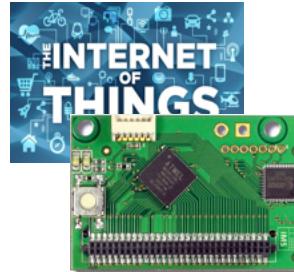


DEPLOYING LOW-COST AND LONG-RANGE INTERNET OF THINGS IN DEVELOPING COUNTRIES



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





IoT FOR DEVELOPMENT



Irrigation



Livestock farming



Fish farming & aquaculture



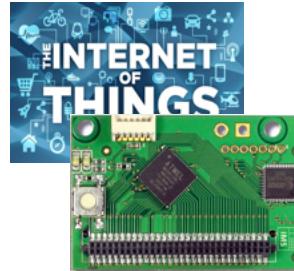
Storage & logistic



Agriculture



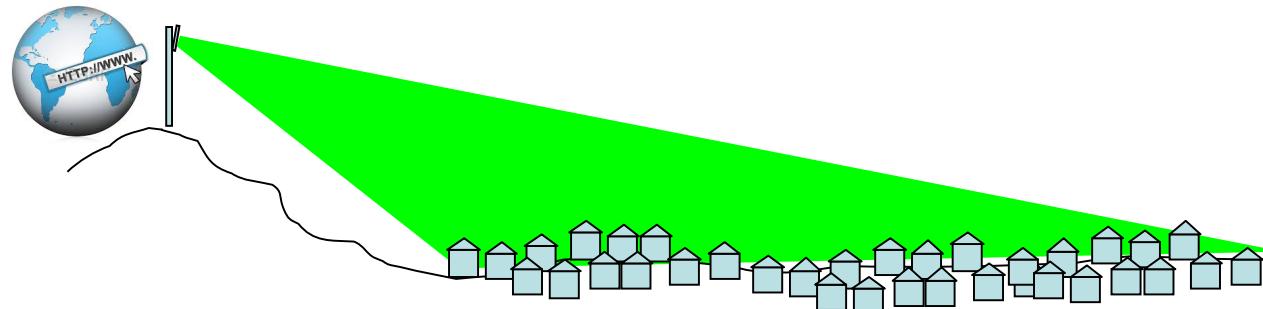
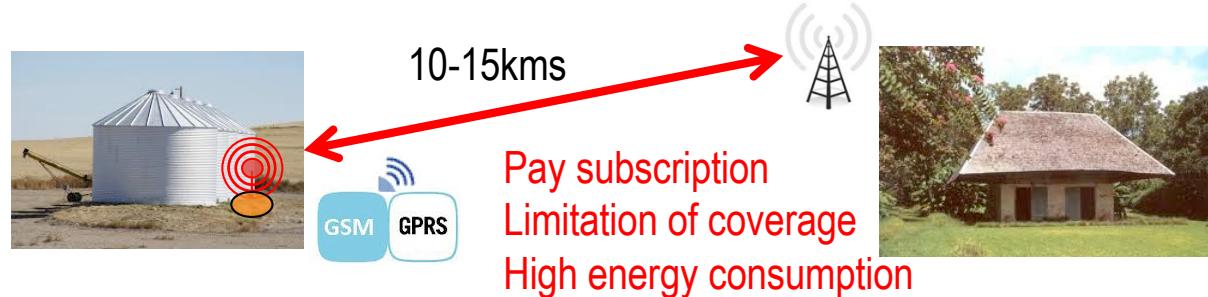
Fresh water



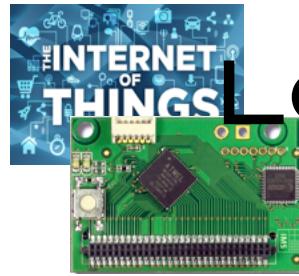
LONG-RANGE SENSING



Moisture/
Temperature of
storage areas



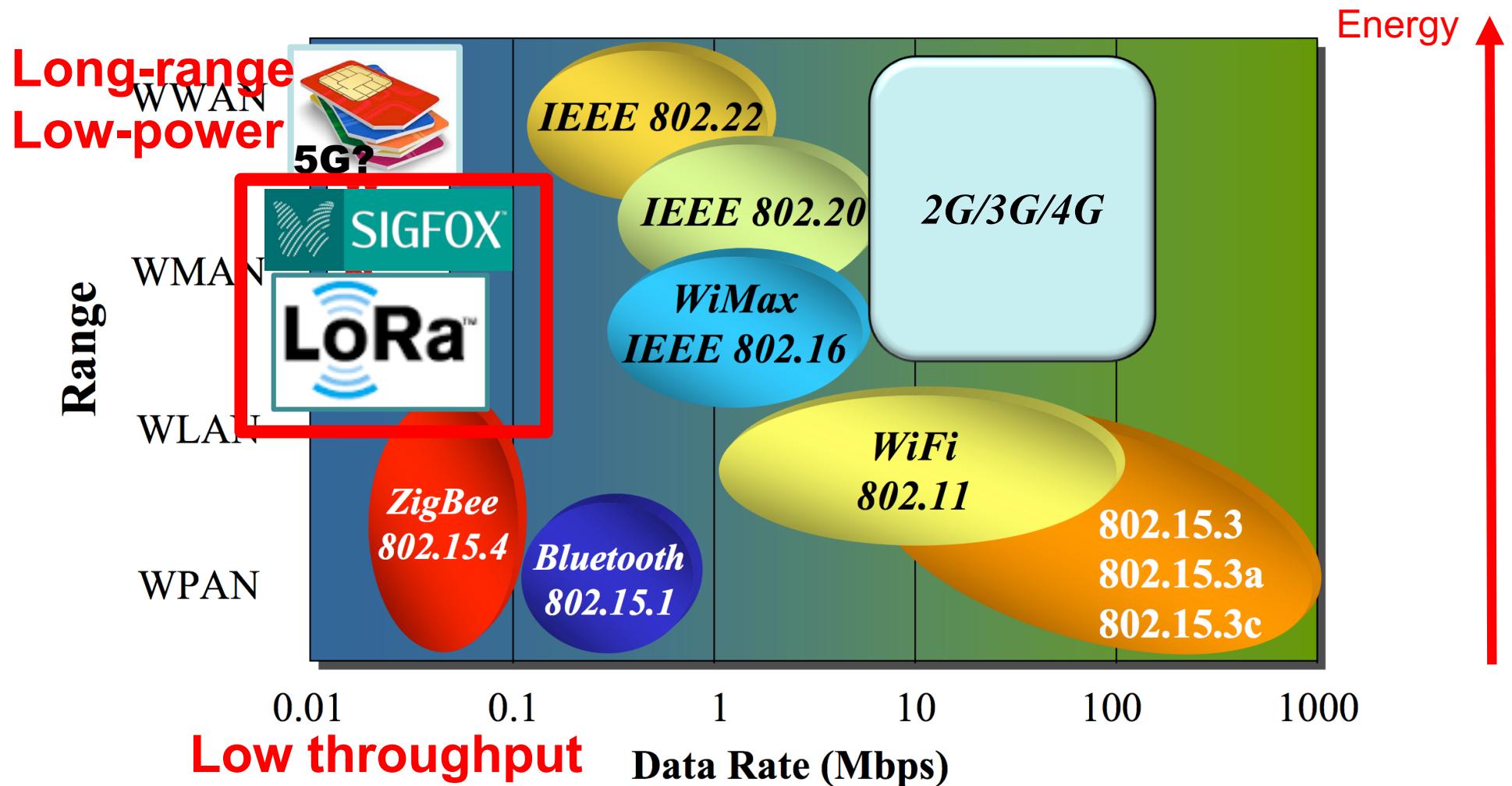
Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200-500mA	500-1000mA	100-300mA
Standby current	2.3mA	3.5mA	NC

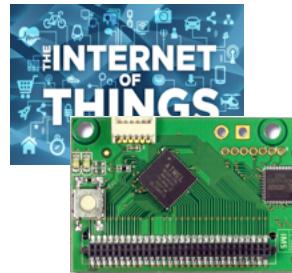


LOW-POWER & LONG-RANGE RADIO TECHNOLOGIES



Energy-Range dilemma

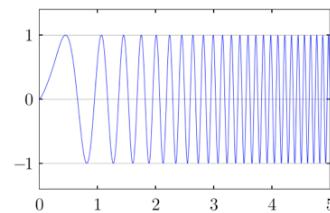




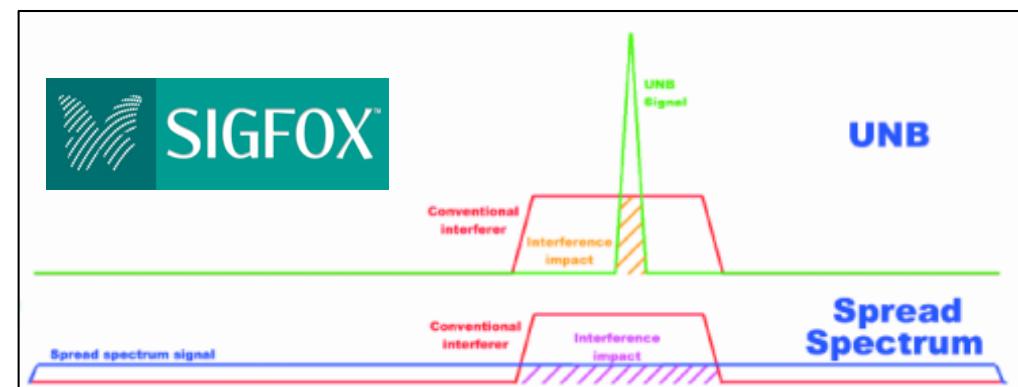
INCREASING RANGE?

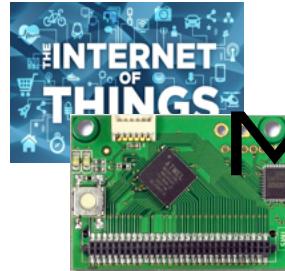


- Generally, robustness and sensitivity can be increased when **transmitting much slower**
- A Sigfox message is sent relatively slowly in an ultra narrow band of spectrum. **Max throughput=~100bps**
- LoRa also increases time-on-air when maximum range is needed. But LoRa uses spread spectrum approach. **Throughput=~300bps-37500bps**



LoRa™



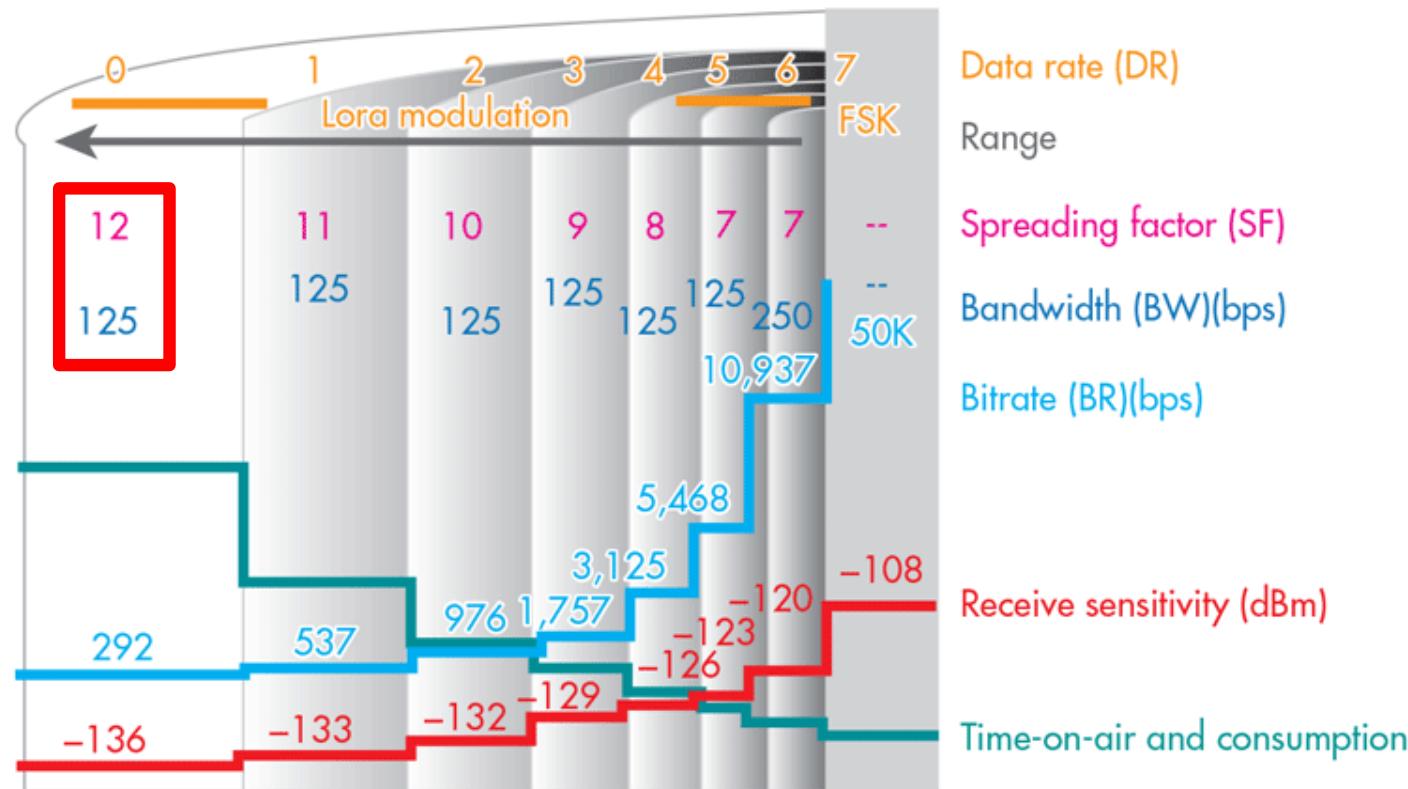


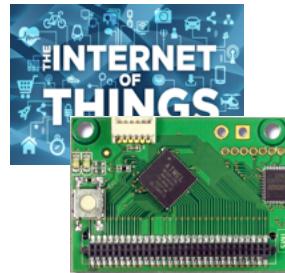
MAIN LORA PARAMETERS



□ Main parameters

- Bandwidth: 62.5kHz, 125kHz, 250kHz, 500kHz
- Spreading factor: 6 to 12





LORA DETAILS SPECS



□ Main parameters

- Bandwidth: 62.5kHz, 125kHz, 250kHz, 500kHz
- Spreading factor: 6 to 12
- Rate code: 4/4+CR (CR=1, 2, 3, 4)

$$R_b = SF * \frac{\text{Rate Code}}{\left[\frac{2^SF}{BW} \right]} \text{ bits/sec}$$

Sensitivity: lowest input power with acceptable link quality, typically 1% PER

<i>SpreadingFactor (RegModemConfig2)</i>	Spreading Factor (Chips / symbol)	LoRa Demodulator SNR
6	64	-5 dB
7	128	-7.5 dB
8	256	-10 dB
9	512	-12.5 dB
10	1024	-15 dB
11	2048	-17.5 dB
12	4096	-20 dB

Bandwidth (kHz)	Spreading Factor	Nominal Rb (bps)	Sensitivity (dBm)
125	6	9380	-122
125	12	293	-137
250	6	18750	-119
250	12	586	-134
500	6	37500	-116
500	12	1172	-131

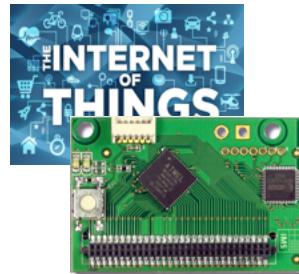
Rule of thumb

6dB increase = twice the range in LOS

12dB needed for urban areas

Bandwidth (kHz)	Spreading Factor	Coding rate	Nominal Rb (bps)	Sensitivity (dBm)
125	12	4/5	293	-137
250	12	4/5	586	-134
500	12	4/5	1172	-131

Tables from Semtech

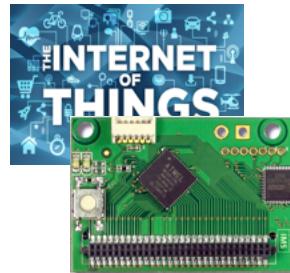


LORA TIME-ON-AIR



**Very low throughput
Transmission time can be several seconds**

LoRa mode	BW	CR	SF	time on air in second for payload size of						max thr. for 255B in bps
				5 bytes	55 bytes	105 bytes	155 Bytes	205 Bytes	255 Bytes	
1	125	4/5	12	0.95846	2.59686	4.23526	5.87366	7.51206	9.15046	223
2	250	4/5	12	0.47923	1.21651	1.87187	2.52723	3.26451	3.91987	520
3	125	4/5	10	0.28058	0.69018	1.09978	1.50938	1.91898	2.32858	876
4	500	4/5	12	0.23962	0.60826	0.93594	1.26362	1.63226	1.95994	1041
5	250	4/5	10	0.14029	0.34509	0.54989	0.75469	0.95949	1.16429	1752
6	500	4/5	11	0.11981	0.30413	0.50893	0.69325	0.87757	1.06189	1921
7	250	4/5	9	0.07014	0.18278	0.29542	0.40806	0.5207	0.63334	3221
8	500	4/5	9	0.03507	0.09139	0.14771	0.20403	0.26035	0.31667	6442
9	500	4/5	8	0.01754	0.05082	0.08154	0.11482	0.14554	0.17882	11408
10	500	4/5	7	0.00877	0.02797	0.04589	0.06381	0.08301	0.10093	20212



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	20-40mA
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 -

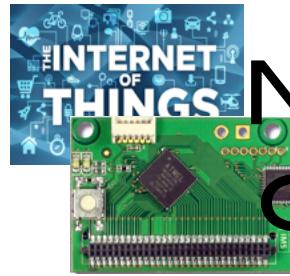


Example for energy meter

1 year

5 years

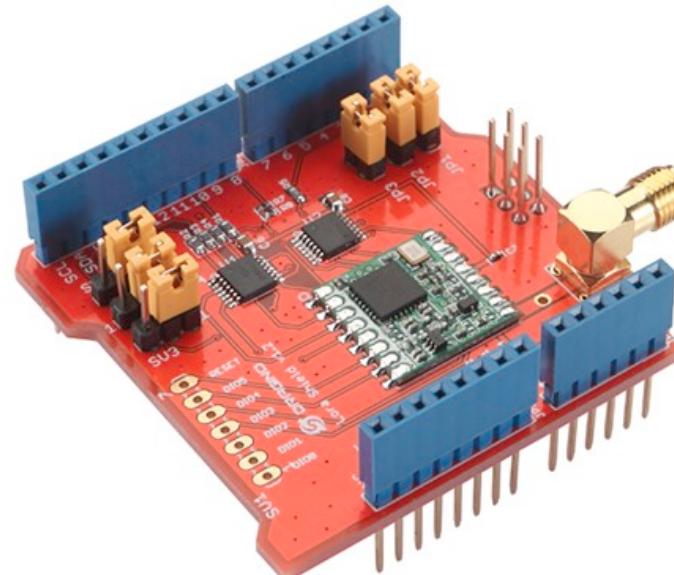
10 years



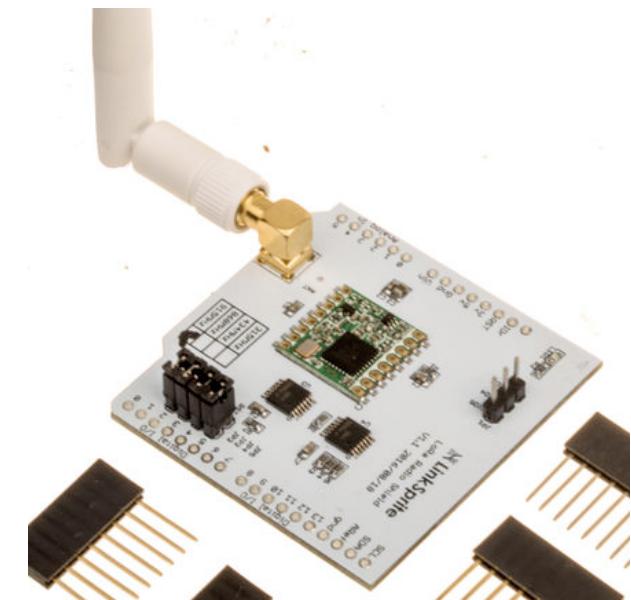
MORE AND MORE EASY-TO-CONNECT LORA MODULES!



LORANGA LoRa +
2G/3G board,
mainly for
Raspberry PI



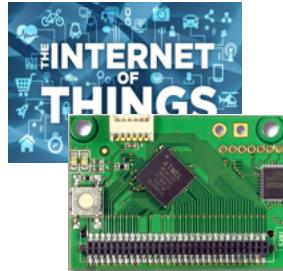
Dragino LoRa shield
for Arduino



LinkSprite LoRa shield
for Arduino

MATURATION OF THE IOT MARKET...





IoT BECOMES REALITY!



SIGFOX
One network A billion dreams

LoRa™

NB-LTE

WEIGHTLESS

DASH7™ ALLIANCE

Bluetooth® 4.0

nwave

LTE-M

EC-G

EC-U

EC-C

EC-S

EC-T

EC-R

EC-B

EC-A

EC-D

EC-H

EC-F

EC-G

EC-I

EC-J

EC-K

EC-L

EC-M

EC-N

EC-O

EC-P

EC-Q

EC-R

EC-S

EC-T

EC-U

EC-V

EC-W

EC-X

EC-Y

EC-Z

The
INTERNET
of
THINGS

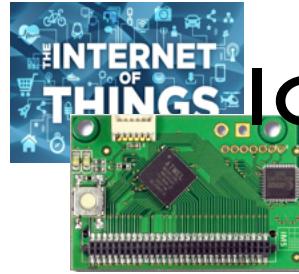
Anything
Any Device

Any Place
Anywhere

Any Path
Any Network

Any Service
Any Business

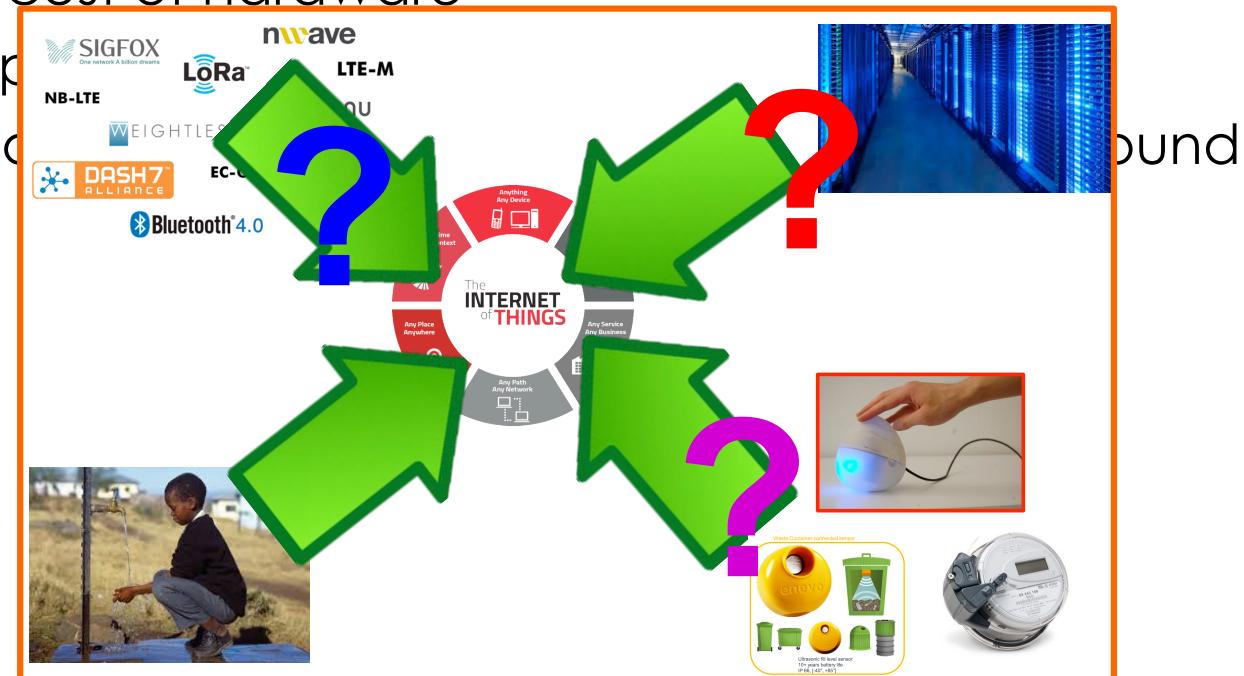




THE INTERNET OF THINGS IN DEVELOPING COUNTRIES OR RURAL AREAS?

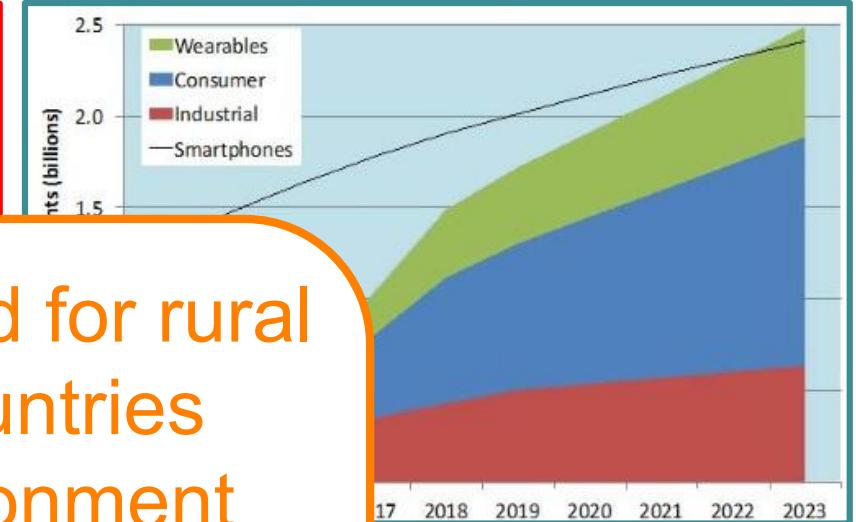


- Developing countries/rural areas are still far from being ready to enjoy the smallest benefit of IoT
 - lack of infrastructure
 - high cost of hardware
 - competition
 - lack of skilled labor





MATURATION OF THE IOT MARKET...



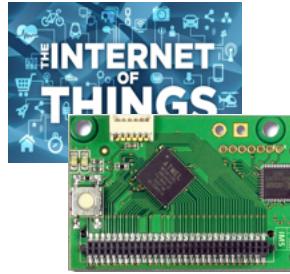
... but not adapted for rural developing countries context & environment

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

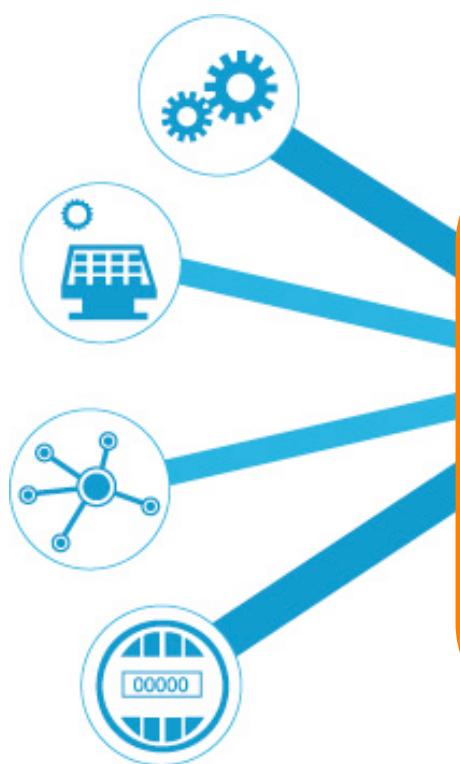


Ultrasonic fill level sensor
10+ years battery life
IP 66, [-40°, +85°]



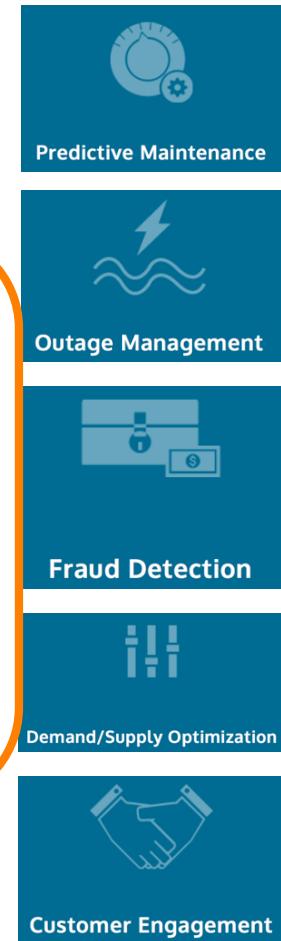


INTERNET, CLOUD & BIG DATA ANALYTICS

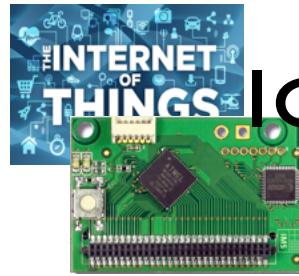


Internet connectivity is weak and expensive!

Nearly impossible in remote/rural areas



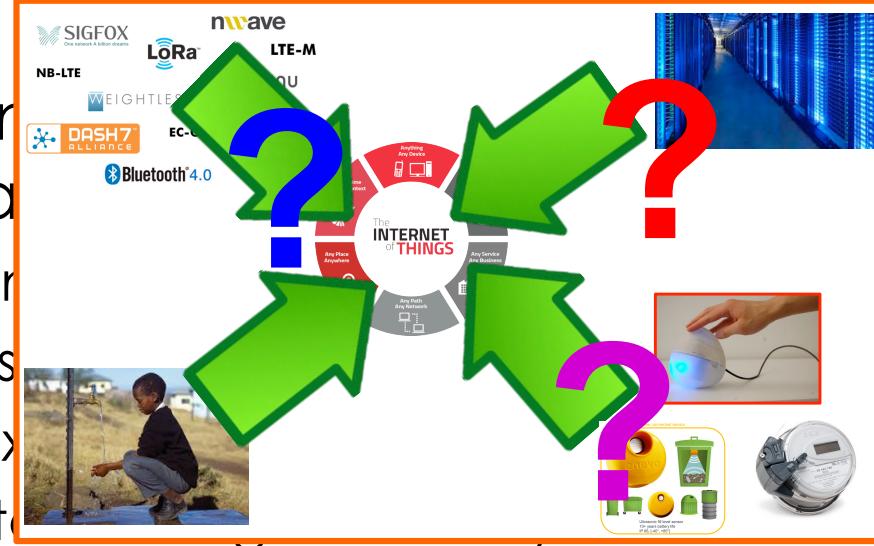
Graphics from <http://www.vitria.com/iot-analytics/>

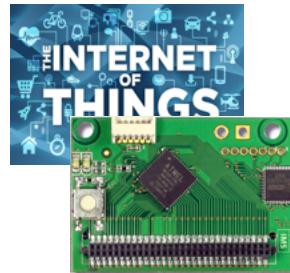


IoT IN DEVELOPING COUNTRIES AND RURAL AREAS



- Developing countries being ready
 - lack of infrastructure
 - high costs
 - complex regulations
 - lack of technology
- 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



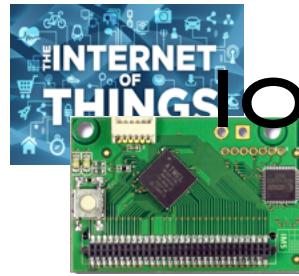


WAZIUP: LOW-COST IoT



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

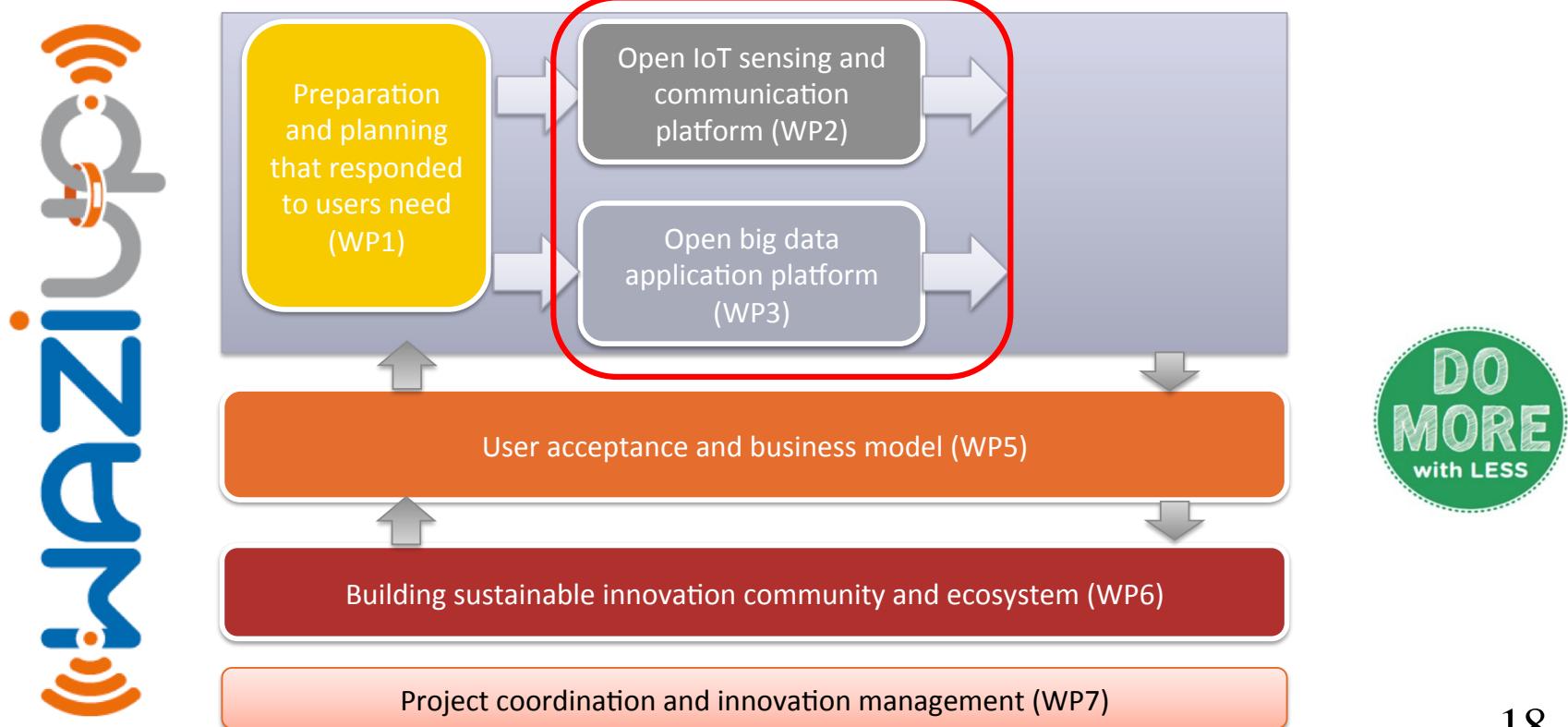


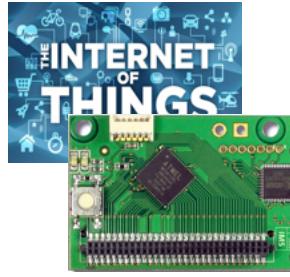


IoT FOR RURAL APPLICATIONS IN DEVELOPPING COUNTRIES

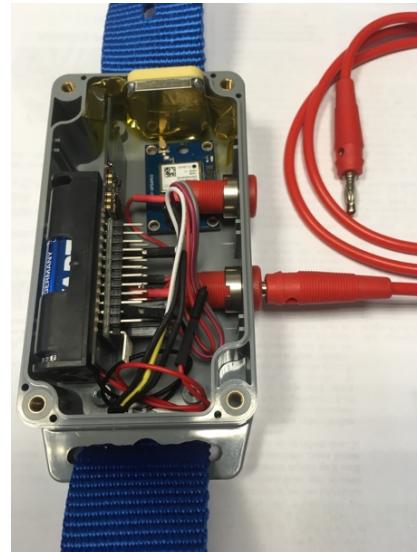


- ❑ WAZIUP is an EU H2020 project (2016-2019)
- ❑ contributes to long-range networks for rural applications with WP2 and big data with WP3





LOW-COST IOT DEVICES





LOW-COST HARDWARE INITIATIVE



WHAT IS ARDUINO?

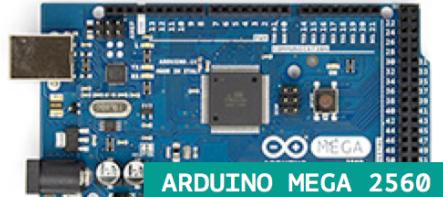
Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects.

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



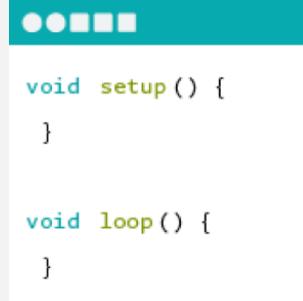
ARDUINO MICRO



ARDUINO PRO MINI



ARDUINO NANO

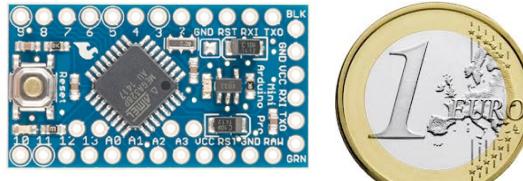


ARDUINO SOFTWARE

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

<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



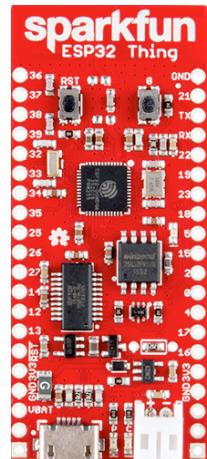
STM32 Nucleo-32



Teensy 3.2



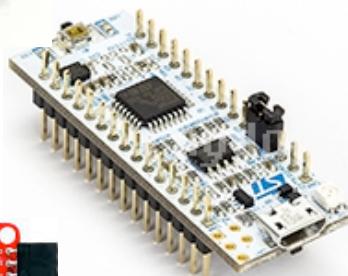
Adafruit Feather



Sparkfun ESP32 Thing



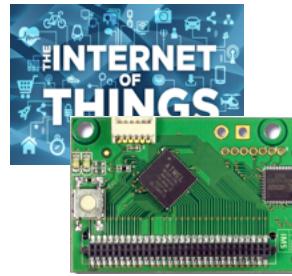
Tessel



SodaqOnev2



Tinyduino



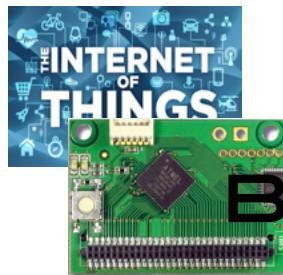
... STIMULATING "DO-IT-YOURSELF" WORLDWIDE



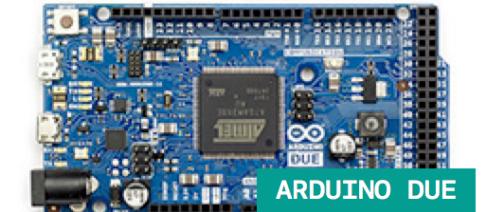
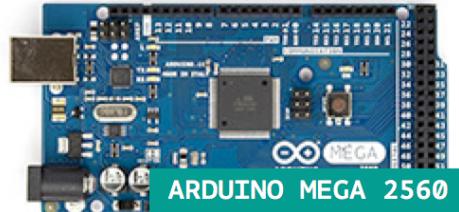
- DIY usually means
 - More open-source software from larger community
 - More flexibility

The screenshot shows the homepage of Projets DIY. At the top, there's a navigation bar with links like 'Domotique | IoT', 'Arduino | ESP8266 | ESP32', 'Raspberry Pi | Orange Pi', 'Impression 3D', 'Projets', 'Bons Plans', and 'Forums'. Below the navigation is a large banner for 'Gearbest' with text about 'Black Friday' deals. To the right of the banner is a section for 'Arduino' projects, showing a small image of a breadboard setup. Further down, there are sections for 'Raspberry Pi' and 'Arduino' with various project thumbnails.

The screenshot shows a Pinterest board titled 'Arduino' under the category 'Bricolage et artisanat'. The board contains numerous pins, each representing a different DIY project. Some visible pins include a breadboard setup for a water level sensor, a 'Solar Powered WiFi Weather Station' (a green box with a small screen), a 'CLICK HERE' button for a project, a '200+ ARDUINO PROJECTS' guide, and a 'RÉALISATION DE MON' (Realization of my) project involving a breadboard and a small motor. The board is filled with images of various electronic components and finished projects.



WAZIUP PROVIDES SW/HW BUILDING BLOCKS INTEGRATION



More to come...



LoRa radios that
our library already
supports



HopeRF RFM9x



Libelium LoRa

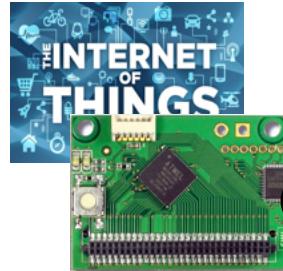


Modtronix inAir4/9/9B



NiceRF LoRa1276

Long-Range communication library



WAZIUP PROPOSES 100% 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
 * but WITHOUT ANY WARRANTY;
 * without even the implied warranty of
 * MERCHANTABILITY or FITNESS
 * for a particular purpose. See the
 * GNU General Public License
 * for more details.
 *
 * You should have received
 * along with the program.
 */
*****  

// Include the SX1272.h  

#include "SX1272.h"  

//  

// IMPORTANT  

// please uncomment only 1 ch  

// it seems that both HopeRF  

// boards we set the initial  

// channel if your radio is  

// define RADIO_HOPERF_S9  

// uncomment if your radio is  

// #define RADIO_INAIRBB  

//  

// THINOSTANT  

*/
```

CongducPham / LowCostLoRaGw

Code Issues 62 Pull requests 2 Projects 0 Pulse Graphs

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

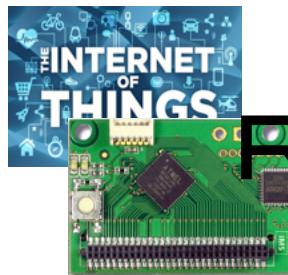
122 commits 1 branch 0 releases 2 contributors

Branch: master New pull request Find file Clone or download

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

File	Commit Message	Date
Arduino	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

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



READY-TO-USE TEMPLATES



Moisture/
Temperature of
storage areas



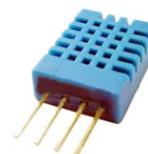
Physical
sensor



Physical
sensor

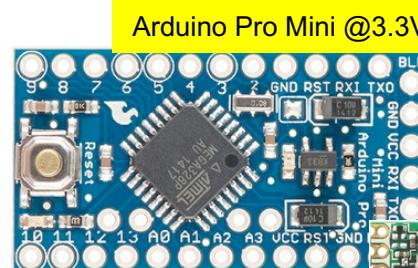


Physical
sensor



***VERY*
IMPORTANT**

Physical
sensor
mgmt



Activity
duty-cycle,
low power

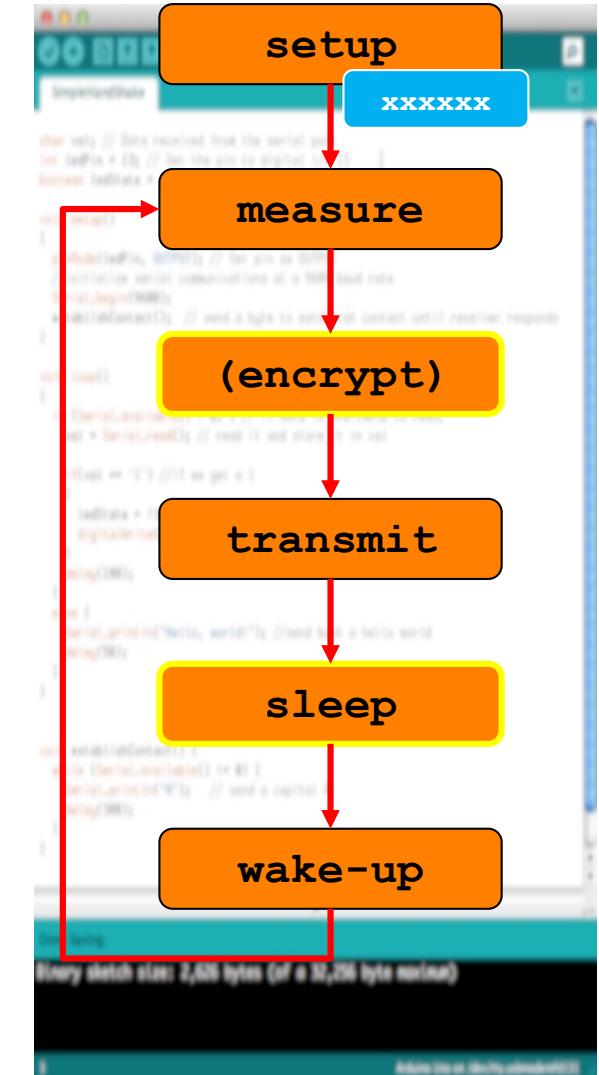
***VERY*
IMPORTANT**

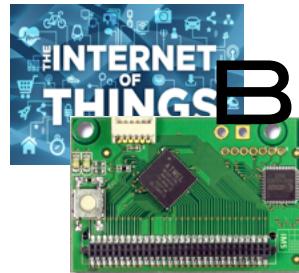
AES
encryption



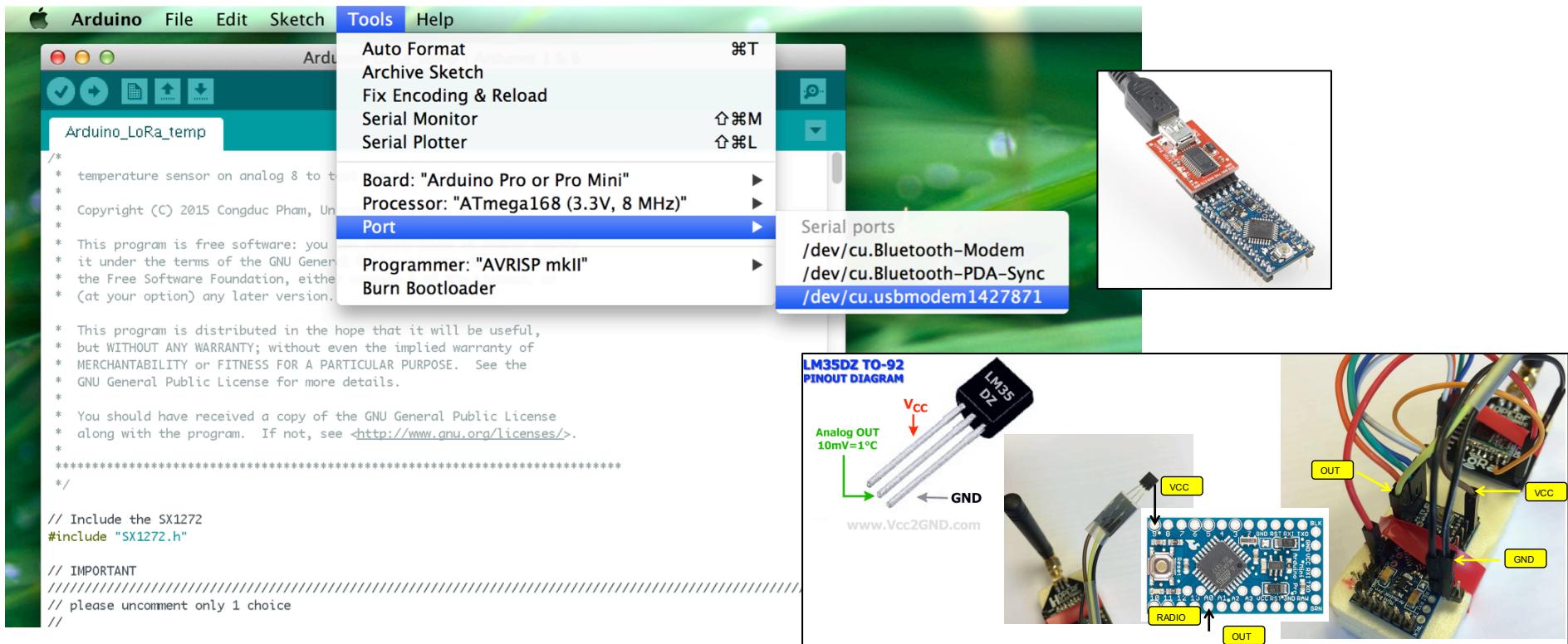
Long-range
transmission

Logical
sensor
mgmt



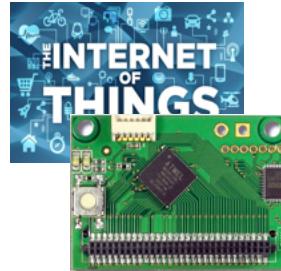


BUILD YOUR FIRST LORA IOT DEVICE

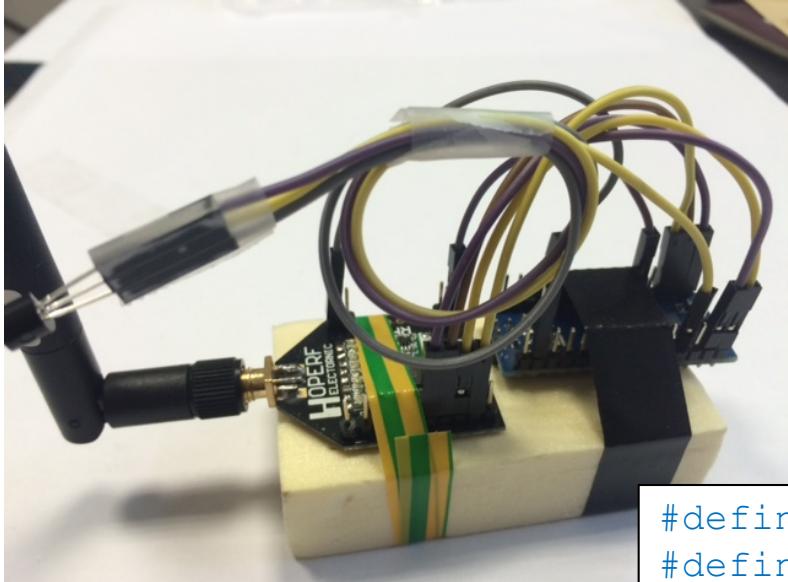


Connect the USB end to your computer and the USB port should be detected in the Arduino IDE. Select the serial port for your device. It may have another name than what is shown in the example. Then click on the « upload » button

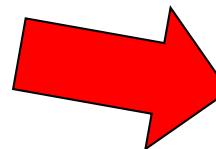




DEFAULT CONFIGURATION



!\!TC/18.5



```
#define DEFAULT_DEST_ADDR 1  
#define LORAMODE 1  
#define node_addr 6
```

The default configuration in the Arduino_LoRa_Simple_temp example is:

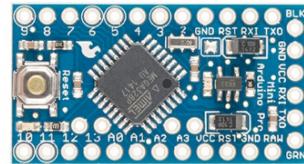
Send packets to the gateway (one or many if in range)

LoRa mode 1

Node short address is 6



LOW-COST INTEGRATION

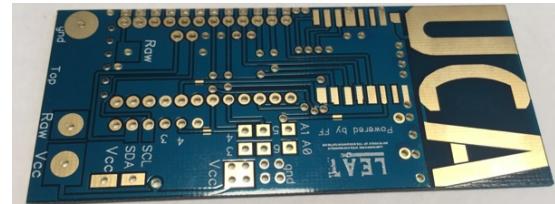


1.5€

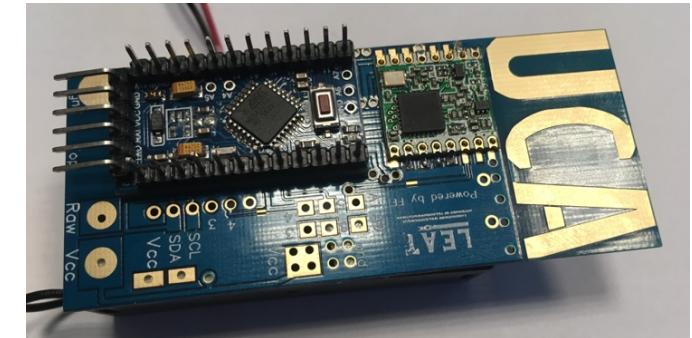
https://github.com/FabienFerrero/UCA_Board



4€



1€



2017 FIRST PCB DESIGN CONTEST Win Awards Worth \$ 1000.00

C****rum Follow

UCA reverse with LoRa and Arduino

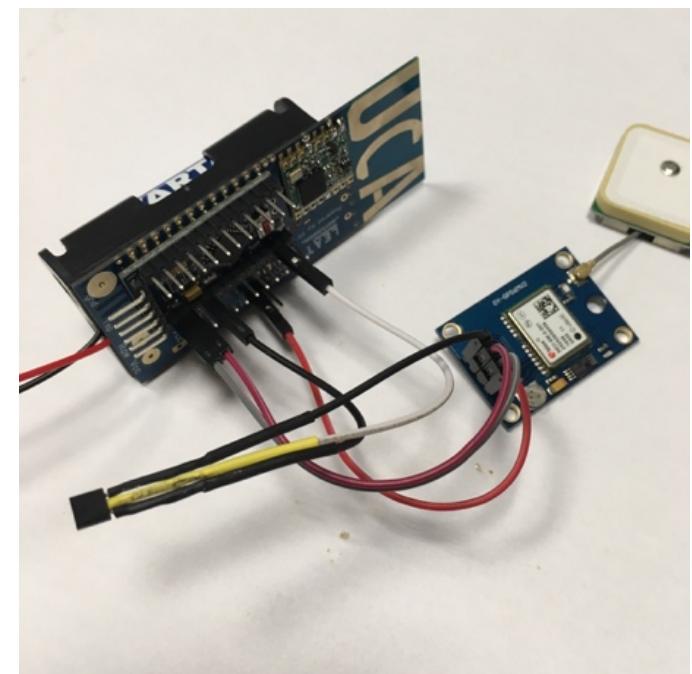
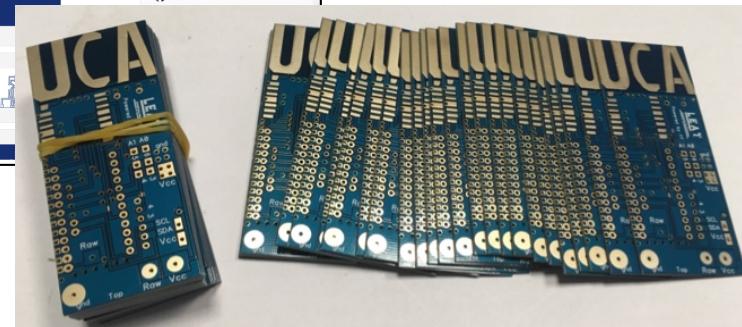
2 Layers PCB 34x80mm FR-4, 0.8mm, 1 oz Cu, HASL with lead, Blue Solder Mask, White silkscreen

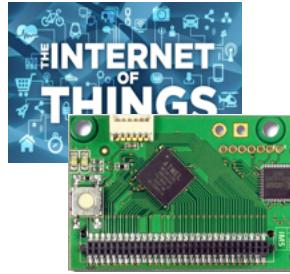
Published: October 24, 2017

Download 0 Documentation Source Code

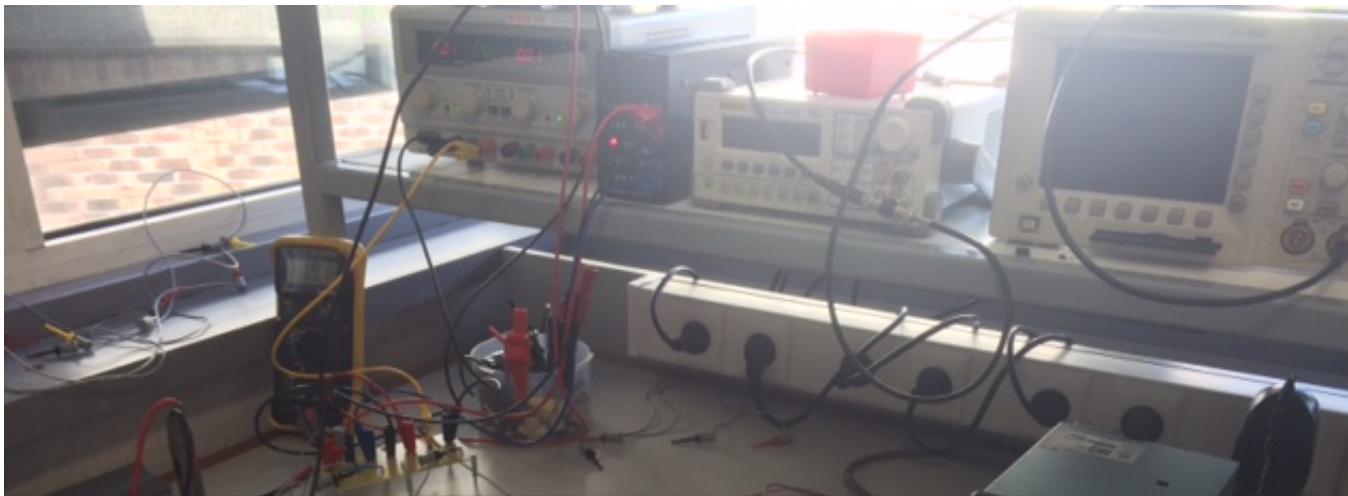
Less than
10€/device

1-click order

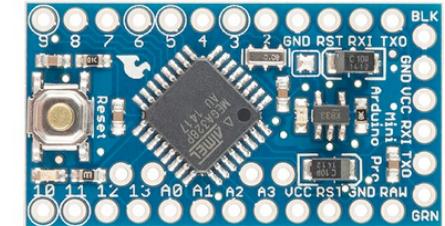




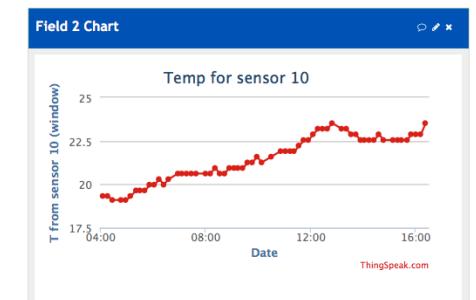
LOW-POWER FOR LONGER LIFETIME!



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



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

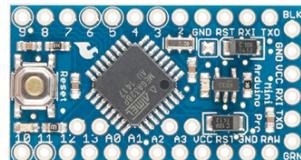


5µA in deep sleep mode, about 40mA when active and sending!



A SIMPLE TEMPERATURE SENSOR EXAMPLE

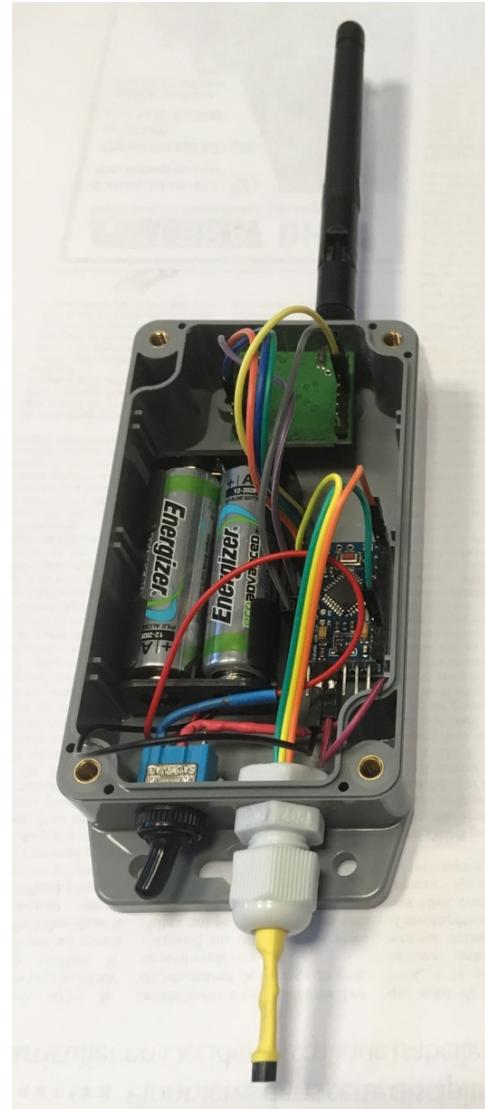
Arduino Pro Mini @3.3V

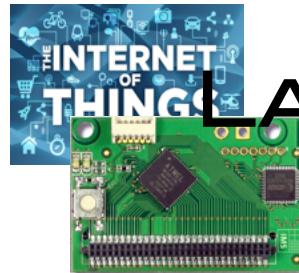


Modtronix inAir9



TMP36





LARGE VARIETY OF EXAMPLES TO LEARN AND ADAPT



CongducPham / LowCostLoRaGw

Unwatch 49 Unstar 216 Fork 120

Code Issues 96 Pull requests 2 Projects 0 Wiki Insights Settings

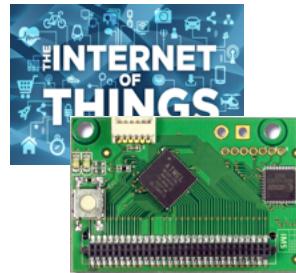
Branch: master LowCostLoRaGw / Arduino /

Create new file Upload files Find file History

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

..

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



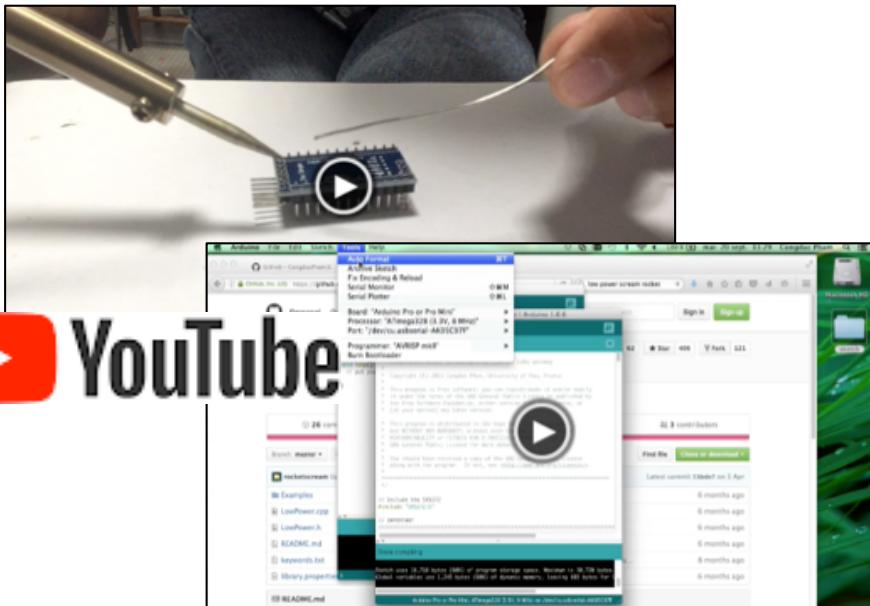
TUTORIALS AND VIDEOS



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



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



YouTube

Arduino IDE

GitHub Repository: LoRa Arduino Library



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



<http://www.waziup.eu>

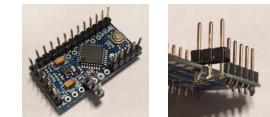
The generic hardware platform

The Arduino Pro Mini

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



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



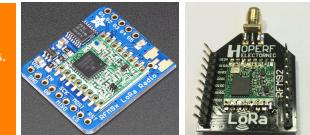
Depending on how many sensors you want to connect, the number of ground (GND) pins may be limited. You can extend a GND pin with a header pin where all pins are soldered together.

The LoRa radio module

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

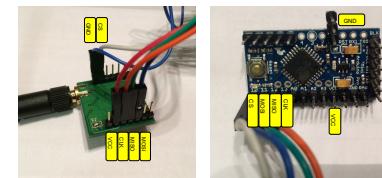


Most of SPI-based LoRa radio modules are supported. We recommend the Modtronix inAir model if you don't have delicate soldering experience as this module can come with header pins ready to be connected with Dupont wires.



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

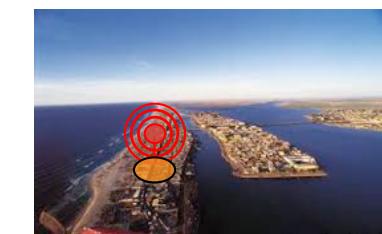
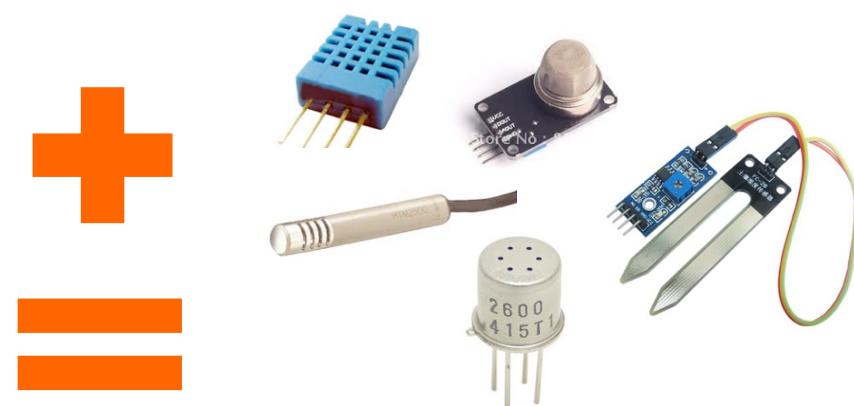
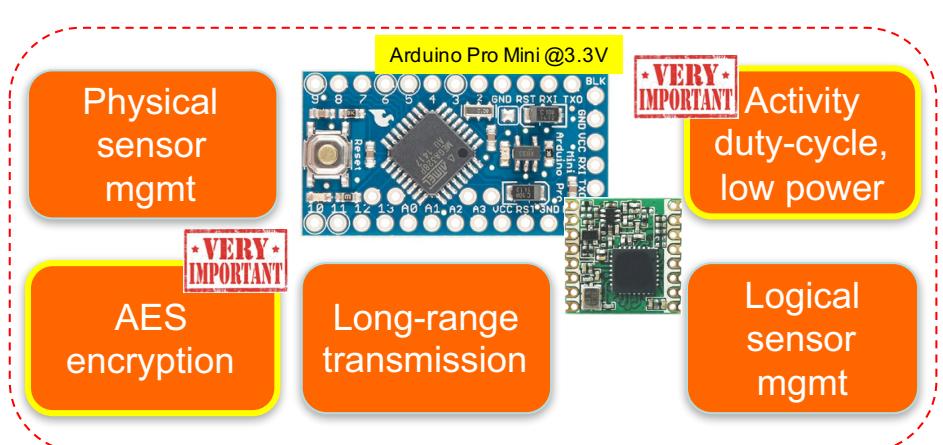
Connect the LoRa radio module



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

GENERIC SENSING IOT DEVICE

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

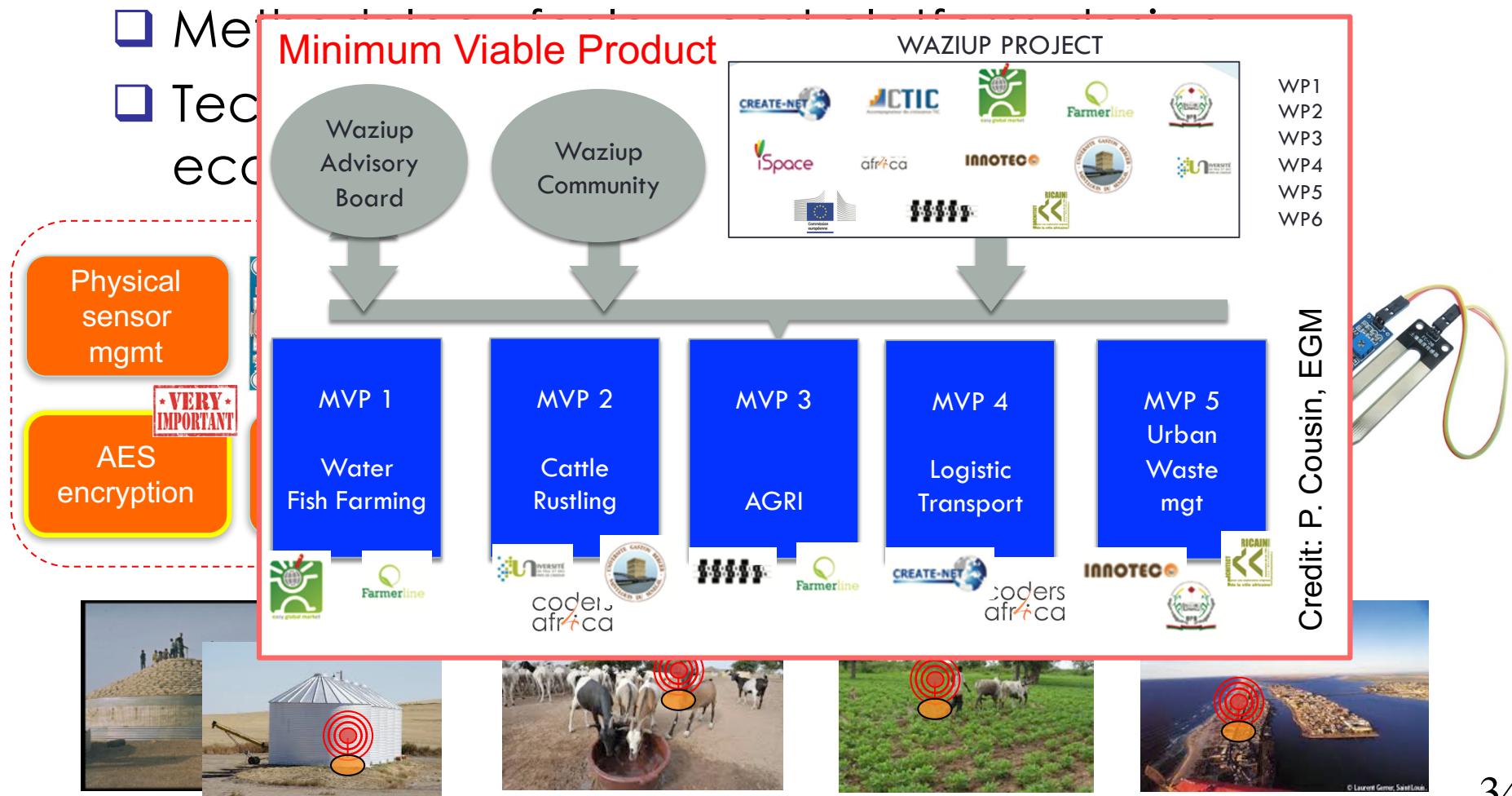


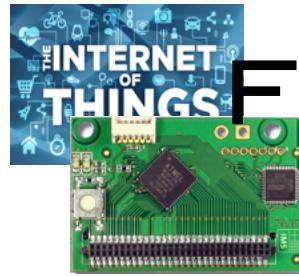
GENERIC SENSING IOT DEVICE

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

- Meet the needs of the end users
- Technical validation

- Economic viability





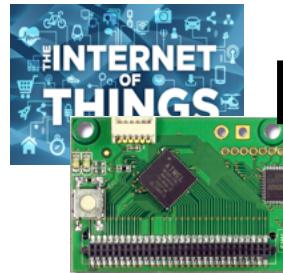
FROM GENERIC TO SPECIFIC APPLICATIONS



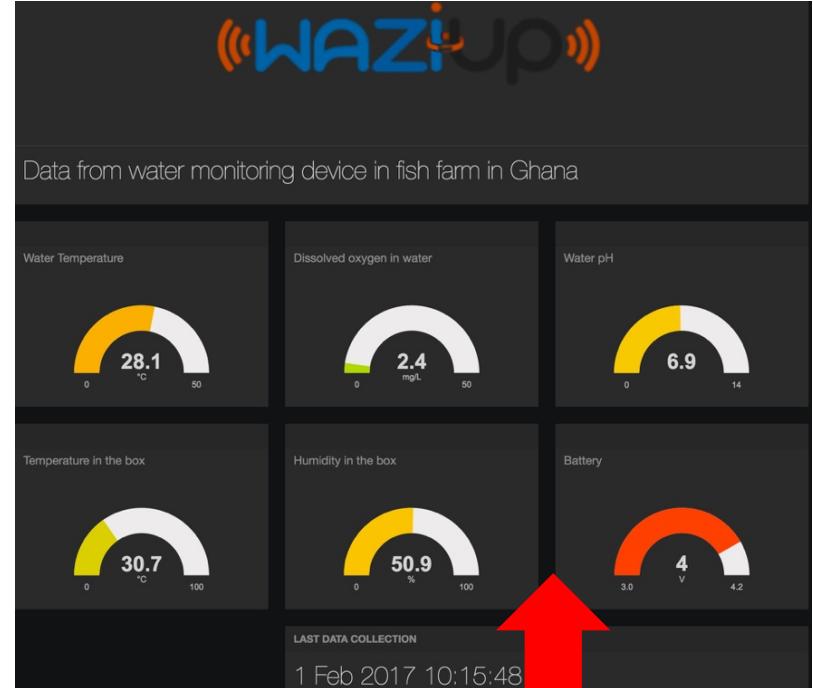
The collage consists of nine photographs arranged in a grid-like pattern:

- Image sensors:** A close-up of a device with multiple image sensors and internal components.
- GPS collar:** A GPS tracking device attached to a animal's neck via a blue strap.
- Soil Moisture:** A soil moisture sensor probe connected to a data logger in a field.
- Weather Station:** A weather station mounted on a pole in a dry, open landscape.
- Buoy for water quality:** A man standing next to a large cylindrical buoy used for monitoring water quality.
- Waste Mngt:** A wooden waste bin with a cloth covering, presented at Woelab.
- Photo from EGM:** Two men working on a water sampling equipment in a flooded area.
- Photo from Unparallel:** A close-up view of a soil moisture probe installed in a cornfield.

Each photograph is accompanied by a green text box containing its respective title.

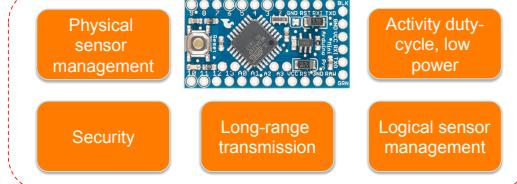


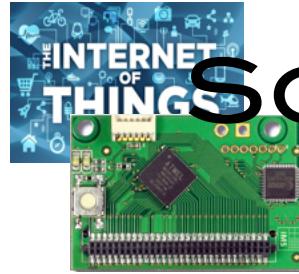
LOW-COST BUOY FOR FISH FARMING MVP



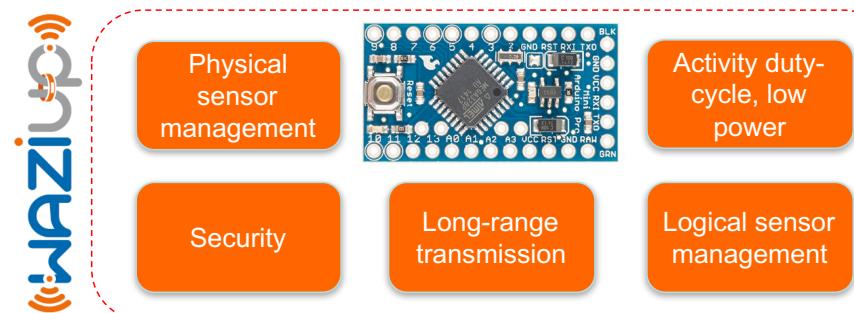
Physical sensor reading

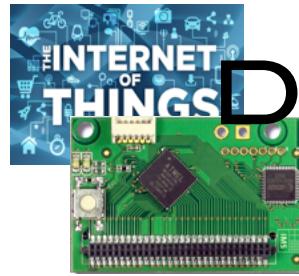
Credit: EGM





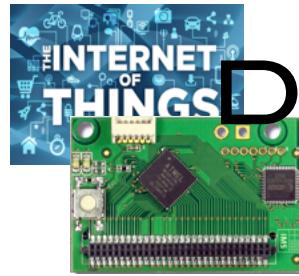
SOIL HUMIDITY SENSORS FOR AGRI MVP



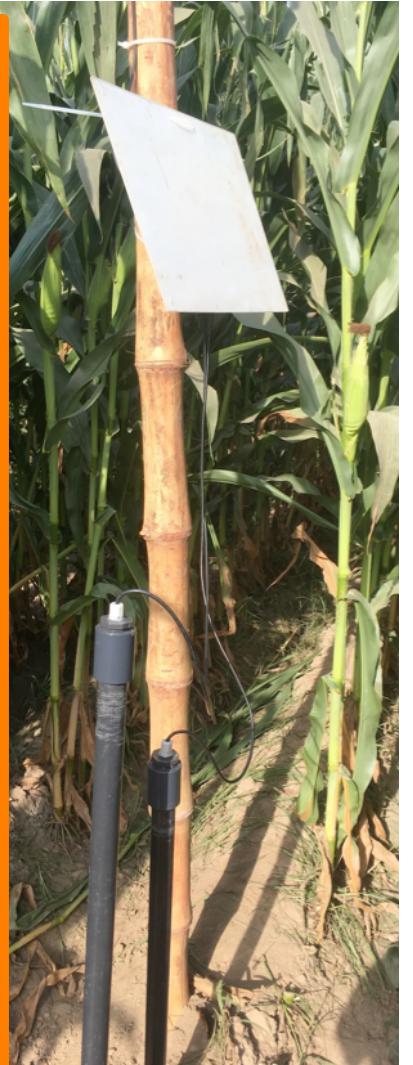
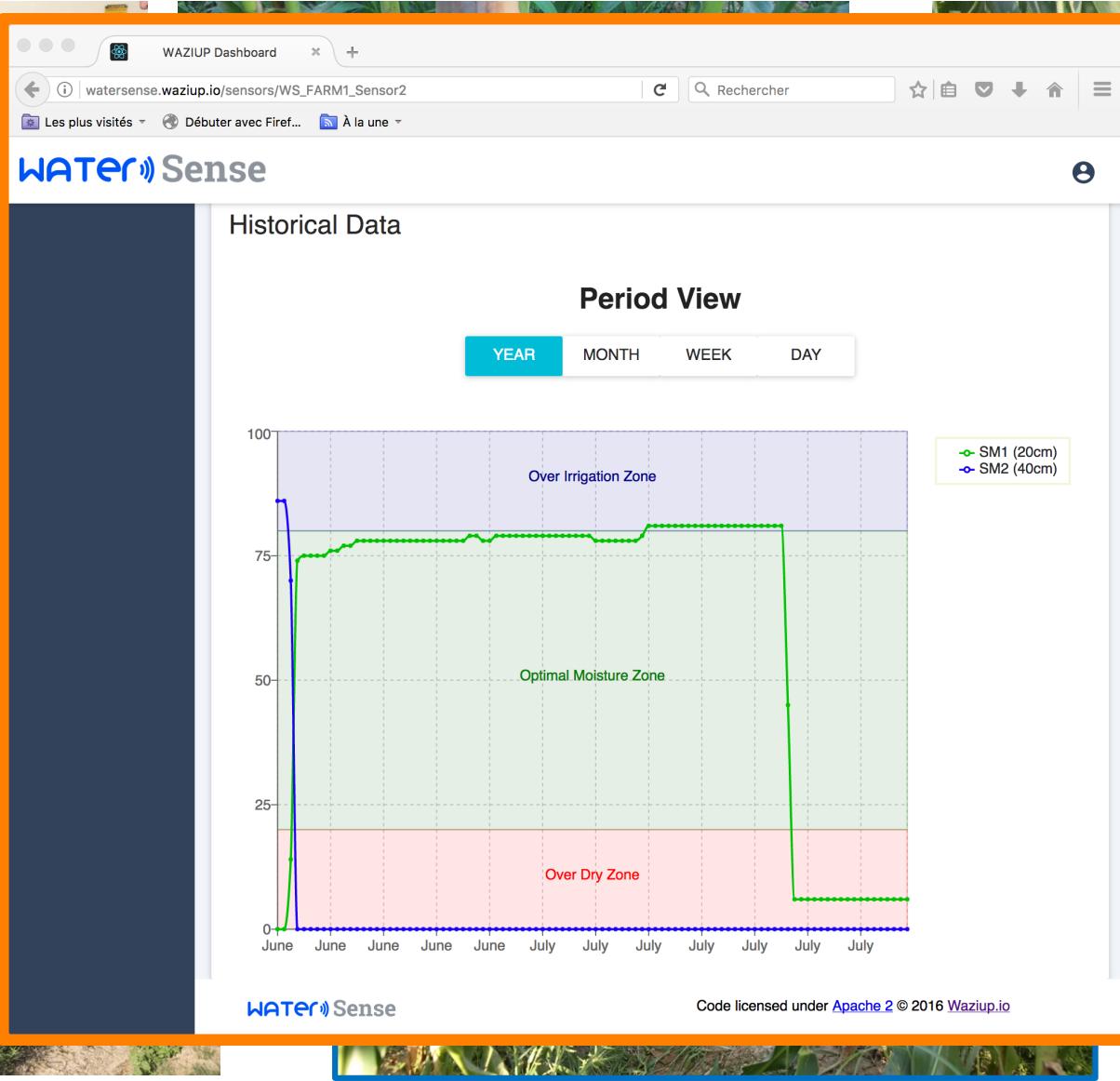


DEPLOYMENT FOR NESTLÉ'S WATERSENSE PROJECT





DEPLOYMENT FOR NESTLÉ'S WATERSENSE PROJECT

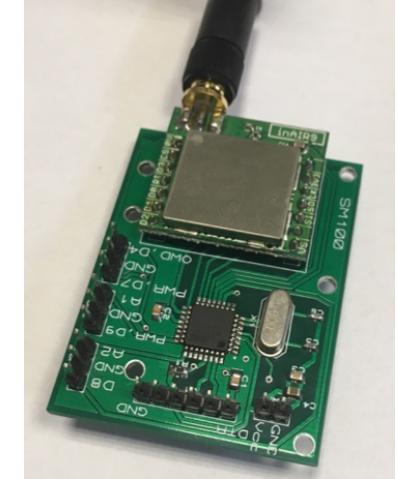
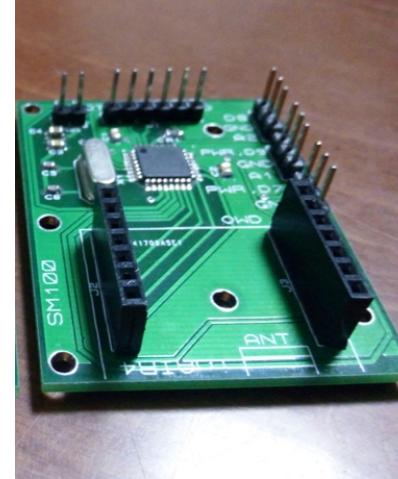


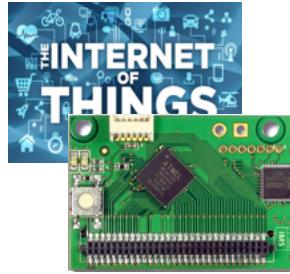


LOCAL INTEGRATION WITH TECHNOLOGY TRANSFER

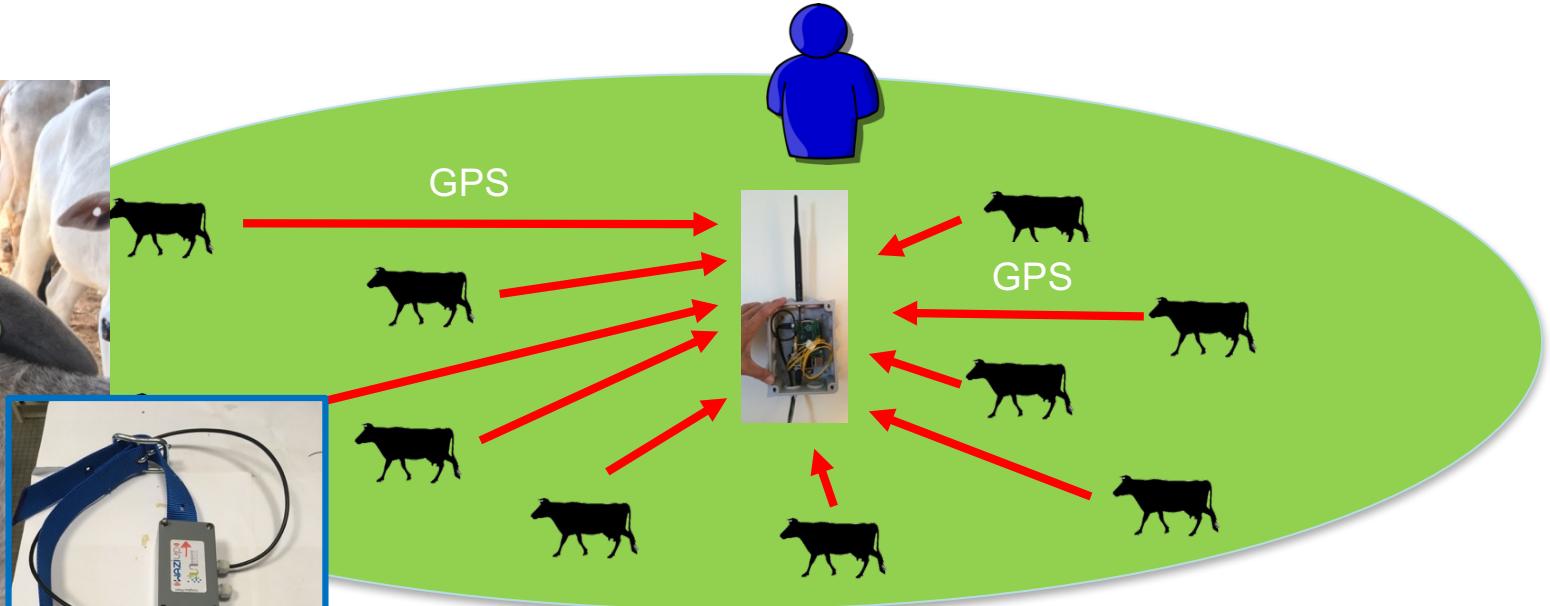


HORIZON 2020



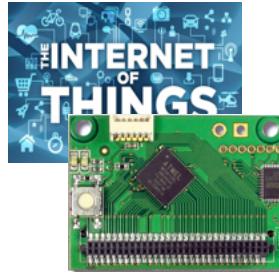


COLLAR FOR CATTLE RUSTLING MVP

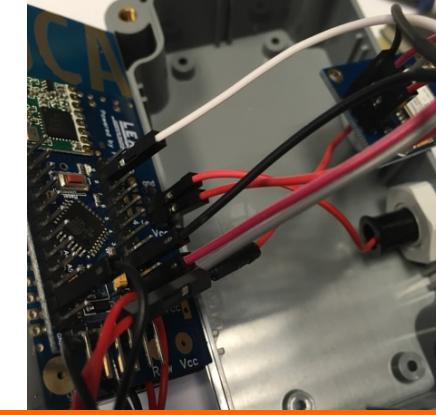
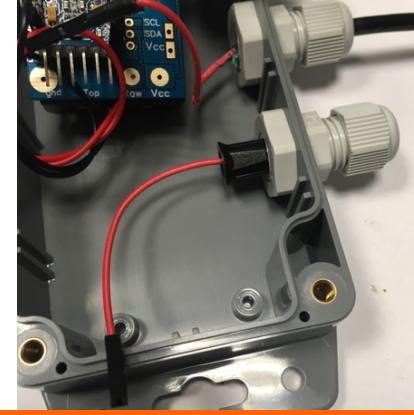
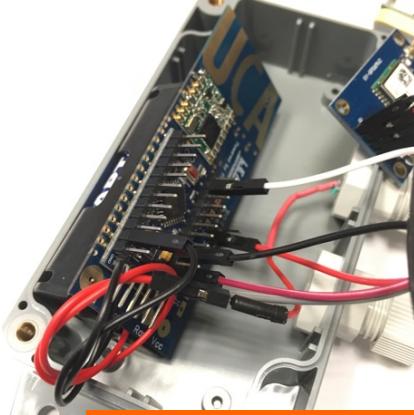
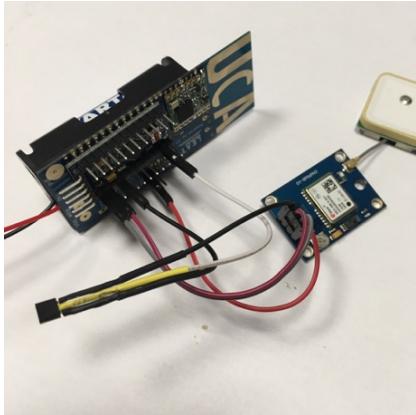


In Africa, the practice of animal husbandry has always been and still remain farmers' livelihood and incomes

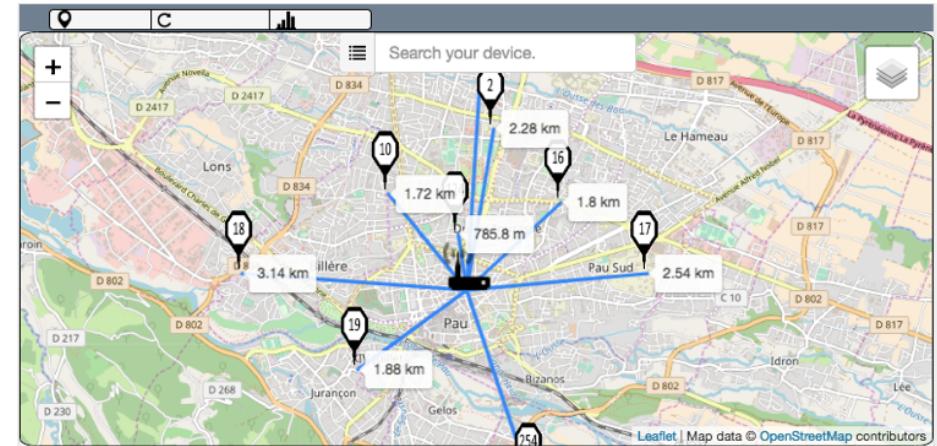
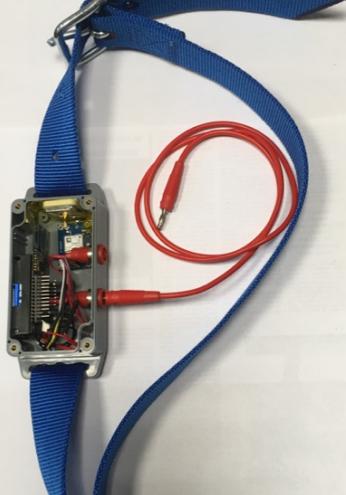
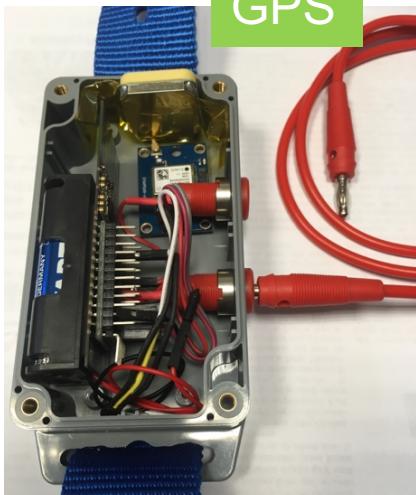
Their main problem in this activity remain the cattle rustling and some families are put in dramatic situation after a theft (reported 2 billions CFA losses)



EASY INTEGRATION AND CUSTOMIZATION



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

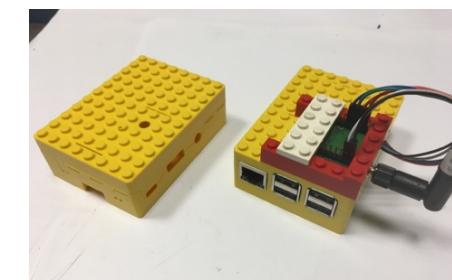


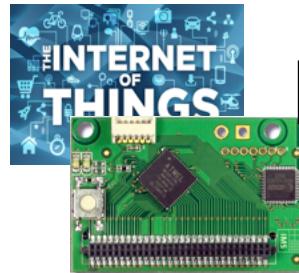
Dedicated tutorial on low-cost IoT collar w/GPS

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



THE VERSATILE IOT GATEWAY

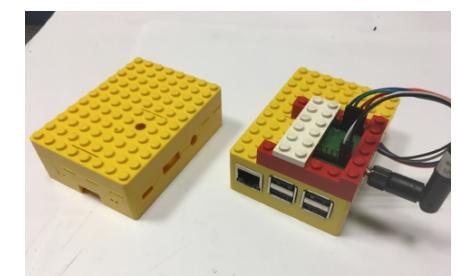




RASPBERRY-BASED LOW-COST LORA GATEWAY



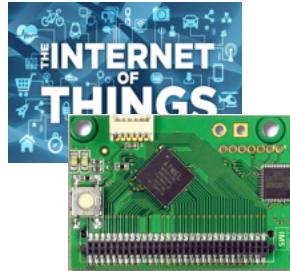
We can use all model of Raspberry. The most important usefull feature is the Ethernet interface for easy Internet connection. Then WiFi and Bluetooth can be added with USB dongles. RPI3 provides built-in Ethernet, WiFi and Bluetooth!



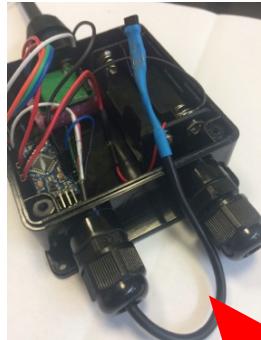
Get the ready-to-use SD card image



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



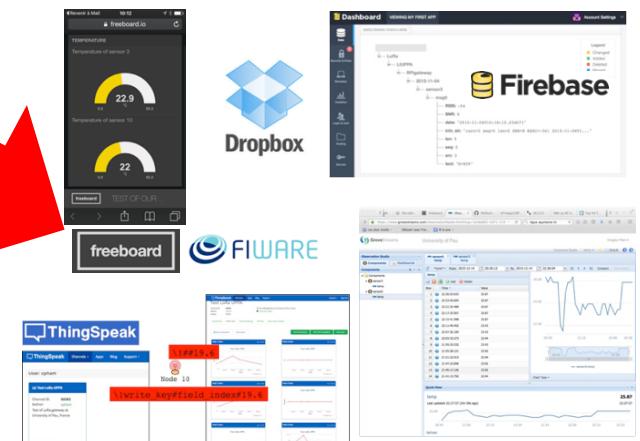
100% DO-IT-YOURSELF !



Step-by-step tutorial
and source code
available

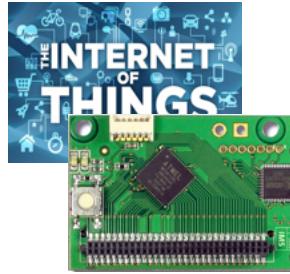


Step-by-step tutorial
and source code
available



Python scripts
available

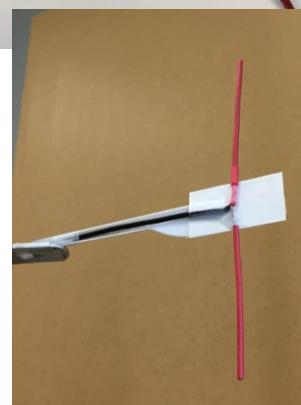
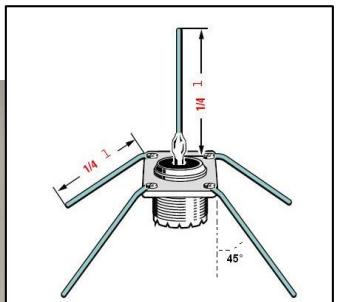
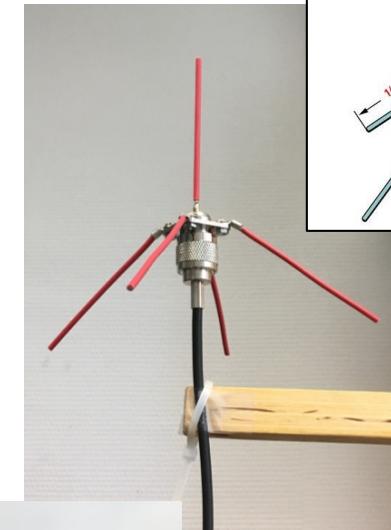
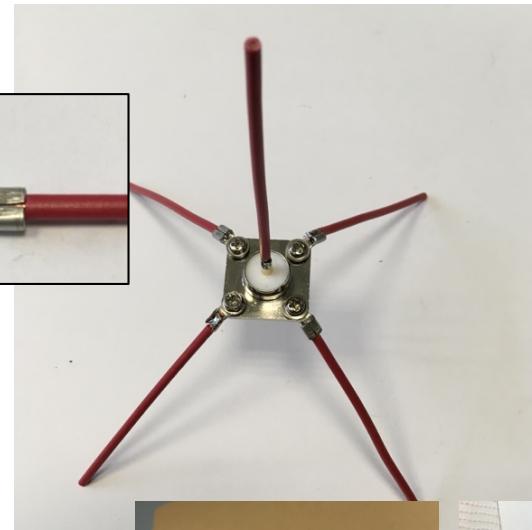
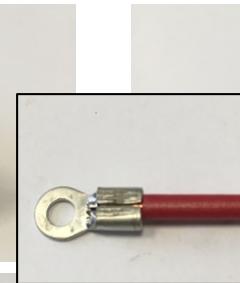
<https://github.com/CongducPham/LowCostLoRaGw>



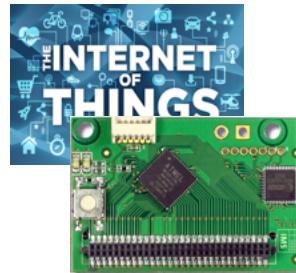
DIY ANTENNA AS WELL



- The ground plane antenna can be made with 5 pieces of $\frac{1}{4}$ wave wires. $\frac{1}{4}$ wave in 868MHz is about 8.2cm.



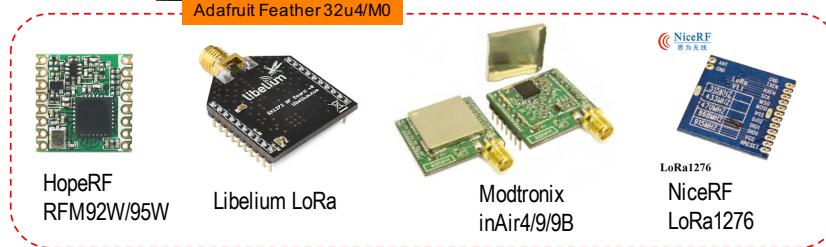
- Simple dipole antenna



SIMPLICITY!



LoRa radios that our library already supports

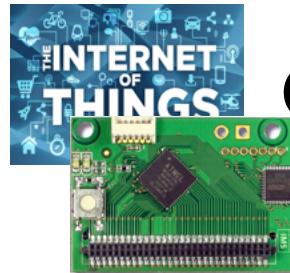


Long-Range communication library

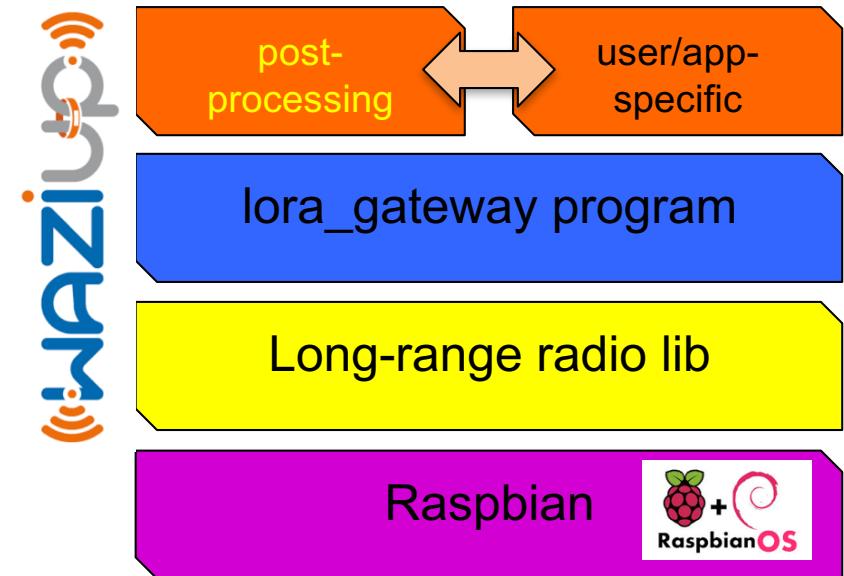
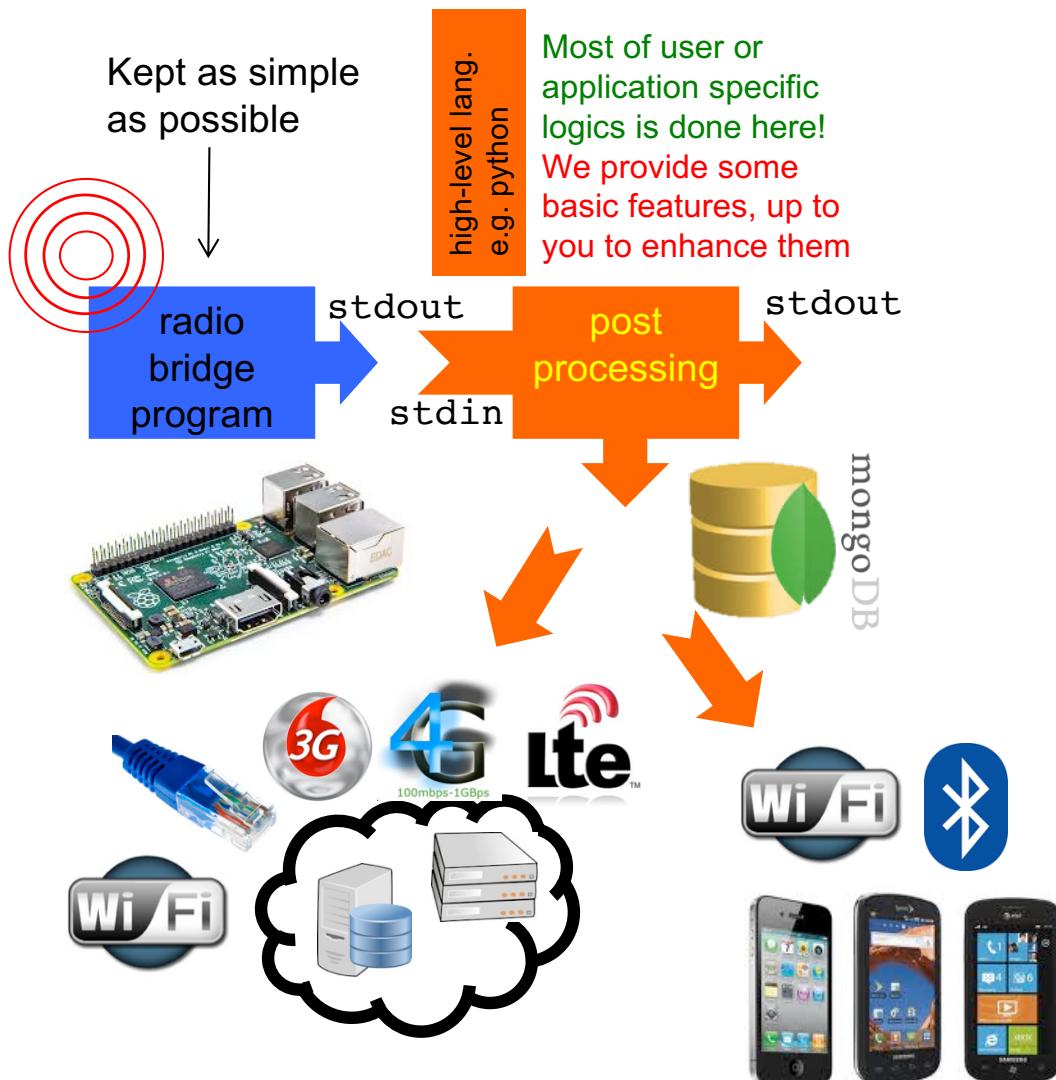
```
sendPacketTimeout("TC/18.5");
// sends to gateway
// TC : temperature celcius
// 18.5 : value
```

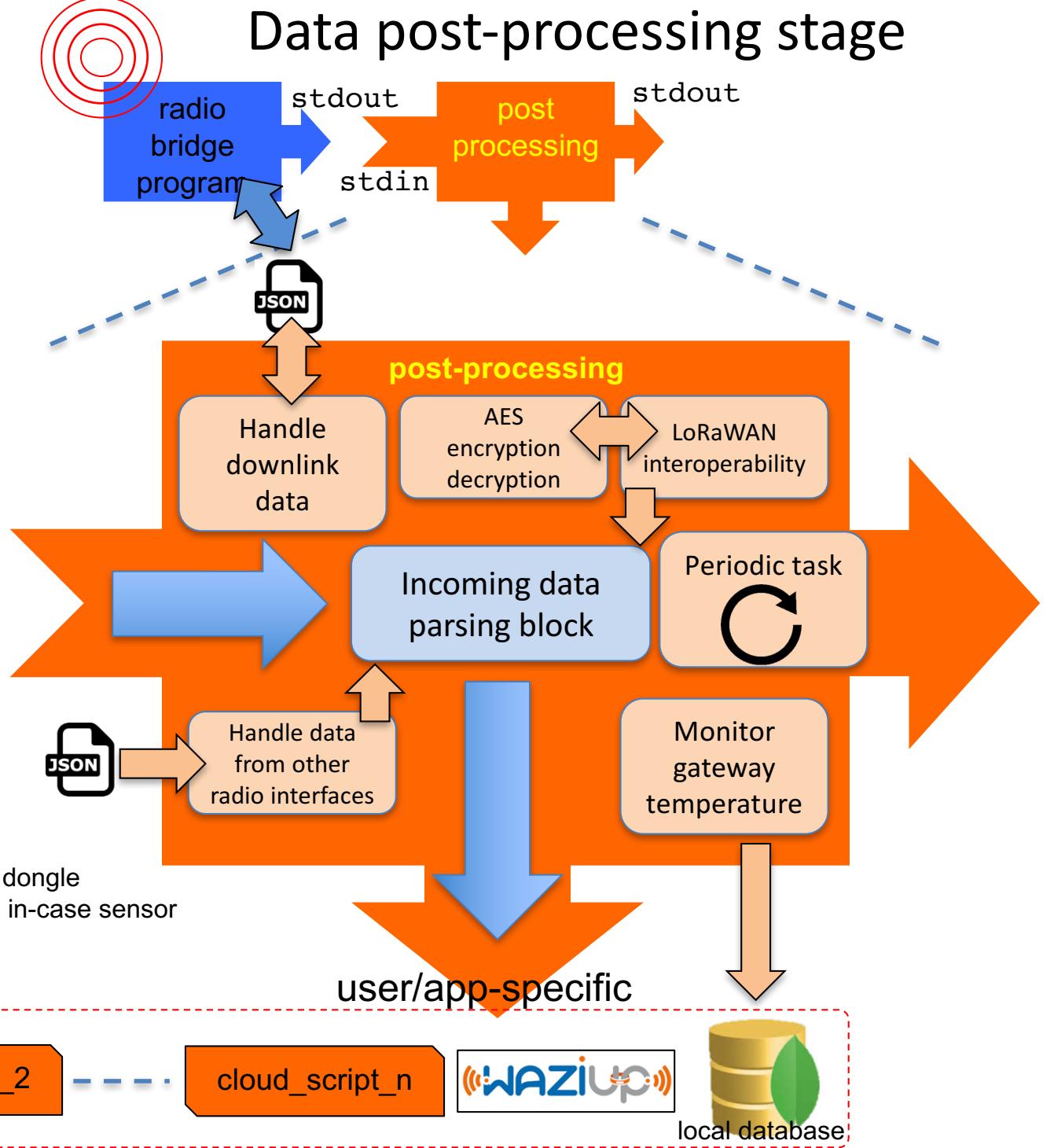
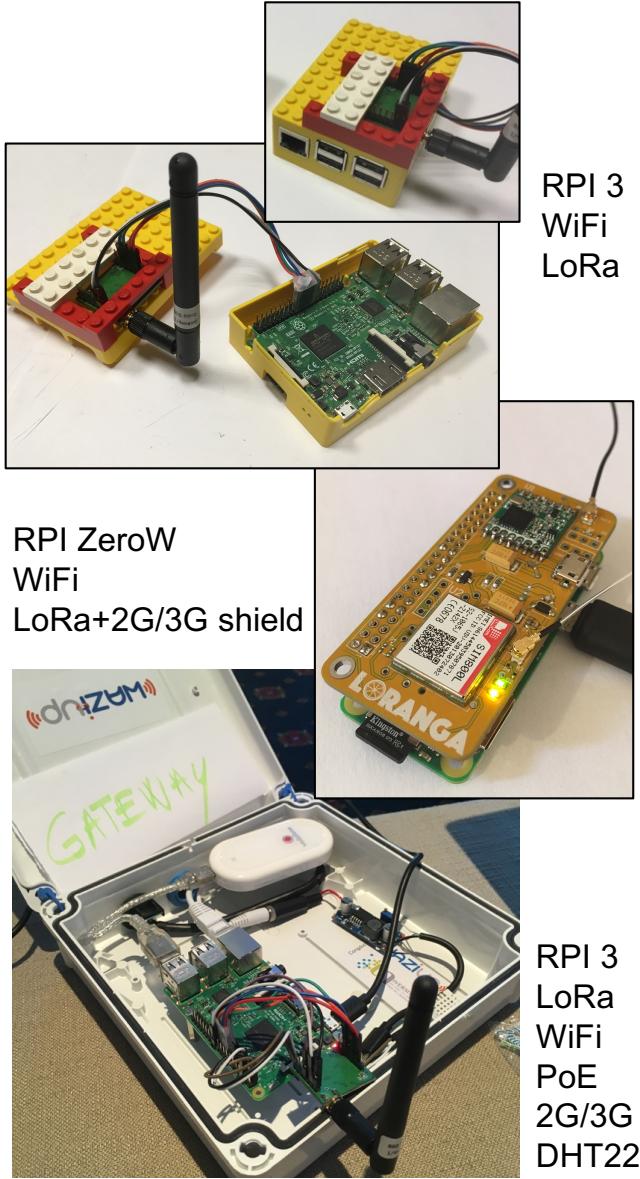
1 send function!





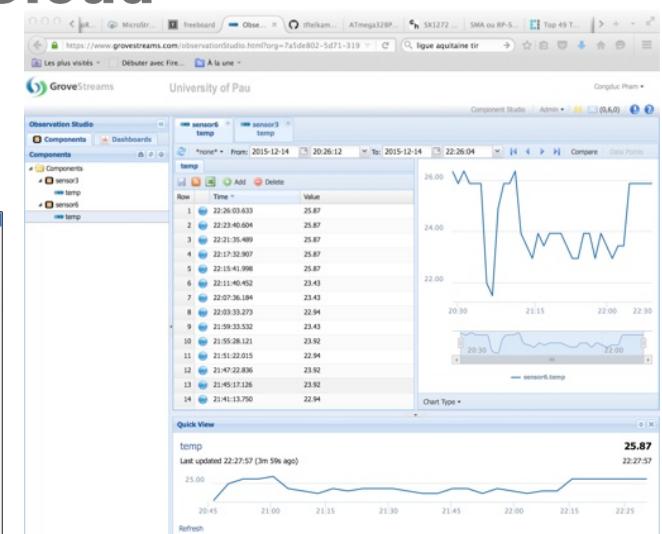
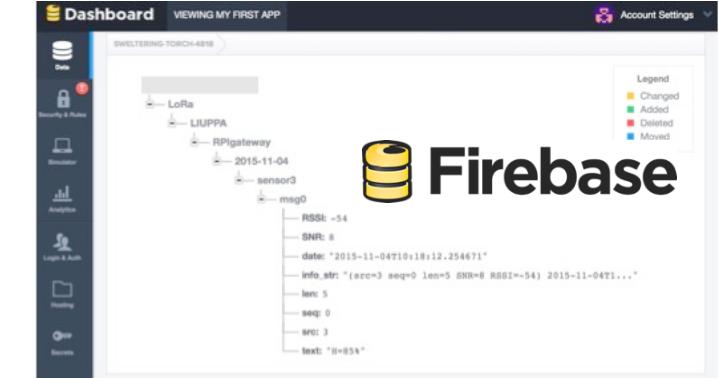
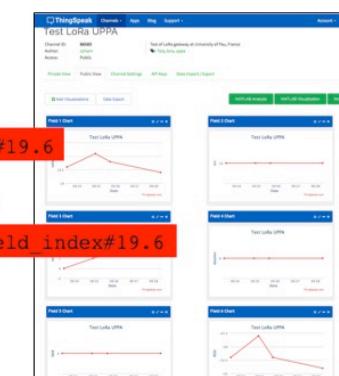
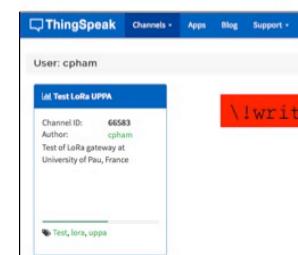
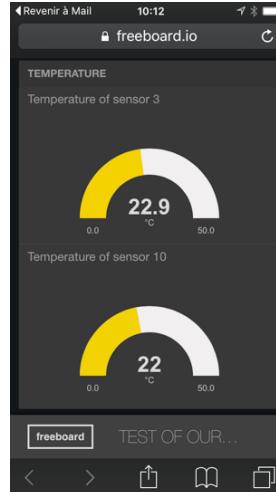
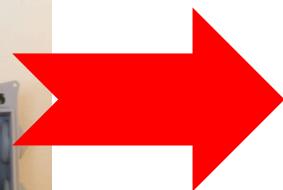
OUR LOW-COST GATEWAY ARCHITECTURE



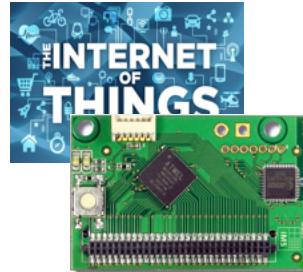




TEMPLATES FOR VARIOUS CLOUDS



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

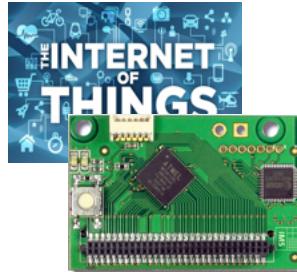


THE WAZIUP CLOUD PLATFORM



□ dashboard.waziup.io

The screenshot displays the WAZIUP Cloud Platform dashboard. On the left, a sidebar lists three nodes: "Node UPPA Sensor 6", "Node (UPPA_Sensor3)", and "Node (UPPA_Sensor10)". Each node entry includes a small icon of a green circuit board with a Wi-Fi signal, followed by the node name and a green rectangular card showing a temperature gauge. The "UPPA Sensor 6" card shows "Temperature" at 17.21 °C. The "UPPA_Sensor3" card shows "(TC)" at 21.43. The "UPPA_Sensor10" card shows "(TC)" at 23.97. On the right, a detailed view of "UPPA Sensor 6" is shown. It features a "Temperature" gauge with a value of 17.21 °C and a line graph showing historical data. Below this, a map of France and surrounding regions is displayed, with a blue marker indicating the location of the sensor. Buttons for "EDIT", "ADD MEASUREMENT", and "DELETE" are visible at the top of this panel.



CLOUDS.JSON

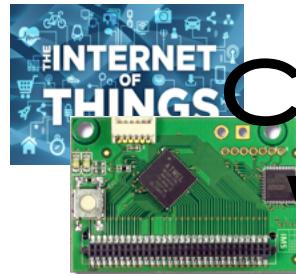


```
{  
  "clouds": [  
    {  
      "notice": "do not remove the MongoDB cloud declaration",  
      "name": "Local gateway MongoDB",  
      "script": "python CloudMongoDB.py",  
      "type": "database",  
      "max_months_to_store": 2,  
      "enabled": true  
    },  
    {  
      "name": "WAZIUP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

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

Enabled clouds will be called by the post-processing stage

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



CONFIGURE YOUR GATEWAY WITH THE WEB INTERFACE



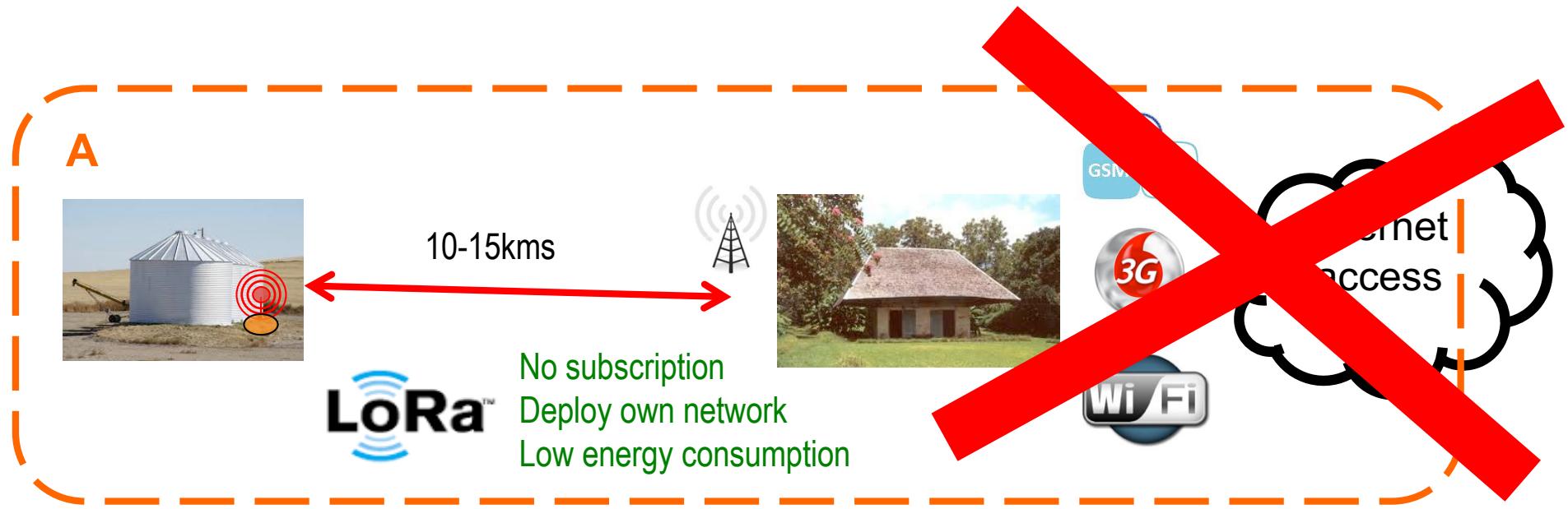
□ <http://192.168.200.1/admin>

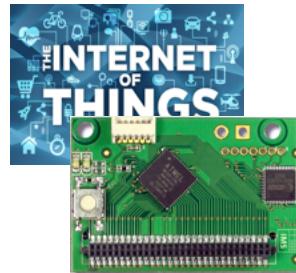
- Login: admin
- Password: loragateway

The screenshot shows a web browser window titled "Admin" with the URL "192.168.200.1/admin/pages/gateway_config.php". The page is titled "Gateway configuration". At the top, there is a navigation bar with tabs for "Internet", "Low-level status ON", "Reboot", and "Shutdown". On the left, there is a sidebar with links for "Clouds", "Gateway Update", and "System". The main content area has a tab bar with "Radio" selected, followed by "Gateway", "Alert Mail", "Alert SMS", "Downlink Request", and "Get post-processing.log file". Below this, there are two rows of settings: "Mode" set to "4" and "Frequency" set to "-1", each with an edit icon.

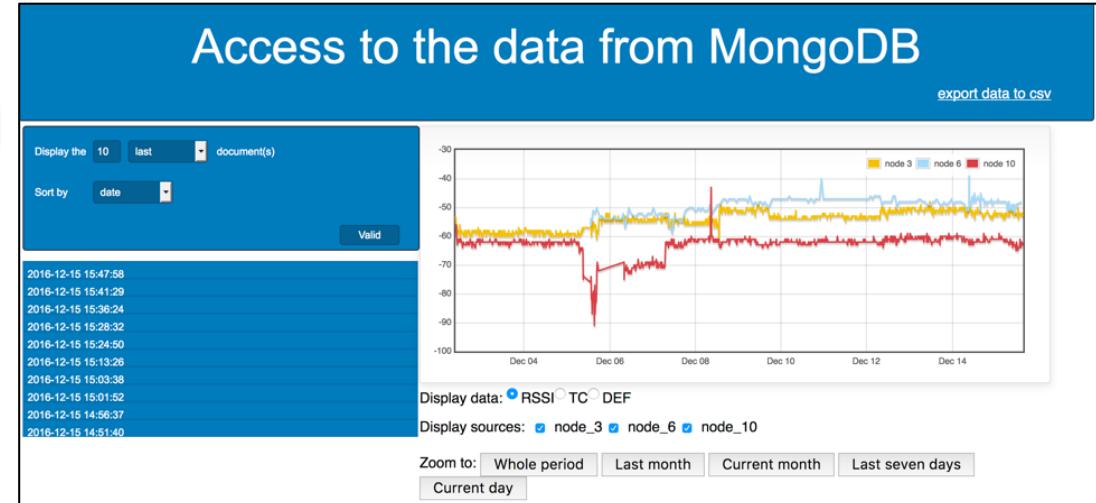
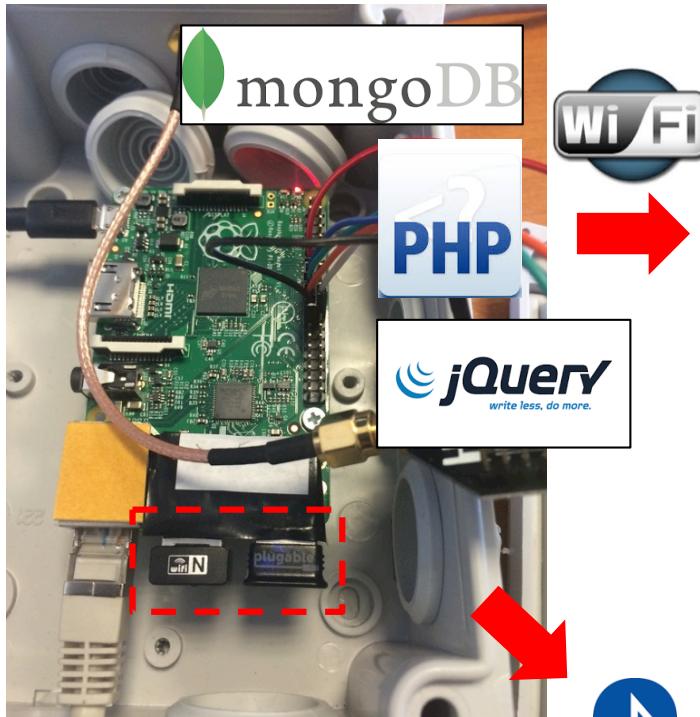


WORKING WITHOUT INTERNET ACCESS





STANDALONE GATEWAY



Orange F * 10:34

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 * 10:37

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 * 10:39

Bluetooth_raspi

Display data

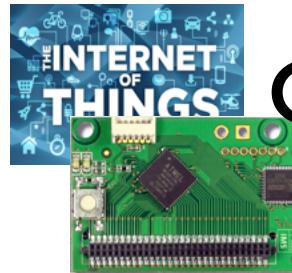
Retrieve data in a csv file

Display data

Retrieve data in a csv file

Isolated areas

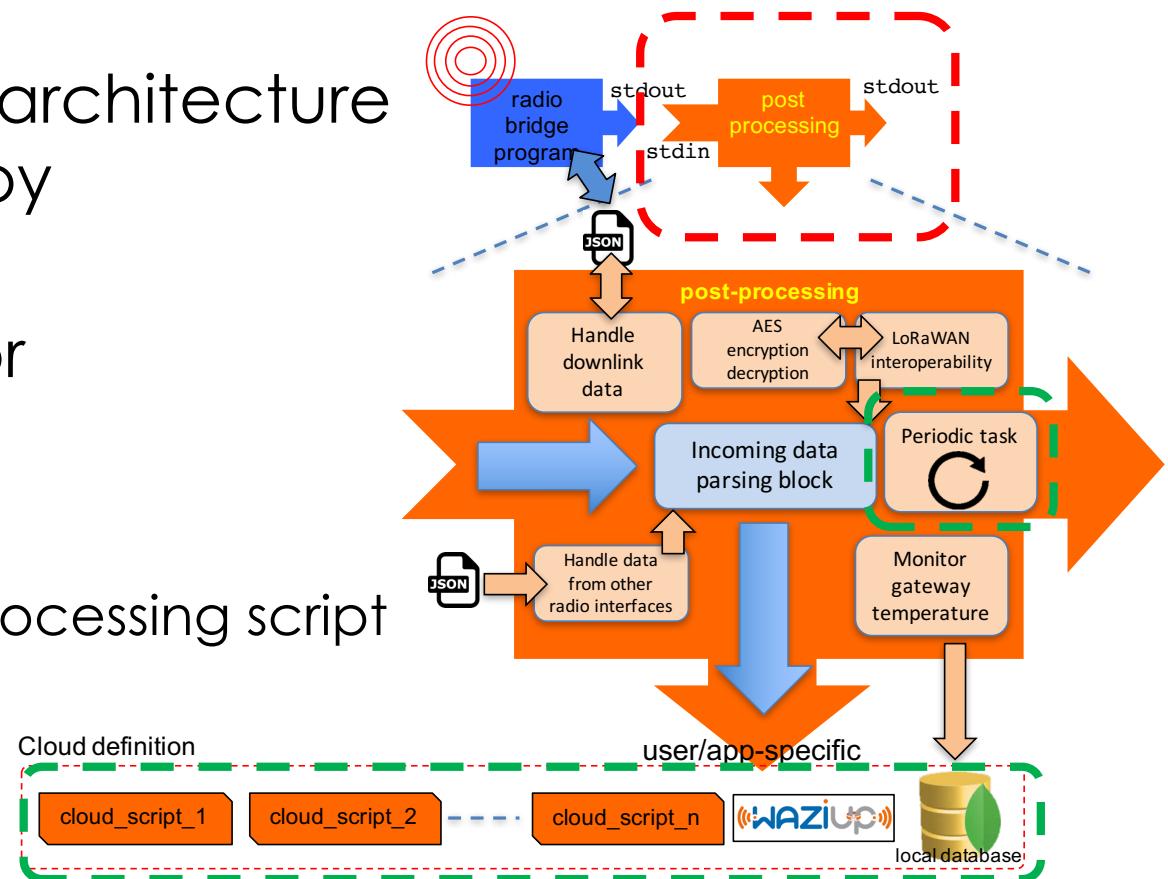




CUSTOMIZING/EXTENDING YOUR GATEWAY



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



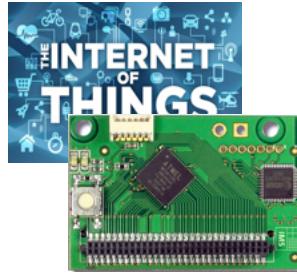


WRITE YOUR OWN CLOUD SCRIPT

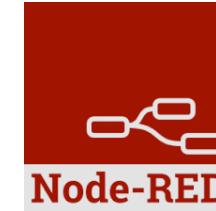


- Use our templates to write your own cloud script
- A cloud script is called with 5 arguments
 - **ldata:** the received data
 - e.g. #4#TC/21.5 as 1st argument (`sys.argv[1]` in python)
 - **pdata:** packet information
 - e.g. "1,16,3,0,10,8,-45" as 2nd argument (`sys.argv[2]` in python)
 - interpreted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

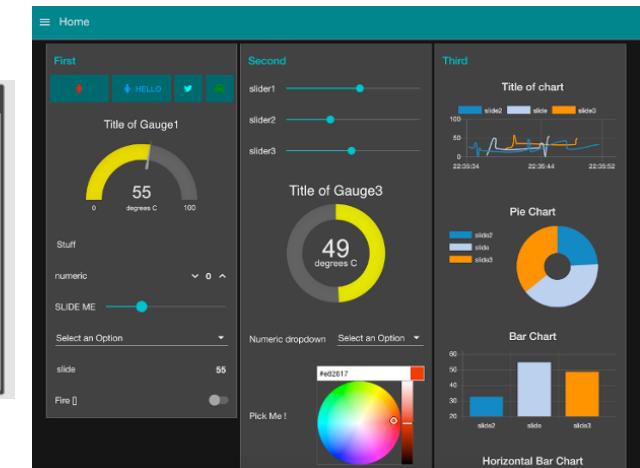
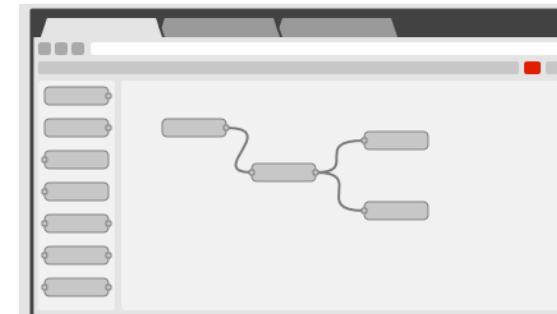
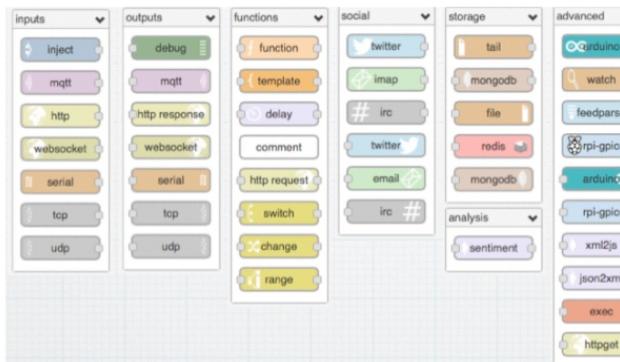
These parameters are passed to the script. It is up to the cloud script to use these parameters or not.

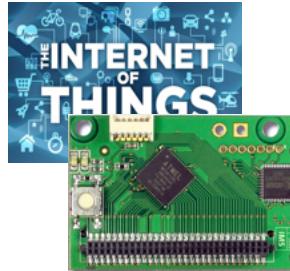


Ex: NODE-RED

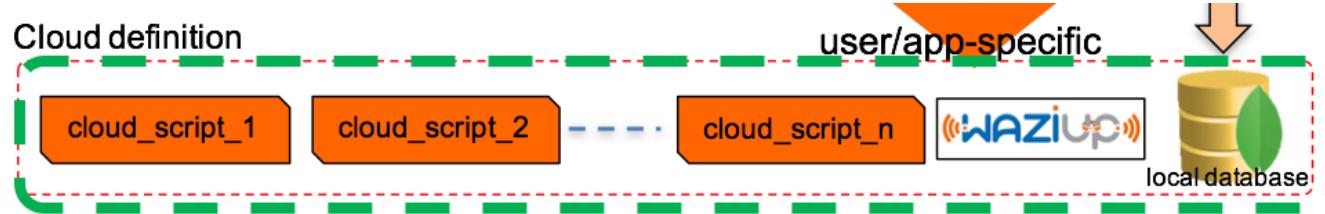


- Node-RED is a programming tool for wiring together hardware devices, APIs and online services, e.g. clouds of various types
- provides a browser-based flow editor to wire together flows with a wide range of nodes

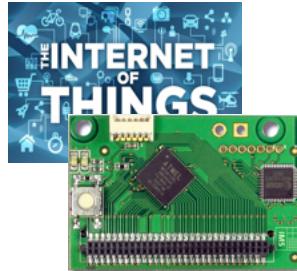




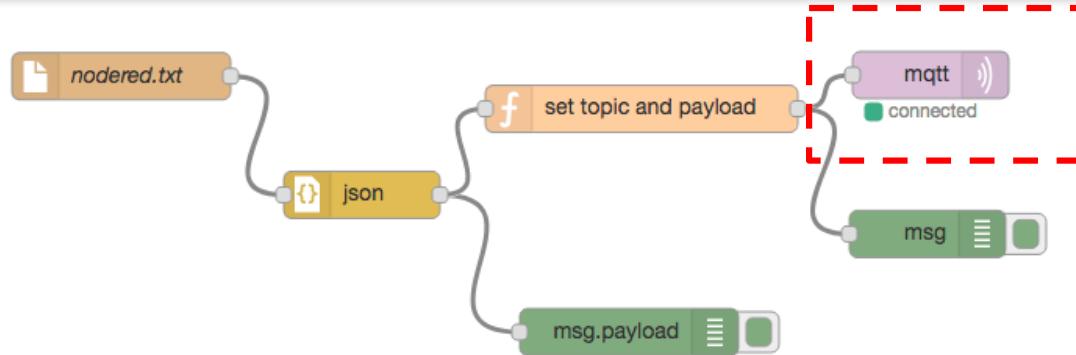
CLOUDNODERED.PY



- ❑ CloudNodeRed.py shows how interface with Node-Red can be simply implemented to benefit from the facility offered by Node-Red
- ❑ 3 variables will be used by CloudNodeRed.py
 - ❑ project_name="waziup"
 - ❑ organization_name="UPPA"
 - ❑ sensor_name="Sensor"
- ❑ when a device which address is 2 sends "TC/21.65/HU/85" to the gateway, CloudNodeRed.py will generate the following json entries in nodered/nodered.txt file
 - ❑ { "source": "waziup/UPPA/Sensor2", "measure": "TC", "value": 21.65 }
 - ❑ { "source": "waziup/UPPA/Sensor2", "measure": "HU", "value": 85 }



ADDING MQTT



- An MQTT node using the test.mosquitto.org broker will receive the messages with the topic defined as waziup/UPPA/Sensor2/TC and waziup/UPPA/Sensor2/HU
- It will then respectively publish 21.65 and 85 under these topics
- More information on:
 - https://github.com/CongducPham/LowCostLoRaGw/blob/master/gw_full_latest/README-NodeRed.md

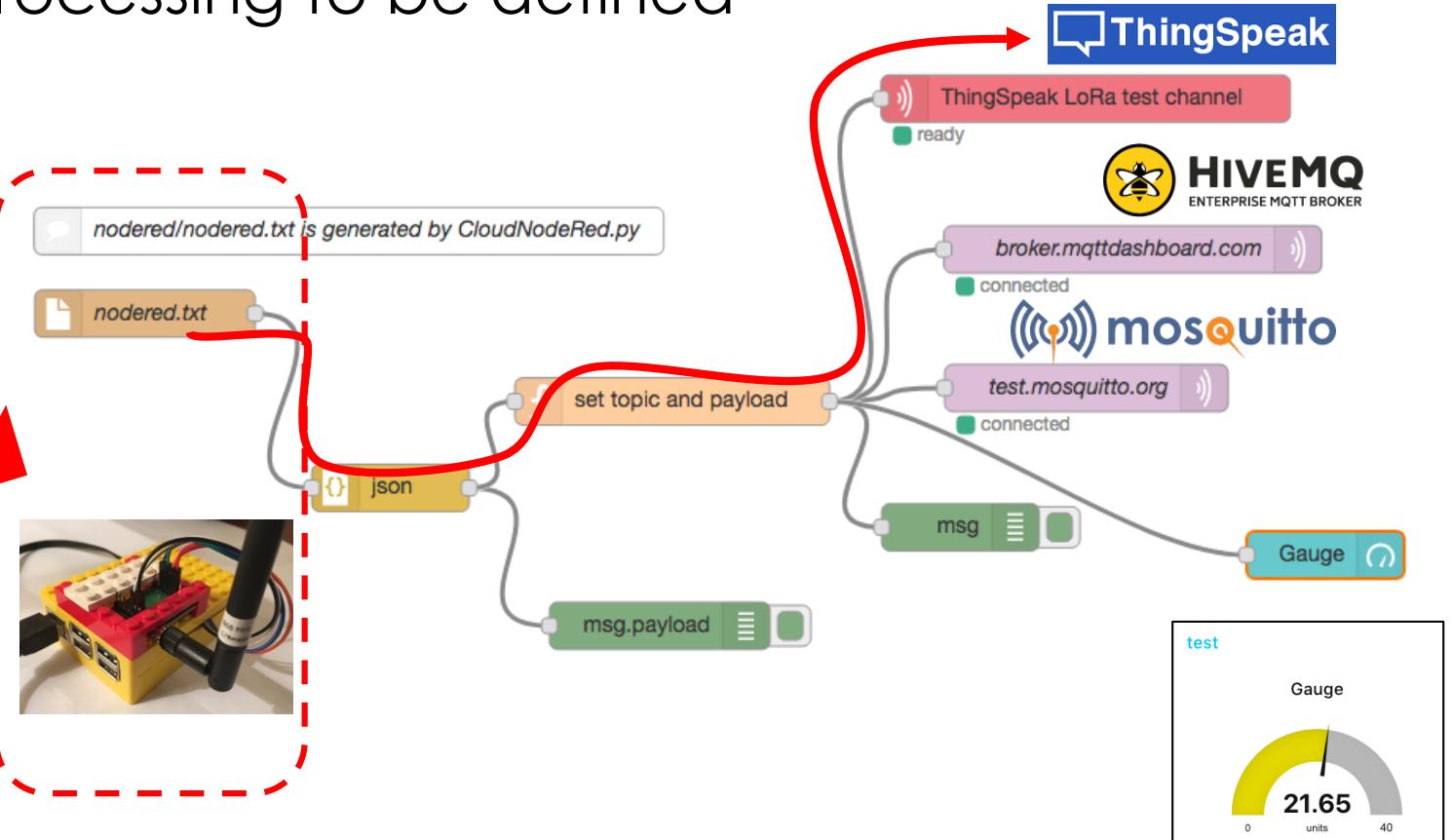


THE NODE-RED ENABLED GATEWAY

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



LoRa™

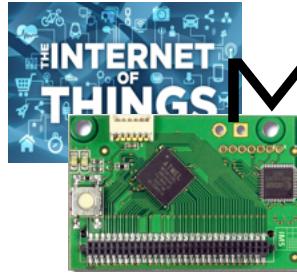


ANOTHER EXAMPLE WITH CLOUDGPSFILE.PY

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

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

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



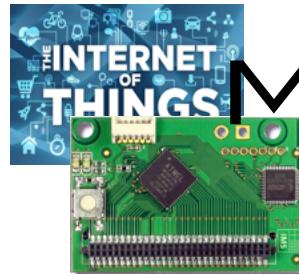
MAINTAINING A LIST OF GPS DEVICES (1)



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

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

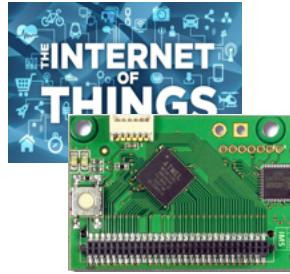
- New devices (from src field) will be added, while existing devices will be updated



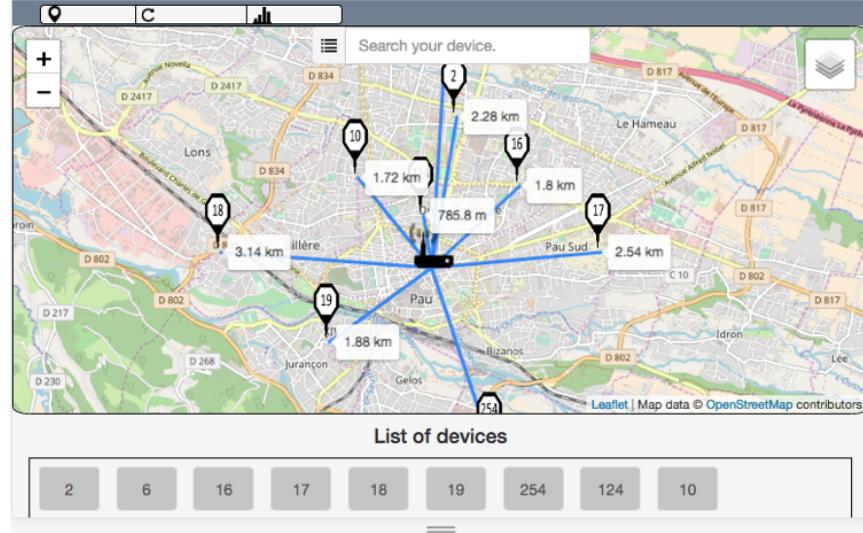
MAINTAINING A LIST OF GPS DEVICES (2)



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



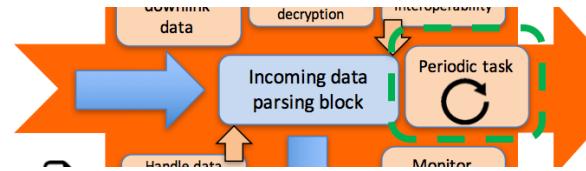
A WEB INTERFACE FOR TRACKING GPS DEVICES



- A web interface could use `gps/gps.json` and `gps/active_gps.json` to show:
 - the last updated GPS device
 - active devices
 - inactive devices
- Especially useful in mobility scenario



EXTENDING BY ADDING A NEW PERIODIC TASK

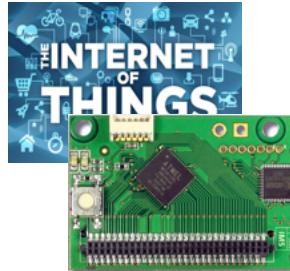


- Illustration with dynamic gateway GPS position
- The gateway's coordinates are stored in `gateway_conf.json`

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

- In a mobility scenario, the position of the gateway can be updated
- `post_status_processing_gw.py` which is periodically called by the main post-processing loop can be extended to get the position of the gateway using a connected GPS module.

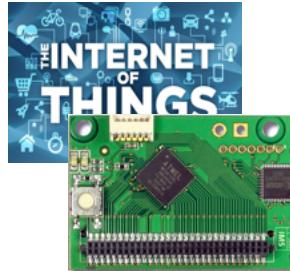




WHEN ENABLING DYNAMIC_GPS



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



NOW,

IoT BECOMES REALITY!



NB-LTE



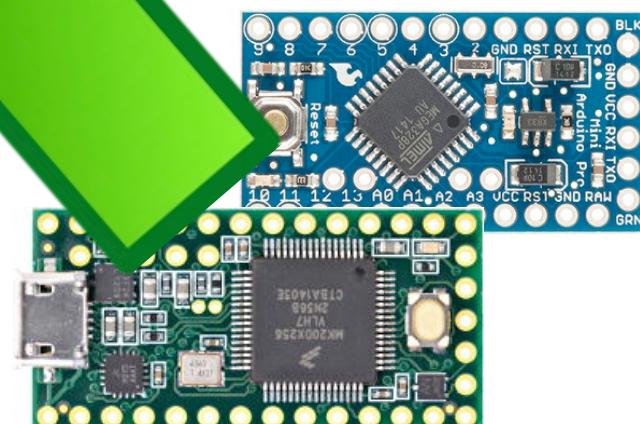
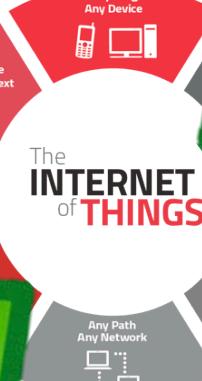
Bluetooth® 4.0

nwave
LoRa™
NB-LTE
WEIGHTLESS
DASH7™
ALLIANCE
Bluetooth® 4.0

LTE-M

EC-G

GU



Firebase

Dropbox

ThingSpeak

SensorCloud™

openRan

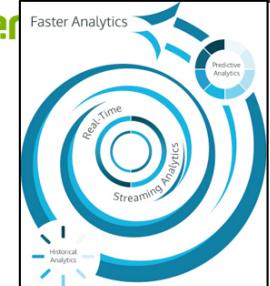
FIWARE

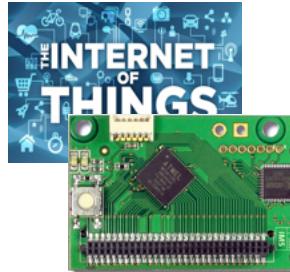
Axēda®

ioBridge®
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freeboard





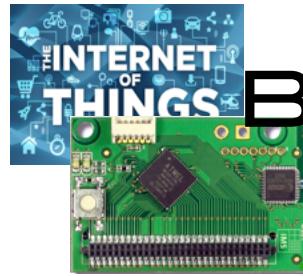
INVOLVING INNOVATION HUBS/STAKEHOLDERS



- **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)

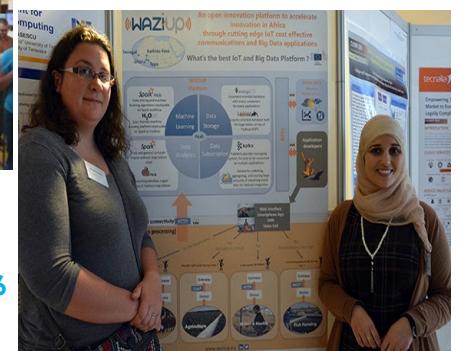
Workshop at the European Conference on Networks & Communications (Greece, CNET)



IoTWeek2016 (Belgrade, EGM)



IoTBIGDATA2016 (Italy, EGM)



IoTCareConference (Budapest, CNET)

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



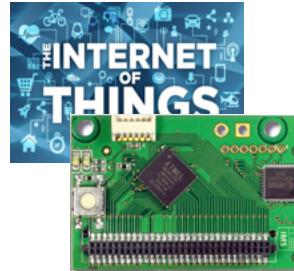
Credit: C. Vavasseur, CTIC Dakar



RESSACS 2016



Workshop at the RESSACS 2016 (France, UPPA) 70



TUTORIALS/RESOURCES



<https://github.com/CongducPham/tutorials>

WAZIUP
EU H2020 grant agreement number 676707
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 virtual personalities 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 external environment, and that can be identified and tracked via unique identifiers and be able to transfer data over 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 development of local economies in Sub-Saharan Africa. First, WAZIUP creates by involving farmers and breeders in order to define the platform specifications in a focused validation cases. Second, WAZIUP proposes solutions aiming at long term sustainability. Third, WAZIUP engages the flourishing ICT ecosystem in those countries by fostering new tools and guidelines for the development of innovative applications/services delivery. WAZIUP is driven by the following vision:
1. Empower the African rural population by enabling them to benefit from the opportunities offered by rapid urbanization and support them in their animal breeding on a new scale.
Author : Congduc Pham, University of Pau
Last update : 07.09.2016

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



PROF. CONGUDC PHAM
HTTP://WWW.UNIV-PAU.FR-/CPHAM
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LOW-COST LoRA IoT DEVICE: A STEP-BY-STEP TUTORIAL



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



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LOW-COST LoRA IoT DEVICE: SUPPORTED PHYSICAL SENSORS



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



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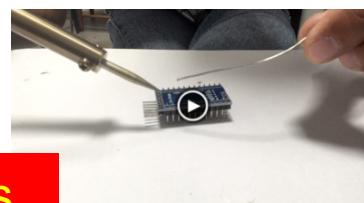
LOW-COST LoRA IoT: USING THE WAZIUP DEMO KIT



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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=mj8ltKA14PY>



Thanks.
Let's keep in touch



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Communication & Event Manager

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