif ESP32

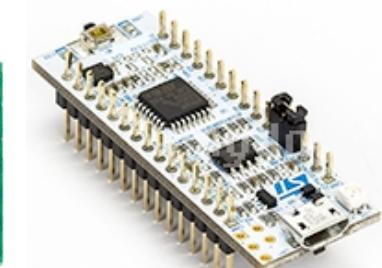
<http://www.postscapes.com/internet-of-things-hardware/>

<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/>



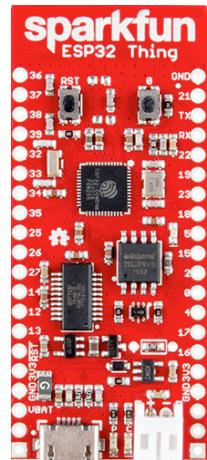
Teensy 3.2



STM32 Nucleo-32



Adafruit Feather



Sparkfun ESP32
Thing



Tessel

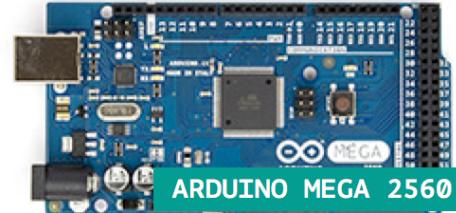
SodaqOnev2



Tinyduino



SW/HW BUILDING BLOCKS INTEGRATION



More to come...



LoRa radios that
our library already
supports



HopeRF
RFM92W/95W



Libelium LoRa

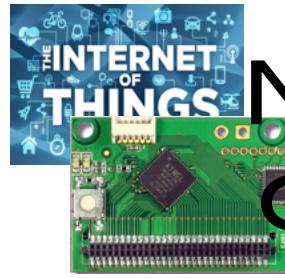


Modtronix
inAir9/9B



NiceRF
LoRa1276

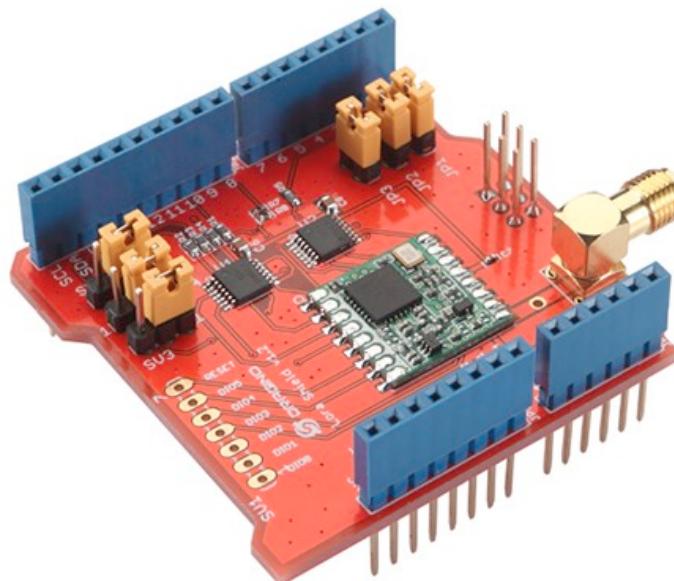
Long-Range communication library



MORE AND MORE EASY-TO-CONNECT LORA MODULES!



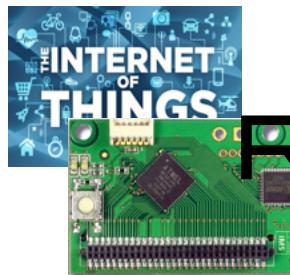
LORANGA LoRa +
2G/3G board



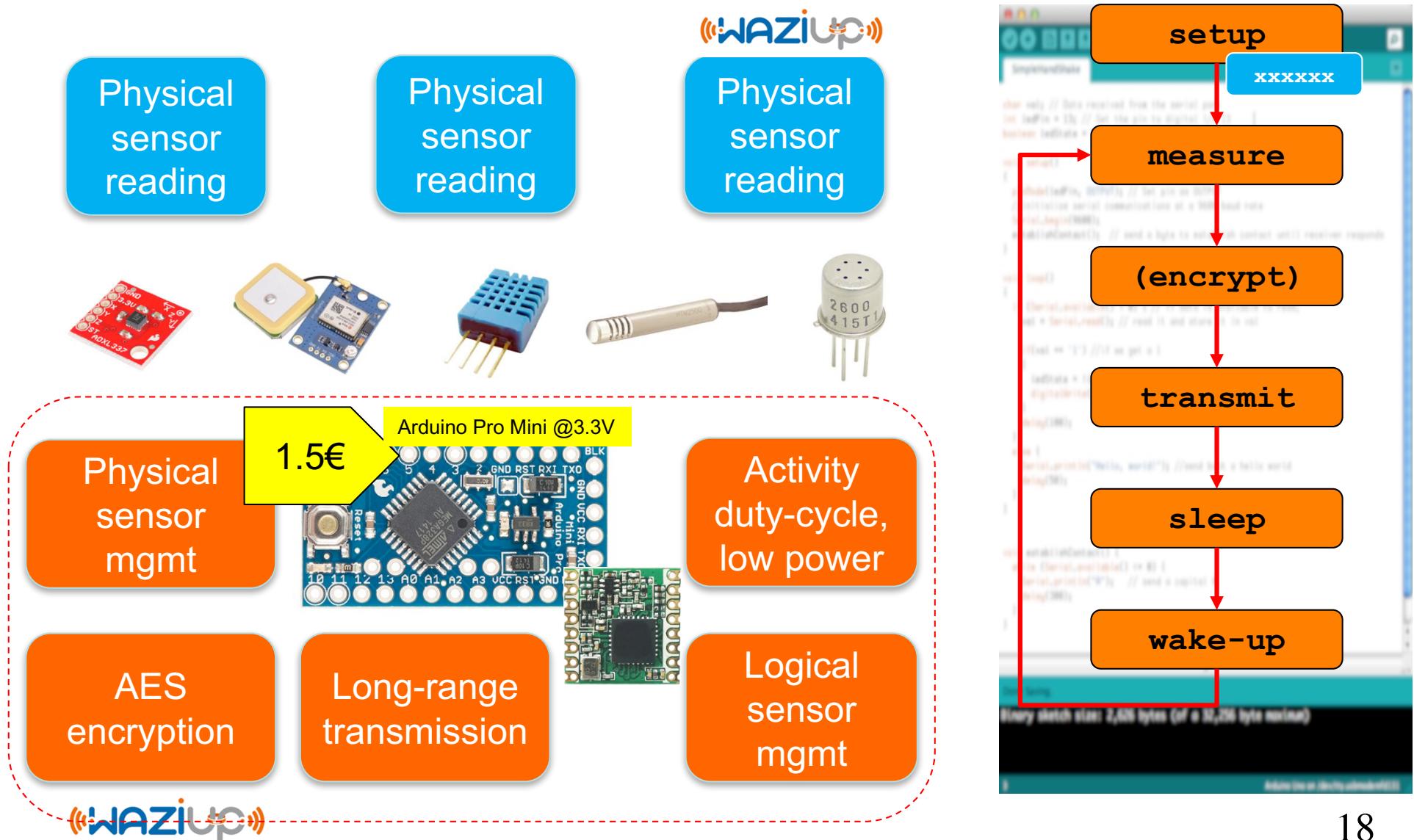
Dragino LoRa shield

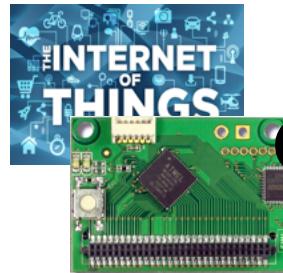


LinkSprite LoRa shield



READY-TO-USE TEMPLATES





OPEN-SOURCE SOFTWARE



```
/*
 * temperature sensor on analog 8 to test the LoRa gateway
 *
 * Copyright (C) 2015 Congduc Pham, University of Pau, France
 *
 * This program is free software: you can redistribute it and/or modify
 * it under the terms of the GNU General Public License as published by
 * the Free Software Foundation, either version 3 of the License, or
 * (at your option) any later version.
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without
 * MERCHANTABILITY or FITNESS FOR
 * GNU General Public License for
 *
 * You should have received a copy
 * along with the program. If not
 */
*****  

// Include the SX1272
#include "SX1272.h"  

// IMPORTANT
// please uncomment only 1 choice
// it seems that both HopeRF and M
// boards we set the initial power
// uncomment if your radio is on Hc
#define RADIO_RF902_95
// uncomment if your radio is a M
#define RADIO_INA1R9B  

// THORNTANT  

*****  

11
```

CongducPham / LowCostLoRaGw

Code Issues Pull requests Projects Pulse Graphs

Watch 50 Star 161 Fork 95

Low-cost LoRa IoT & gateway with SX1272/76, Raspberry and Arduino

122 commits 1 branch 0 releases 2 contributors

Branch: master New pull request Find file Clone or download

Congduc Pham bug fix in lora_gateway.cpp Latest commit a0daa4a a day ago

Arduinopham update SMS scripts 15 days ago

gw_full_latest bug fix in lora_gateway.cpp a day ago

tutorials update SMS scripts 15 days ago

.gitignore .DS_Store banished 10 months ago

README.md update README 11 days ago

Arduinopham update sketch 3 months ago

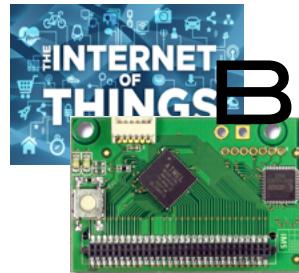
Arduinopham update sketch 3 months ago

Arduinopham update image support 2 months ago

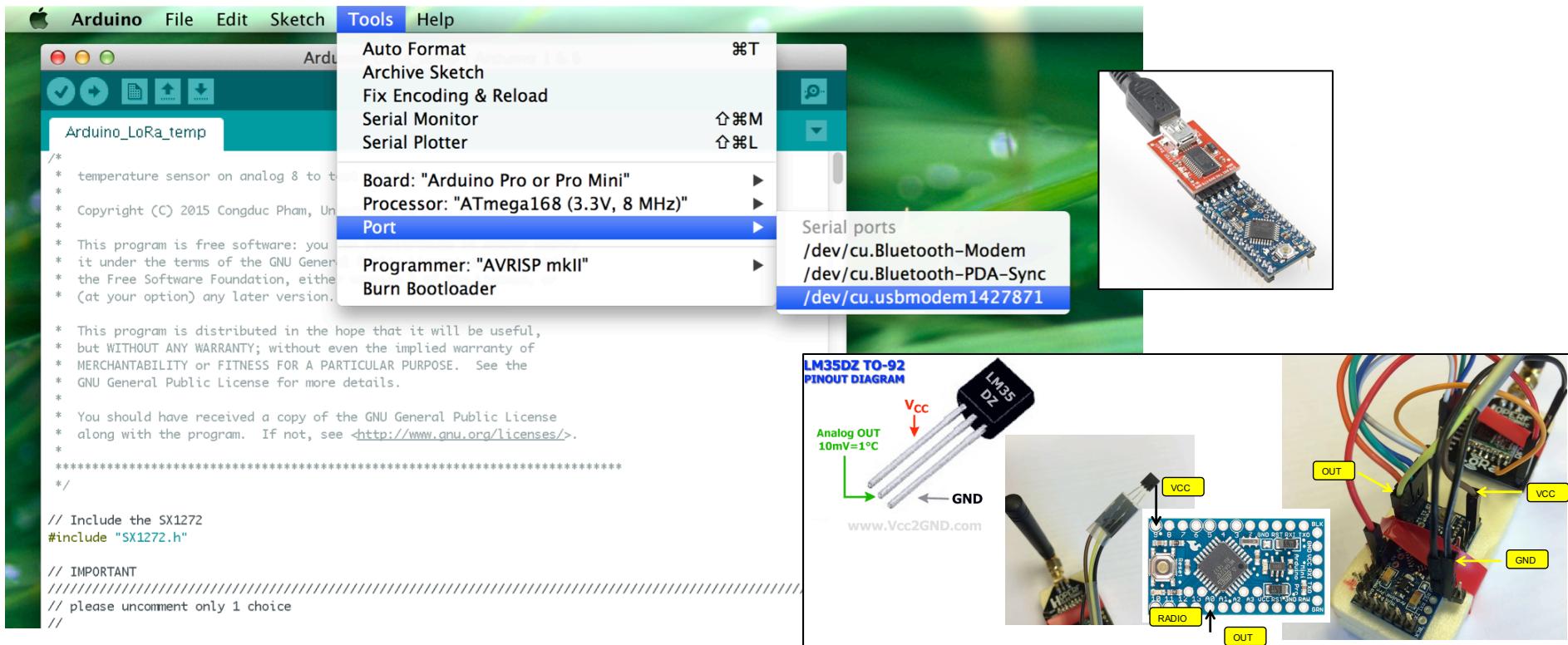
libraries update image support 2 months ago

README.md update image support 2 months ago

LowCostLoRaGw github repository at
<https://github.com/CongducPham/LowCostLoRaGw>

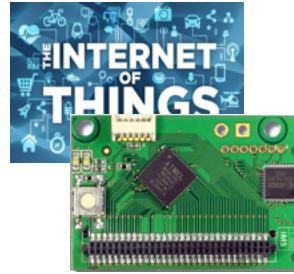


BUILD YOUR FIRST LORA IOT DEVICE



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





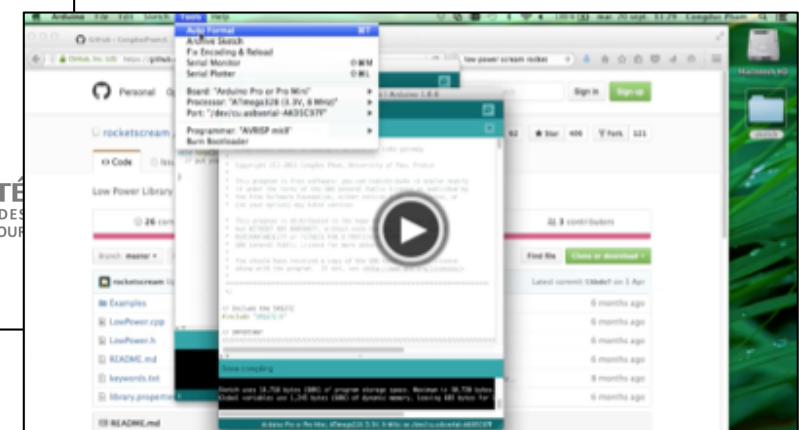
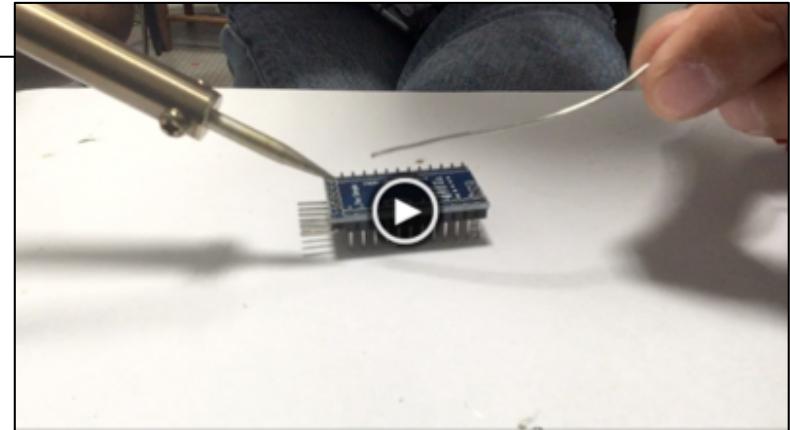
TUTORIALS AND VIDEOS



LOW-COST LoRa IoT DEVICE: A STEP-BY-STEP TUTORIAL

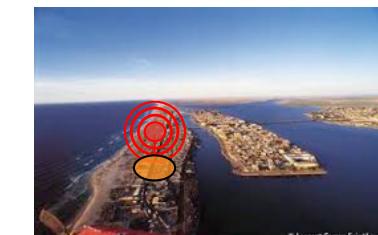
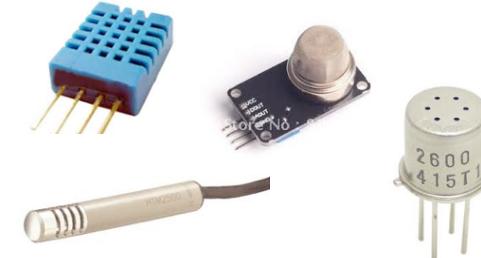
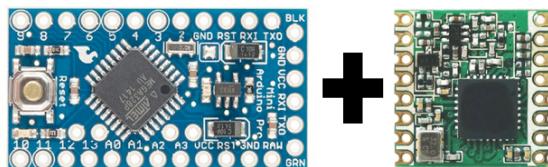


PROF. CONG DUC PHAM
[HTTP://WWW.UNIV-PAU.FR/~CPHAM](http://www.univ-pau.fr/~cpham)
UNIVERSITÉ DE PAU, FRANCE



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,...





GENERIC SENSING IOT DEVICE



- Build low-cost, low-power, Long-range enabled generic platform

- Meet the needs of the African market

- Technical and economic feasibility

Minimum Viable Product

Waziup
Advisory
Board

Waziup
Community

WAZIUP PROJECT



WP1
WP2
WP3
WP4
WP5
WP6

MVP 1
Water
Fish Farming



MVP 2
Cattle
Rustling



MVP 3
AGRI



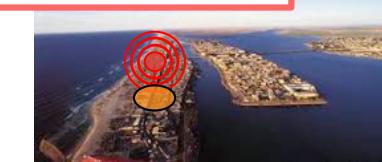
MVP 4
Logistic
Transport

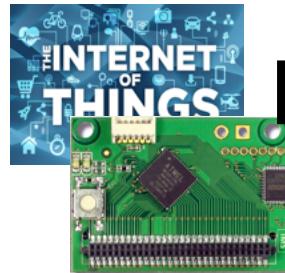


MVP 5
Urban
Waste
mgt



Credit: P. Cousin, EGM





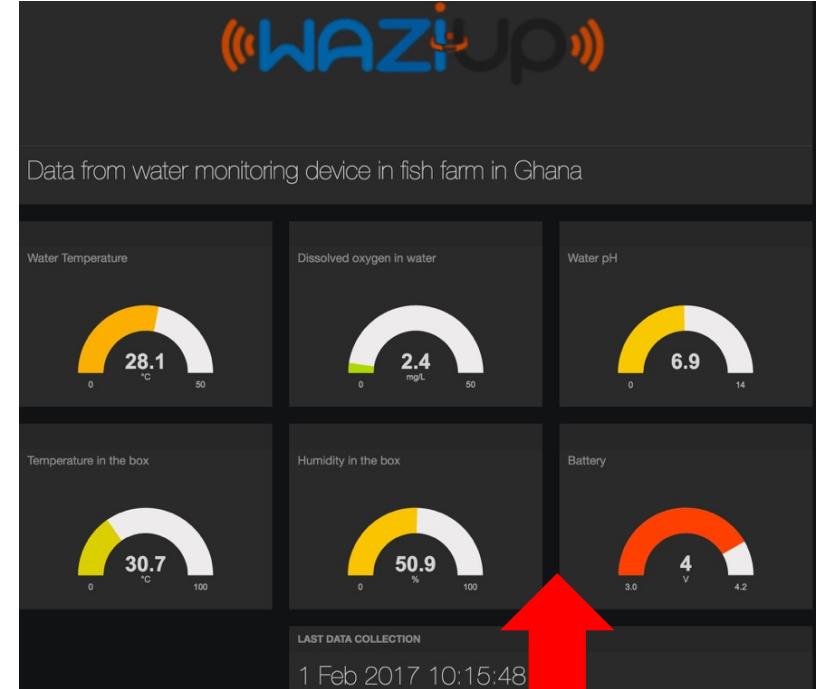
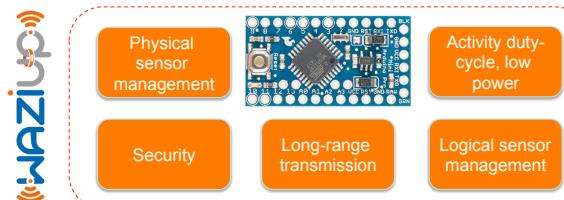
LOW-COST BUOY FOR FISH FARMING MVP



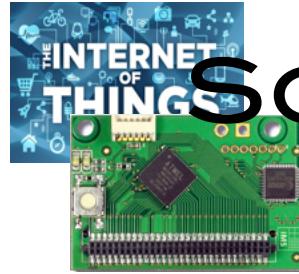
WAZIUP
Physical sensor reading



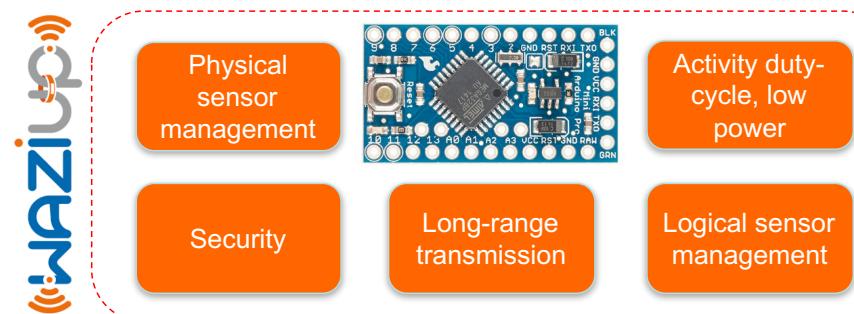
Credit: EGM

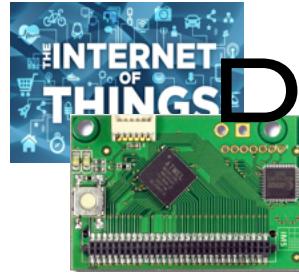


FIWARE



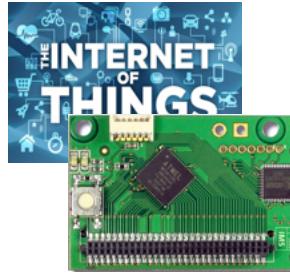
SOIL HUMIDITY SENSORS FOR AGRI MVP



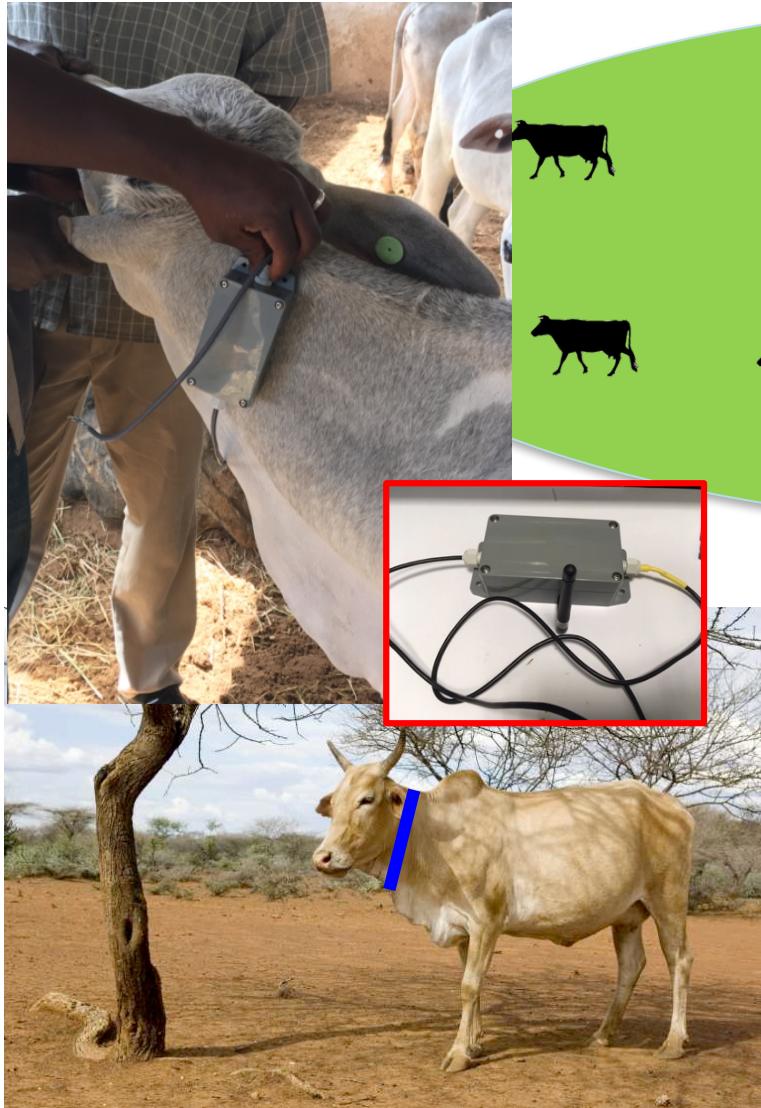


DEPLOYMENT FOR NESTLÉ'S WATERSENSE PROJECT





COLLAR FOR CATTLE RUSTLING MVP

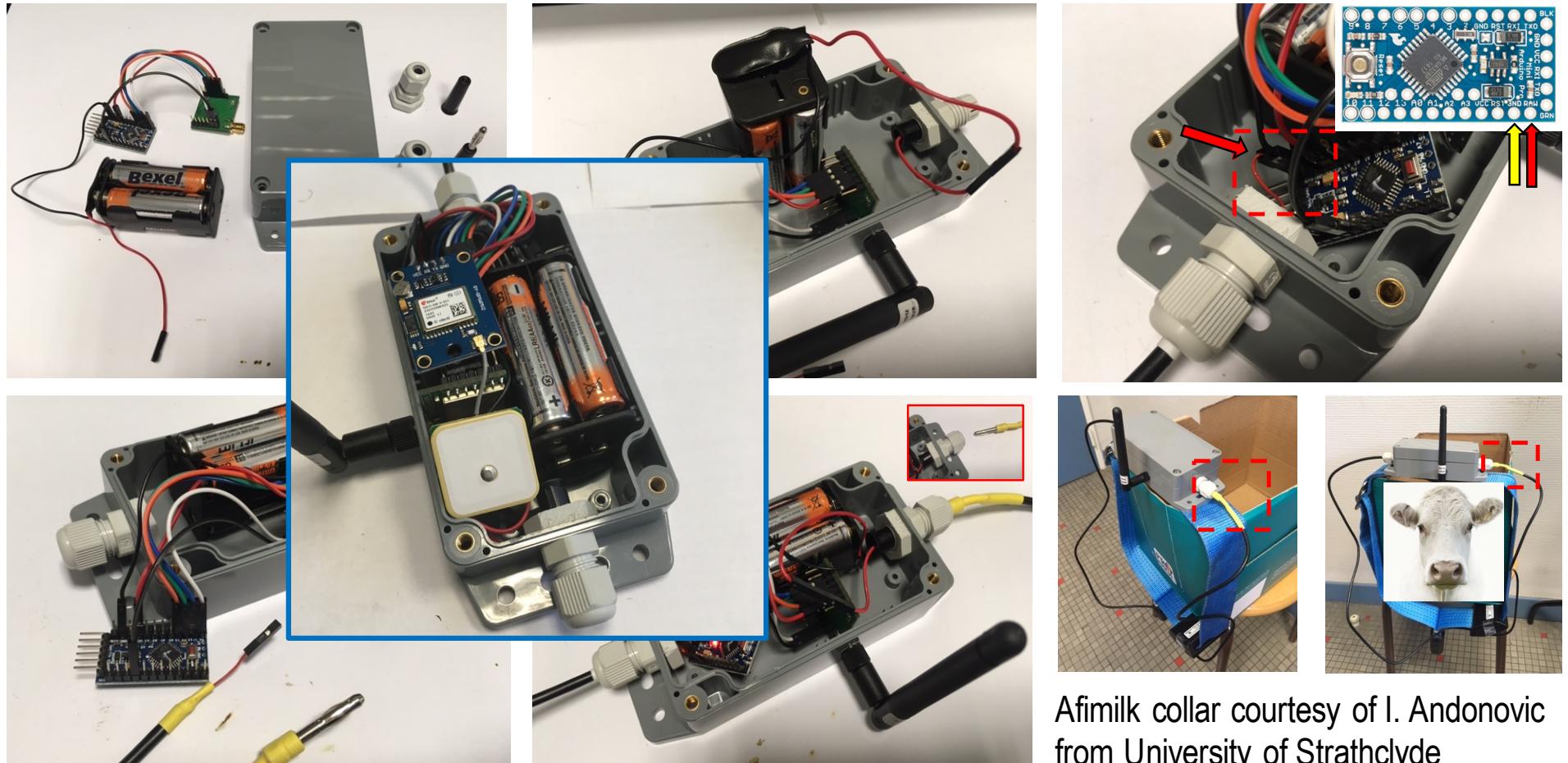


In Africa, the practice of animal husbandry has always been and still remain farmers' livelihood and incomes

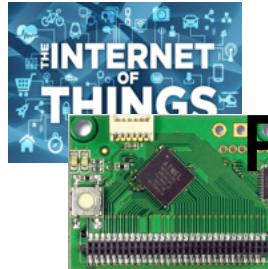
Their main problem in this activity remain the cattle rustling and some families are put in dramatic situation after a theft (reported 2 billions CFA losses)



EASY INTEGRATION AND CUSTOMIZATION



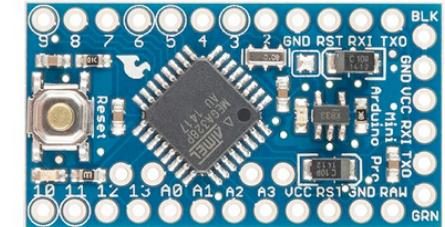
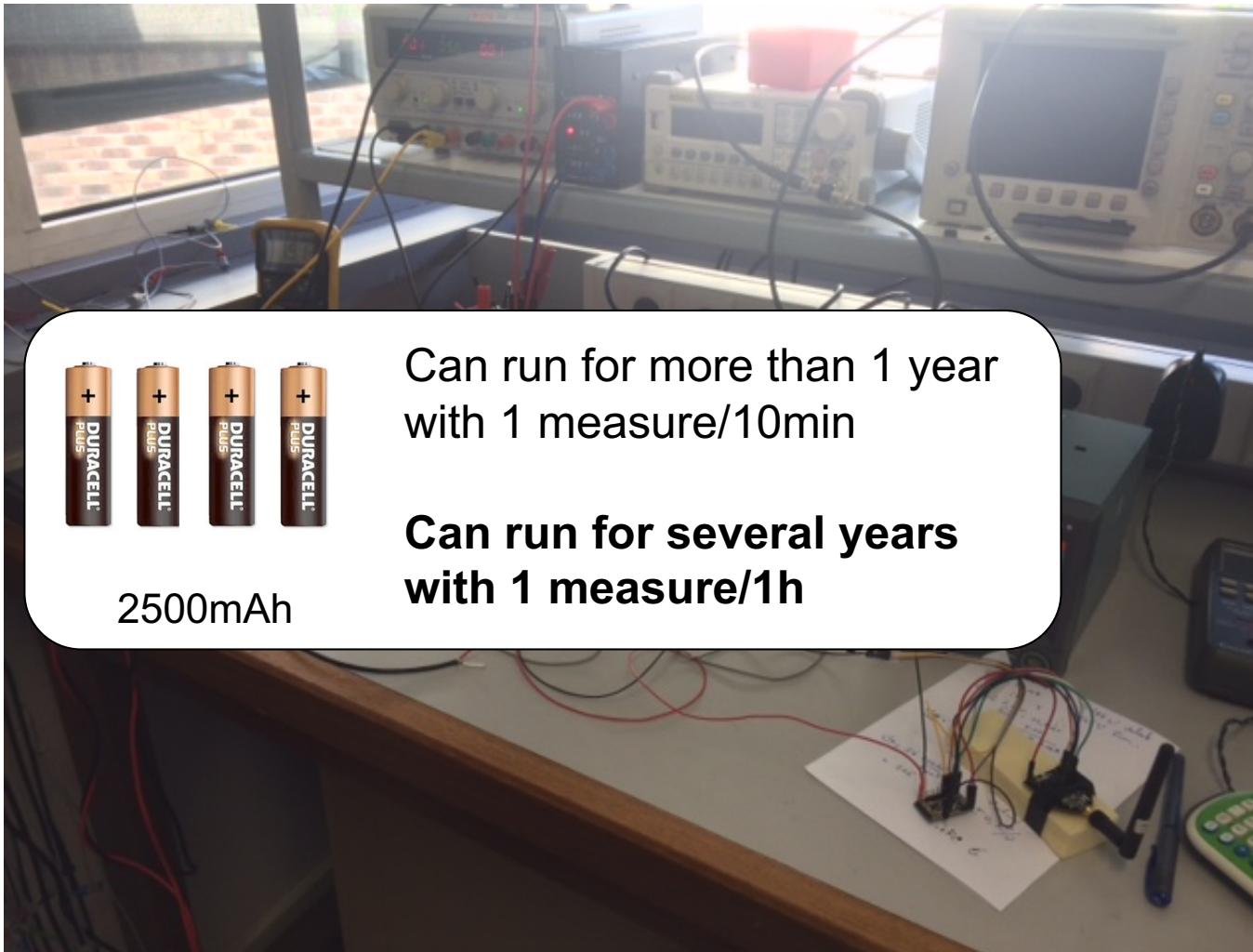
Afimilk collar courtesy of I. Andonovic
from University of Strathclyde



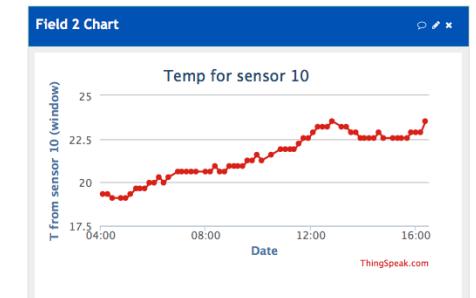
RUNNING FOR SEVERAL YEARS!



Low-Power library from RocketScream

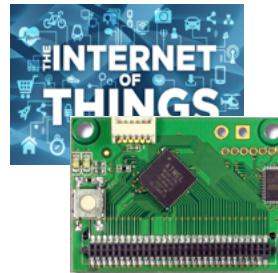


Wakes-up every 10min, take a measure (temp) and send to GW



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

Thanks to T. Mesplou and P. Plouraboué for their help



RASPBERRY-BASED LORA GATEWAY

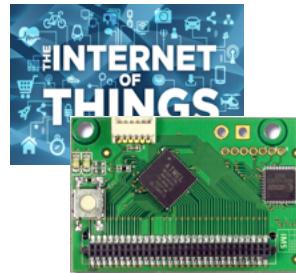


We can use all model of Raspberry. The most important usefull feature is the Ethernet interface for easy Internet connection. Then WiFi and Bluetooth can be added with USB dongles. RPI3 provides built-in Ethernet, WiFi and Bluetooth!

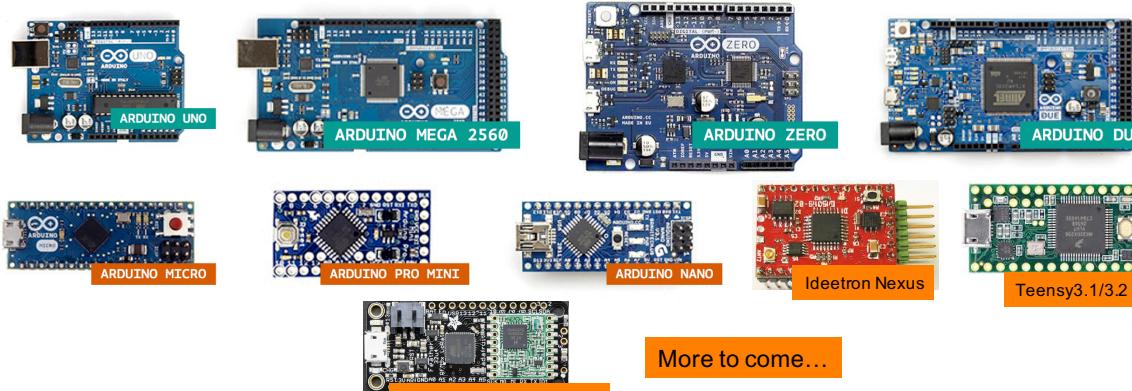


Less than 50€

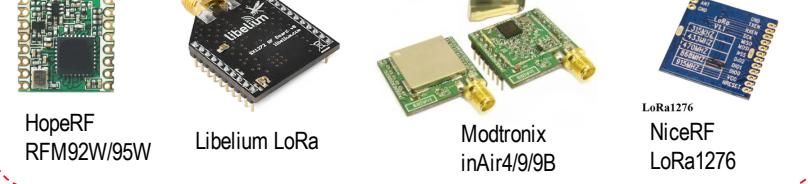




SIMPLICITY!



LoRa radios that our library already supports

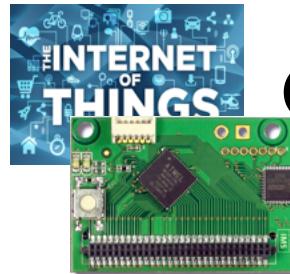


Long-Range communication library

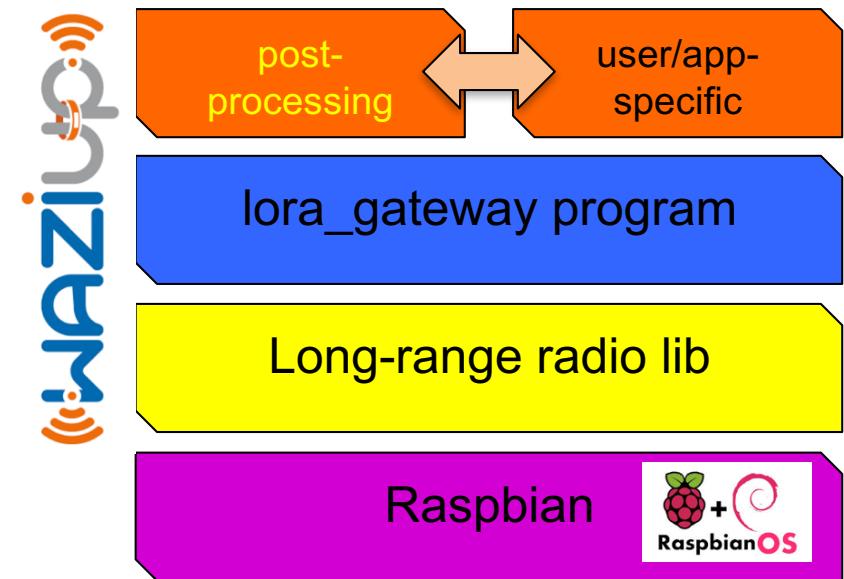
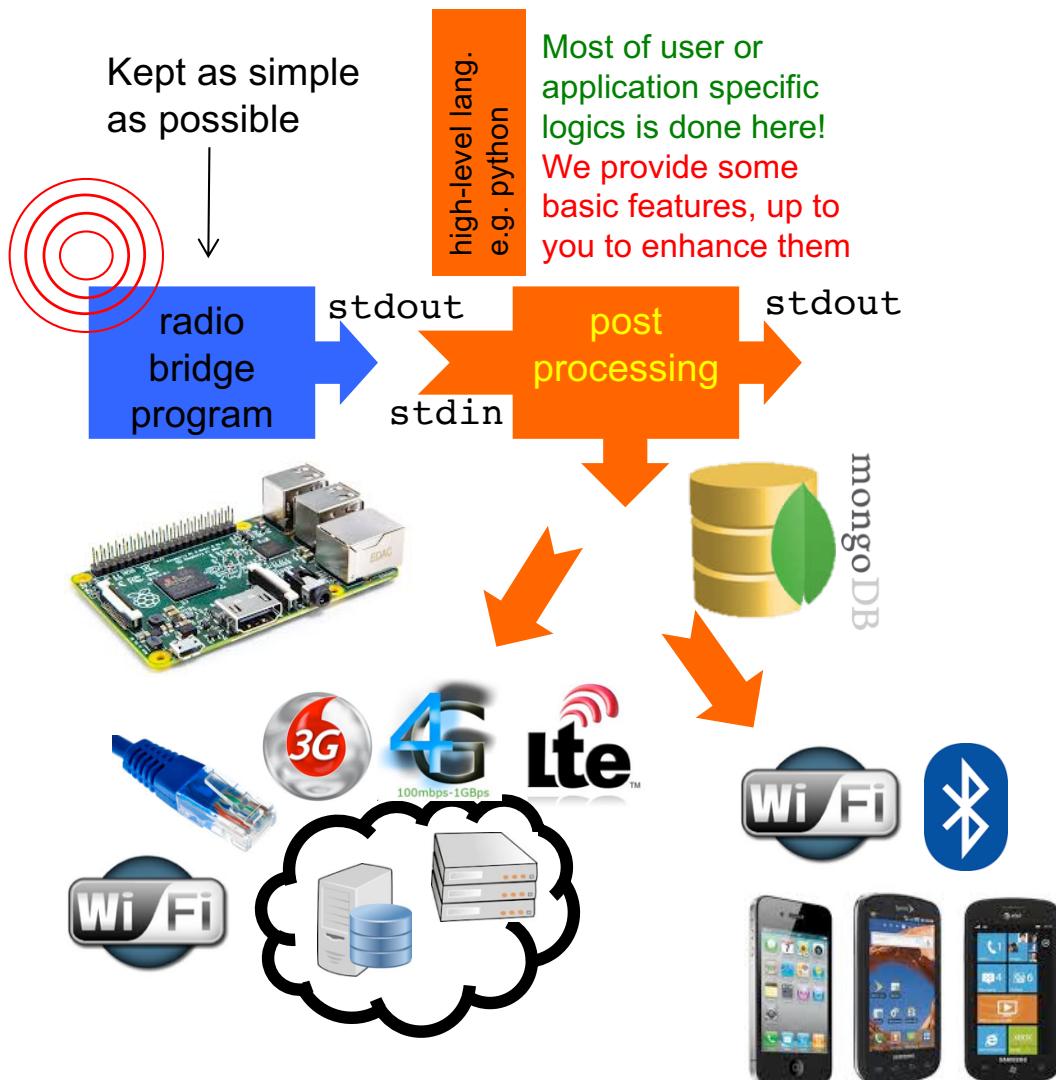
```
sendPacketTimeout("TC/18.5");
// sends to gateway
// TC : temperature celcius
// 18.5 : value
```

1 send function!

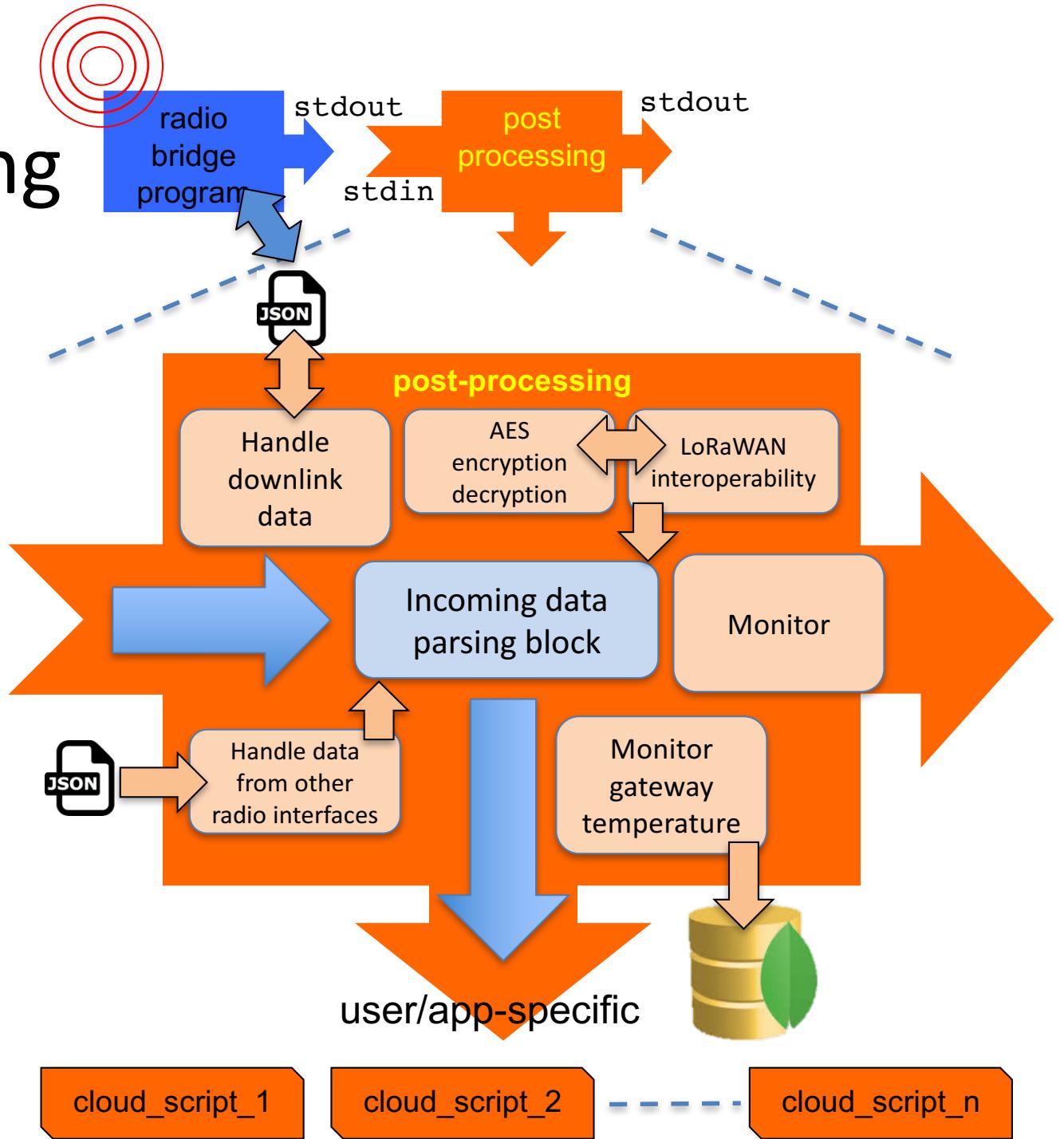




OUR LOW-COST GATEWAY ARCHITECTURE

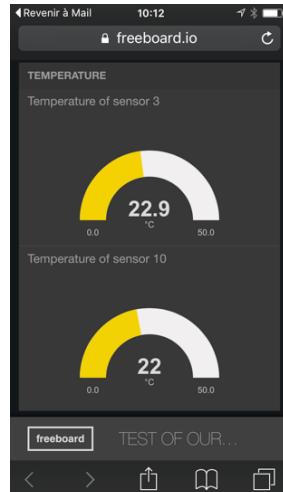


Post-processing stage

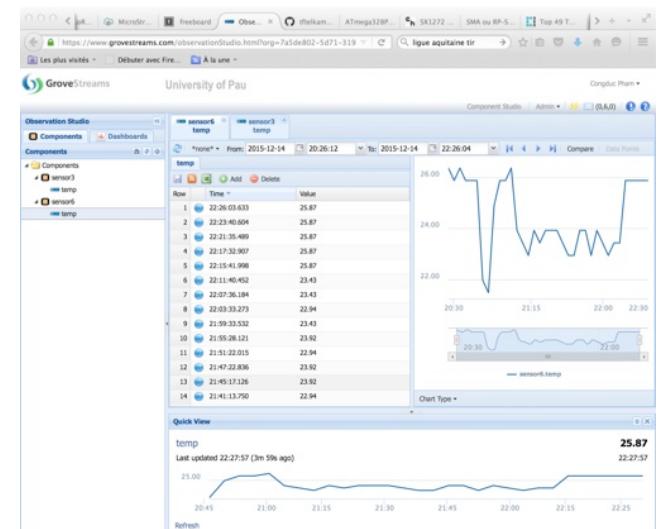
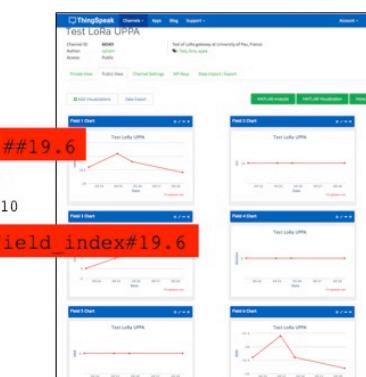


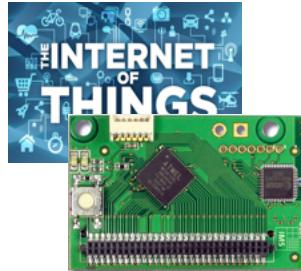


TEMPLATES FOR VARIOUS CLOUDS

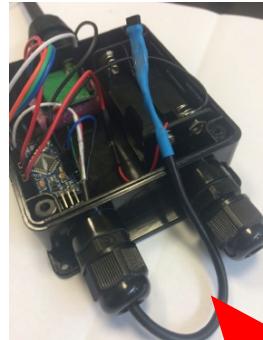


Dropbox





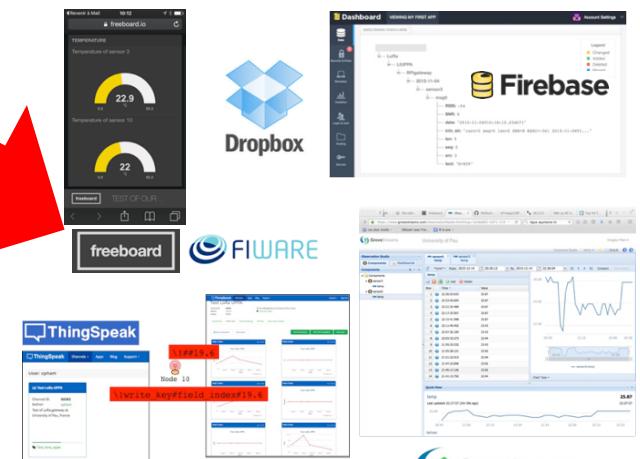
DO IT YOURSELF !



Step-by-step tutorial
and source code
available



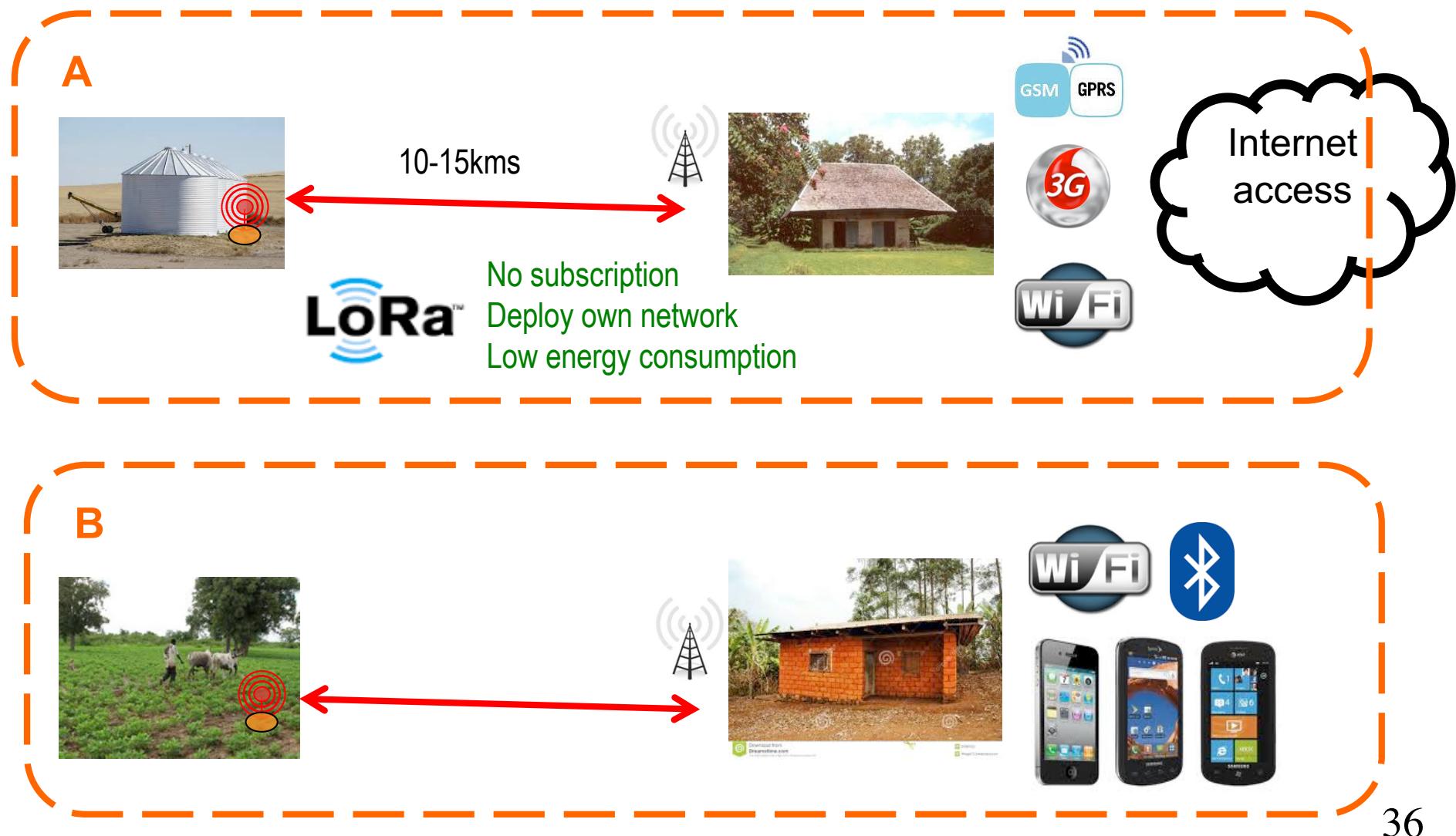
Step-by-step tutorial
and source code
available

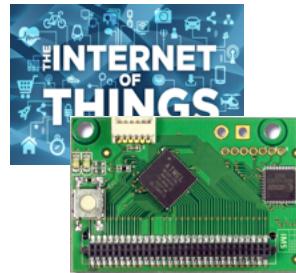


Python scripts
available

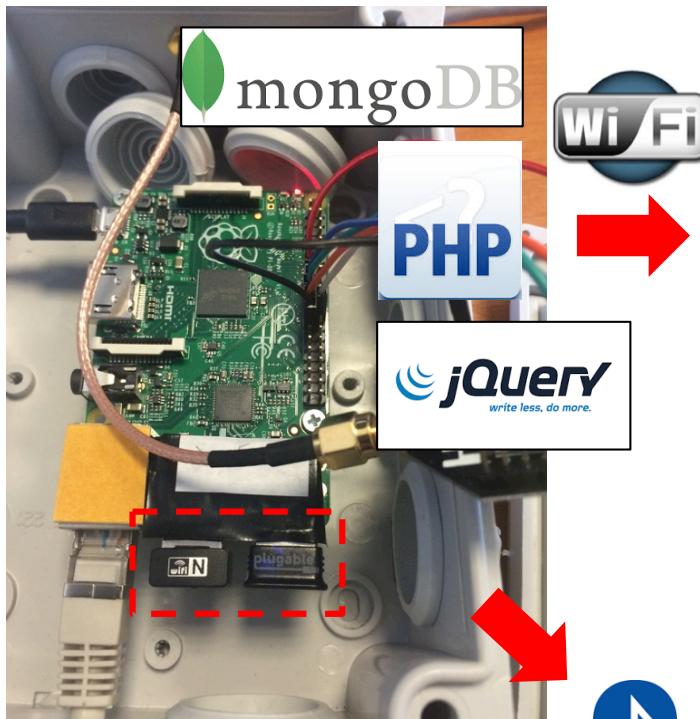


WORKING WITHOUT INTERNET ACCESS

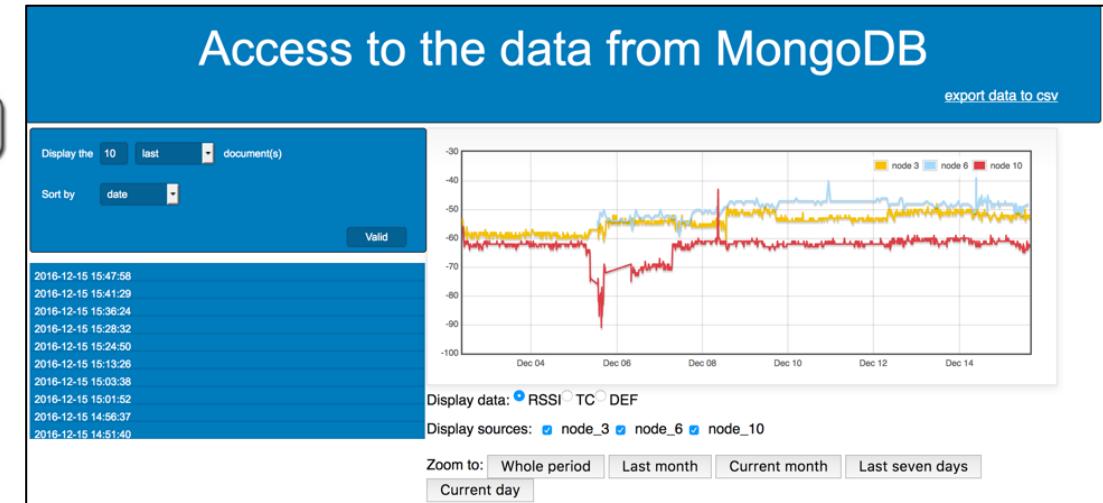




STANDALONE GATEWAY



Isolated areas



Orange F

Bluetooth_raspi

NODES PREFERENCES

1 check to retrieve its data

8 check to retrieve its data

DATES PREFERENCES

Pick a begin date
Retrieve data since 09-05-2016

Pick an end date
Retrieve data until 17-05-2016

Orange F

Bluetooth_raspi

Creating .csv file with the data received...
File 17-05-2016_10h39m36s.csv created and saved in the folder /storage/emulated/0/Raspberry_local_data

Orange F

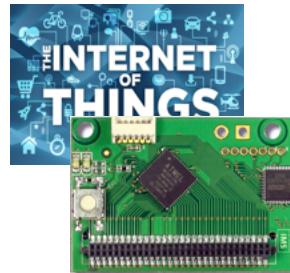
Bluetooth_raspi

Display data

Retrieve data in a csv file

Display data

Retrieve data in a csv file



NOW,

IoT BECOMES REALITY!



SIGFOX
One network A billion dreams

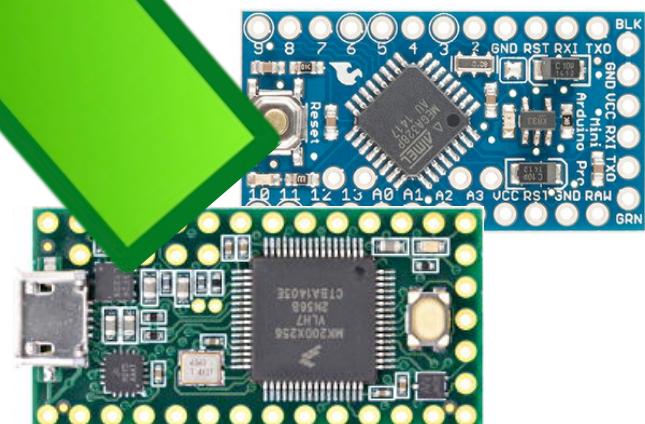
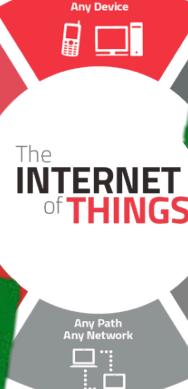
NB-LTE

WEIGHTLESS

DASH7™
ALLIANCE

Bluetooth® 4.0

nwave
LoRa™
LTE-M
NB-IOT
EC-GSM



Firebase
Dropbox

ThingSpeak

ensorCloud™

openRan

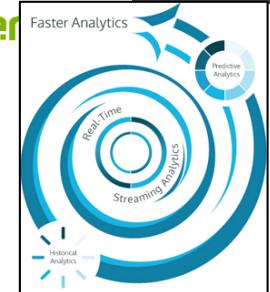
FIWARE

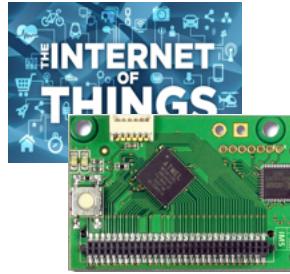
Axēda®

ioBridge®
Connect things.

GroveStreams

freeboard





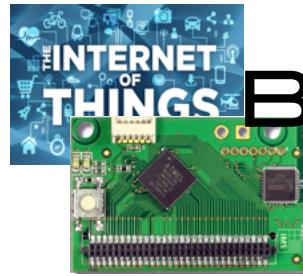
INVOLVING INNOVATION HUBS/STAKEHOLDERS



- **Close to dev & entrepreneurs** communities
- Have their **own community and com channels** (community builders & catalysts)
- Used to organizing disruptive events
- **On the field** (know the targets personally & the market)
- **Used to empowering startups & businesses** (coaching, business dev, incubation, acceleration...)
- Affiliated to **international networks** that could be involved in dissemination or Business dev (Afrilabs)



Credit: C. Vavasseur, CTIC Dakar



BUILDING WAZIUP COMMUNITY AND ECOSYSTEM



International Events
+ 20 organized & attended



Launch event (Senegal, CTIC Dakar)



Launch event (Ghana, iSpace)

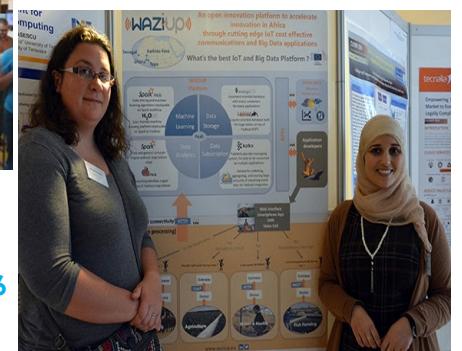
Workshop at the European Conference on Networks & Communications (Greece, CNET)



IoTWeek2016 (Belgrade, EGM)



IoTBIGDATA2016 (Italy, EGM)



IoTCareConference (Budapest, CNET)

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



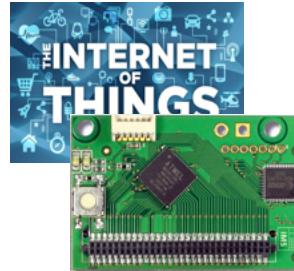
Credit: C. Vavasseur, CTIC Dakar



RESSACS 2016



Workshop at the RESSACS 2016 (France, UPPA) 40



TUTORIALS/RESOURCES



WAZIUP
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-sensing capabilities based on standard communication protocols where physical and virtual "things" have identities, physical attributes, and personal identities and use intelligent interfaces, and are seamlessly integrated into the Internet".
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 via a network without requiring human-to-computer interaction."
From http://internetoffthingsevents.leichtnet.com/definition/internet-of-things-iot/
"The Internet of Things (IoT) is a system of interconnected 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-computer interaction."

2) What is WAZIUP?
The EU-H2020 WAZIUP project, namely the Open Innovation Platform for IoT-dig Data in Sub-Saharan Africa is a collaborative research project using cutting edge technology applying IoT and Big Data to support the modernization of the local economy. In its first year, WAZIUP creates by involving farmers and breeders in order to define the platform specifications in a focused validation cases. Second year, WAZIUP will develop the platform and validate it in pilot sites. Also engages the flourishing ICT ecosystem in those countries by fostering new tools and guidelines for the development of IoT applications 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 platform will be open to other actors in the African Rural Economy. Develop new technological enablers to empower the African Rural Economy now threatened by the concurrent action of rapid urbanization and of climate change. WAZIUP Technologies can support the rural areas and infrastructures to launch agri-food and breeding on a new scale;

Author : Congduc Pham, University of Pau, France
Last update : 07.09.2016

page 1

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



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



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



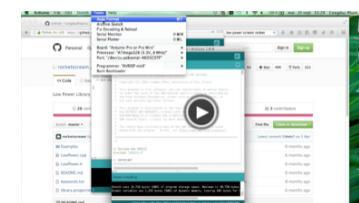
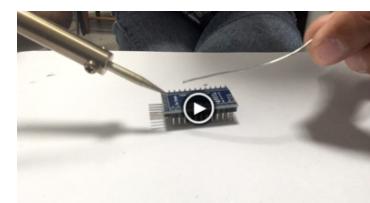
LOW-COST LORA IOT DEVICE: SUPPORTED PHYSICAL SENSORS



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



LOW-COST LORA IOT: USING THE WAZIUP DEMO KIT





Thanks.
Let's keep in touch



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github.com/waziup