The Internet-of-Things revolution for all

UPPA Computer Science
Undergraduate students

november 30th, 2017

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

La révolution de l' Internet-des-Objets à la portée de tous!

"Disciplines et Métiers de l'Informatique"
30 novembre 2017, UPPA

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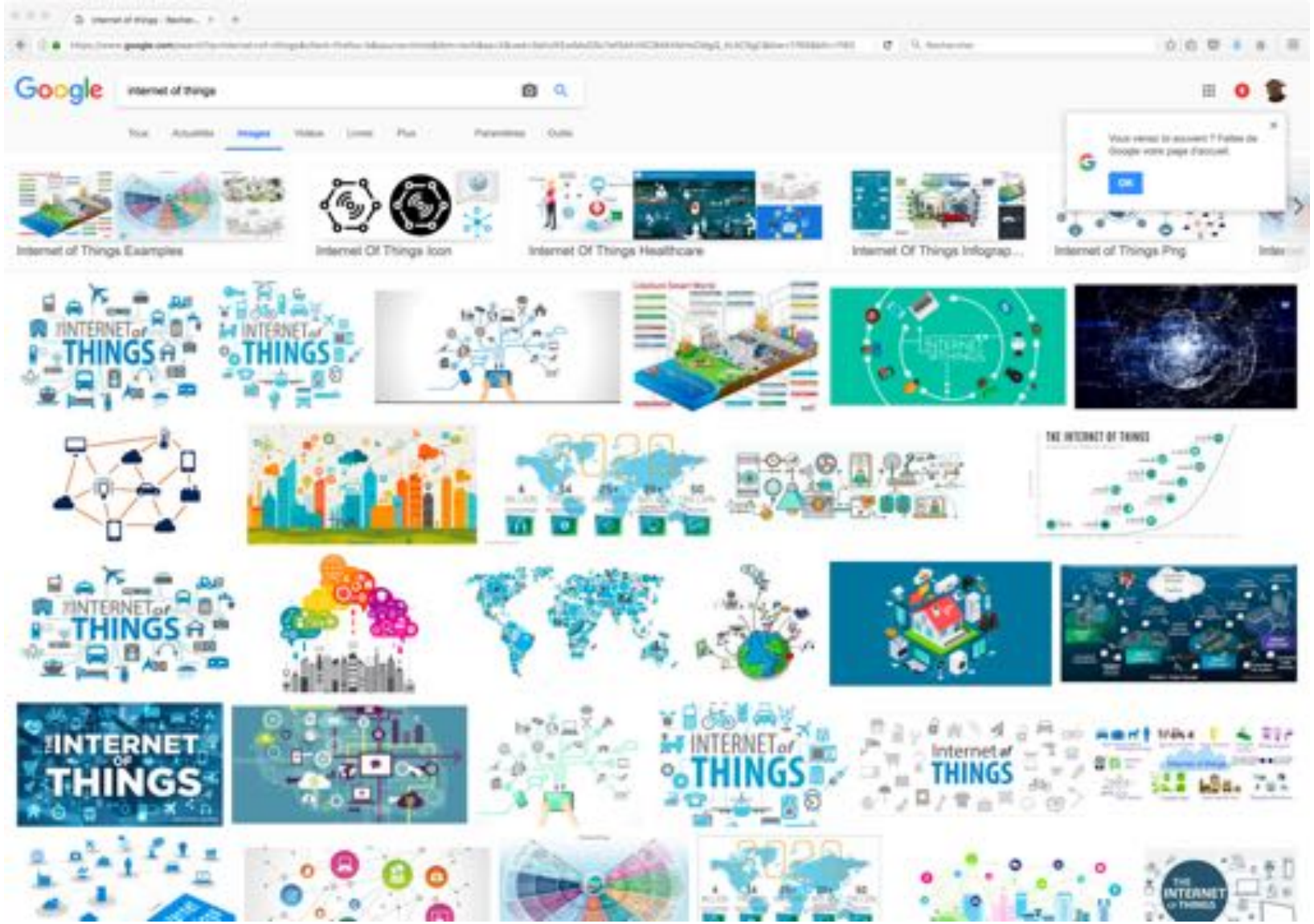
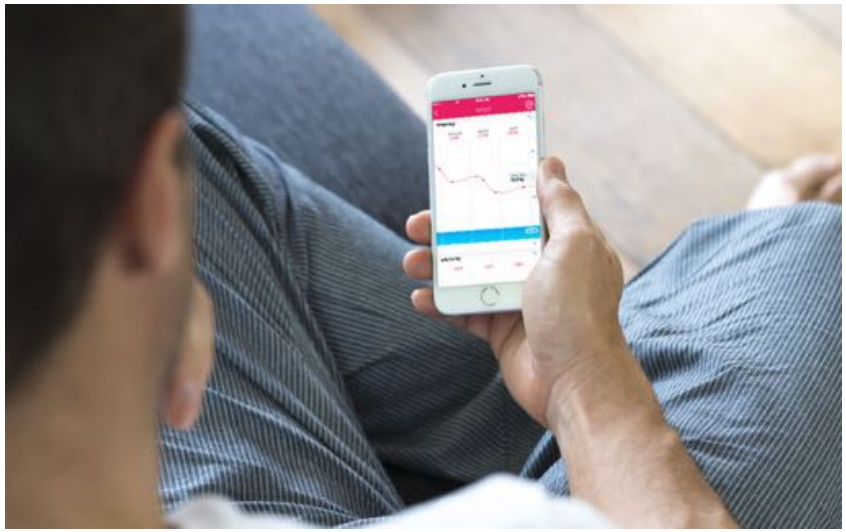
Googling for « Internet of Things »...



… TYPICALLY SHOWS COMMUNICATING OBJECTS

Daily-life IoT



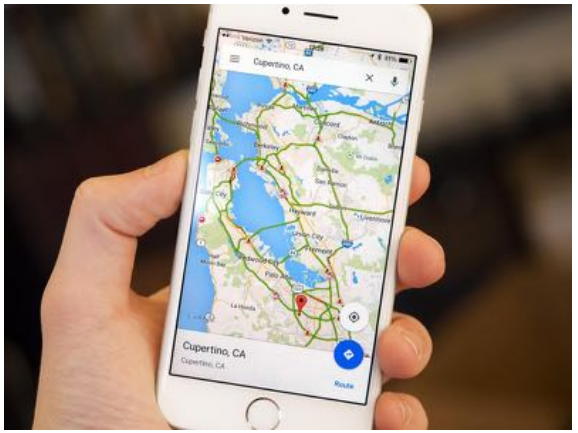
Pictures from WiThing, https://www.withings.com/eu/fr/products/body

IoT in Sport!

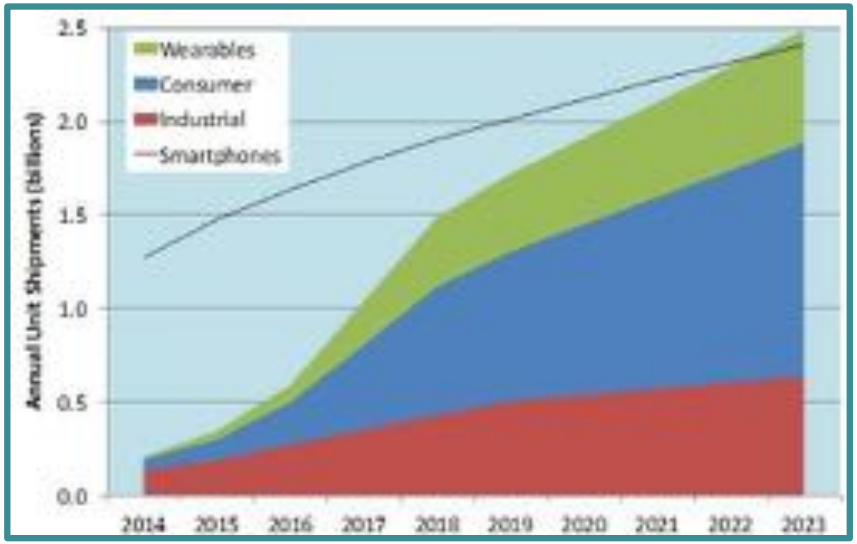

CONNECTED
BASKETBALL
2:32


POUND IT THROUGH THE FLOOR!
7
DRIBBLE POWER
DRIBBLE SPEED
DRIBBLE CONTROL
Back
:13
Time Left
Dribble Power
Ball Control (%)
25
dribbles

IoT & PHYSICAL WORLD



One of the most promising market is IoT!

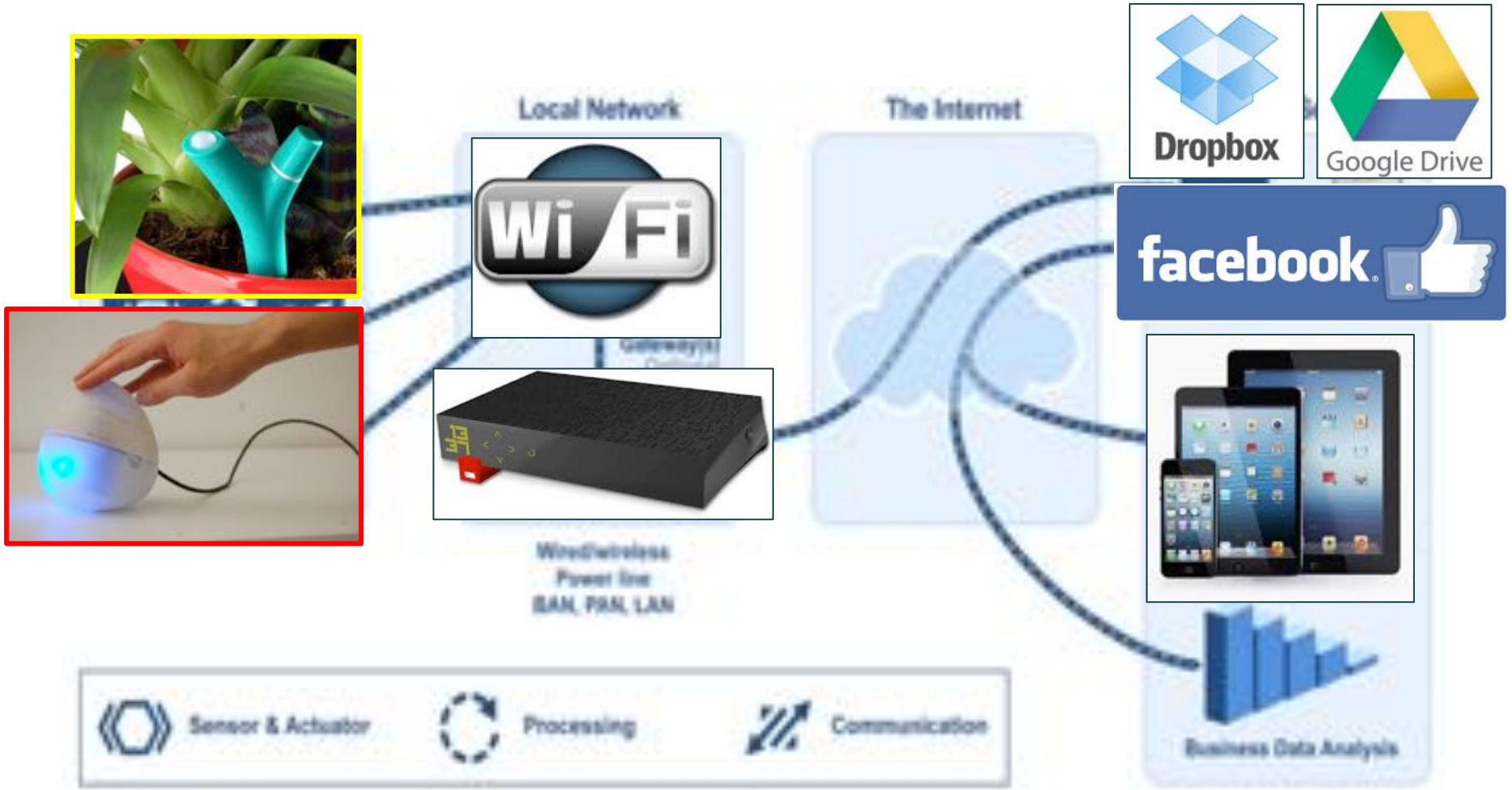


IoT = Data

Lot's of data !

Local interaction is possible

General public IoT architecture



Pictures from ArchitectCorner

Dedicated IoT cloud

Firebase

FIWARE

Axēda®

ioBridge®
Connect things.

ThingSpeak

GroveStreams

SensorCloud™

freeboard

dweet.io

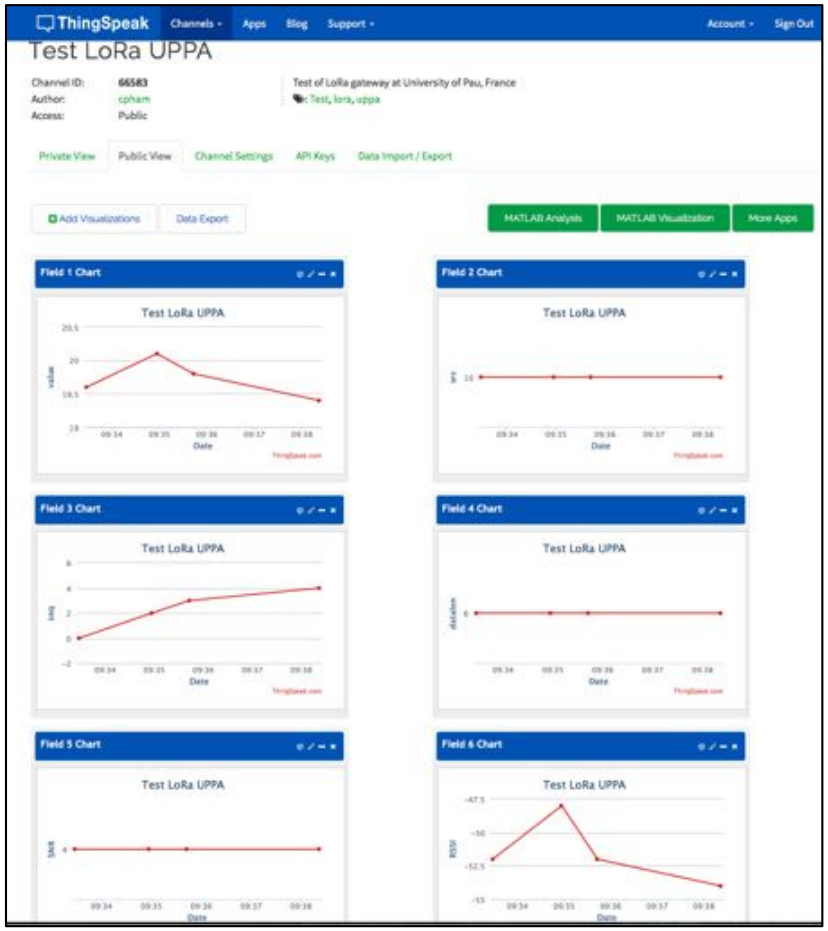
OpenRemote

TempoIQ

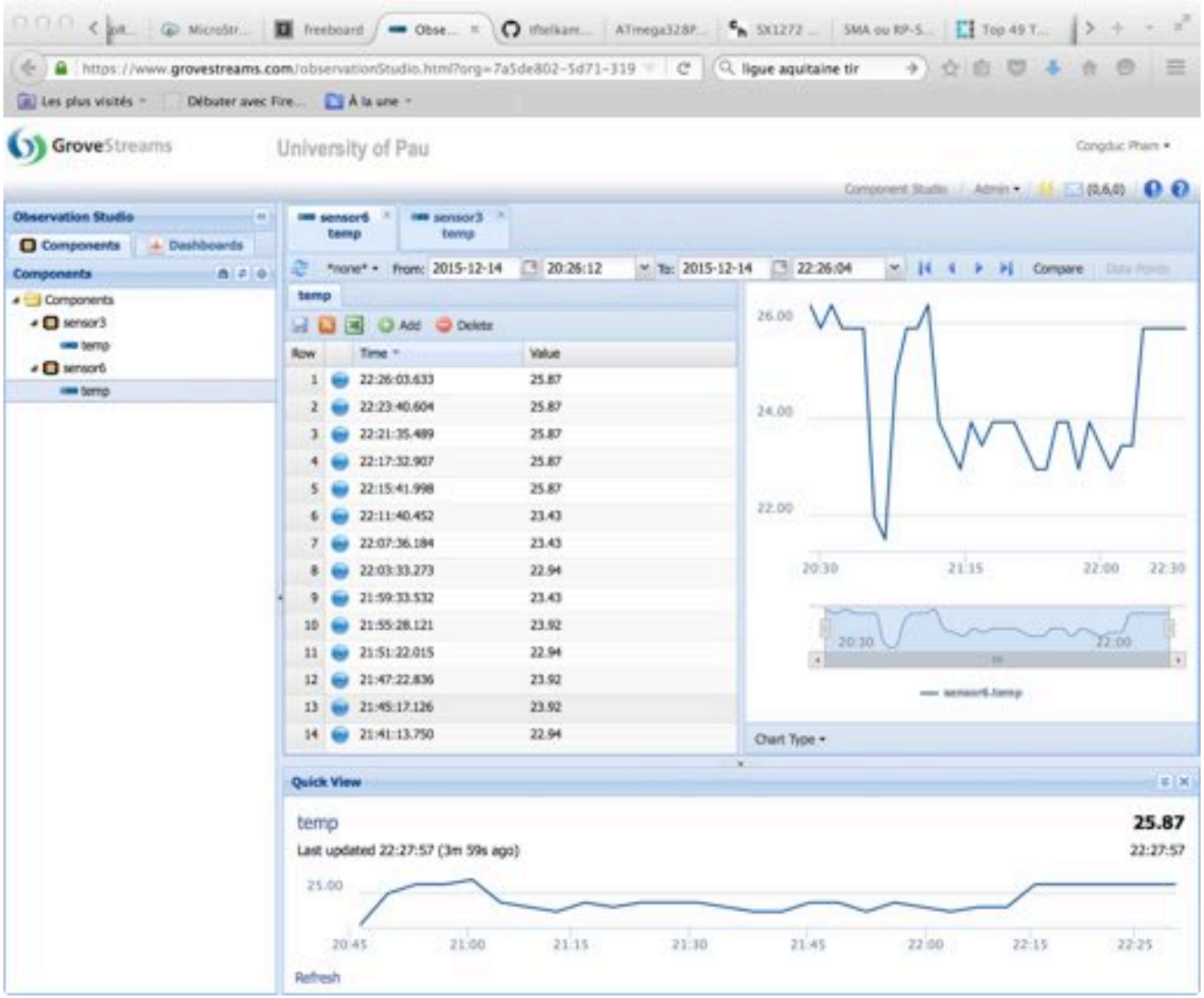
Using ThingSpeak

19.6

Node 10



Using GroveStreams



CONTROL, OPTIMIZE & INSTRUMENT !

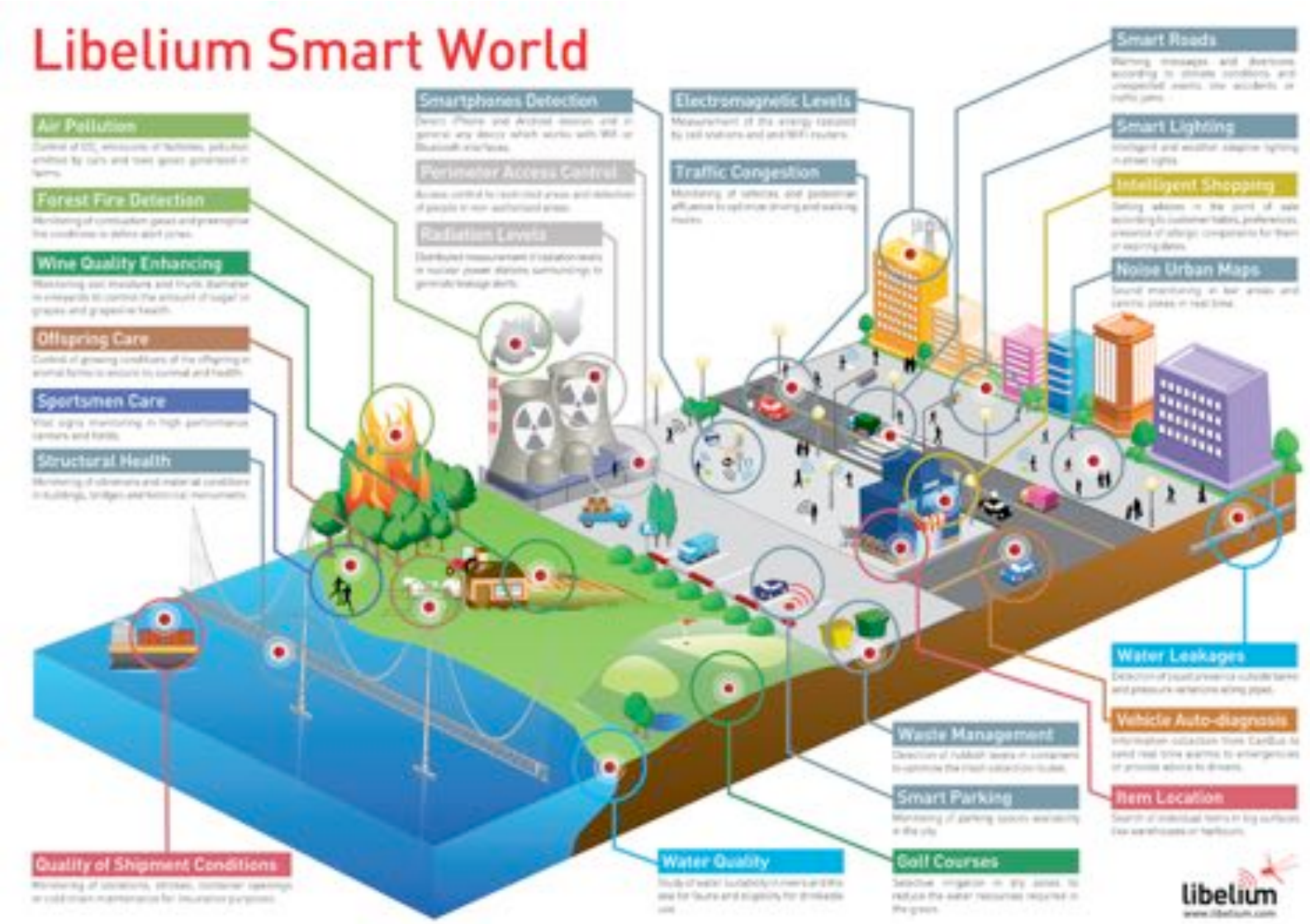
DATA ANALYSIS, OPTIMIZATION & CONTROL

PERVASIVE SYSTEMS

SENSING

PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

Example: Smart Cities



http://www.libelium.com/top_50_iot_sensor_applications_ranking/#show_infographic

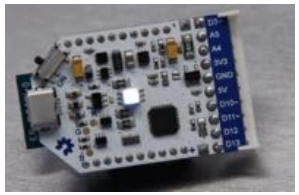
SmartSantander

www.smartsantander.eu

Pictures are taken in the context of the EAR-IT project

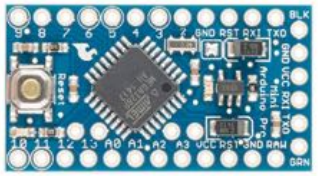
1ST ISSUE: IOT ARE SMALL DEVICES

- ANSWER: Smaller and more powerfull boards are now available!



Theairboard

LoPy



Arduino Pro Mini

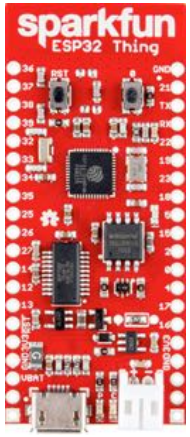
Expressif ESP32

STM32 Nucleo-32

LinkIt
Smart7688 duo

Teensy 3.2

Adafruit Feather



Sparkfun ESP32 Thing

Tessel

SodaqOnev2

Tinyduino

2ND ISSUE: COLLECT DATA

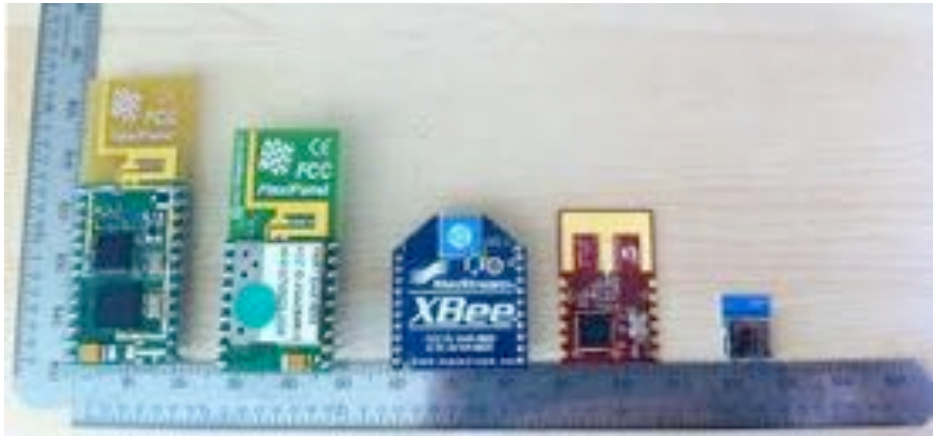
DATA ANALYSIS, OPTIMIZATION & CONTROL

PERVASIVE SYSTEMS

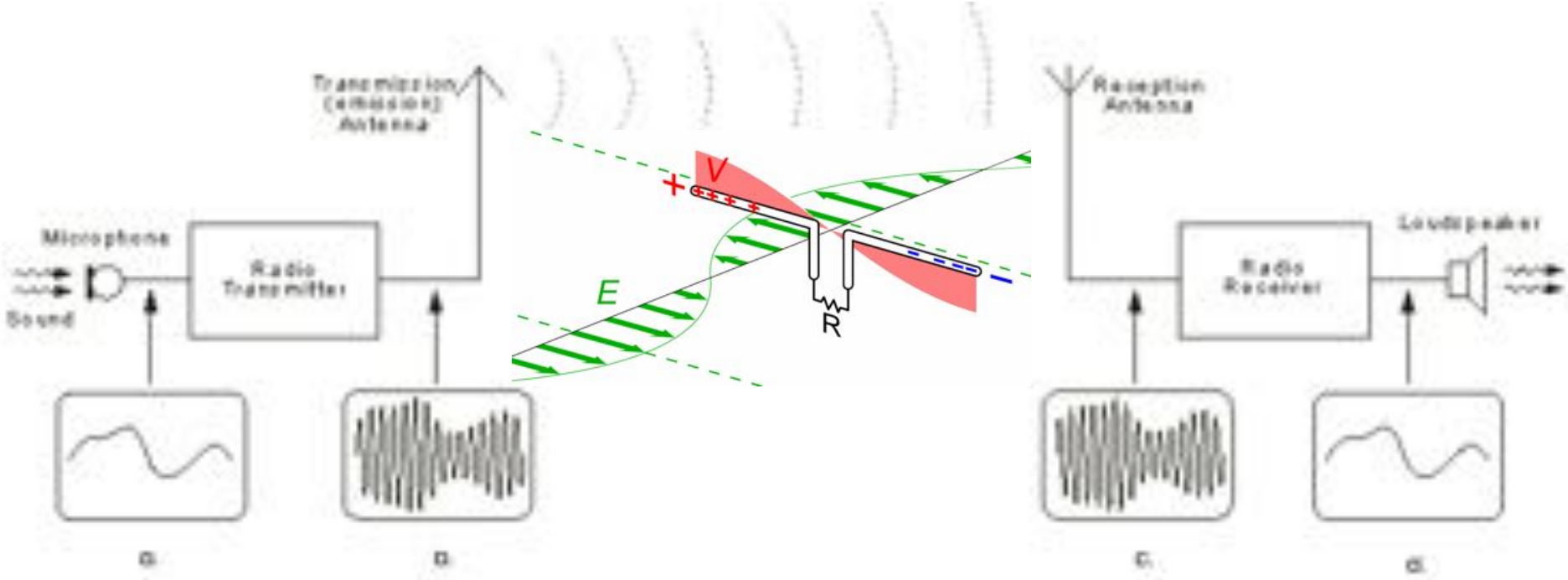
SENSING

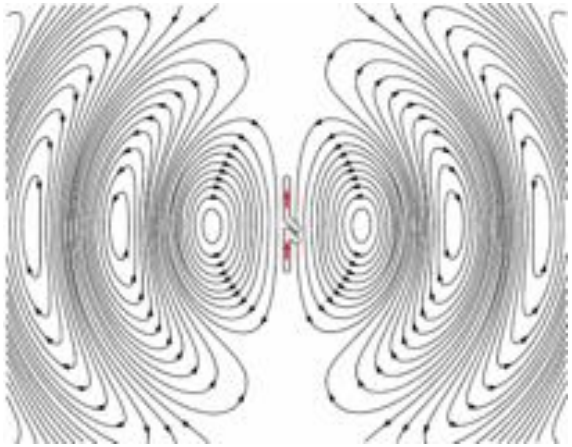
PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

Wireless Communication made easy



Wireless transmission basics

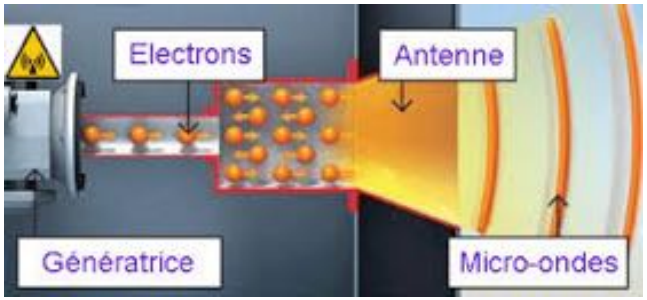




Frequency bands

Frequency Band		Frequency	Frequency Band Use
Radio and Broadcast		600 kHz to 1.6 MHz	AM radio
		88 to 108 MHz	FM radio
		54 to 700 MHz	TV broadcast
Microwave	L band	1 to 2 GHz	Cell phones 0.9-2.4 GHz Microwave 2.4 GHz Wireless Data 2.4 GHz Radar 1-100 GHz
	S band	2 to 4 GHz	
	C band	4 to 8 GHz	
	X band	8 to 12 GHz	
	K_u band	12 to 18 GHz	
	K band	18 to 26.5 GHz	
	K_a band	26.5 to 40 GHz	
	Q band	30 to 50 GHz	
	U band	40 to 60 GHz	
	V band	50 to 75 GHz	
	E band	60 to 90 GHz	
	W band	75 to 110 GHz	
	F band	90 to 140 GHz	
	D band	110 to 170 GHz	
Terahertz		1 to 10 THz	Bio-imaging
Infrared		300 to 400 THz	Remotes, night vision
Visible Light		400 to 800 THz	
Ultraviolet		800 THz to 30 PHz	Dental curing, tanning
X-ray		30 PHz to 30 EHz	Baggage screening
Gamma		> 30 EHz	PET imaging

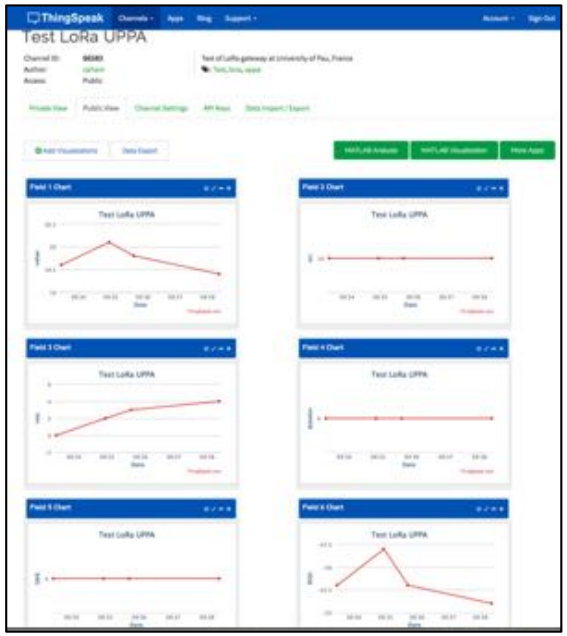
Table 1: Chart of the electromagnetic spectrum.
Source: Southeastern Universities Research Assn. and the Radio Society of Great Britain



Example & demo

- ESP8266 (WiFi) and DHT22 sensor (temp, hum)

ThingSpeak



IoT=DEVELOPMENT OPPORTUNITIES

Irrigation

Livestock farming

Fish farming & aquaculture

Storage & logistic

Agriculture

Fresh water

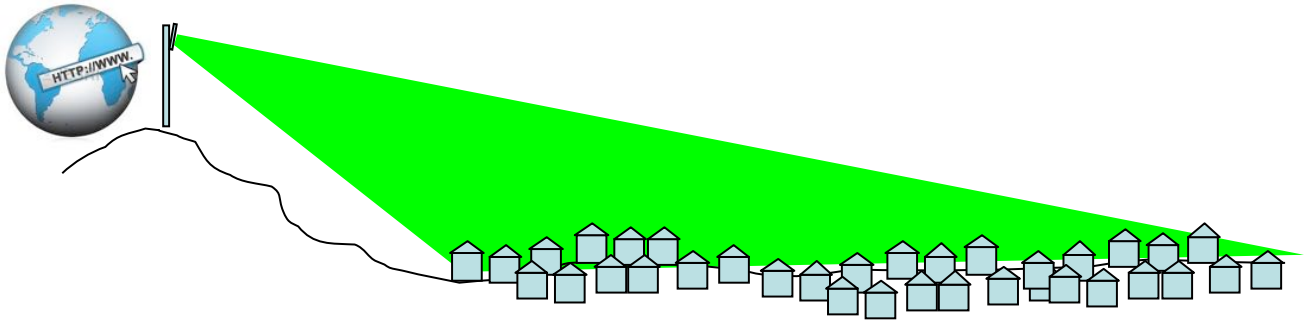
IoT=WIRELESS+BATTERY

Telemetry and Transmission cost

Moisture/
Temperature of
storage areas

10-15kms

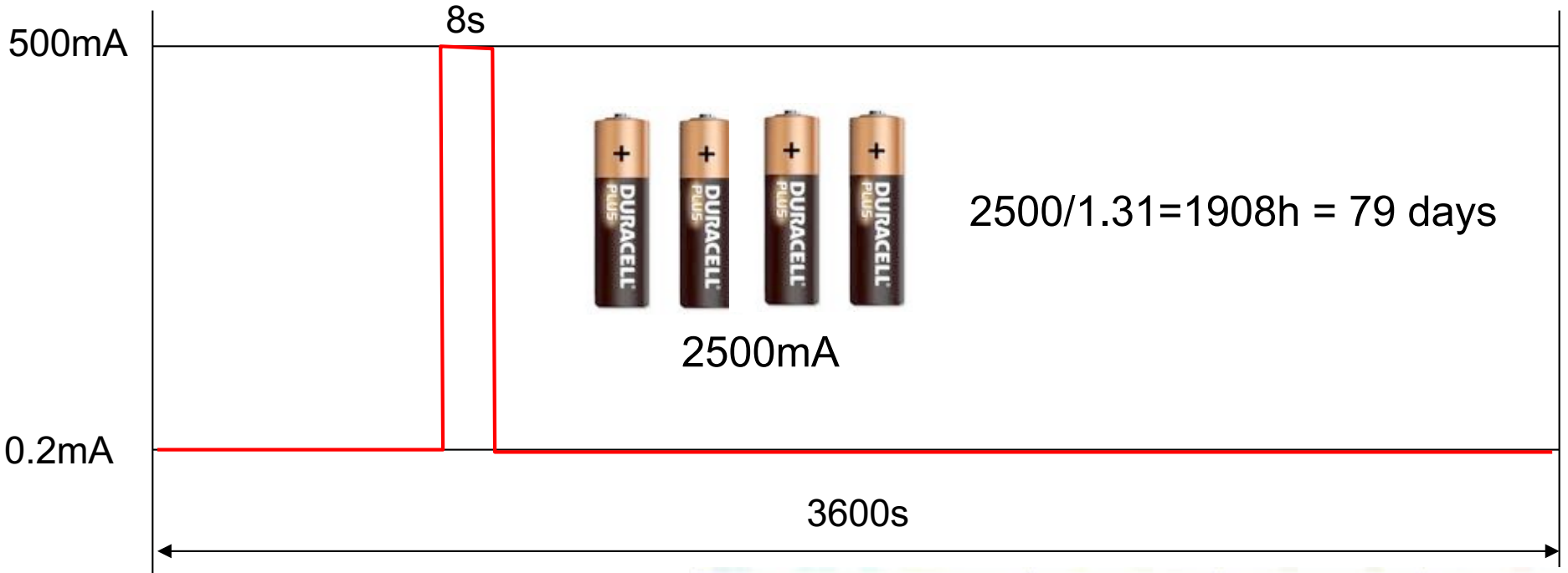
GSM GPRS



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

Energy consideration

TX power: 500mA. Mean consumption: (8x500+3592x0.2)/3600=1.31mA



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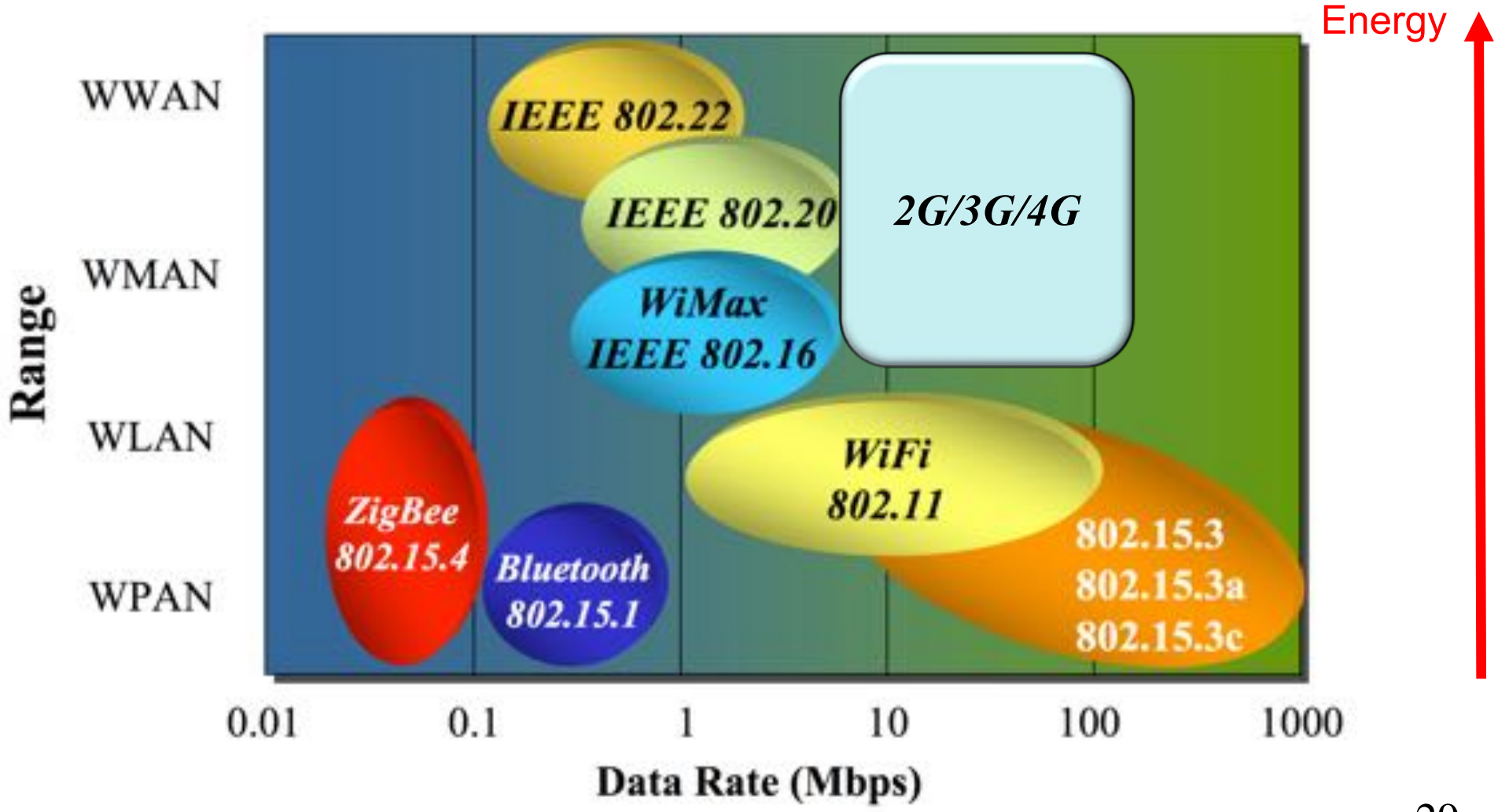
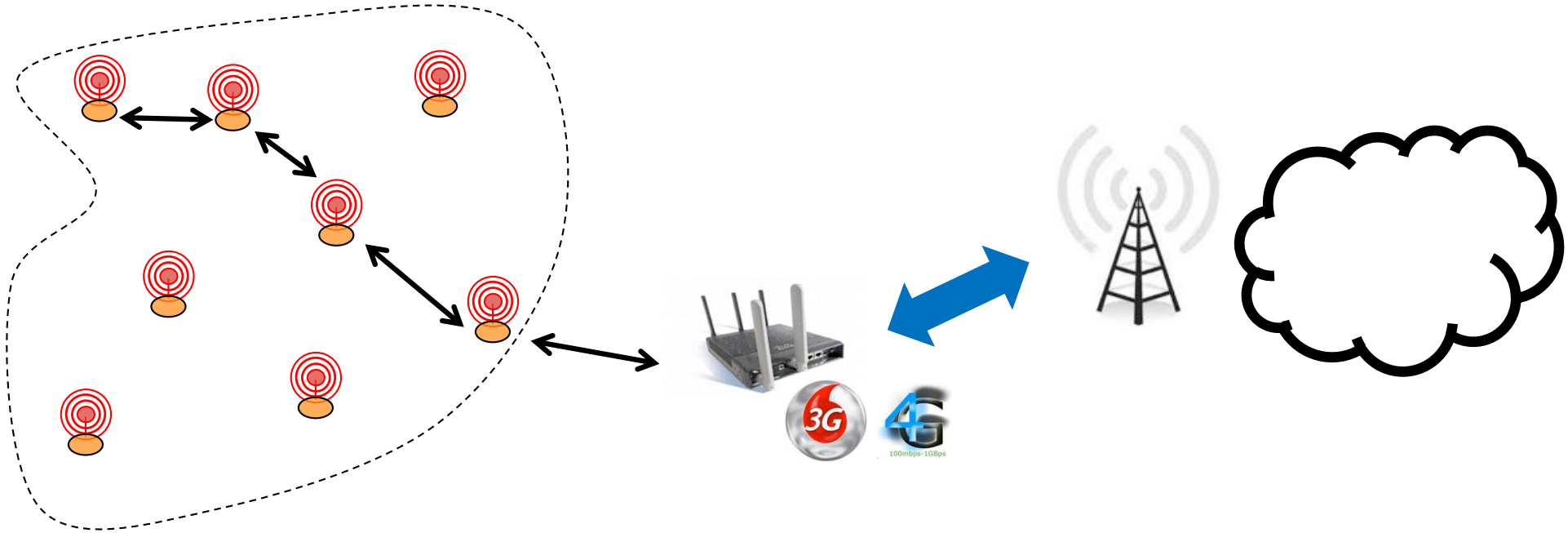
The wireless space

Energy-Range dilemma



Lower energy means shorter range!

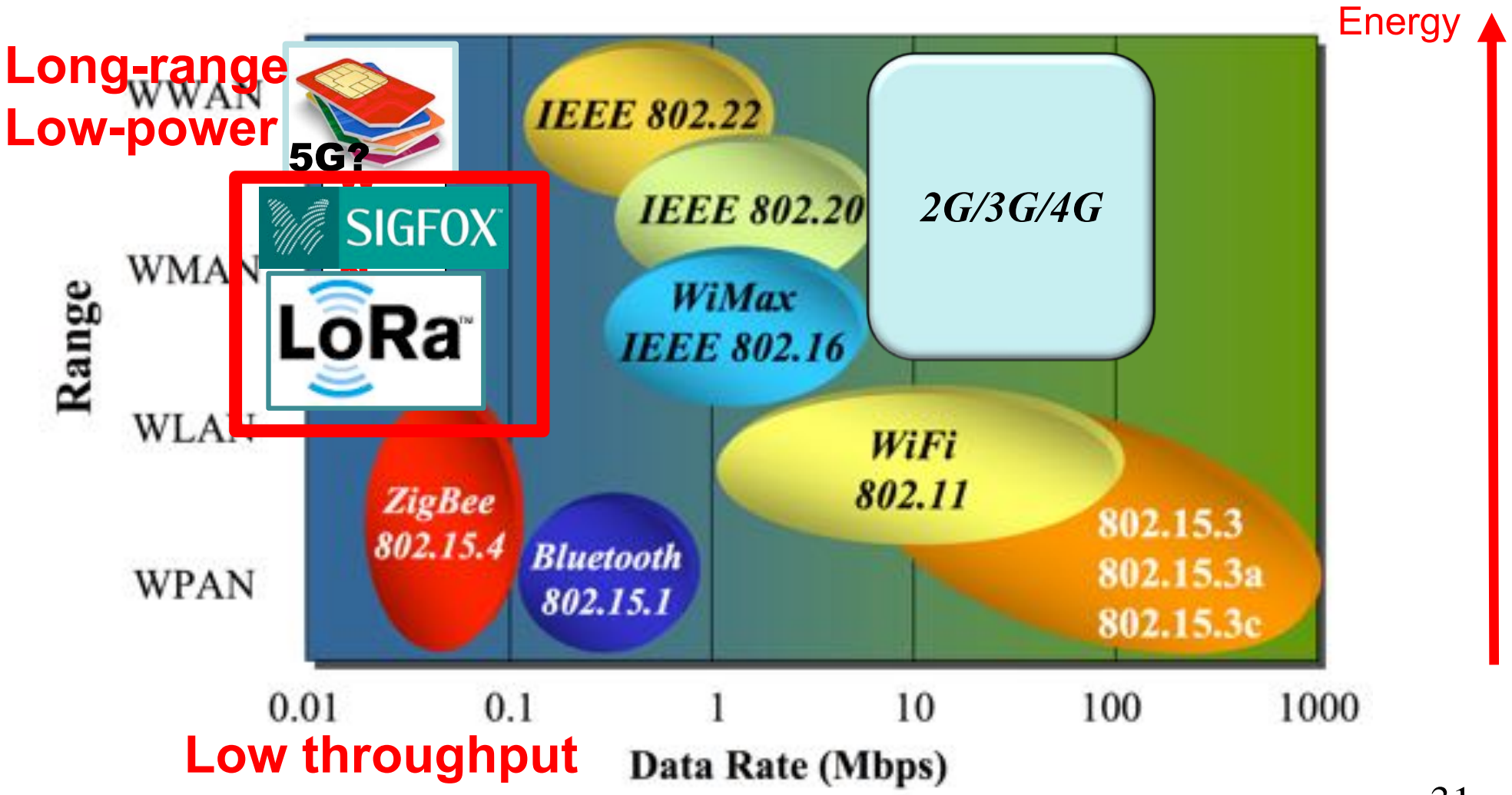


How bad is multi-hop routing?

- Increases packet loss rate
- Increases end-to-end delivery time
- Consumes more energy as intermediate nodes must relay packets
- Limits energy saving mechanism benefits as both sender and intermediate node must be somehow synchronized
- Is impacted by intermediate node failure

LOW-POWER & LONG-RANGE RADIO TECHNOLOGIES

Energy-Range dilemma



LINK BUDGET OF LPWAN

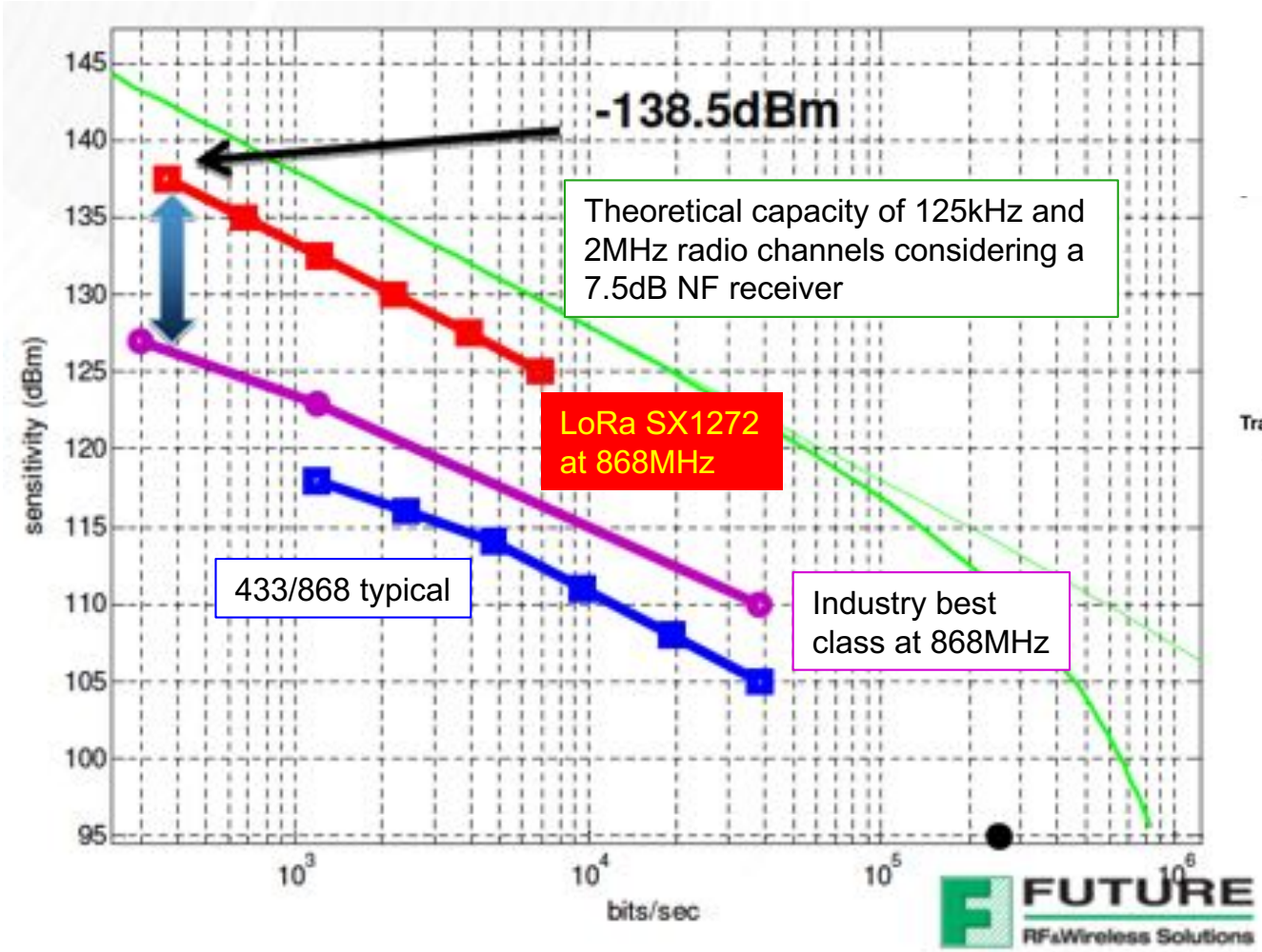
$$P_{RX} = P_{TX} + G_{TX} - L_{TX} -$$

KEY PRODUCT FEATURES

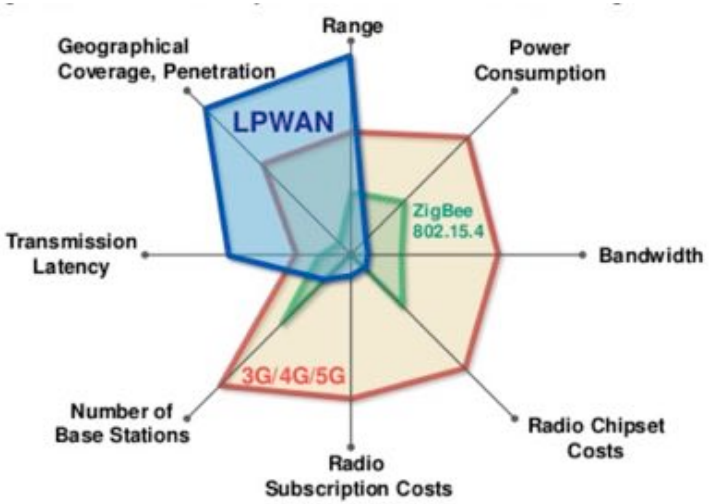
- LoRa™ Modem
- 157 dB maximum link budget
- +20 dBm at 100 mW constant RF output vs. V supply
- +14 dBm high efficiency PA
- Programmable bit rate up to 300 kbps
- High sensitivity: down to -137 dBm

From Peter R. Egli, INDIGOO.COM

The long-range revolution



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



From Peter R. Egli, INDIGOO.COM

The lower the receiver sensitivity, the longer is the range!

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-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)

TX power: 30mA. Mean consumption: (8x30+3592x0.2)/3600=0.266mA

2500/0.266=9398h = 391 days = 13 months

3RD ISSUE: FINDING THE INFORMATION YOU NEED

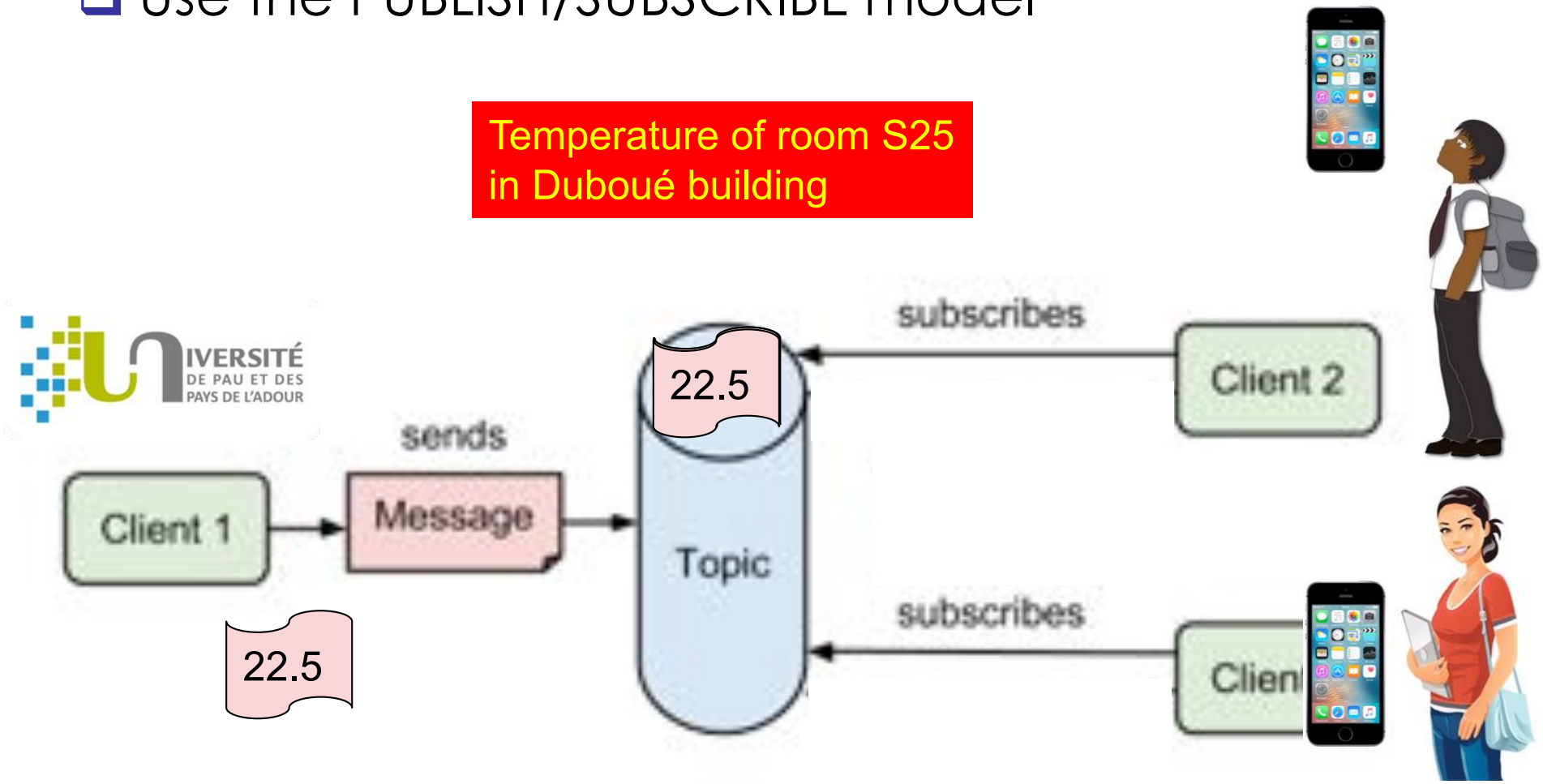
- Searching for information is a tough issue
  - Web search engine: Google,…
- Many IoT clouds uses HTTP request (GET, POST, PUT, …) to push/store data to web platforms/servers

ThingSpeak

- If you need an information, for instance the temperature in room S25 of Duboué building in UPPA, then you have to go to the right web page
- When there can be millions of IoT nodes providing large variety of data, it is difficult to find your way!

From "search for info" to "get the info"

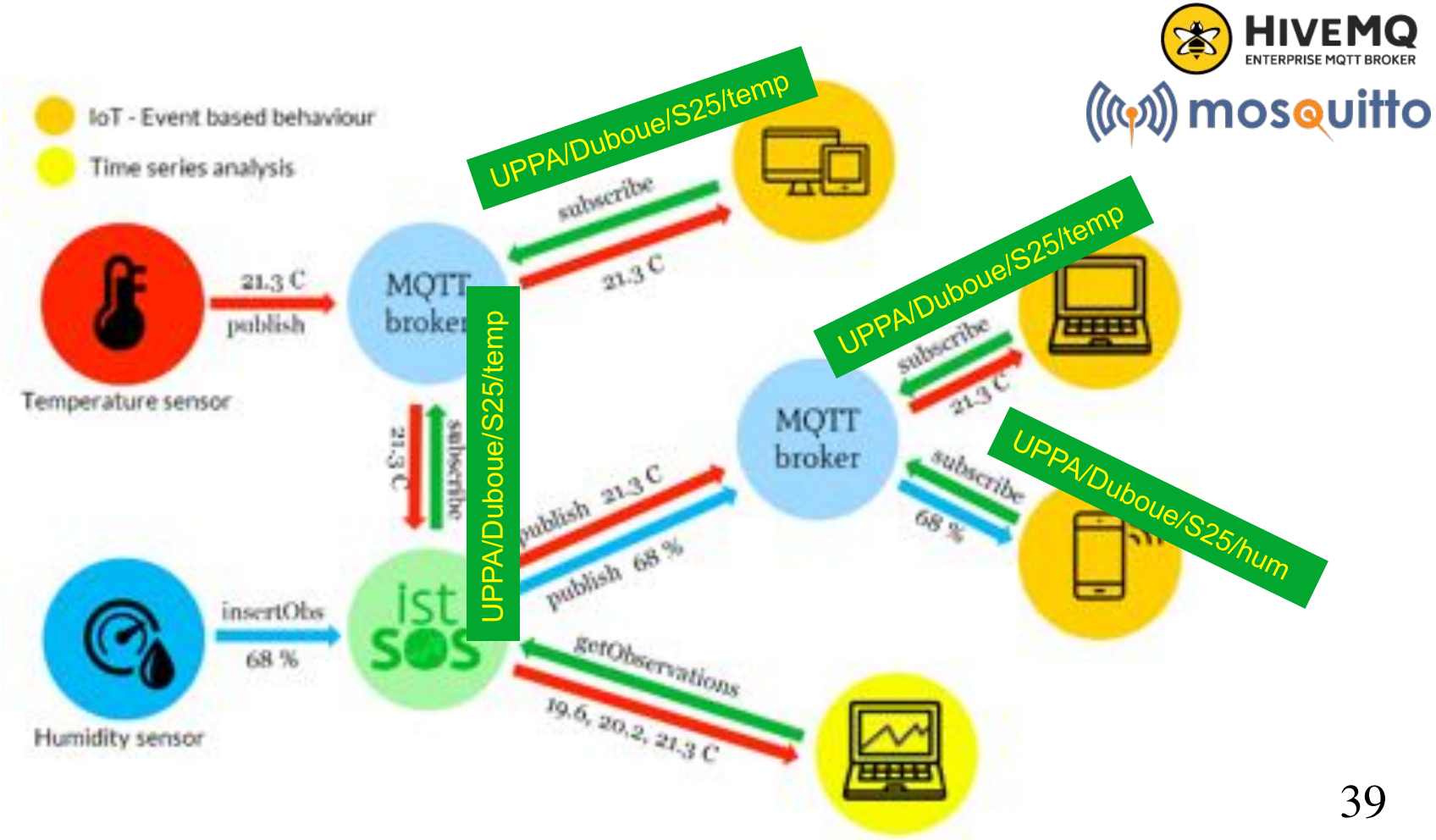
- Use the PUBLISH/SUBSCRIBE model



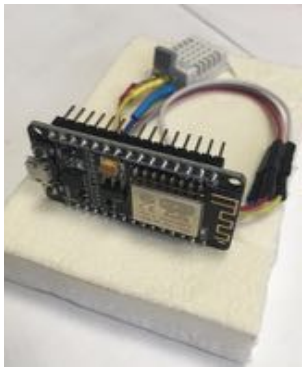
MQTT

Message Queue Telemetry Transport

- Use broker nodes to manage topics
  - UPPA/Duboue/S25/temp, UPPA/Duboue/S25/hum



4TH ISSUE: MAKE IT SIMPLER?



FIWARE

Firebase

ioBridge
Connect things.

dweet.io

TempoIQ

freeboard

ThingSpeak

GroveStreams

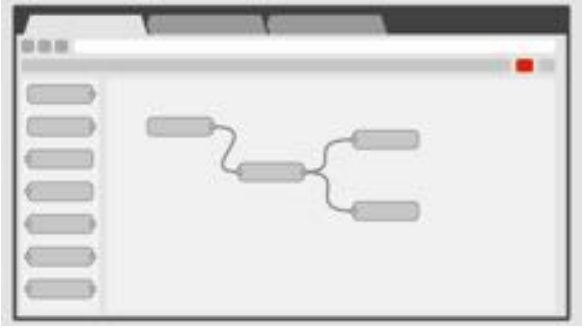
SensorCloud™

OpenRemote

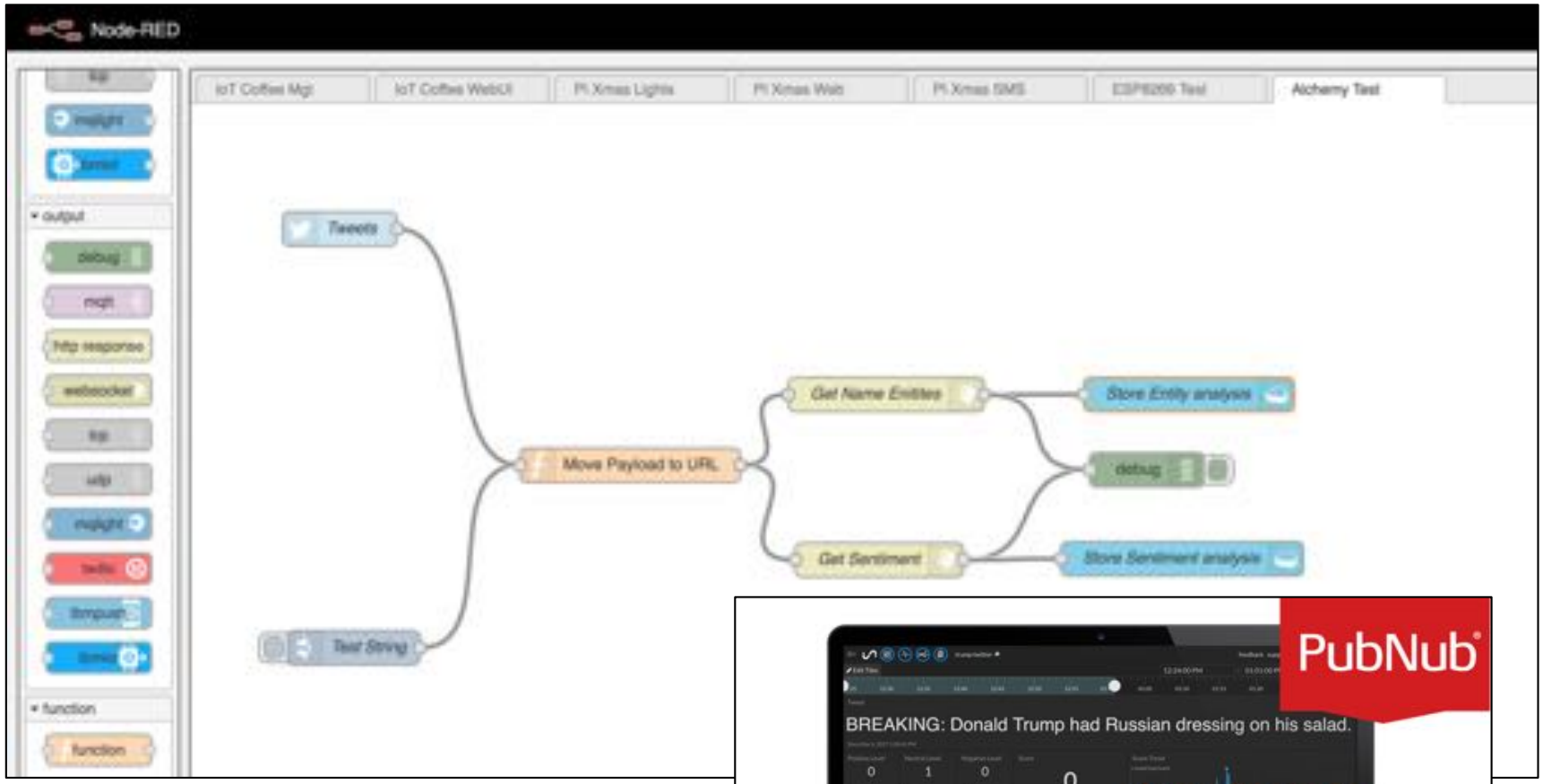
- End-users are not necessarily computer science experts nor high-skilled programmers
- Use graphical tools to build data processing flows, allowing intuivive connection from data producers to data consumers

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



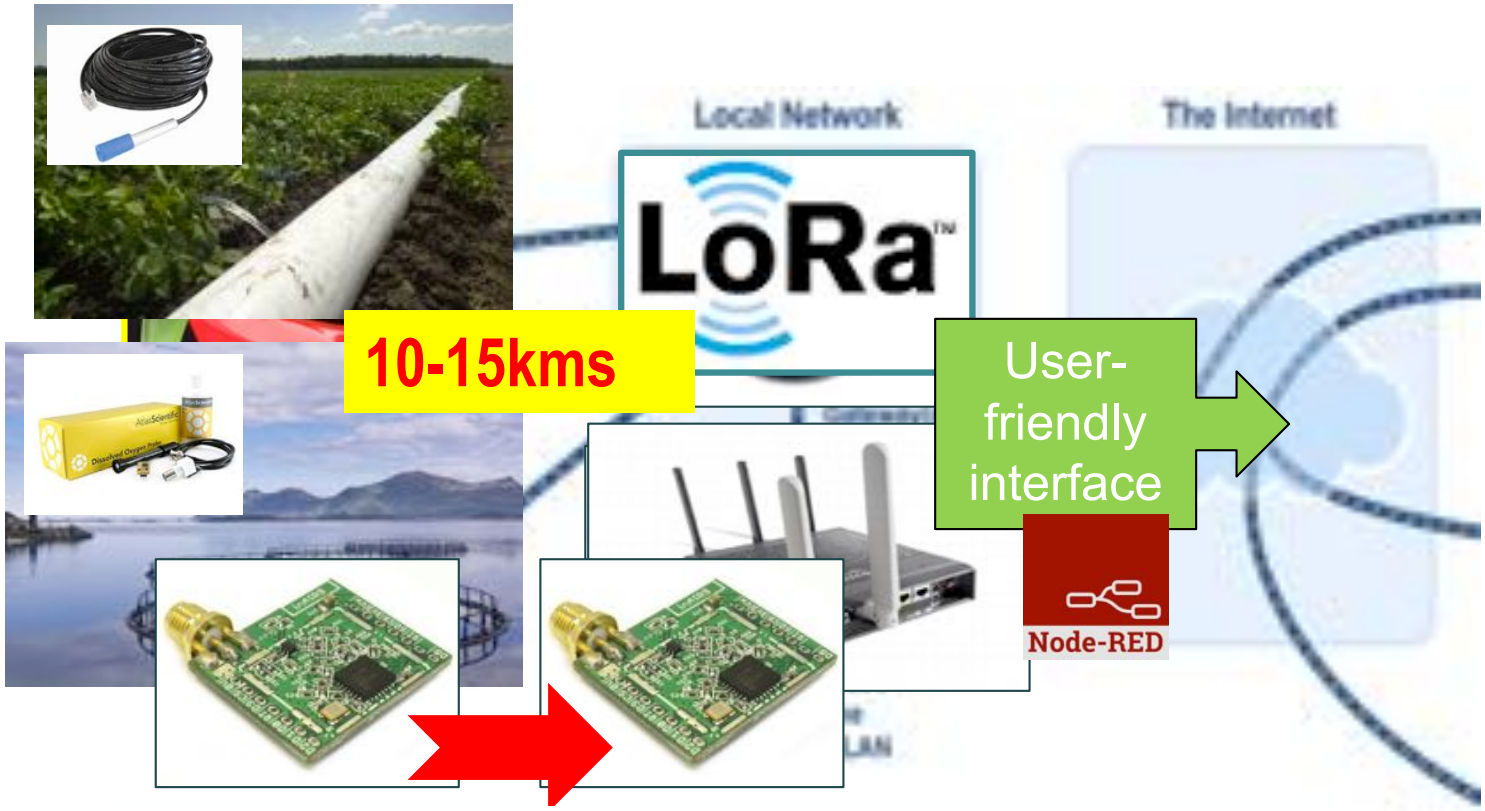
Example



From AlchemyAPI and NodeRED on Bluemix

From PubNub Live Twitter Dashboard (feat. President Trump)

Global picture of long-range IoT ecosystem



FIWARE
dweet.io
ioBridge
Connect things.
freeboard
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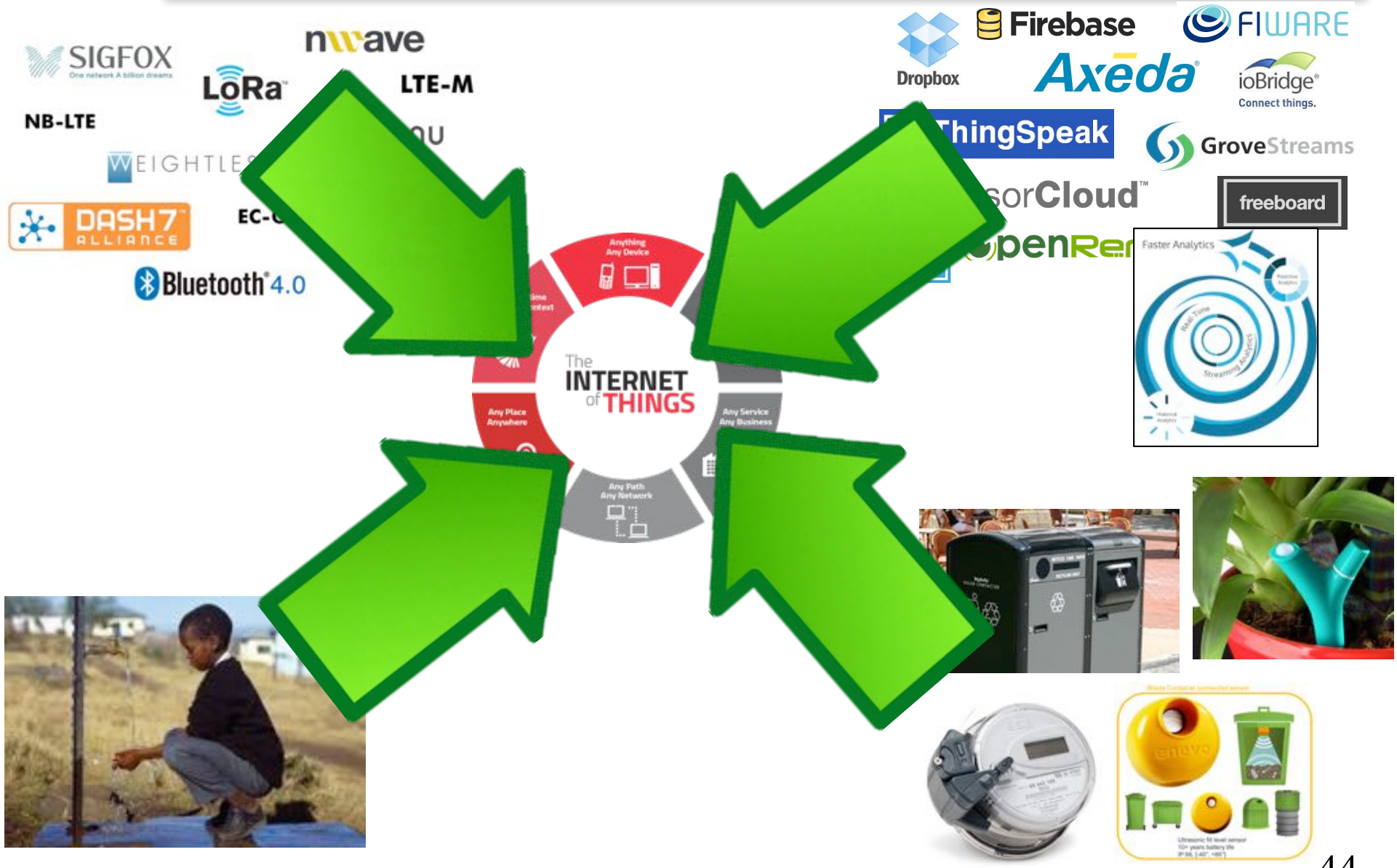
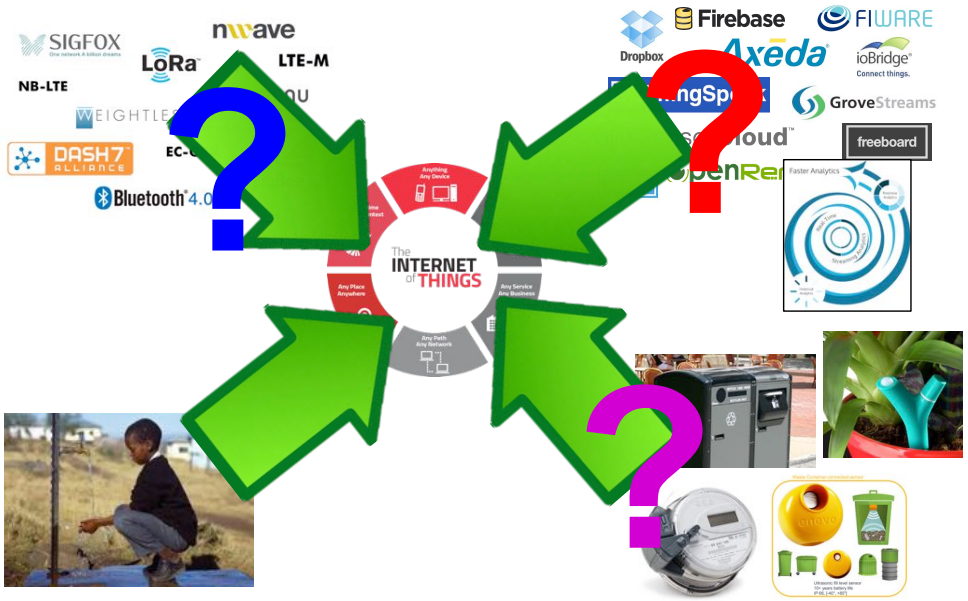
IoT becomes reality!



A REALITY FOR EVERYBODY?

IoT for All?

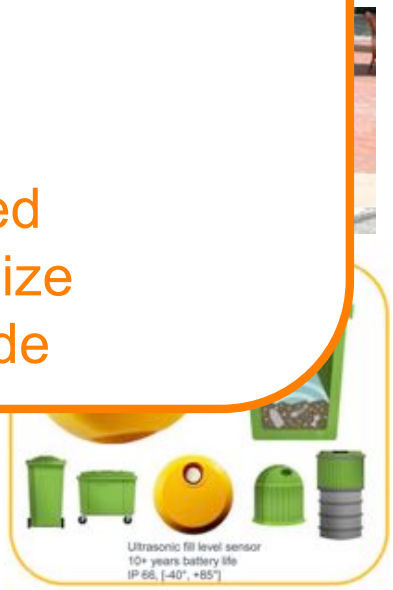
- Many areas and countries are still far from being ready to enjoy the smallest benefit of IoT
  - lack of infrastructure
  - high cost of hardware
  - complexity in deployment
  - lack of technological eco-system and background



MATURATION OF THE IoT MARKET…

… but not adapted for rural developing countries context & environment

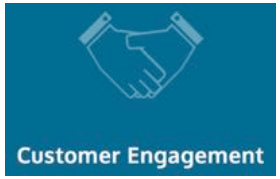
Too expensive
Too integrated
Highly specialized
Difficult to customize
Difficult to upgrade



Internet, Cloud & big data analytics

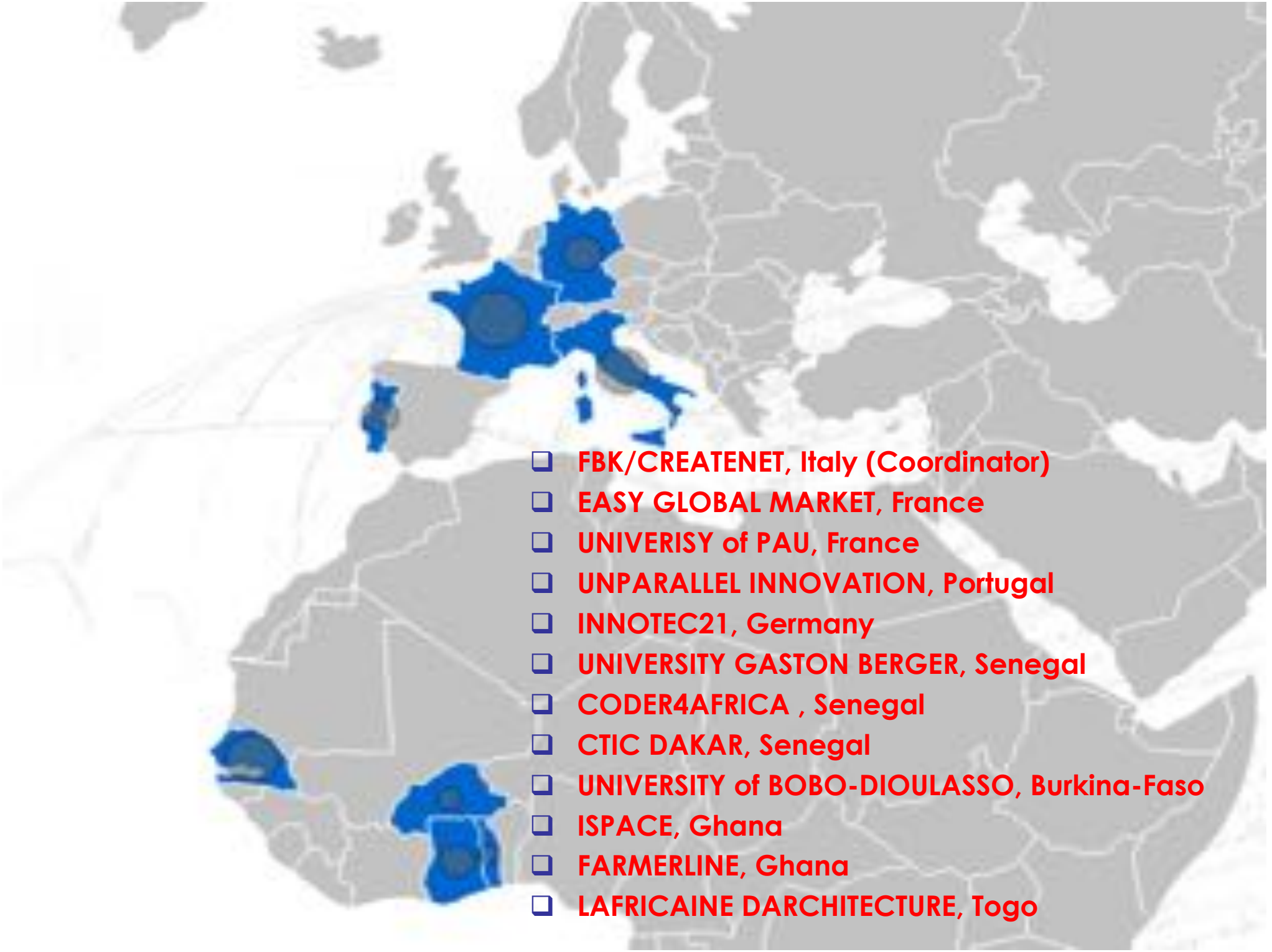
Internet connectivity is weak and expensive!

Nearly impossible in remote/rural areas



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

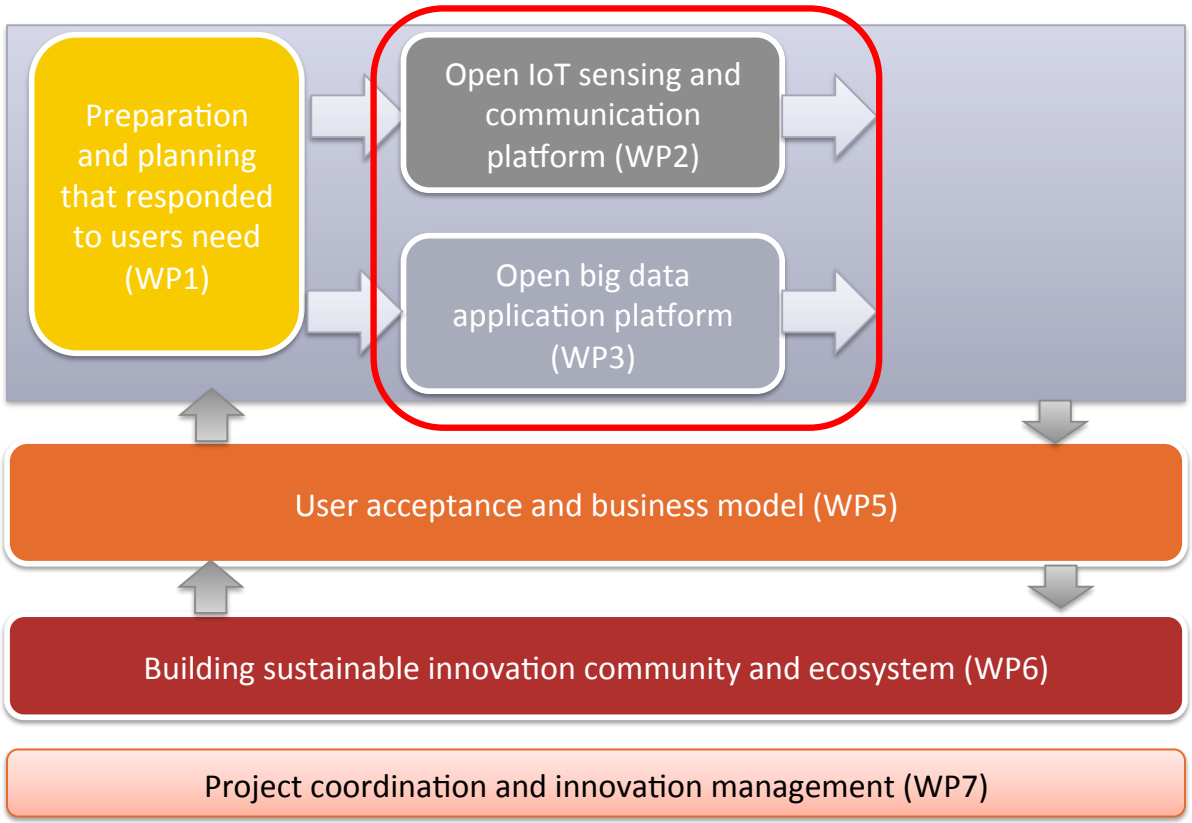
WAZIUP: LOW-COST IOT



- FBK/CREATENET, Italy (Coordinator)
- EASY GLOBAL MARKET, France
- UNIVERISY of PAU, France
- UNPARALLEL INNOVATION, Portugal
- INNOTEC21, Germany
- UNIVERSITY GASTON BERGER, Senegal
- CODER4AFRICA , Senegal
- CTIC DAKAR, Senegal
- UNIVERSITY of BOBO-DIOULASSO, Burkina-Faso
- ISPACE, Ghana
- FARMERLINE, Ghana
- LAFRICAINE DARCHITECTURE, Togo

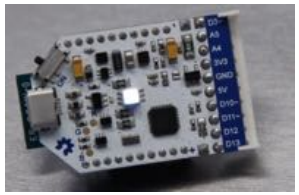
IoT FOR RURAL APPLICATIONS IN DEVELOPPING COUNTRIES

- WAZIUP is an EU H2020 project (2016-2019)
- contributes to long-range IoT & open big data with WP2 & WP3



Very low-cost devices

- Smaller and more powerfull boards are now available



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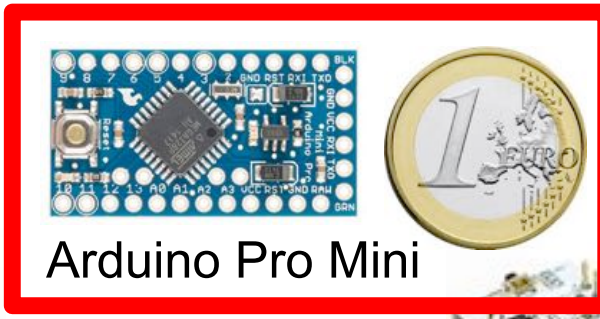

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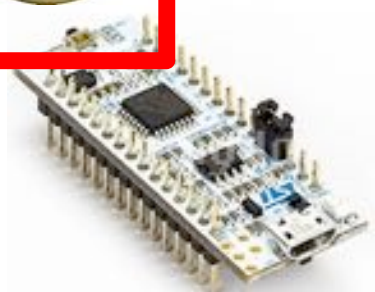

STM32 Nucleo-32

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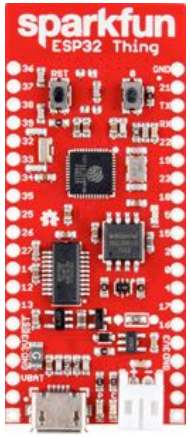

Sparkfun ESP32 Thing

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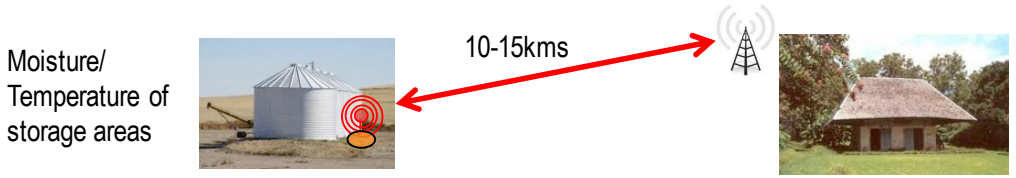
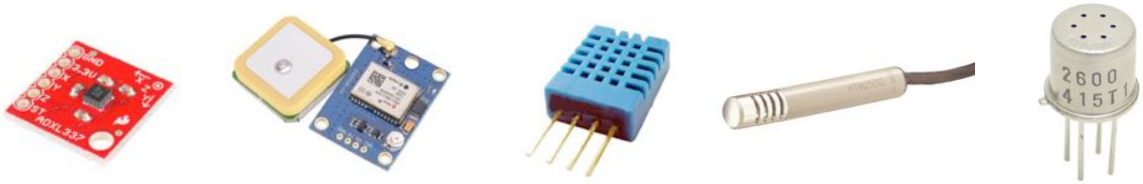
Tinyduino

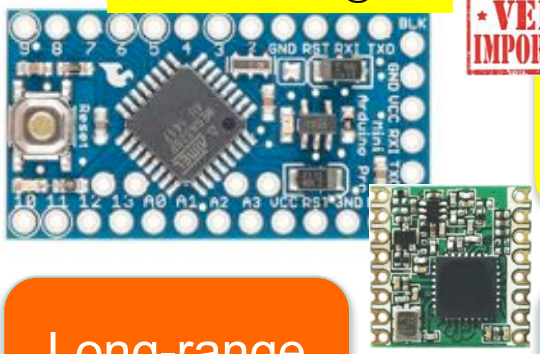
Ready-to-use templates



Physical sensor | Physical sensor | Physical sensor



Arduino Pro Mini @3.3V



Physical sensor mgmt

VERY IMPORTANT

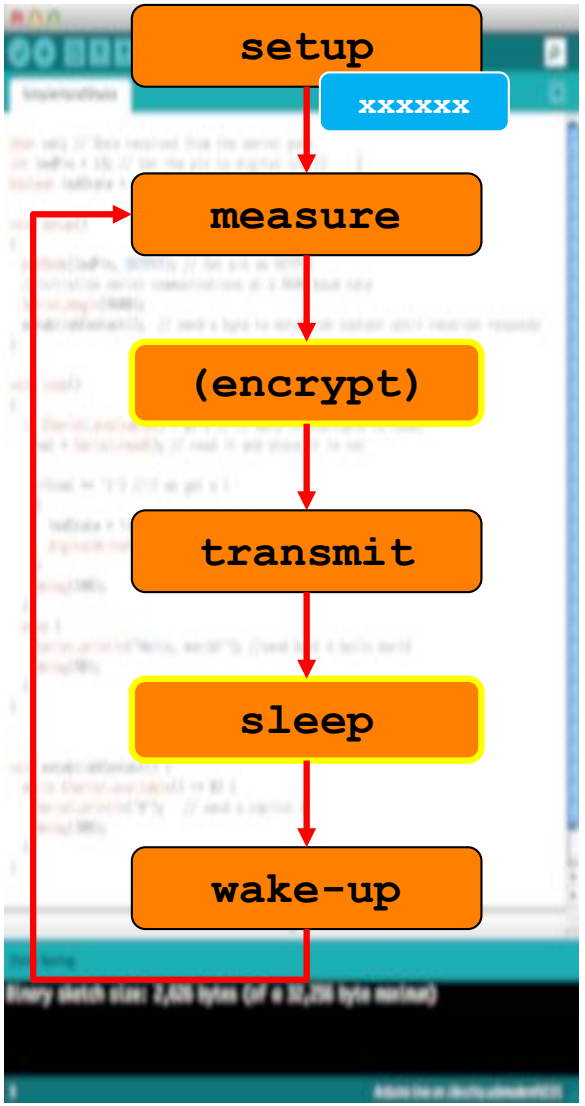
Activity duty-cycle, low power

VERY IMPORTANT

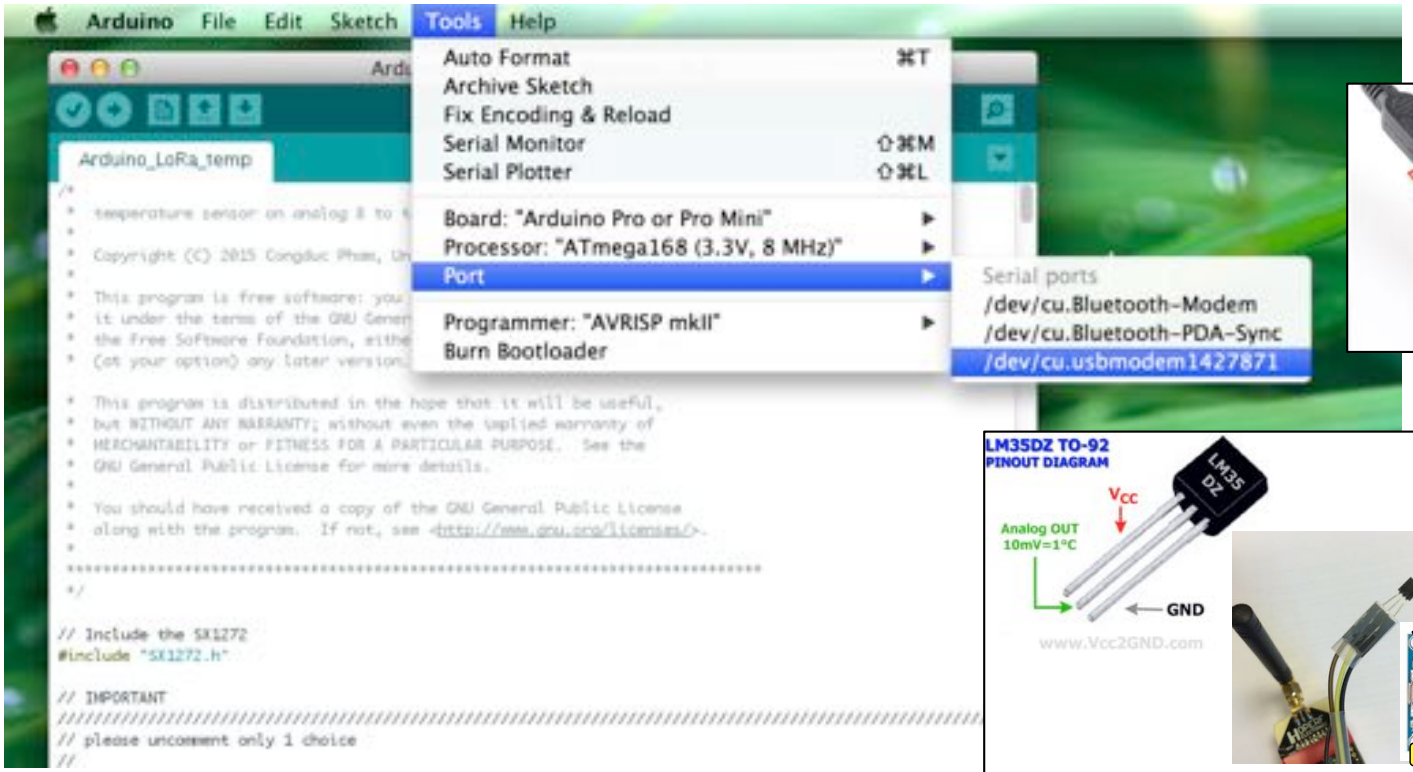
AES encryption

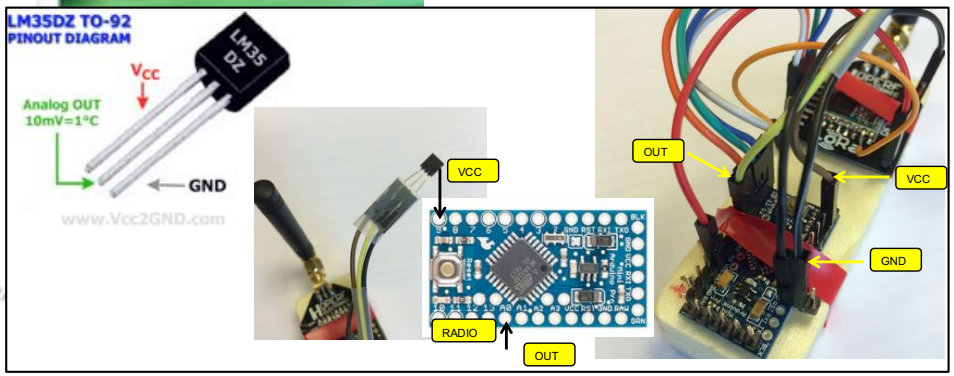
Long-range transmission

Logical sensor mgmt

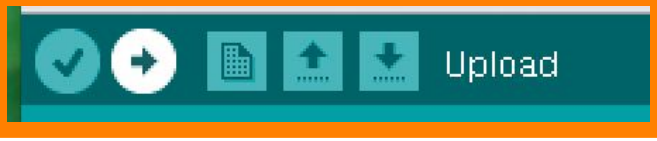


Build your first LoRa IoT device

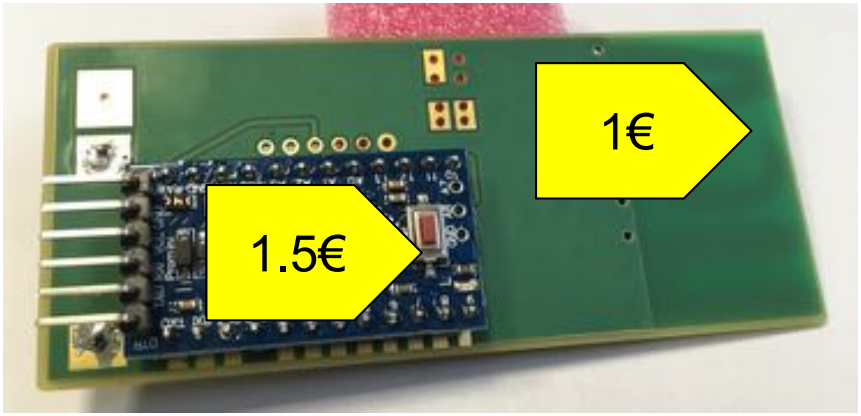




Connect the USB end to your computer and the USB port should be detected in the Arduino IDE. Select the serial port for your device. It may have another name than what is shown in the example. Then click on the « upload » button



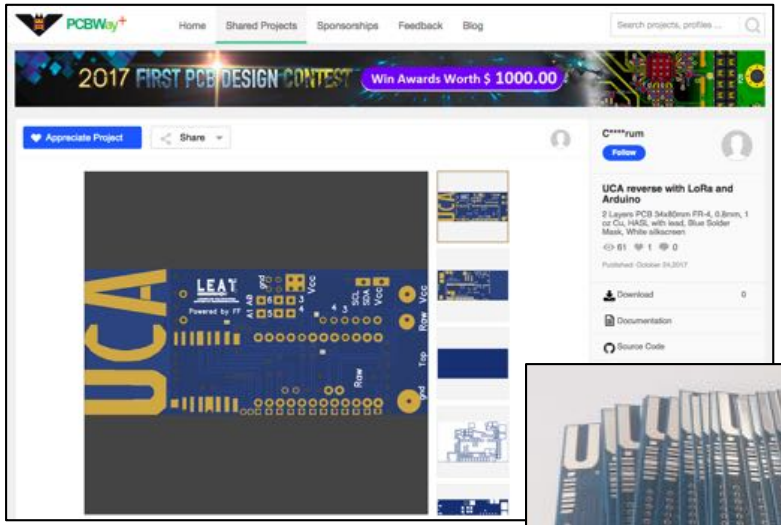
Low-cost integration



5€

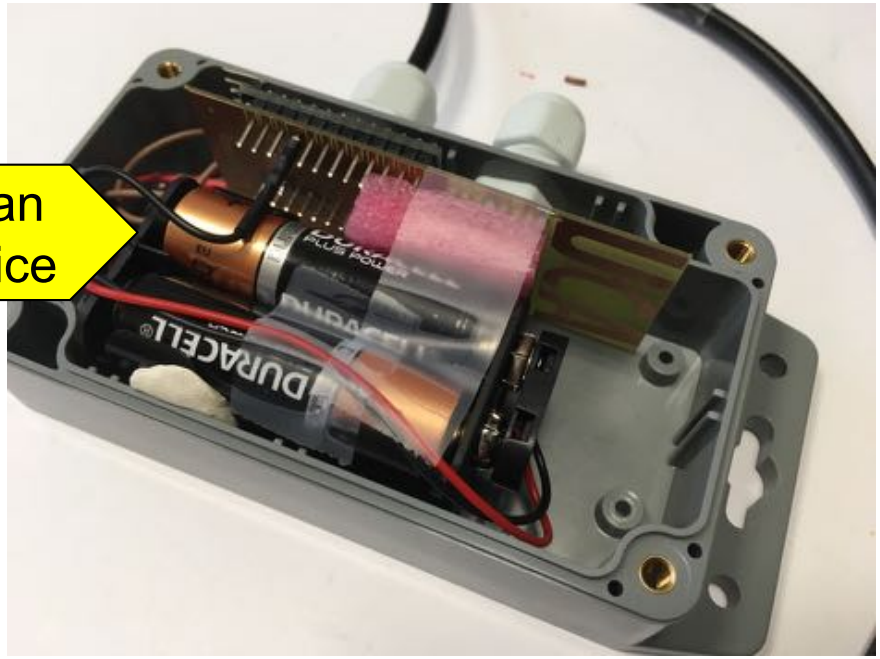
HopeRF
RFM92W/95W

https://github.com/FabienFerrero/UCA_Board

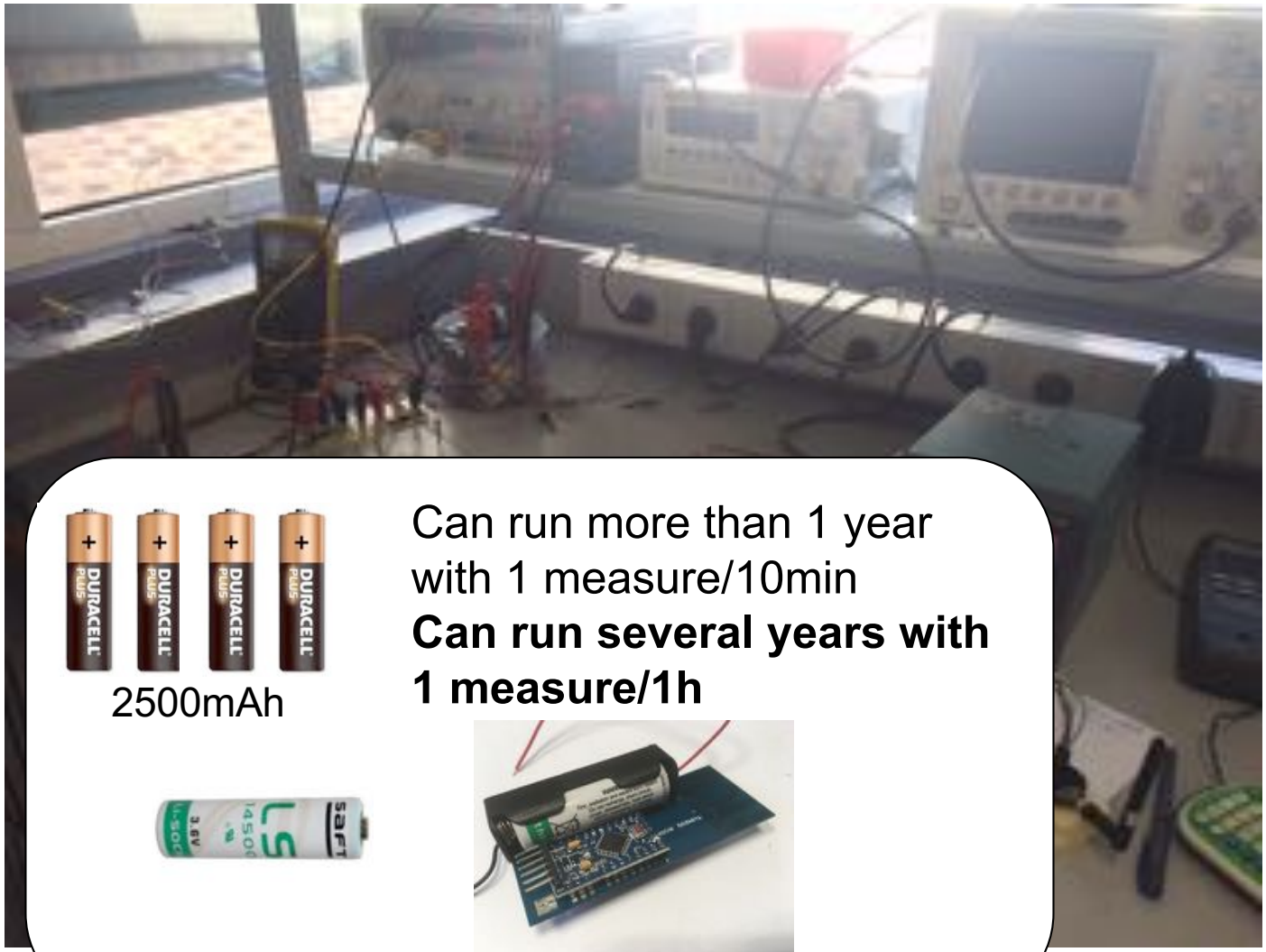


1-click order

Less than
10€/device



Low-power for longer lifetime!



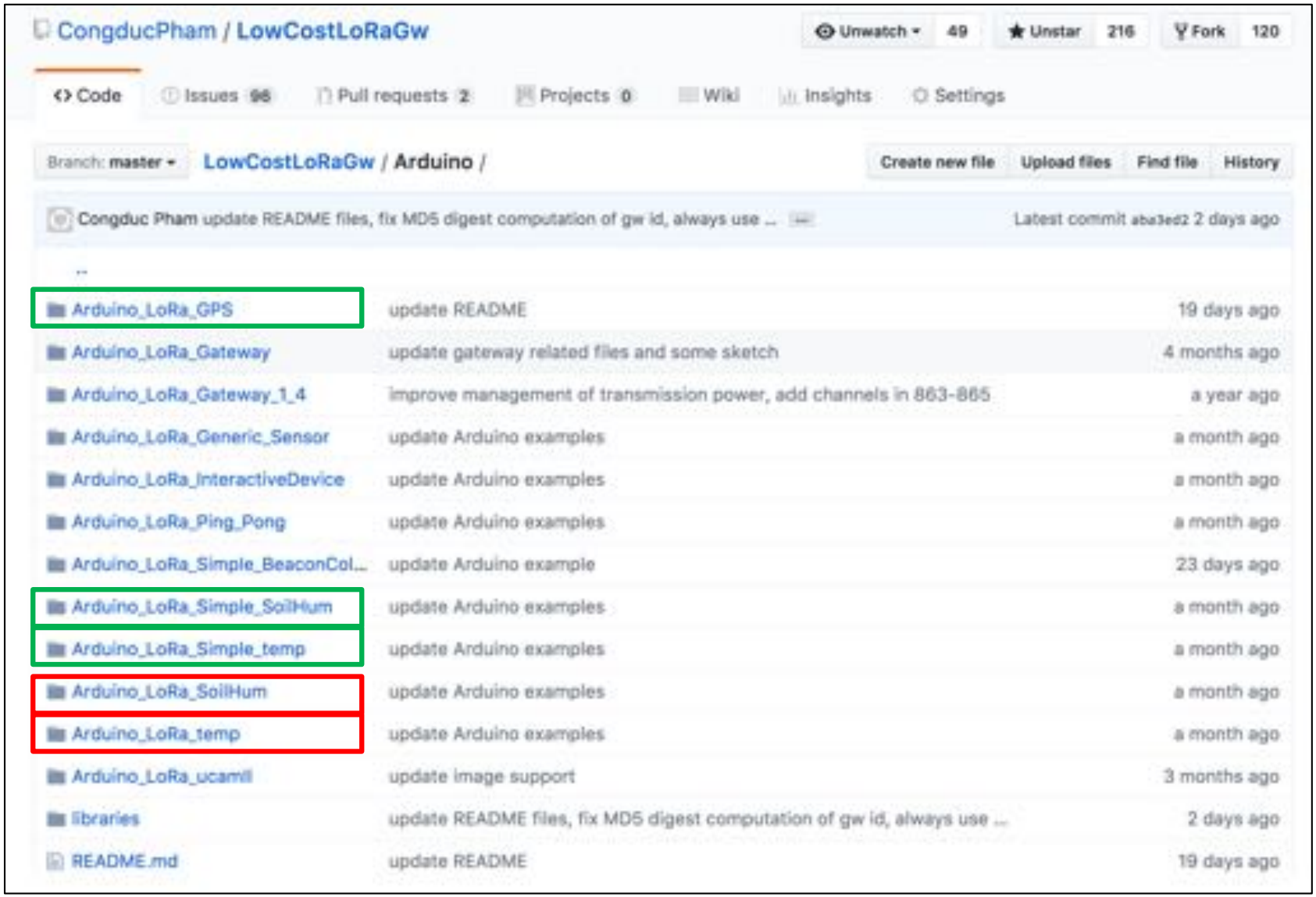
Wakes-up every 10min, take a measure (temp) and send to GW

2500mAh

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

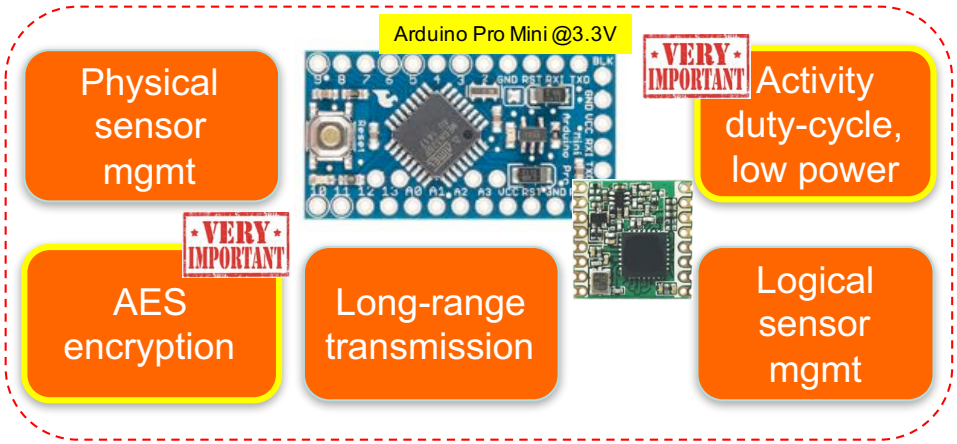
5µA in deep sleep mode, about 40mA when active and sending!

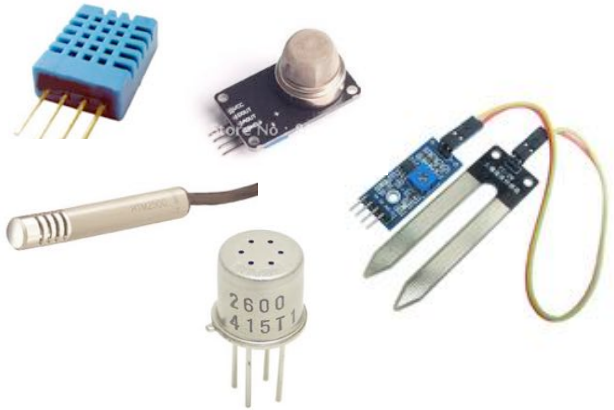
LARGE VARIETY OF EXAMPLES TO LEARN AND ADAPT



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
- Me
- Tec
  ec

Minimum Viable Product

WAZIUP PROJECT

WP1
WP2
WP3
WP4
WP5
WP6

Waziup Advisory Board

Waziup Community

Physical sensor mgmt

VERY IMPORTANT

AES encryption

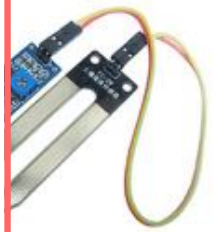
MVP 1
Water
Fish Farming

MVP 2
Cattle
Rustling

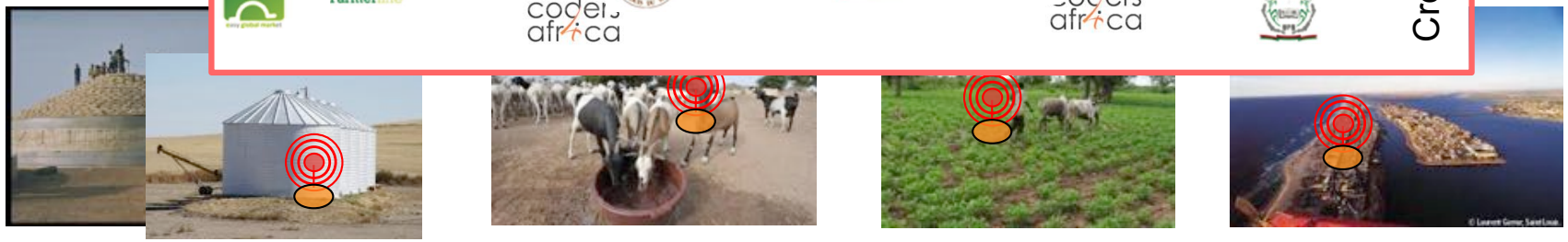
MVP 3
AGRI

MVP 4
Logistic
Transport

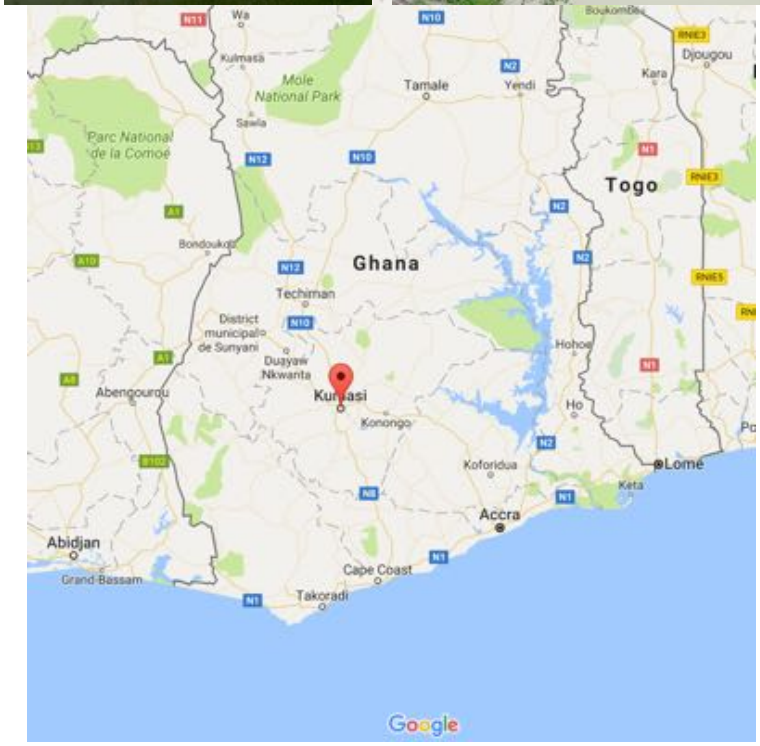
MVP 5
Urban
Waste
mgt



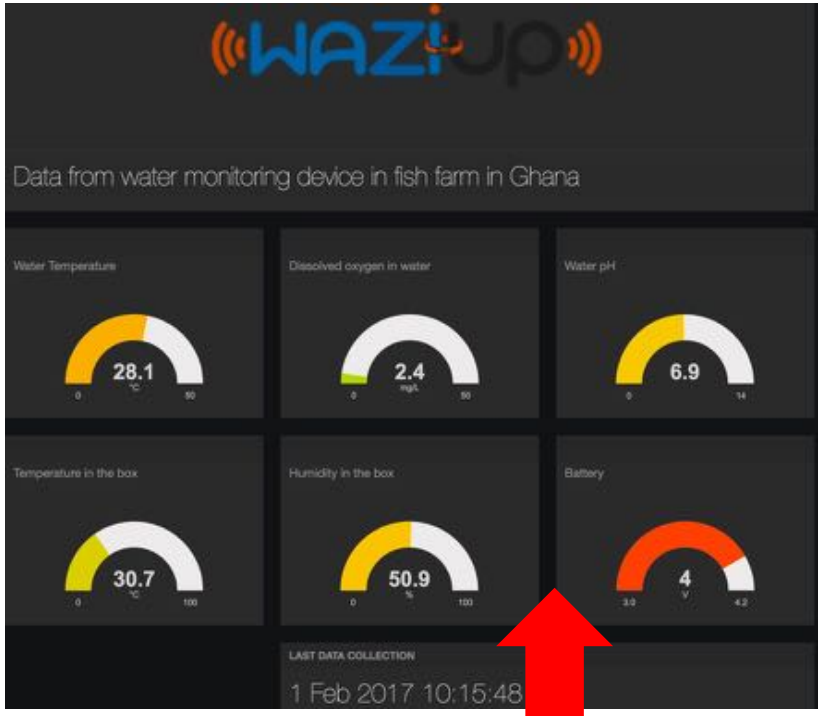
Credit: P. Cousin, EGM



Fish Farming in Kumasi, Ghana



Low-cost buoy for fish farming MVP



WAZIUP

Physical sensor reading

Credit: EGM

FIWARE

WAZIUP

Physical sensor management

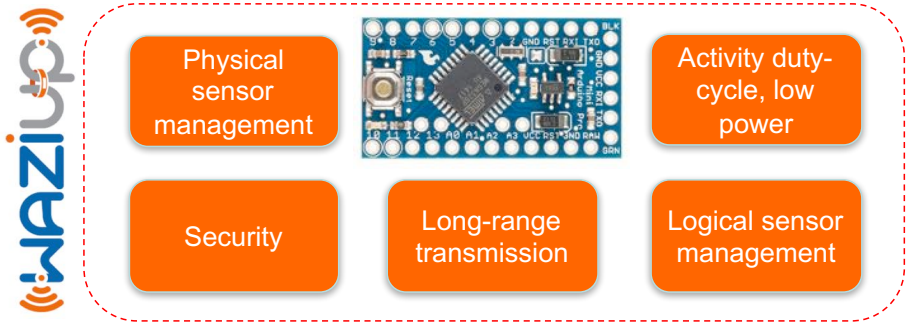
Activity duty-cycle, low power

Security

Long-range transmission

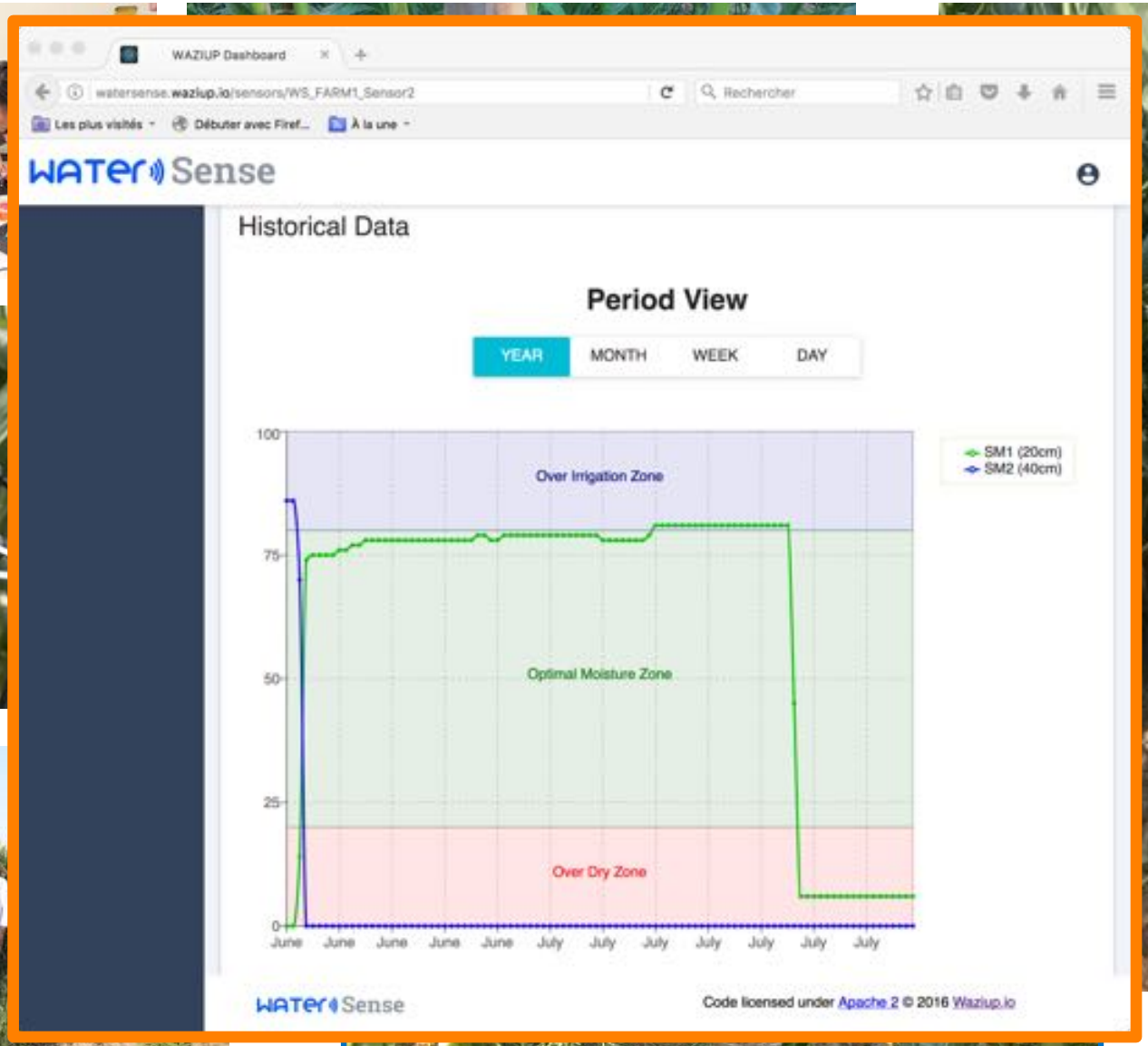
Logical sensor management

SOIL HUMIDITY SENSORS FOR AGRI MVP



Deployment for Nestlé's WaterSense project

Deployment for Nestlé's WaterSense project



Local weather station for AGRI MVP

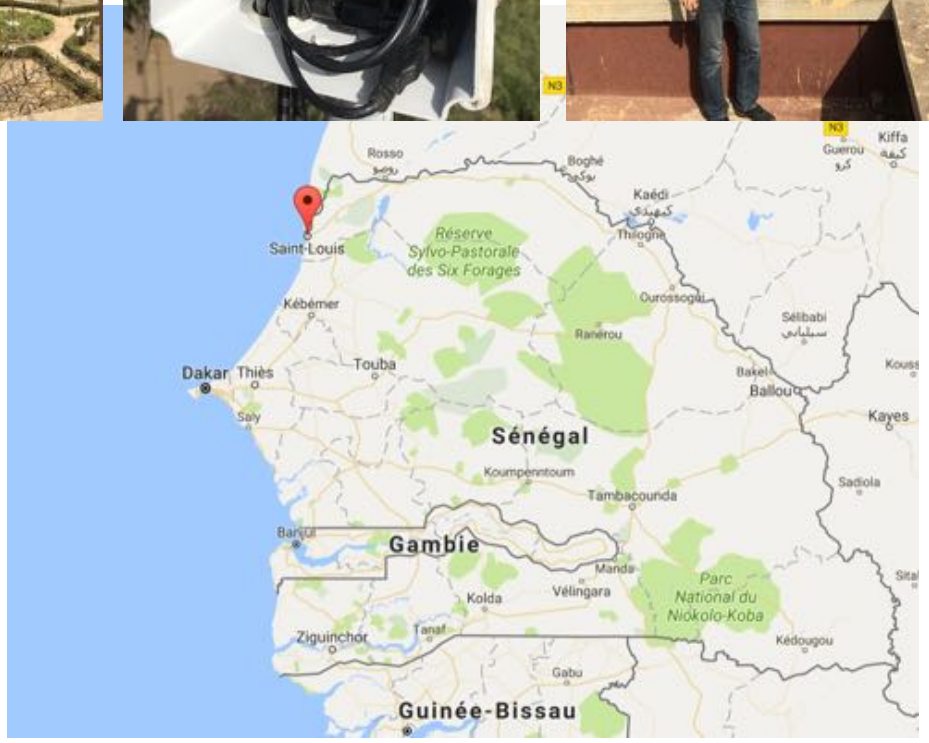
https://openweathermap.org/

Photo from Unparallel

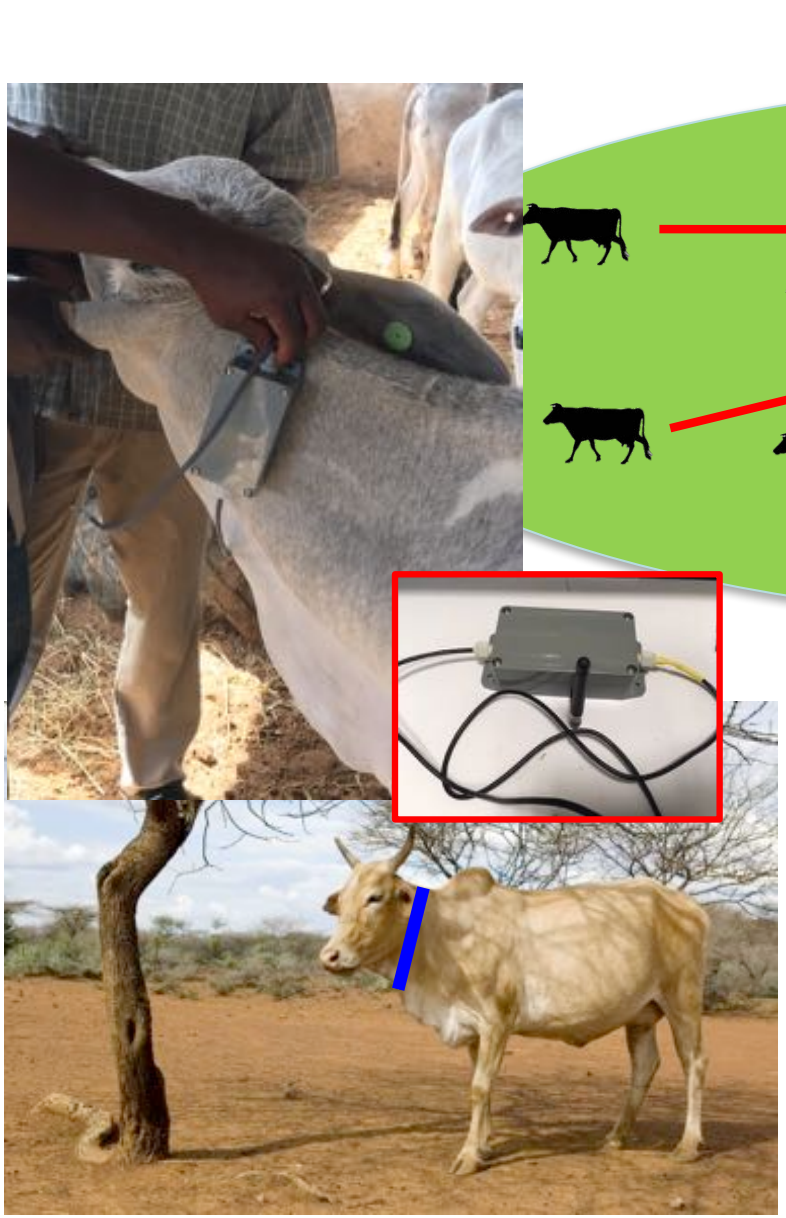
Get local weather measuments

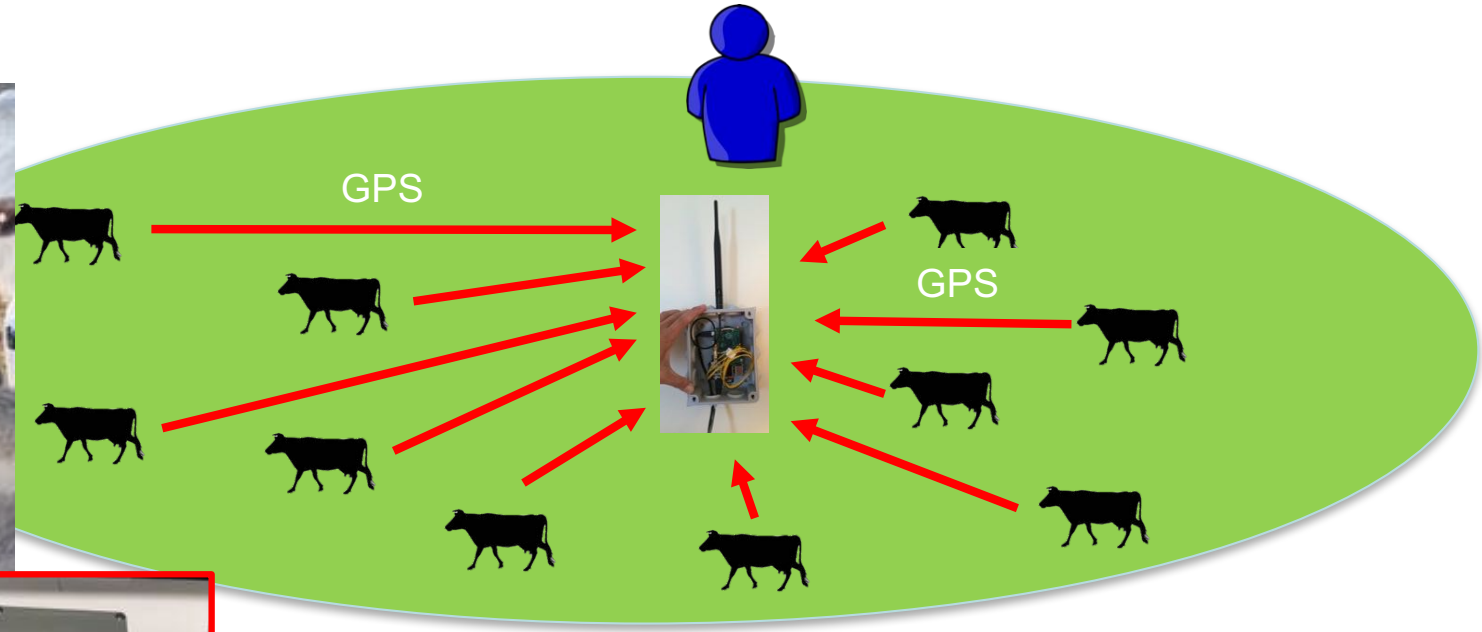
Combine with open weather data to get more accurate predictions

Cattle Rustling in Saint-Louis, Senegal



Collar for Cattle Rustling MVP

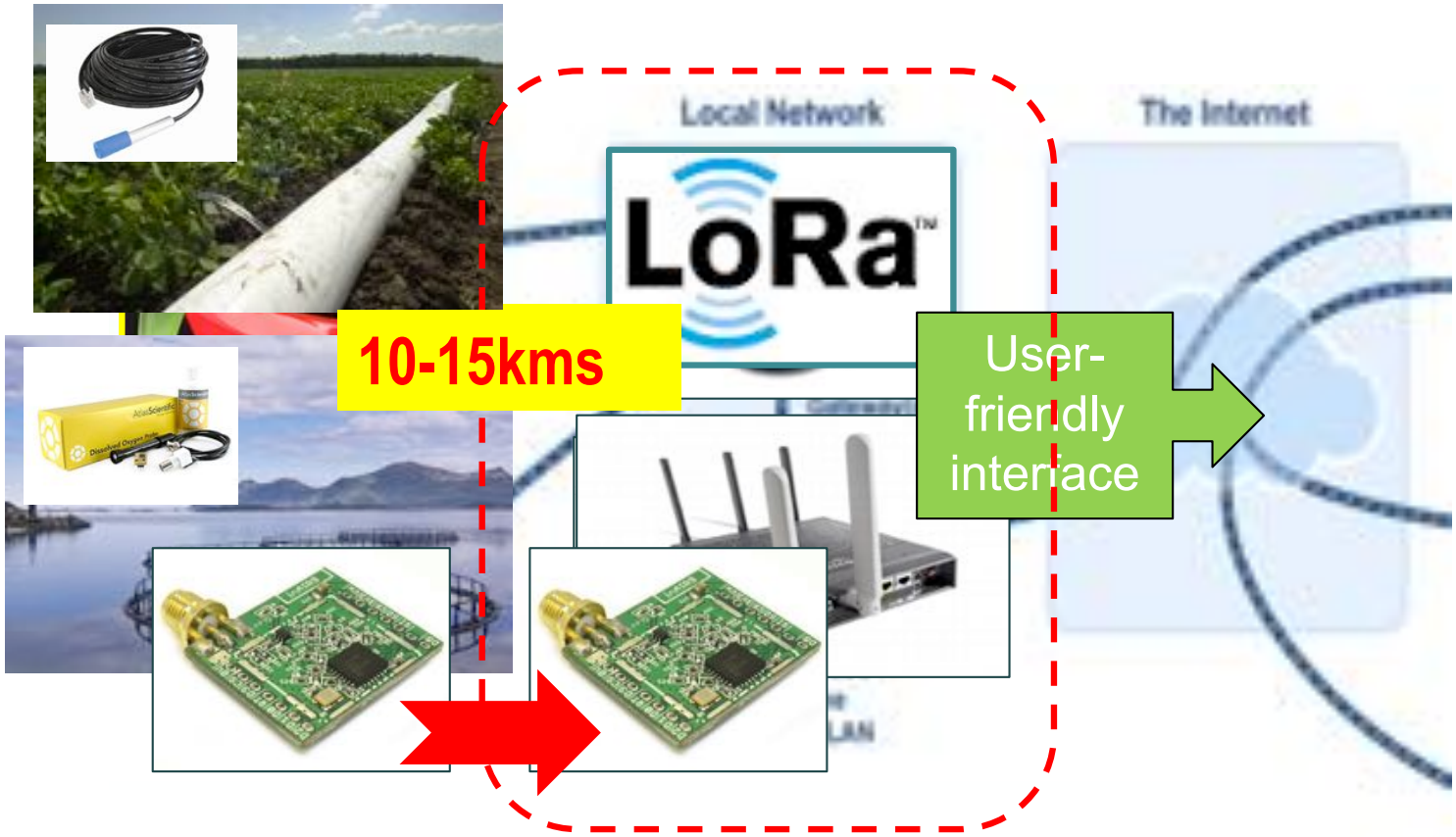




In Africa, the practice of animal husbandry has always been and still remain farmers' livelihood and incomes

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)

WE NEED A GATEWAY!



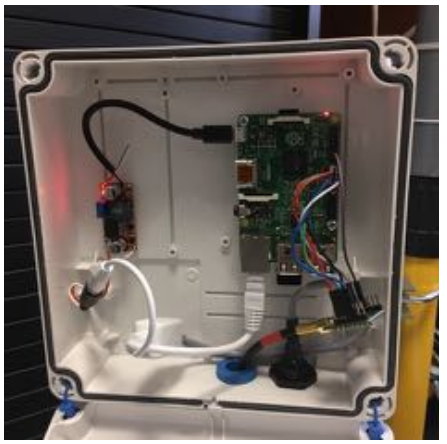
FIWARE
dweet.io
ioBridge
Connect things.
freeboard
GroveStreams
Firebase
TempoIQ
ThingSpeak
SensorCloud
OpenRemote

Raspberry-based low-cost LoRa gateway

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



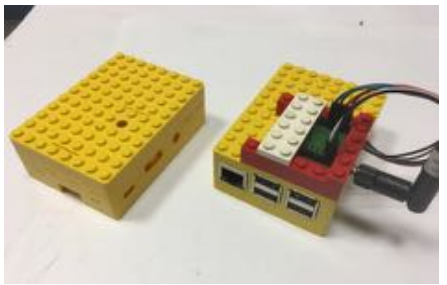




Less than 50€



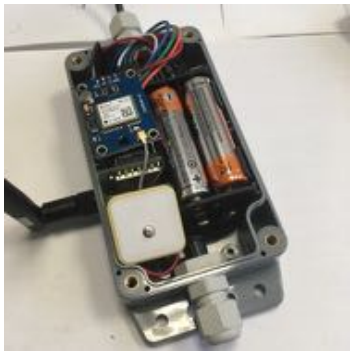


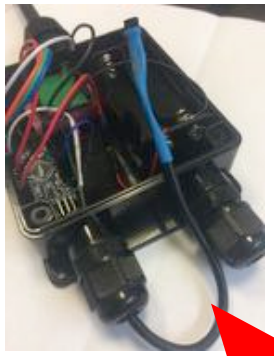


Get the ready-to-use SD card image

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

100% DO-IT-YOURSELF !





Step-by-step tutorial and source code available

Step-by-step tutorial and source code available

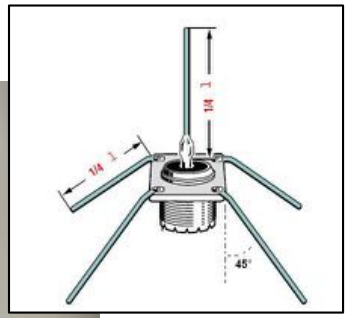
Python scripts available

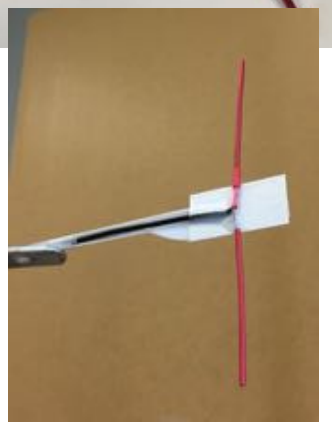
https://github.com/CongducPham/LowCostLoRaGw

DIY ANTENNA AS WELL

- The ground plane antenna can be made with 5 pieces of ¼ wave wires. ¼ wave in 868MHz is about 8.2cm.

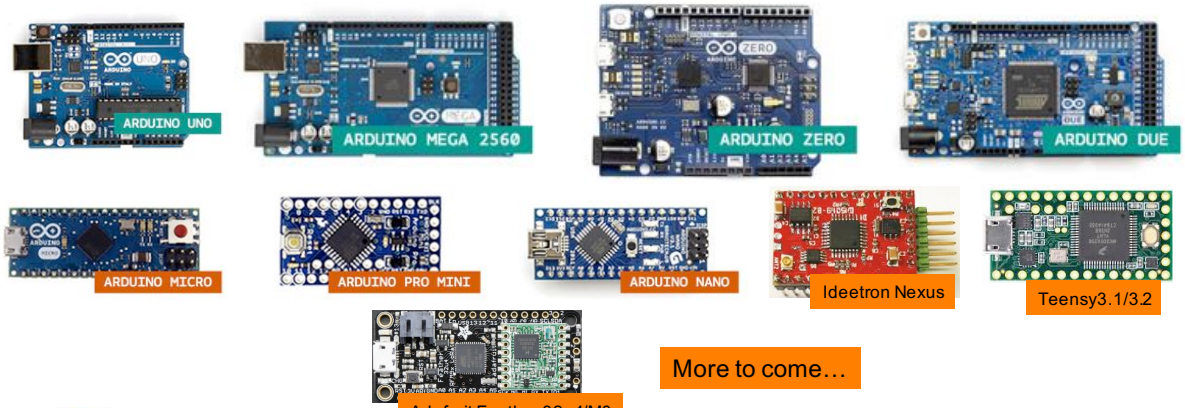





- Simple dipole antenna

SIMPLICITY!



LoRa radios that our library already supports

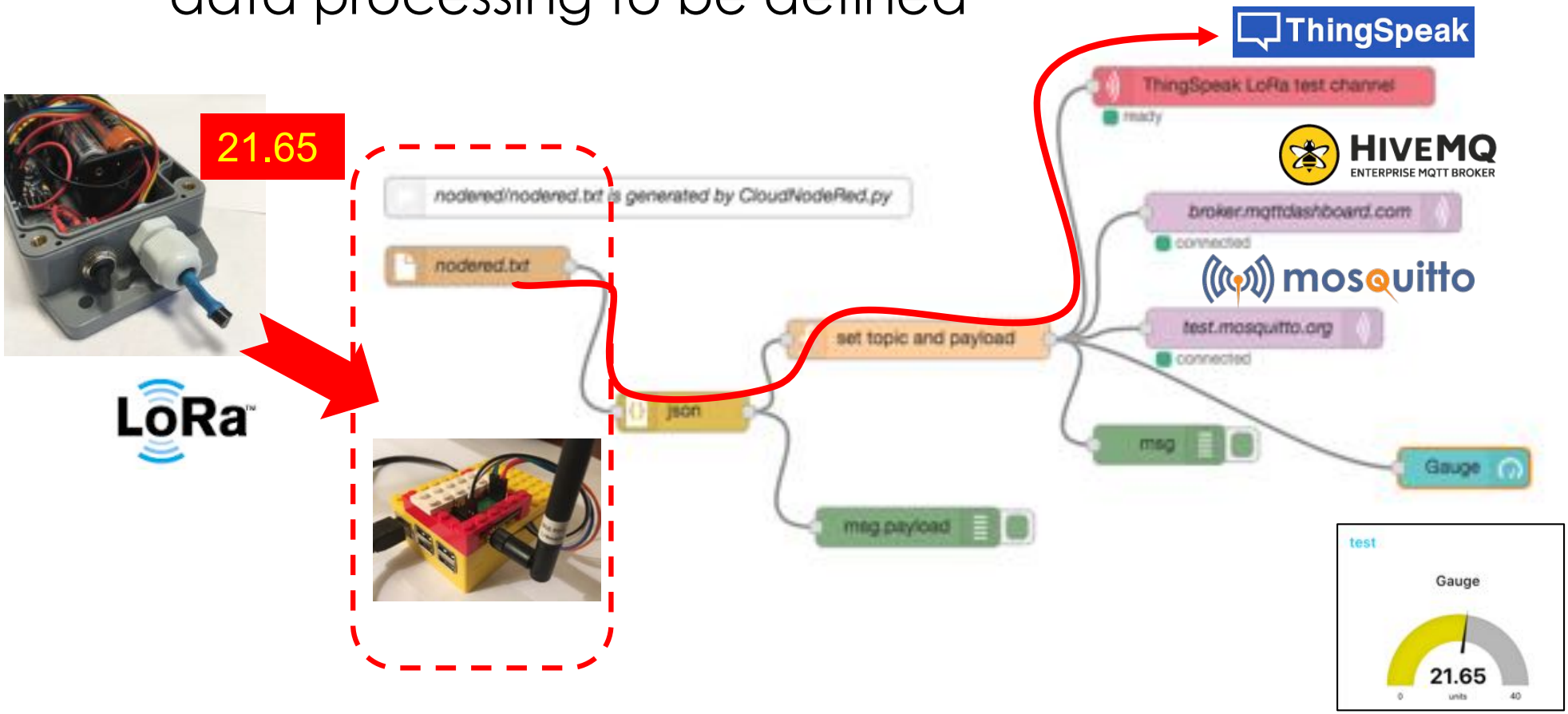
Long-Range communication library

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

1 send function!

Node-red enabled gateway

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



Working without Internet access

A

10-15kms

LoRa™

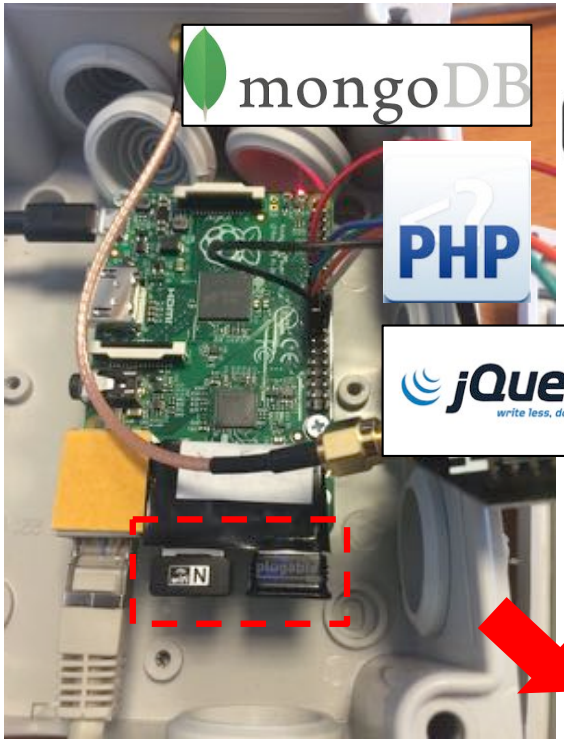
No subscription
Deploy own network
Low energy consumption

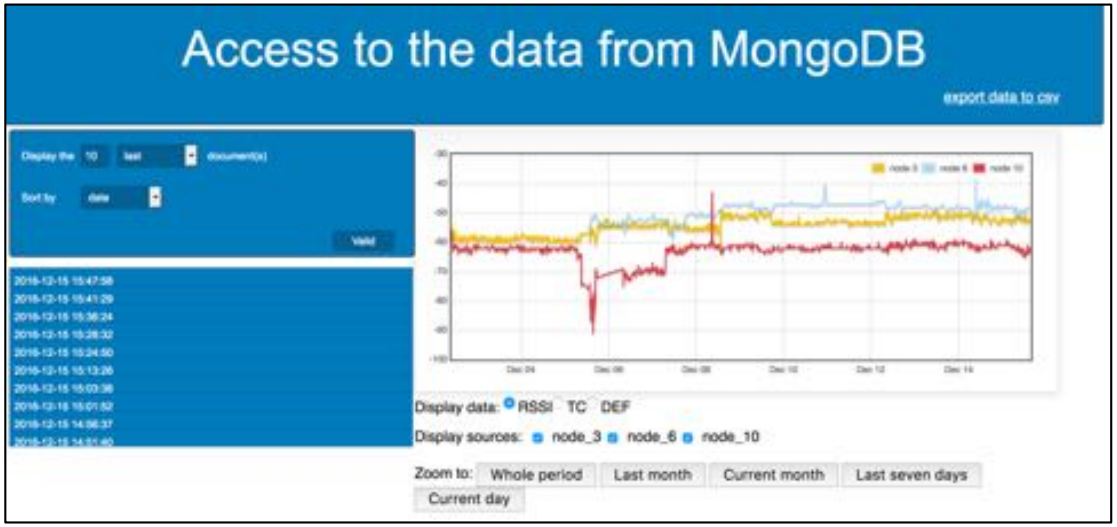
GSM
3G
Wi Fi
net
ccess

B

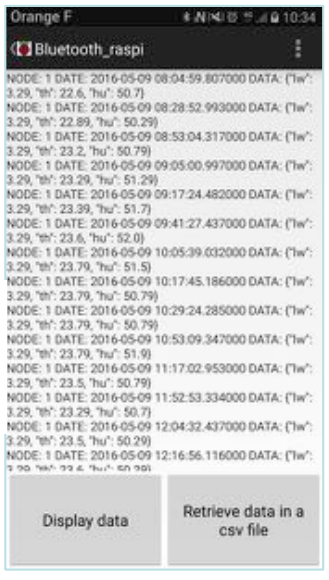
Wi Fi

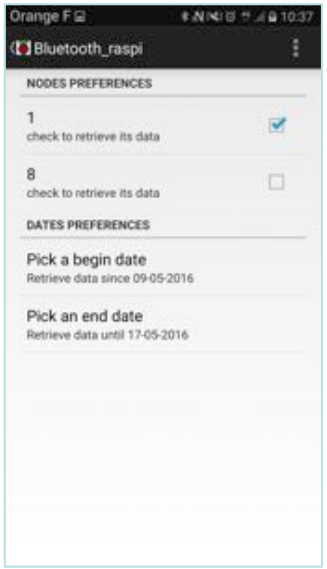
Standalone gateway

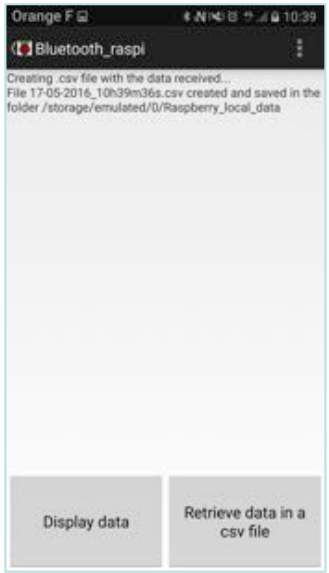




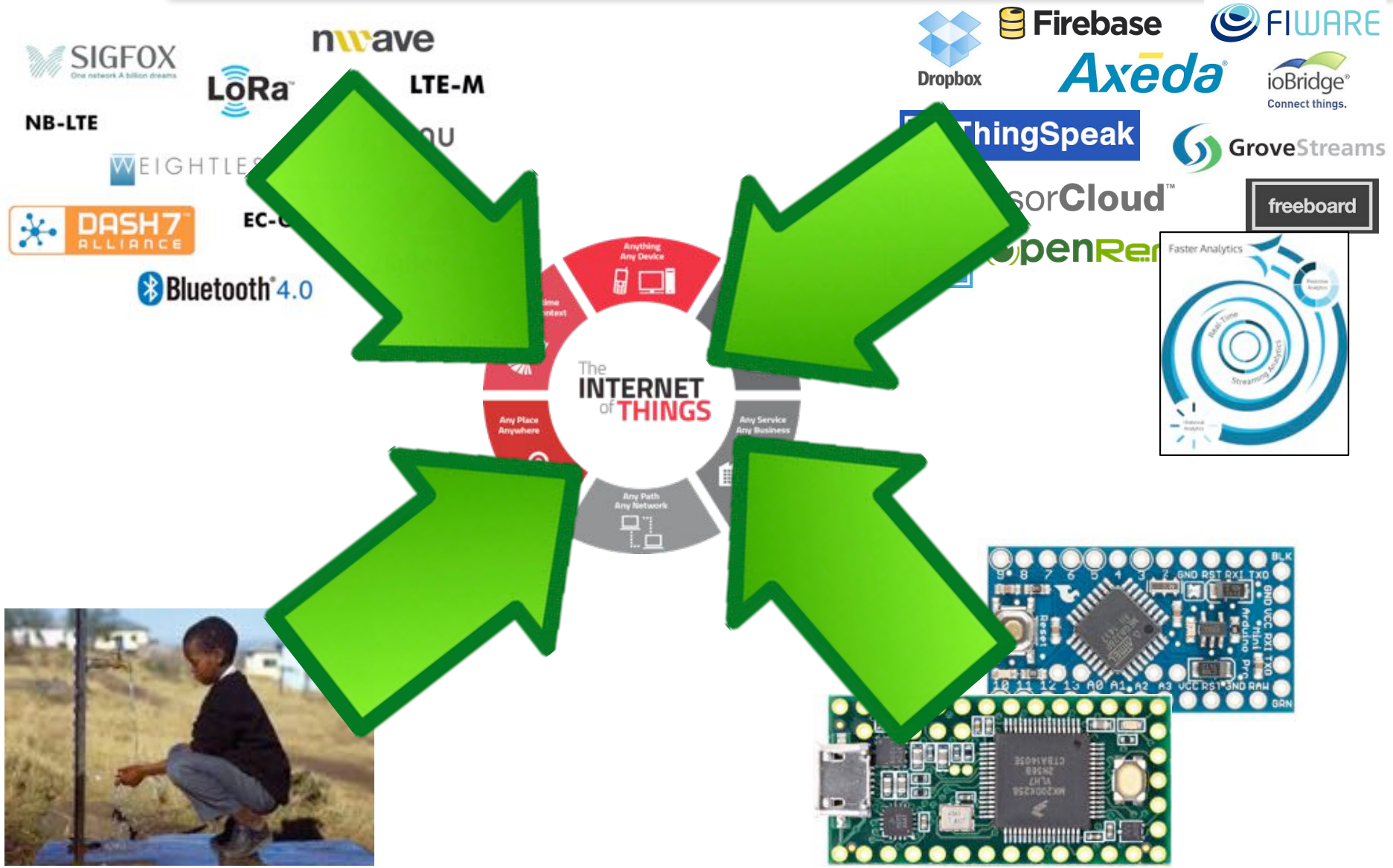
Isolated areas







Now,
IoT can becomes reality!



BUILDING WAZIUP COMMUNITY AND ECOSYSTEM

International Events
+ 20 organized & attended

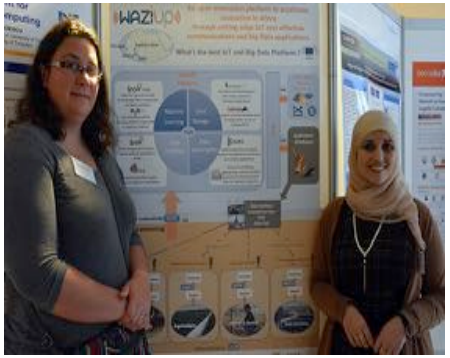
Launch event (Senegal, CTIC Dakar)

Launch event (Ghana, iSpace)

IoTWeek2016 (Belgrade, EGM)

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

IoTBigData2016 (Italy, EGM)



IoTCareConference (Budapest, CNET)

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

Credit: C. Vavasseur, CTIC Dakar

Workshop at the RESSACS 2016 (France, UPPA)

TUTORIALS AND VIDEOS

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

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

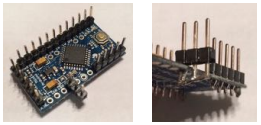
Congduc Pham, **http://cpham.perso.univ-pau.fr**

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.

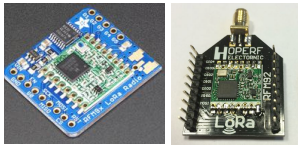
The LoRa radio module

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

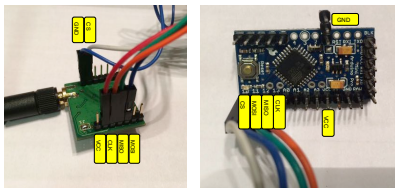
Fully tested LoRa radio modules | HopeRF RFM92W/95W | Libelium LoRa | Modtronix inAir4/9/9B | NiceRF LoRa1276

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 Ideetron 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.

Thanks.

Let's keep in touch

Carine VAVASSEUR

Communication & Event Manager

Carine.vavasseur@cticdakar.com

www.cticdakar.com
contact@cticdakar.com

facebook.com/waziuploT

twitter.com/waziuploT

linkedin.com/groups/8156933

github.com/waziup