The IoT ecosystem and Make it happening!

IRD/UMMISCO–Yaoundé,
University Yaoundé, Cameroon

March 19 th, 2018

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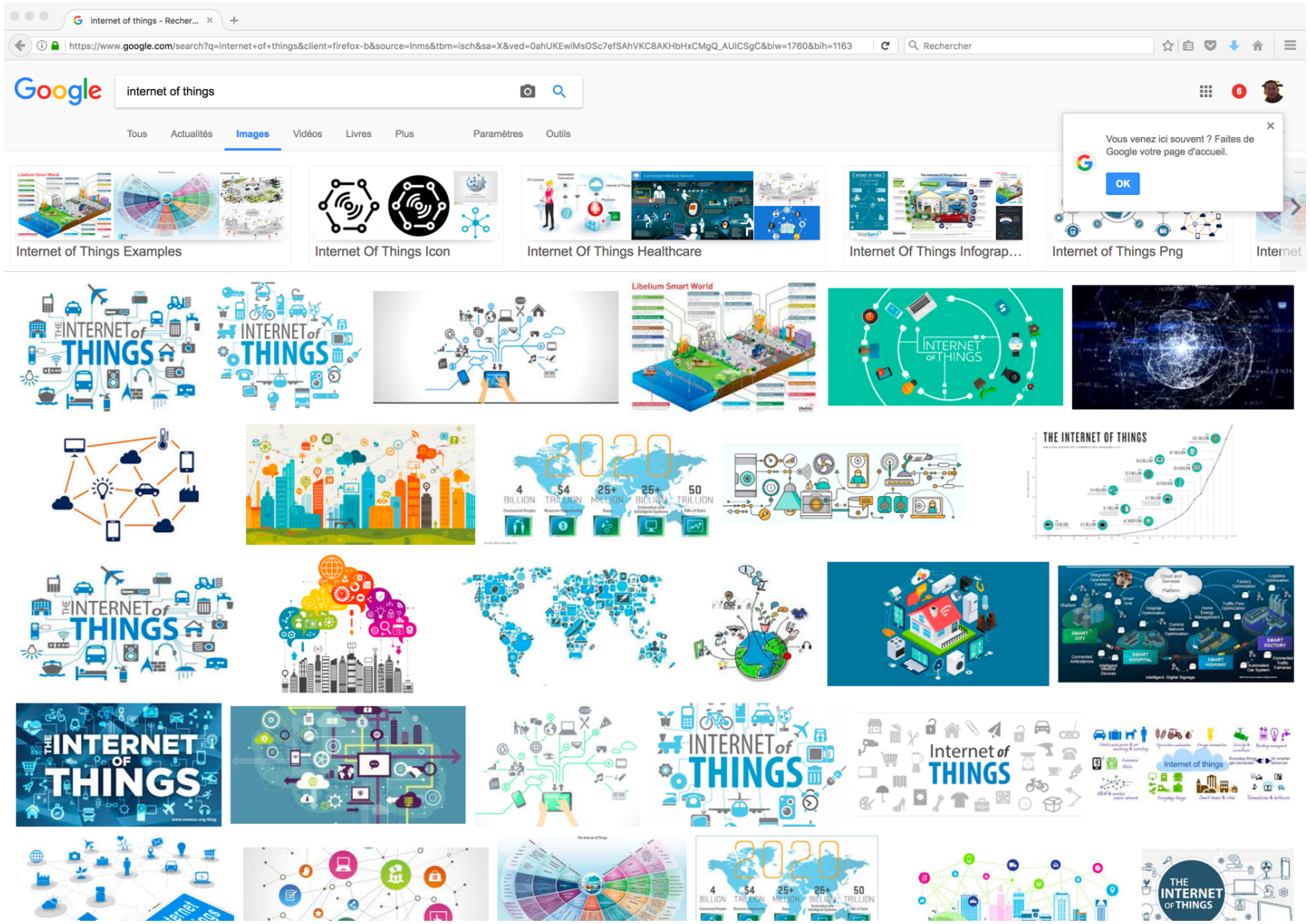
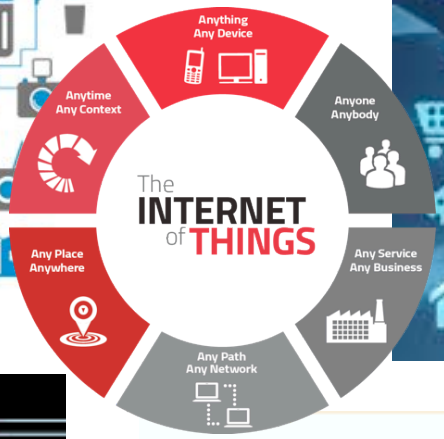
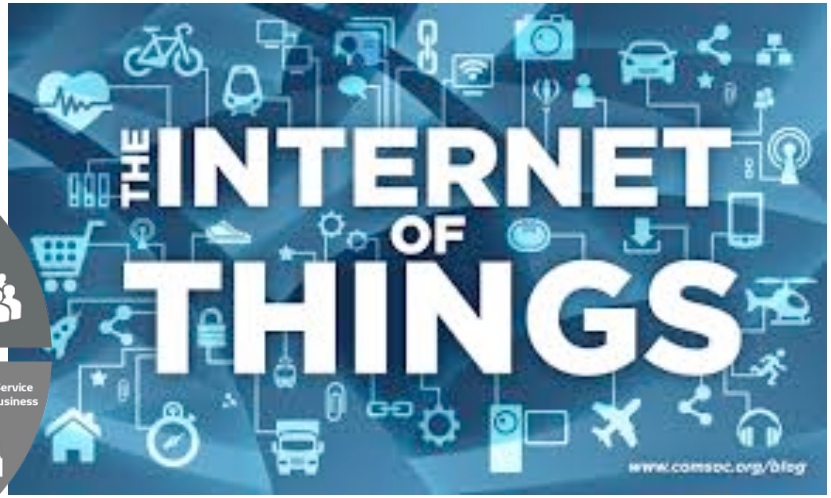
http://www.univ-pau.fr/~cpham
Université de Pau, France

Googling for « Internet of Things »...

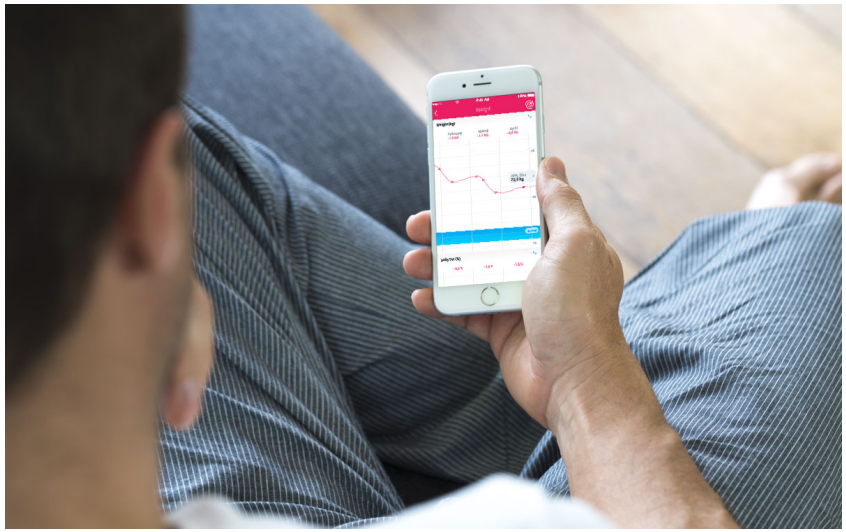


… TYPICALLY SHOWS COMMUNICATING OBJECTS



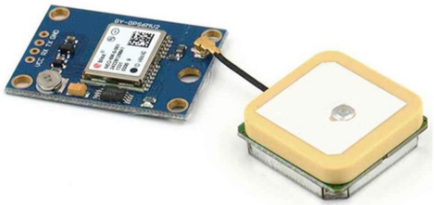


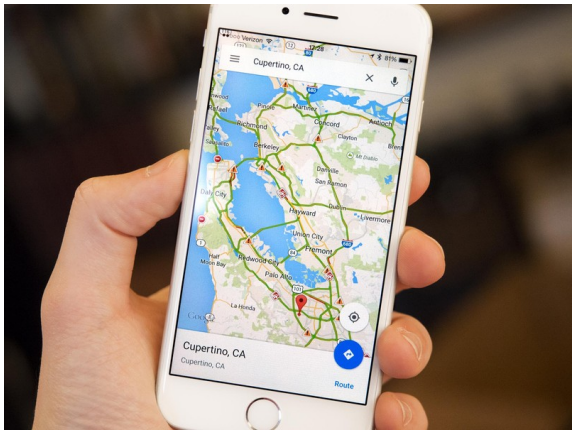
Home/consumer IoT products



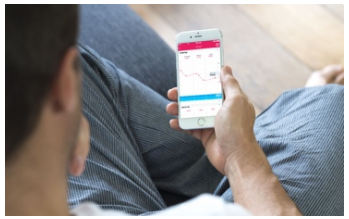
Pictures from WiThing, https://www.withings.com/eu/fr/products/body

IoT & PHYSICAL WORLD





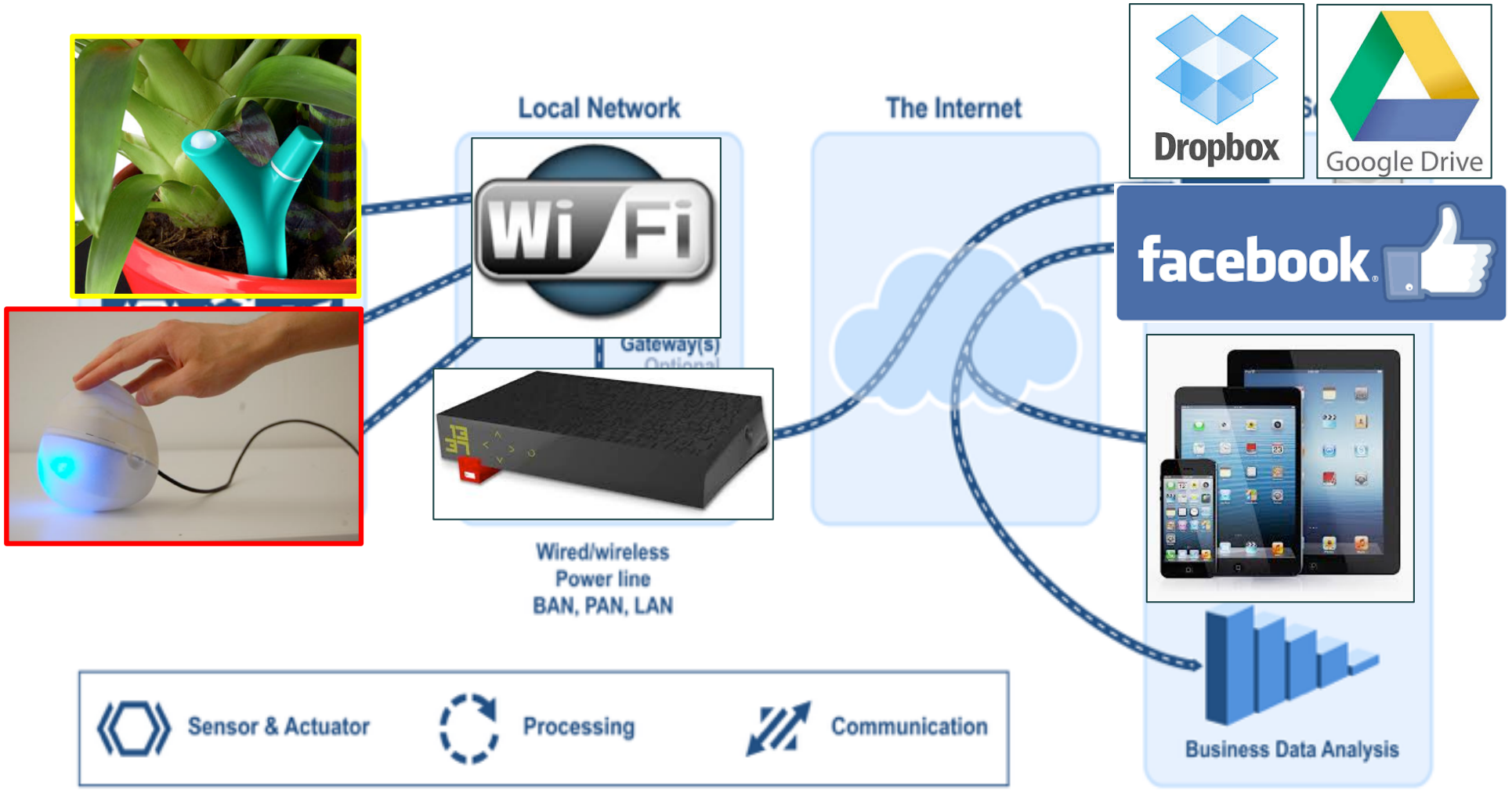
Local interaction is possible



But IoT usually means cloud data

Lot's of data !

General public IoT architecture



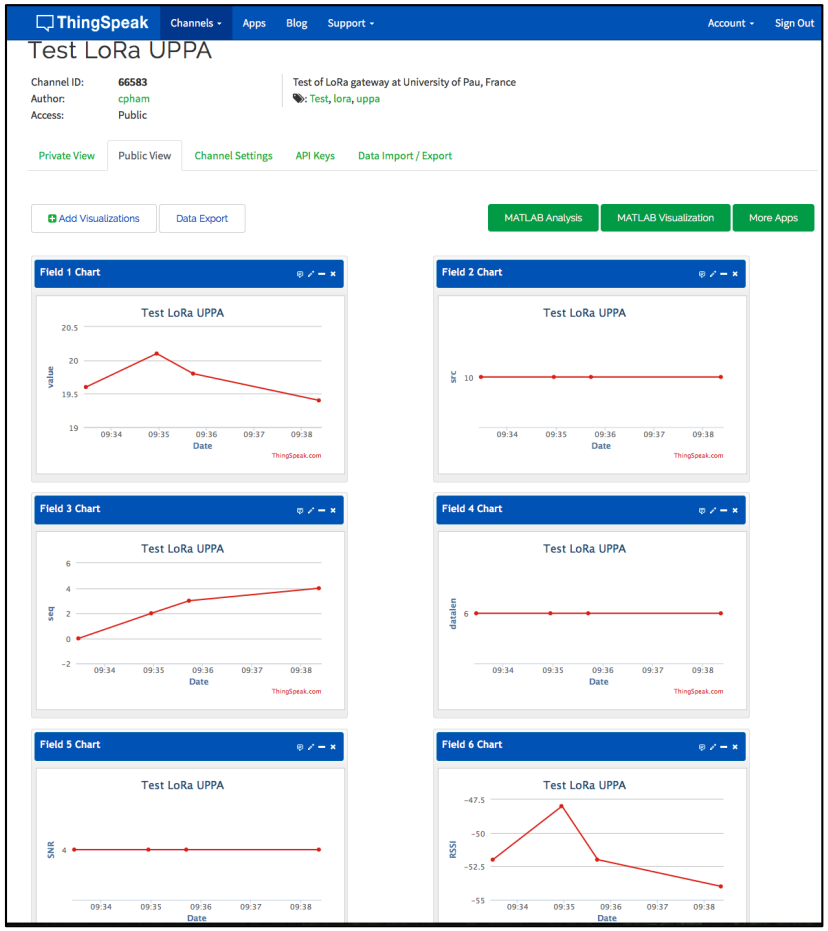
Pictures from ArchitectCorner

Dedicated IoT cloud

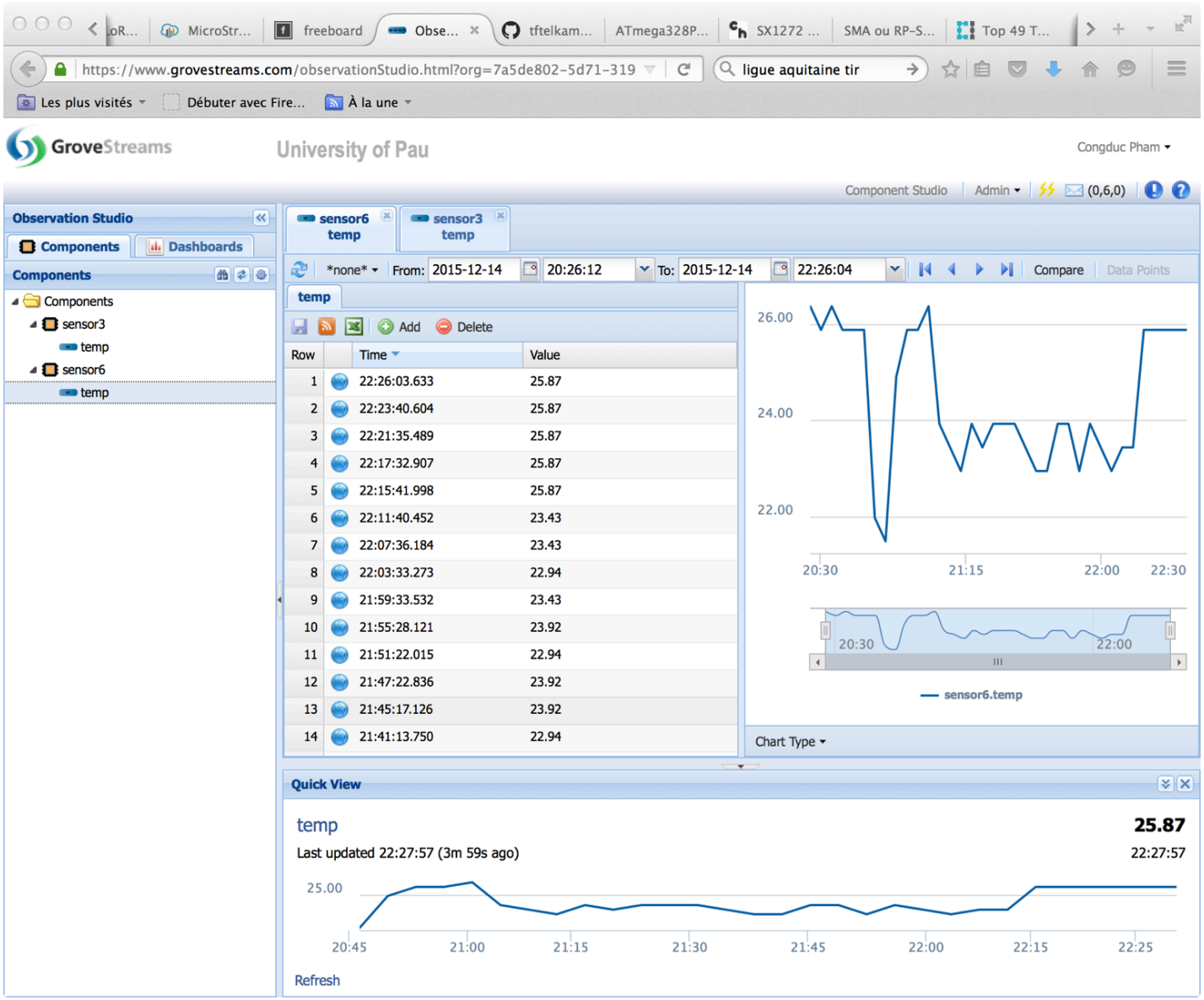
Using ThingSpeak

19.6

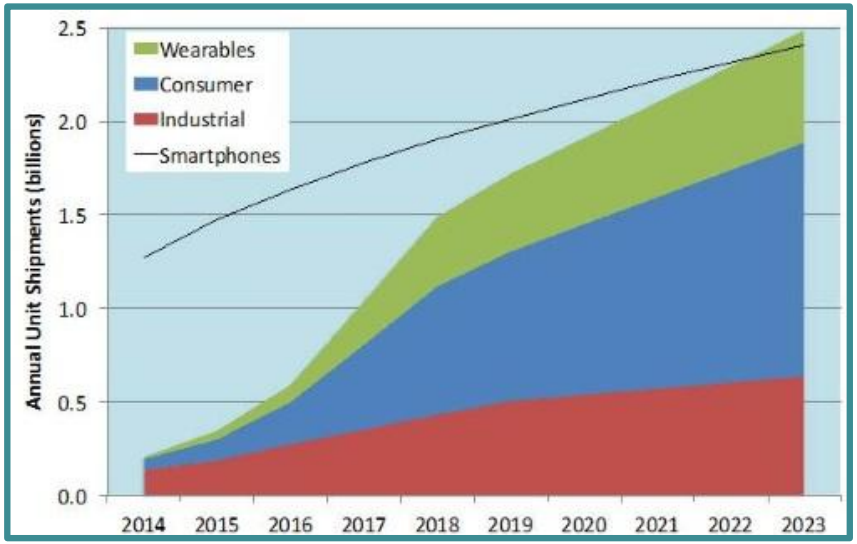
Node 10



Using GroveStreams

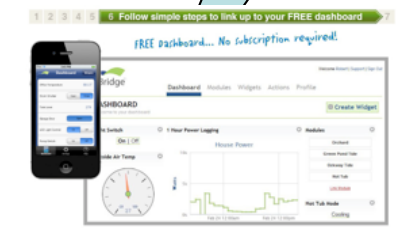


One of the most promising market is IoT!



Waste Container connected sensor

CONTROL, OPTIMIZE & INSTRUMENT !



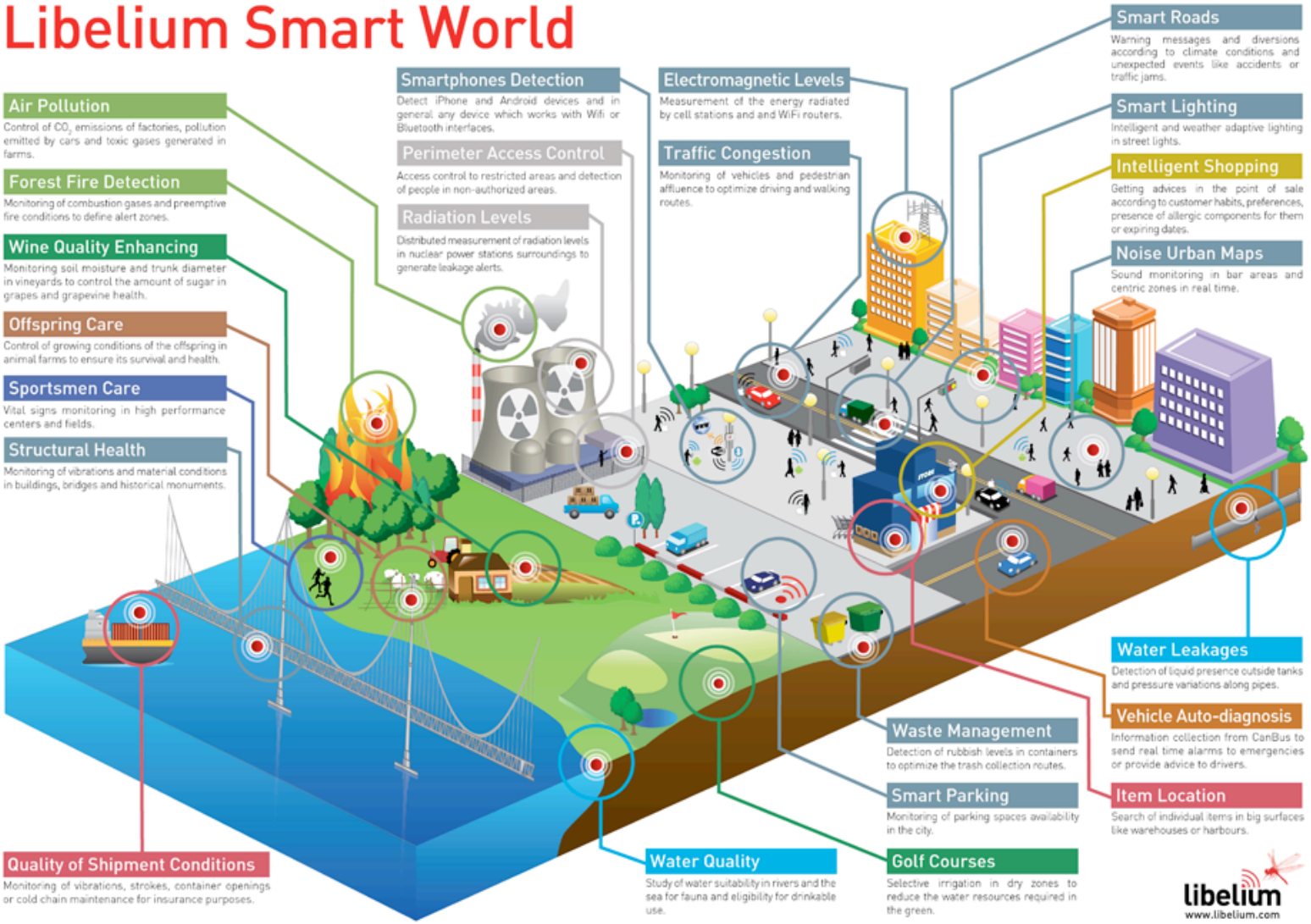
DATA ANALYSIS, OPTIMIZATION & CONTROL

PERVASIVE SYSTEMS

SENSING

PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

Example 1: Smart Cities



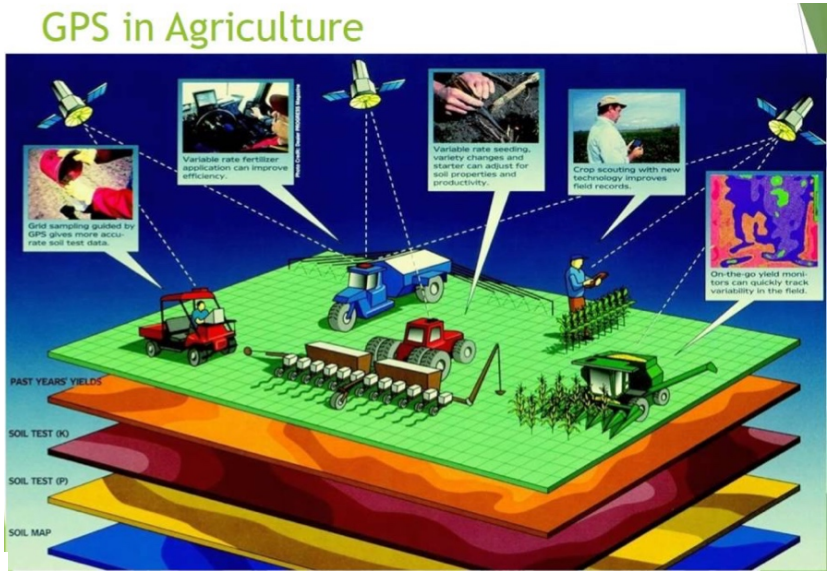
http://www.libelium.com/top_50_iot_sensor_applications_ranking/#show_infographic

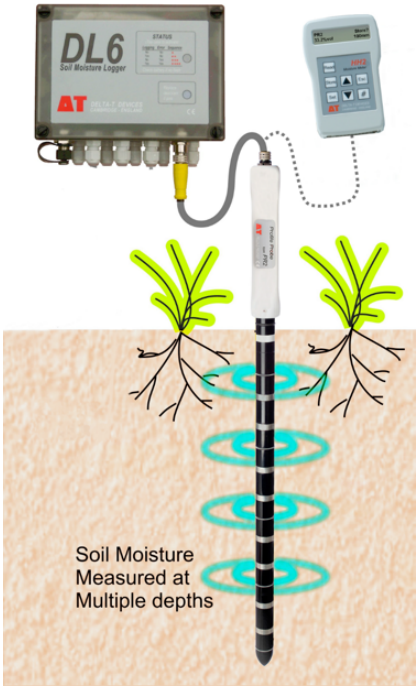
SmartSantander

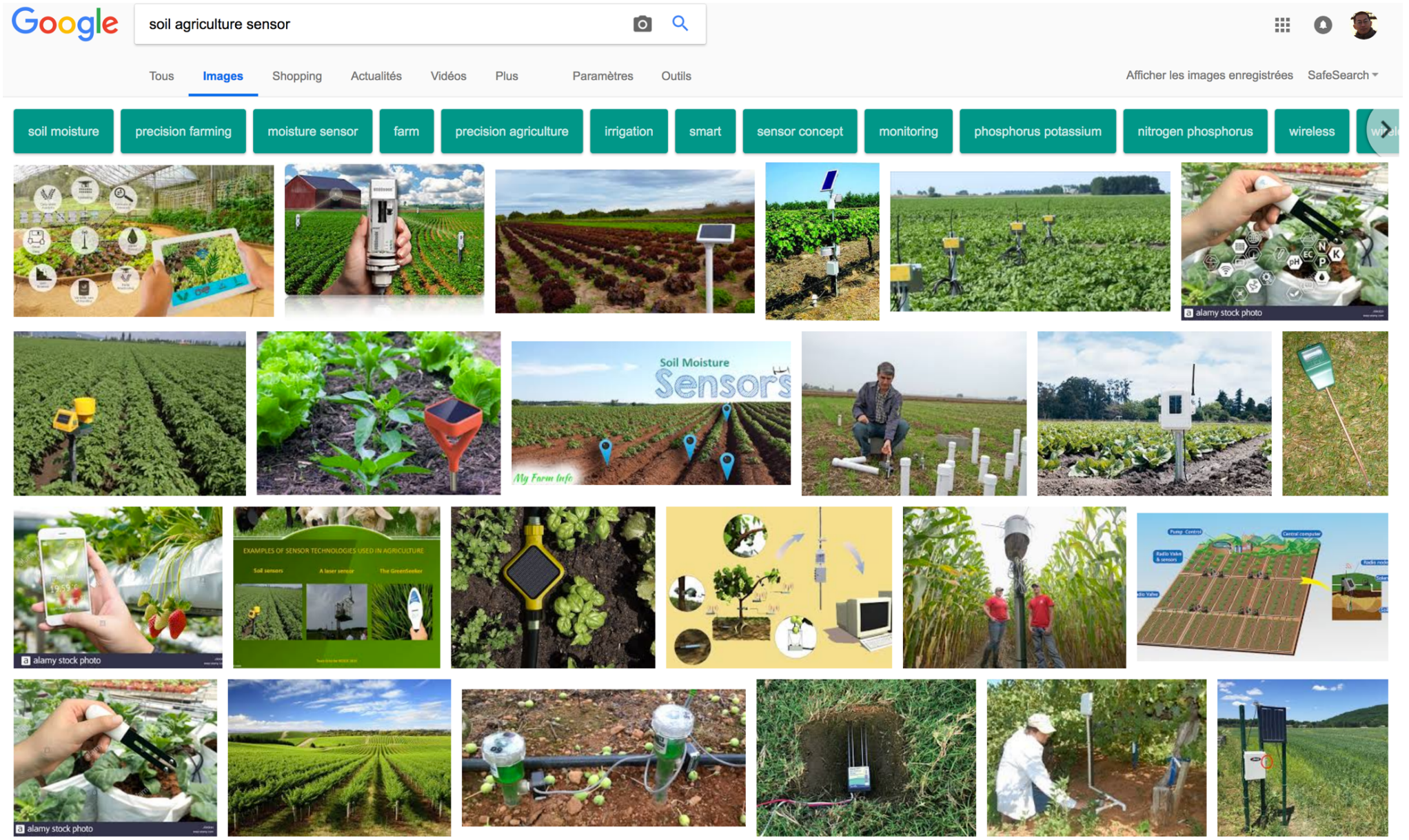
www.smartsantander.eu

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

Example 2: Farming & Agriculture






Google
soil agriculture sensor
Tous
Images
Shopping
Actualités
Vidéos
Plus
Paramètres
Outils
Afficher les images enregistrées
SafeSearch
soil moisture
precision farming
moisture sensor
farm
precision agriculture
irrigation
smart
sensor concept
monitoring
phosphorus potassium
nitrogen phosphorus
wireless
Soil Moisture
Sensors
My Farm Info
EXAMPLES OF SENSOR TECHNOLOGIES USED IN AGRICULTURE
alamy stock photo

Challenge 1: analyse data

- What is the meaning of the collected data?
- Example with farming
  - What is interesting for farmers?
    - Fertility detection
    - Eating/Ruminating time for welfare
  - What data can be easily obtained?
    - accelerometer data with neck-mounted collar
  - How to detect relevant event from these data?

Advanced data analysis

Need of experts from the domain!

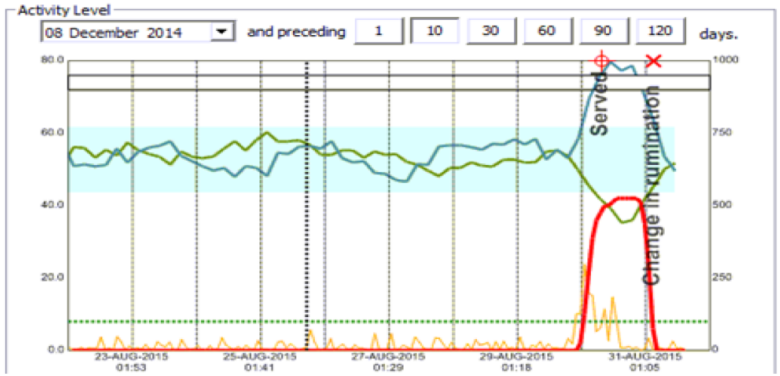
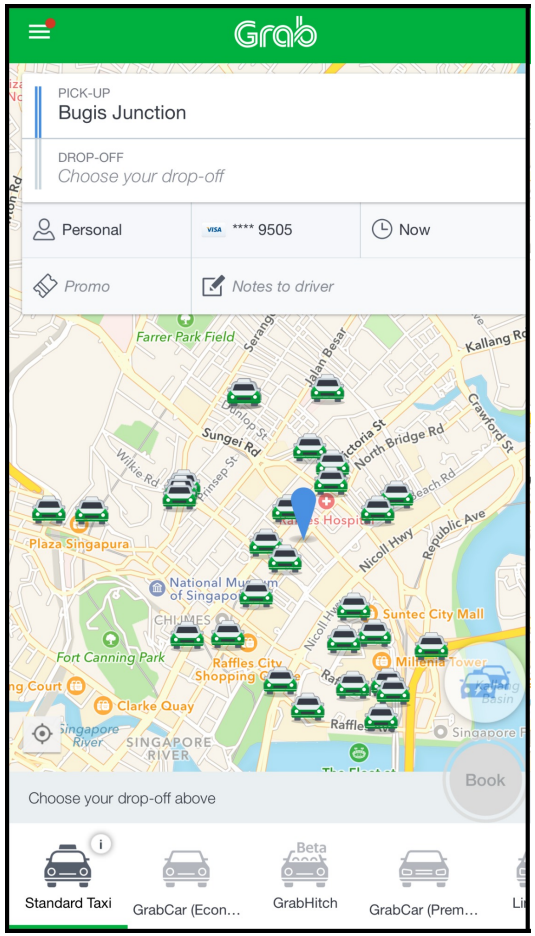


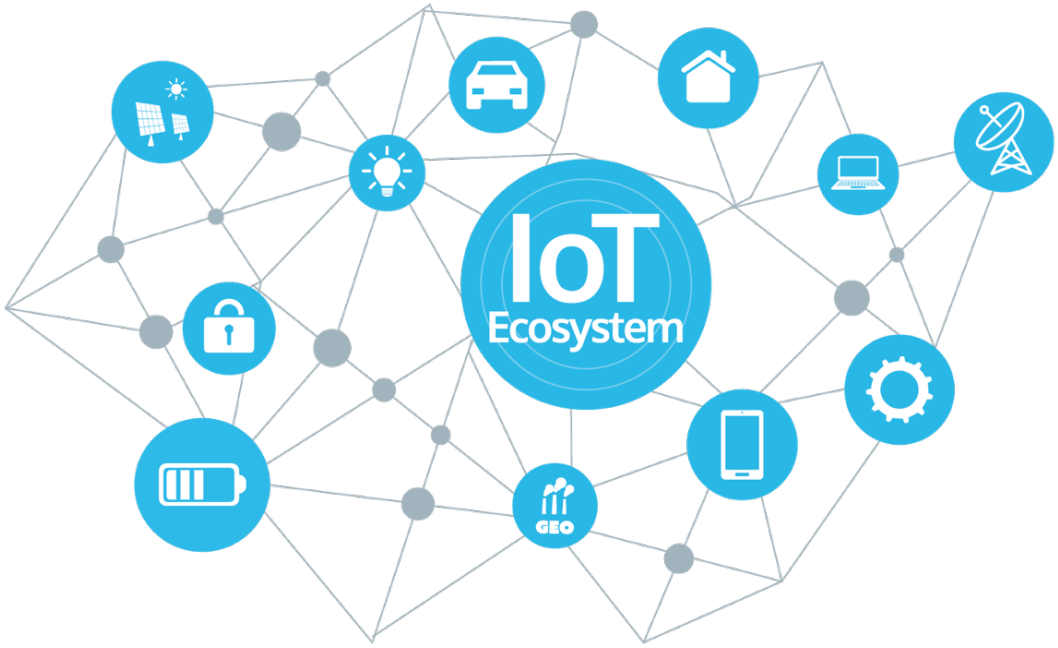
Fig. 3. Illustration of a rise in activity accompanied by a fall in rumination at the point of oestrus

Challenge 2: provide the right system!

- How would you implement a real-time positioning system of city buses?

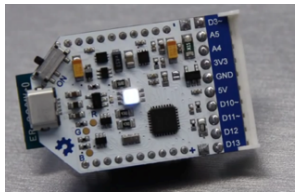


The IoT ecosystem



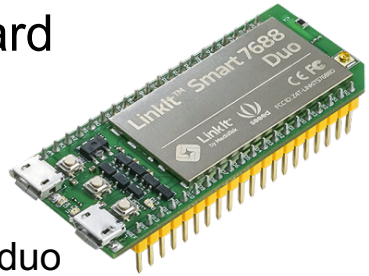
1ST ISSUE: IOT ARE SMALL DEVICES

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



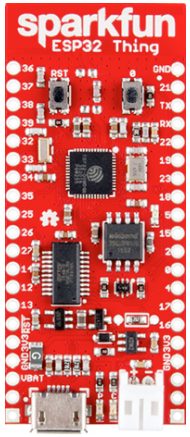
Theairboard

LoPy



LinkIt
Smart7688 duo

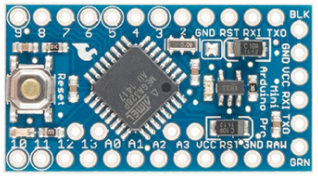
Adafruit Feather



Sparkfun ESP32 Thing

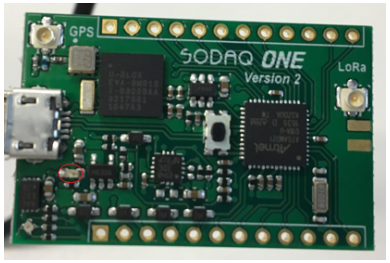
Expressif ESP32

Tessel



Arduino Pro Mini

Teensy 3.2

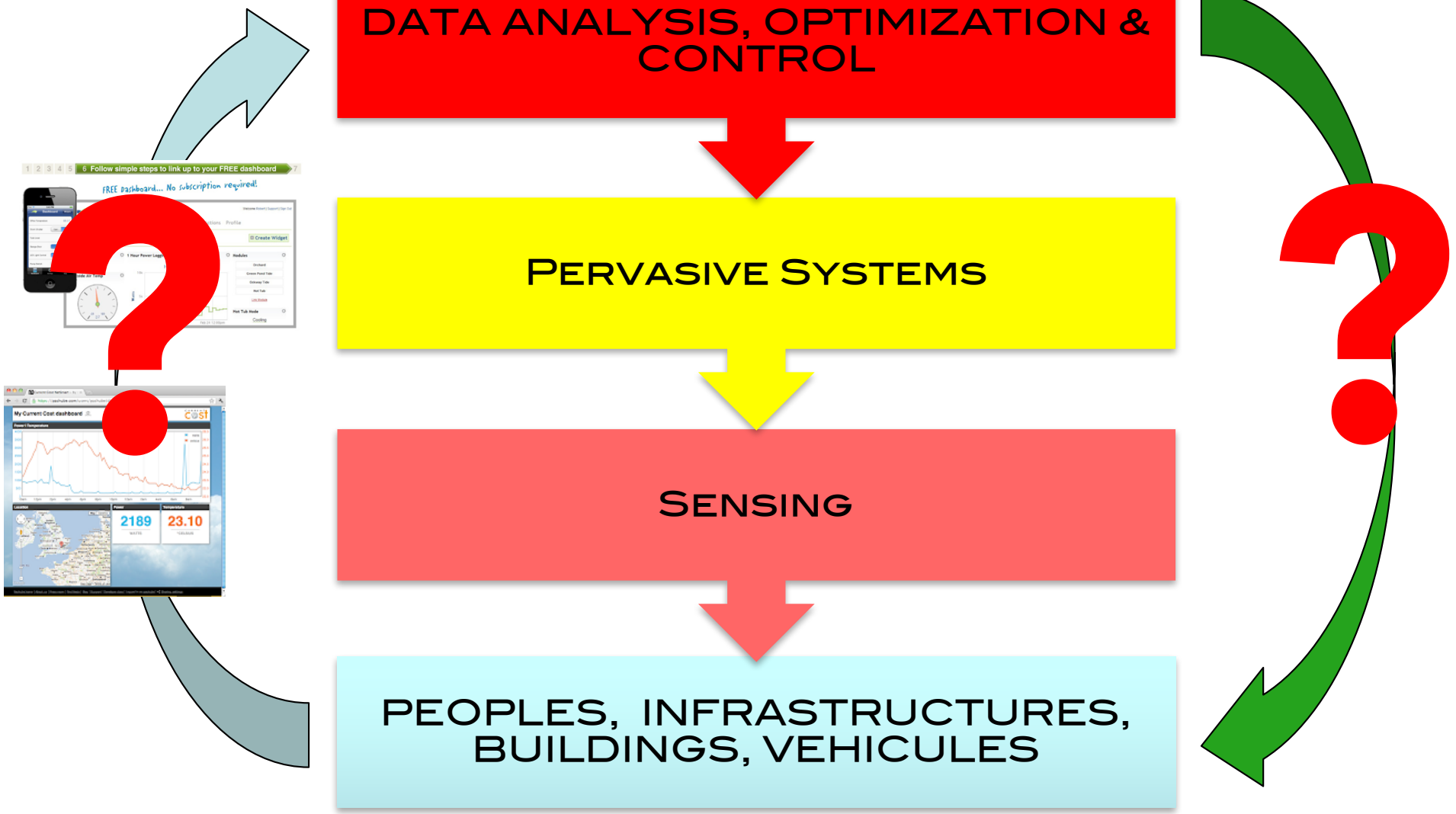


SodaqOnev2

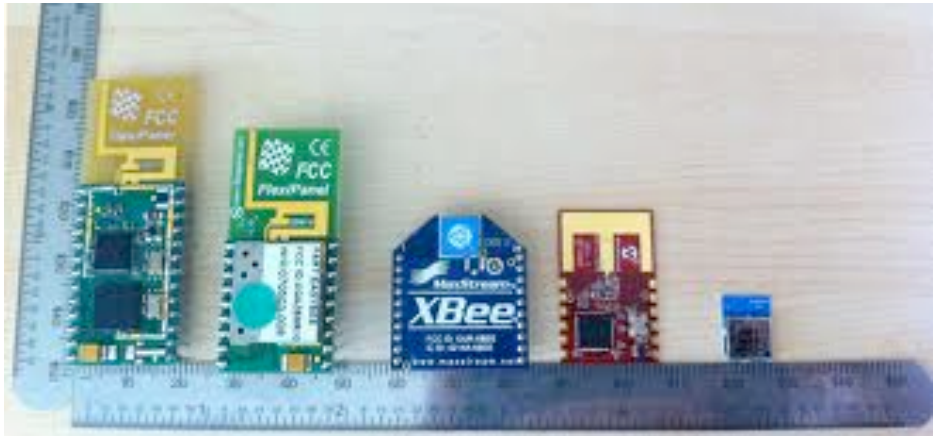
STM32 Nucleo-32

Tinyduino

2ND ISSUE: COLLECT DATA



Wireless Communication made easy



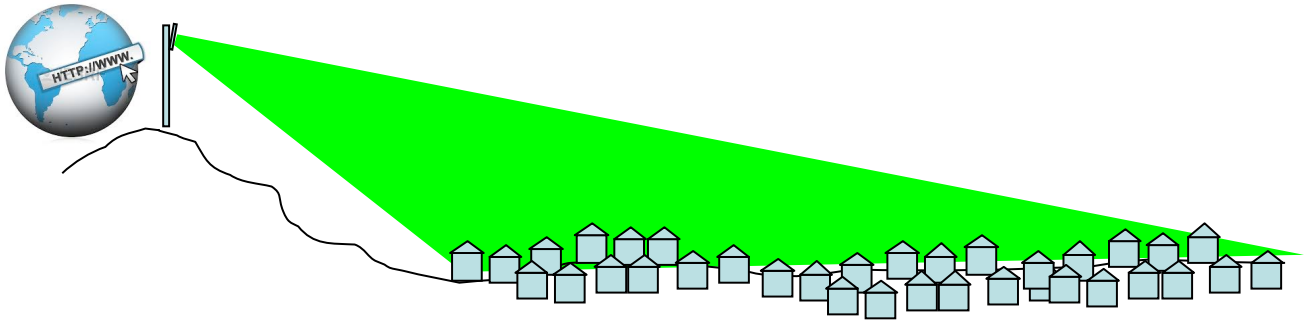
IoT=WIRELESS+BATTERY

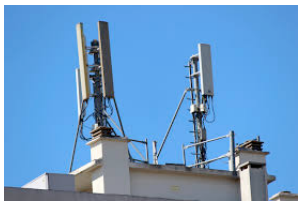
Telemetry and Transmission cost

Moisture/
Temperature of
storage areas

10-15kms

GSM GPRS

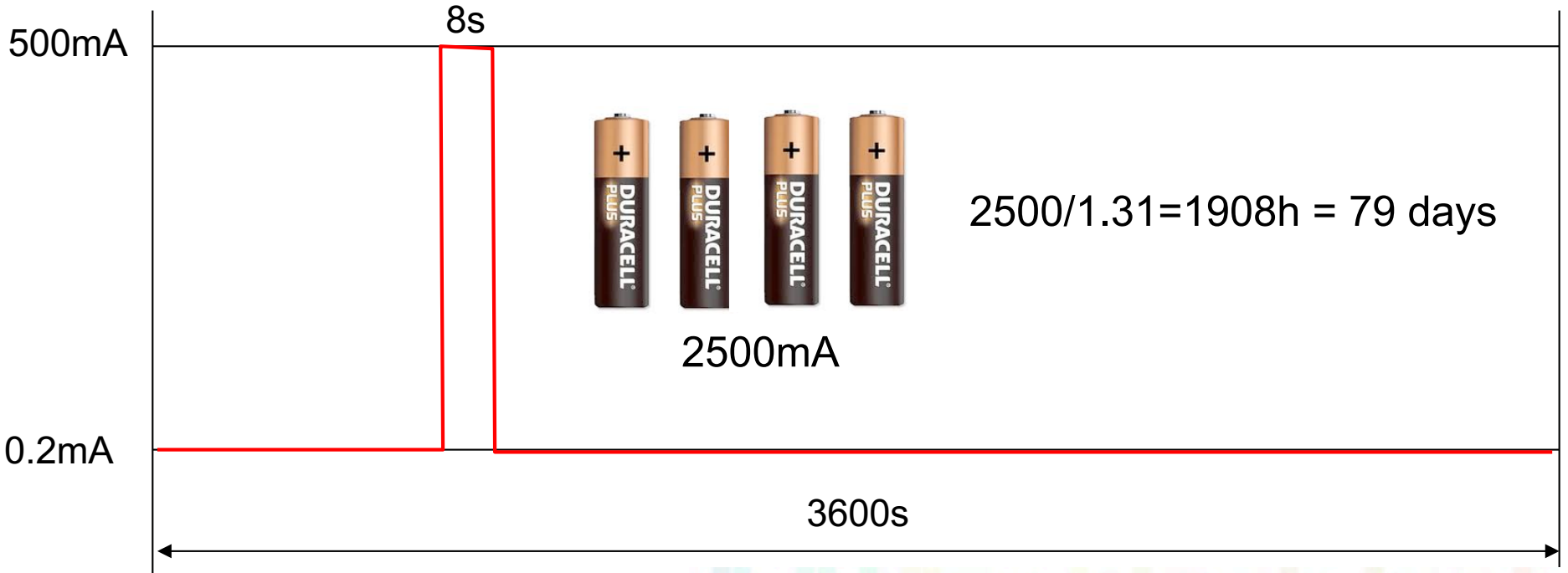


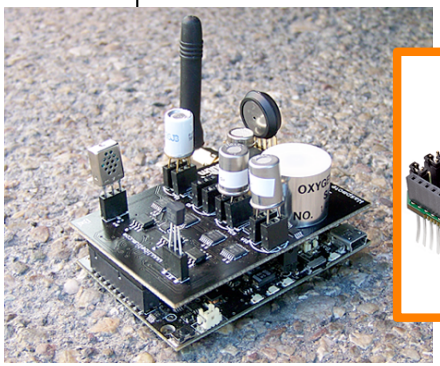


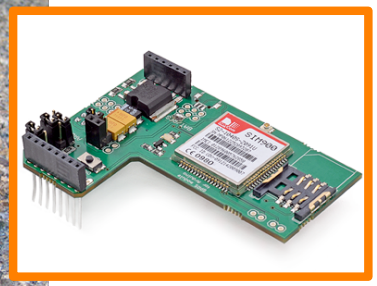
Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200-500mA	500-1000mA	100-300mA
Standby current	2.3mA	3.5mA	NC

Energy consideration

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







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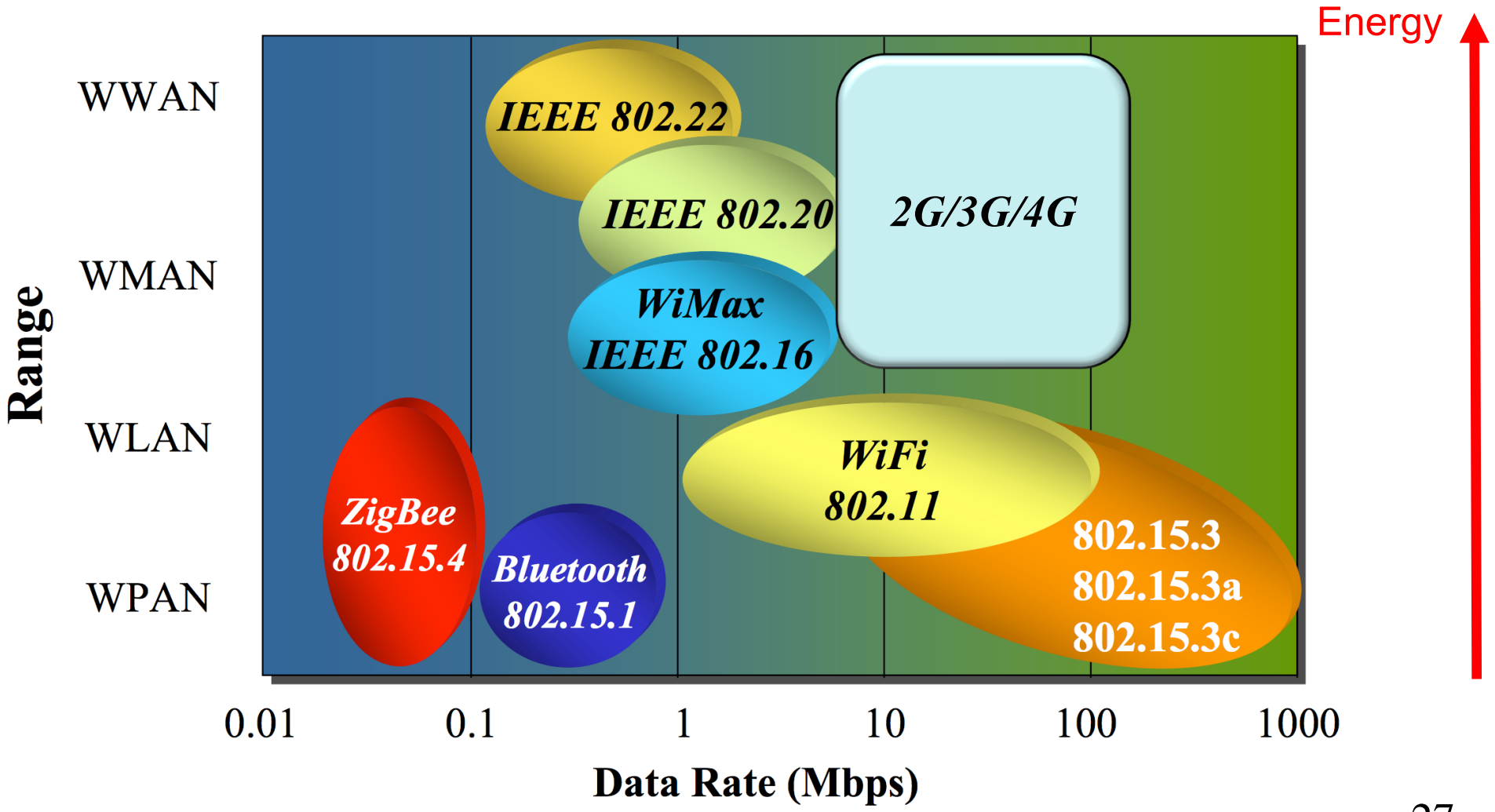
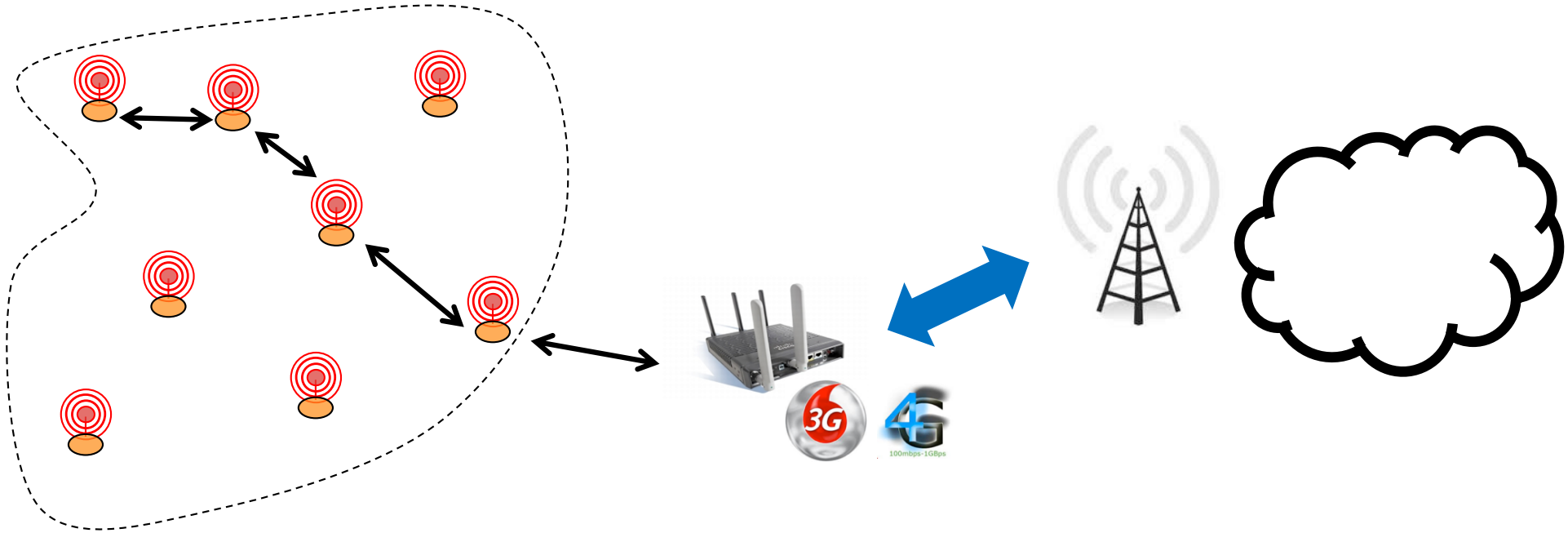
THE WIRELESS SPACE

Energy-Range dilemma



Lower energy means shorter range!

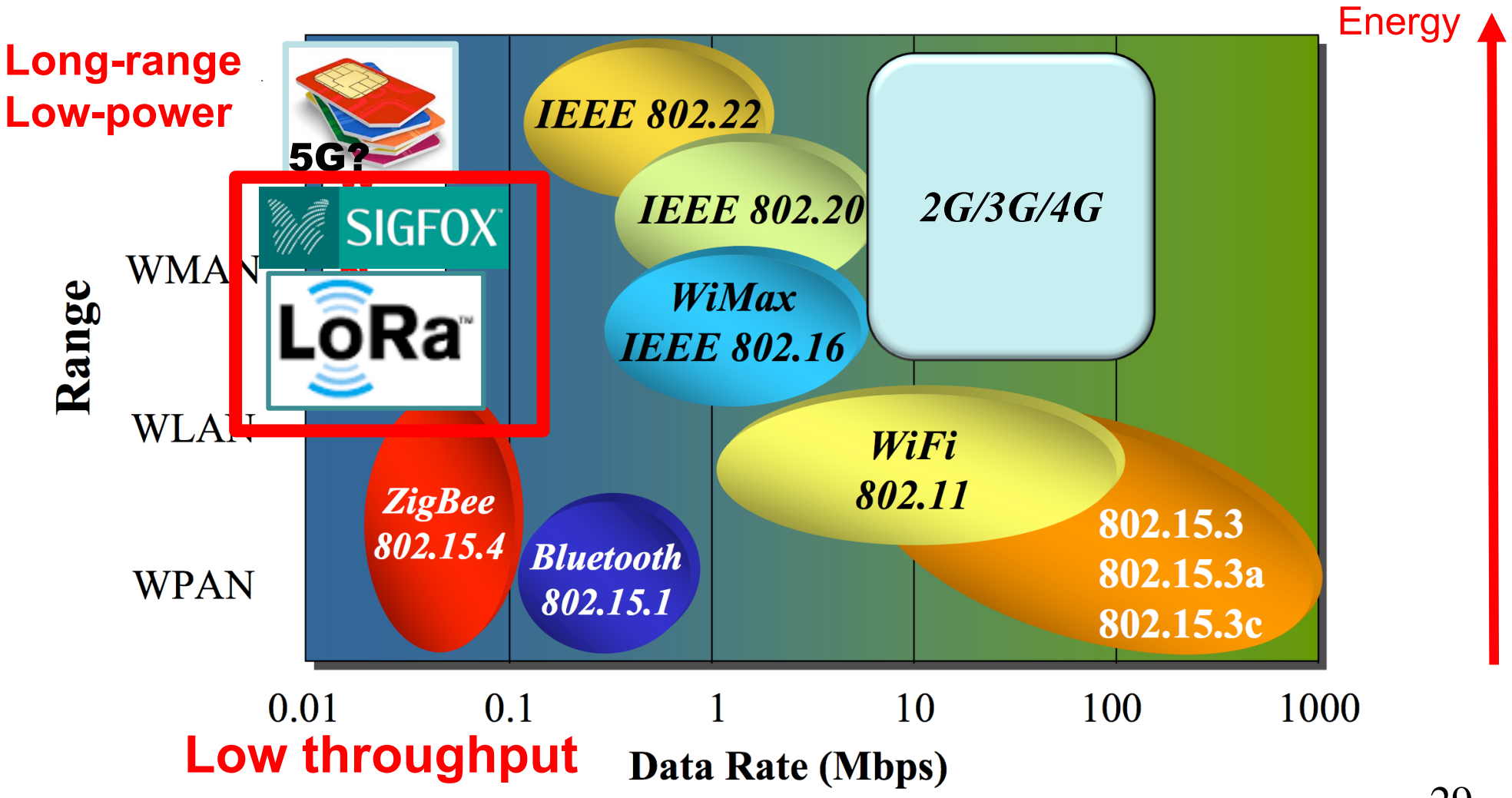


How bad is multi-hop routing?

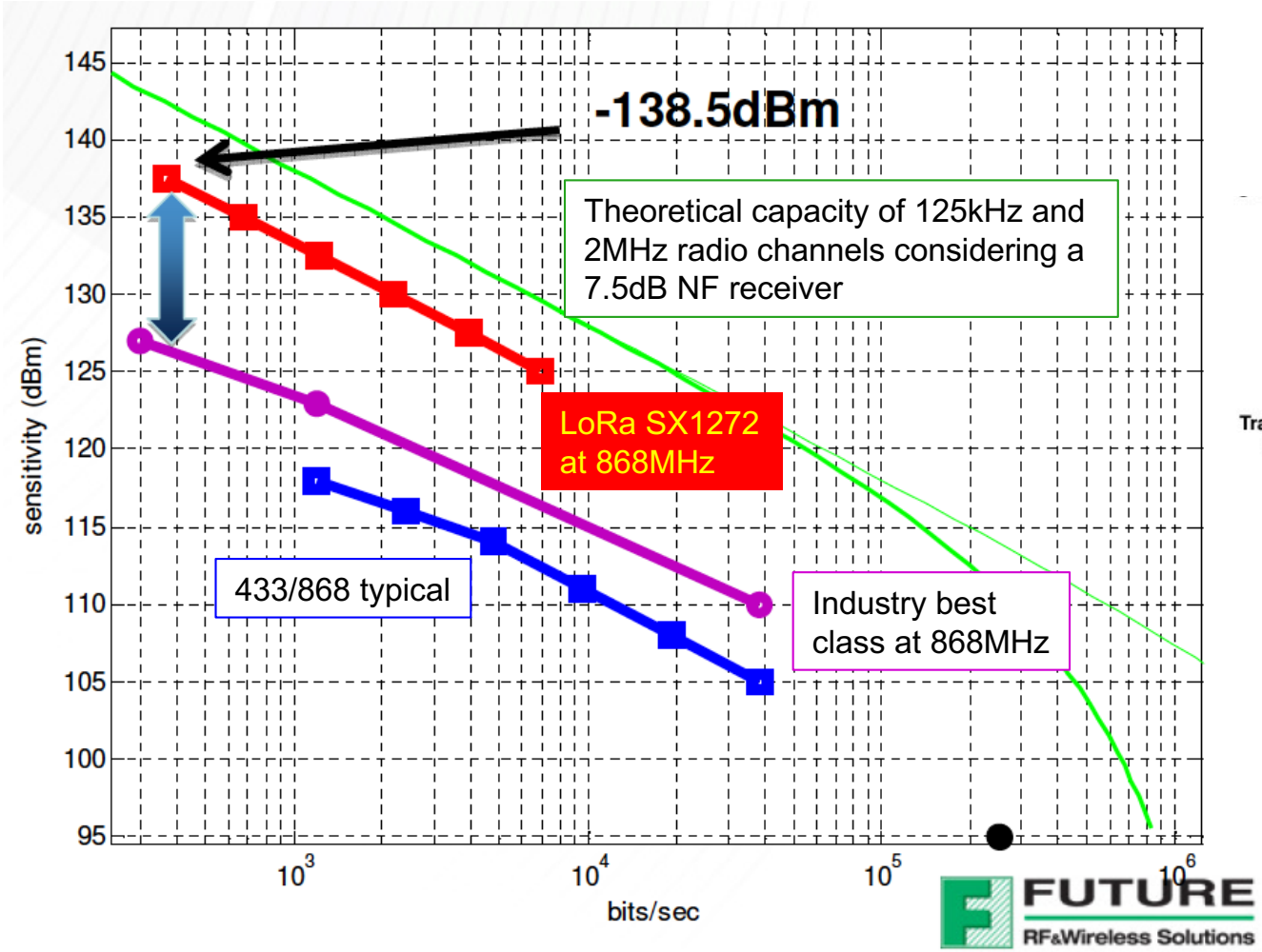
- Increases packet loss rate
- Increases end-to-end delivery time
- Consumes more energy as intermediate nodes must relay packets
- Limits energy saving mechanism benefits as both sender and intermediate node must be somehow synchronized
- Is impacted by intermediate node failure

Low-power & long-range radio technologies

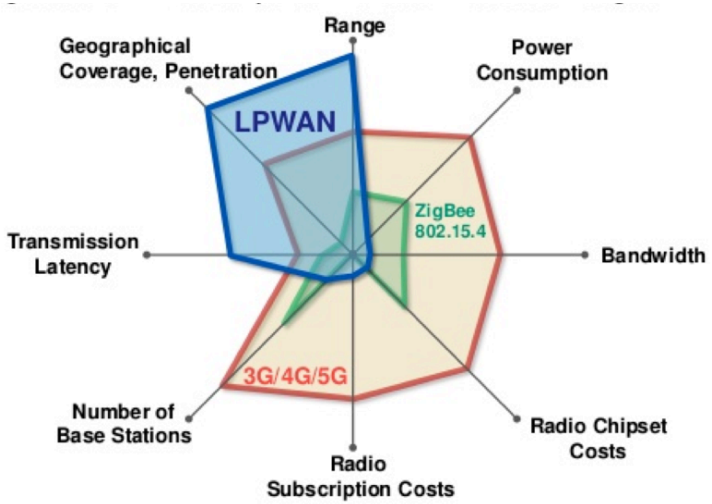
Energy-Range dilemma



The long-range revolution



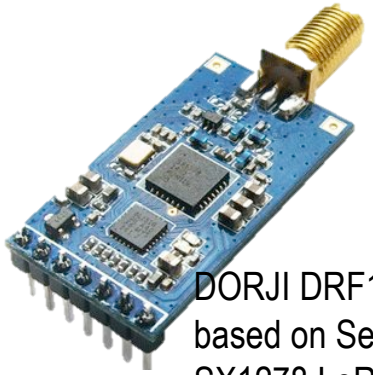
Sensitivity: lowest input power with acceptable link quality, typically 1% PER



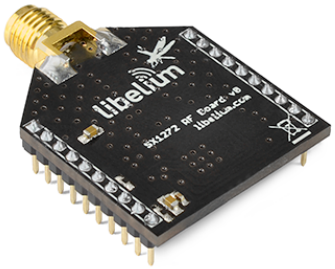
From Peter R. Egli, INDIGOO.COM

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

LoRa modules from Semtech's SX127x chips



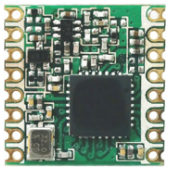
DORJI DRF1278DM is based on Semtech SX1278 LoRa 433MHz



Libelium LoRa is based on Semtech SX1272 LoRa 863-870 MHz for Europe

inAir9 based on SX1276

Froggy Factory LoRa module (Arduino)



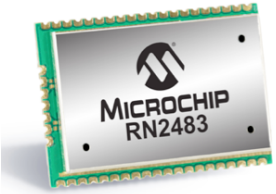
HopeRF RFM series

HopeRF HM-TRLR-D

LinkLabs Symphony module

IMST IM880A-L is based on Semtech SX1272 LoRa 863-870 MHz for Europe

Embit LoRa

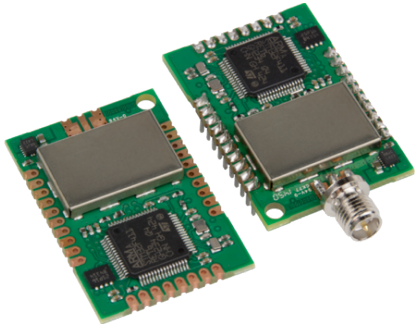


LoRa™ Long-Range Sub-GHz Module (Part # RN2483)

Microship RN2483

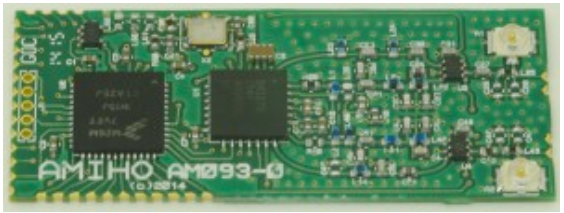
habSupplies

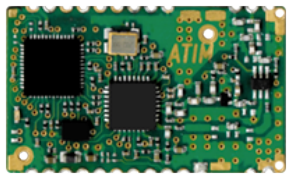
Adeunis ARF8030AA- Lo868



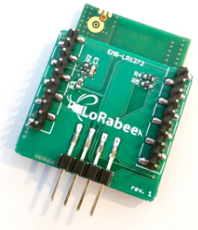
Multi-Tech MultiConnect mDot

AMIHO AM093





ARM-Nano N8 LoRa module from ATIM



SODAQ LoRaBee Embit

SODAQ LoRaBee RN2483

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

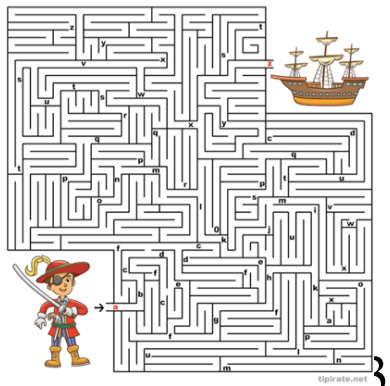
2500/0.266=9398h = 391 days = 13 months

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

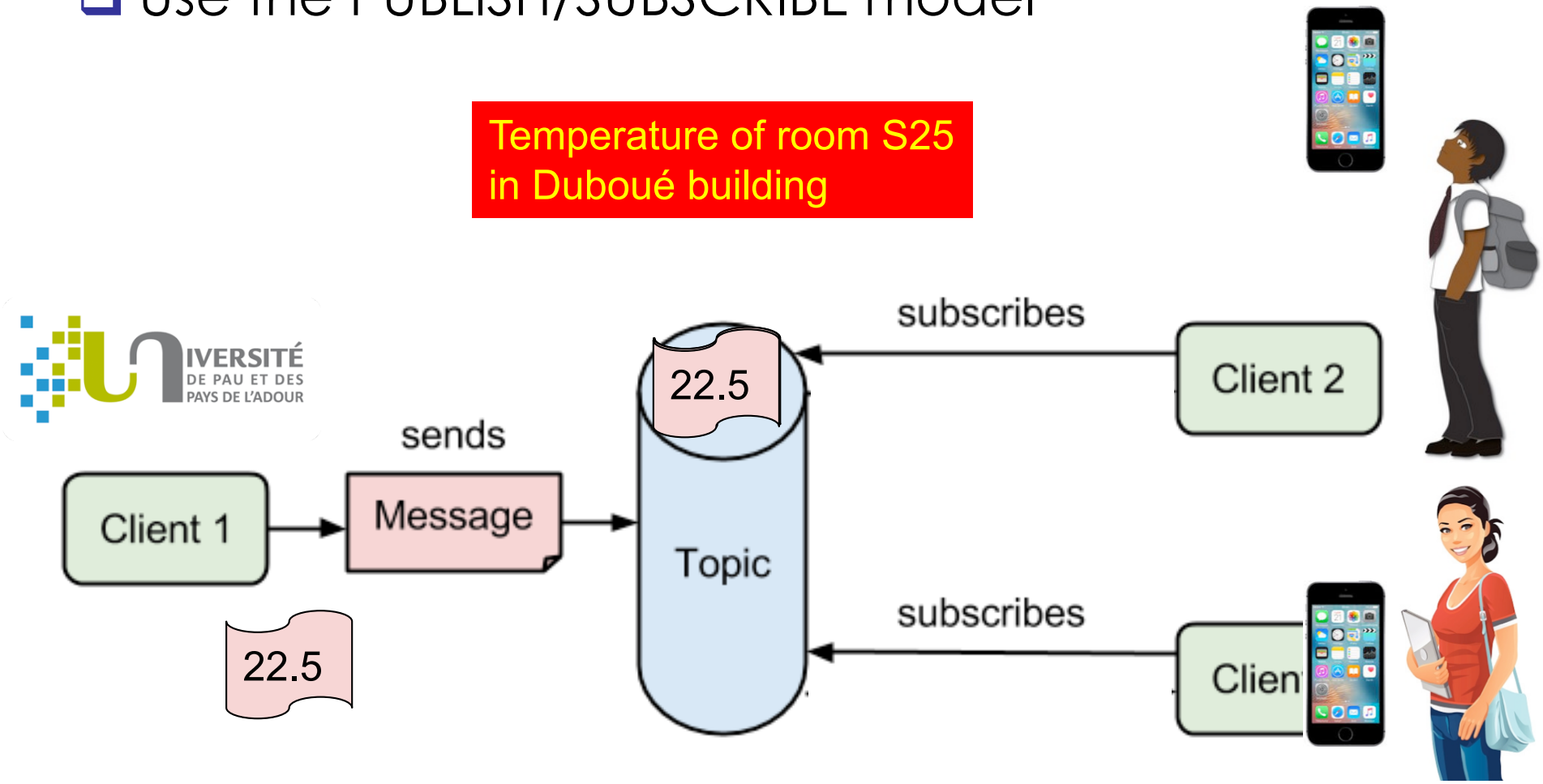
ThingSpeak

- 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"

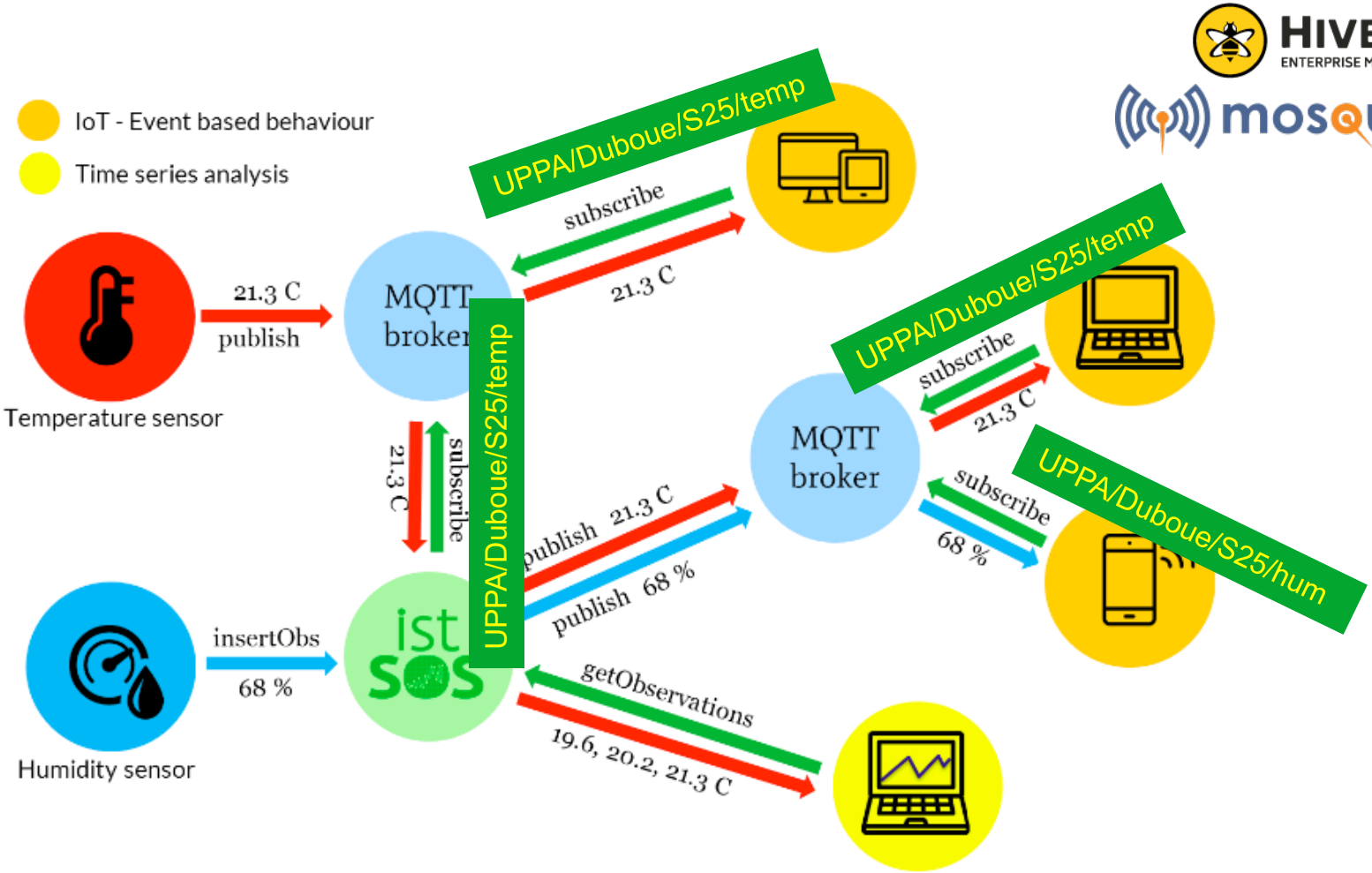
- Use the PUBLISH/SUBSCRIBE model



MQTT

Message Queue Telemetry Transport

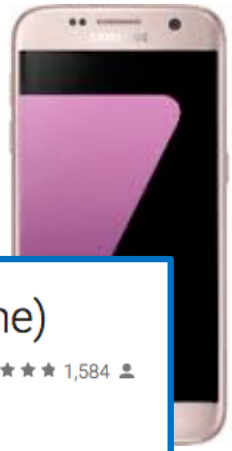
- Use broker nodes to manage topics
  - UPPA/Duboue/S25/temp, UPPA/Duboue/S25/hum



Towards open data?

- CMR/YAOUNDE/UMMISCO/PROJECT1/#
- CMR/YAOUNDE/CITY/WEATHER/#
- CMR/DOUALA/WHARF12/AREA23/CONT/TC
- …

MQTT+SMARTPHONE=



MQTT Dash (IoT, Smart Home)

Routix software Communication 1,584

PEGI 3

This app is compatible with all of your devices.

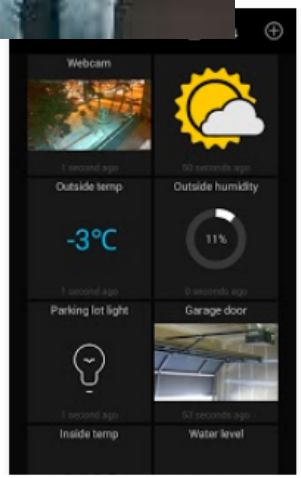
Installed

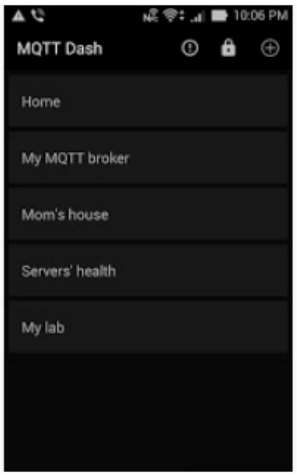
Maxime Carrier

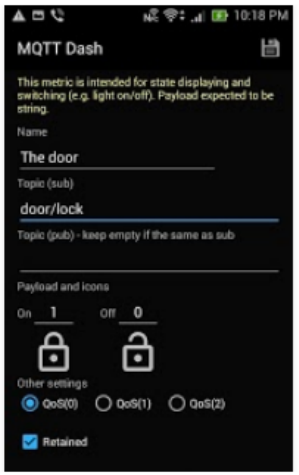
instant:solutions

Mqtt Broker App
Anshul Katta

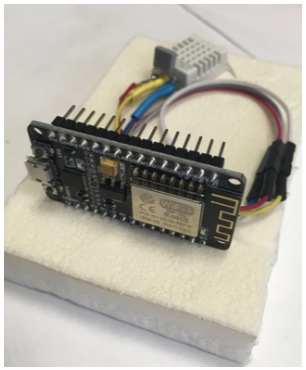
Zanzito - MQTT
Gianluca Barbaro







4TH ISSUE: MAKE IT SIMPLER?



FIWARE

Firebase

ioBridge® Connect things.

dweet.io

TempoIQ

ThingSpeak

freeboard

GroveStreams

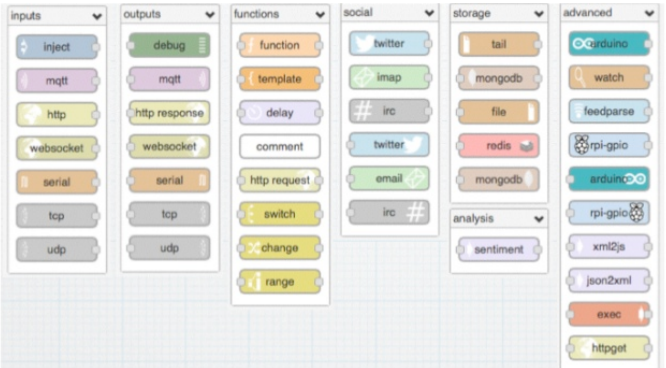
SensorCloud™

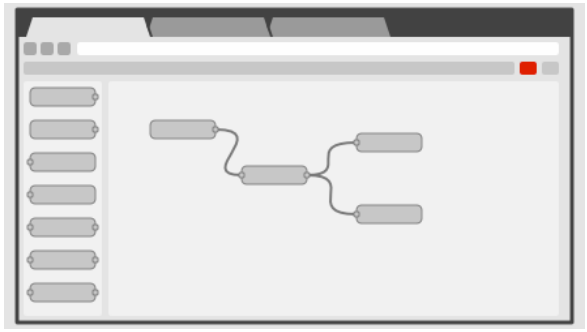
OpenRemote

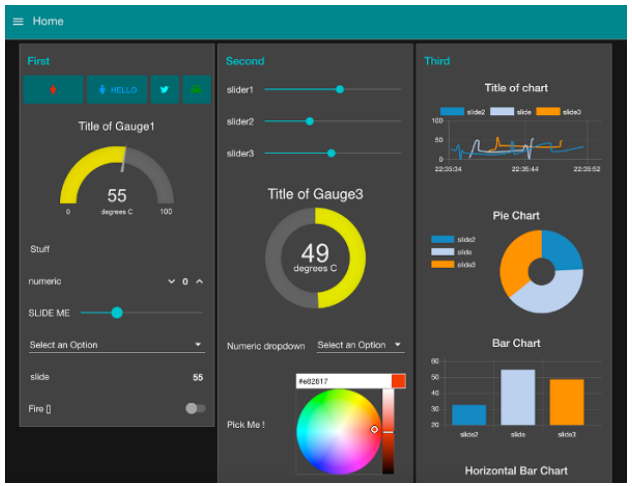
- End-users are not necessarily computer science experts nor high-skilled programmers
- Use graphical tools to build data processing flows, allowing intuivive connection from data producers to data consumers

Node-Red

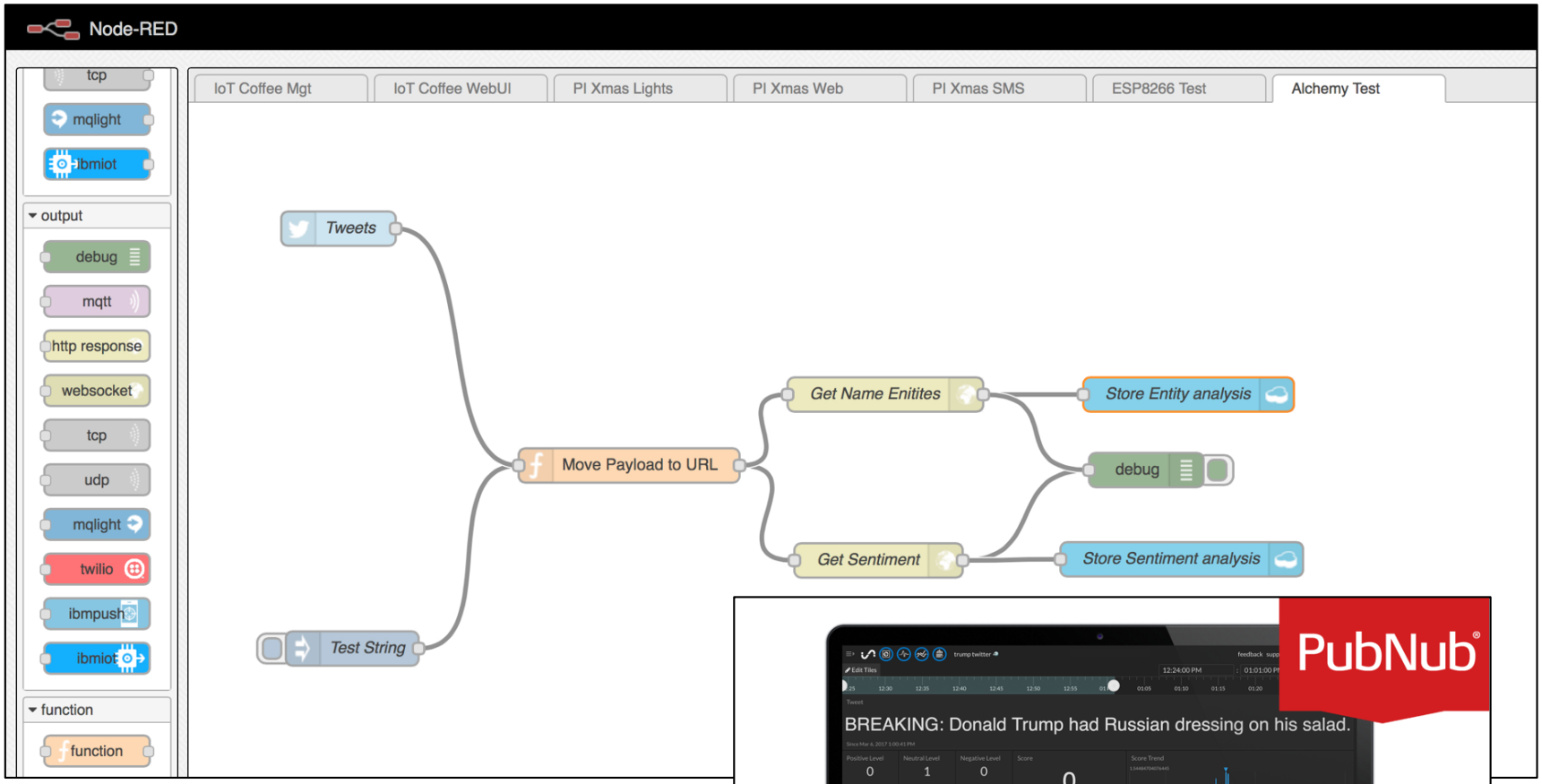
- Node-RED is a programming tool for wiring together hardware devices, APIs and online services, e.g. clouds of various types
- provides a browser-based flow editor to wire together flows with a wide range of nodes







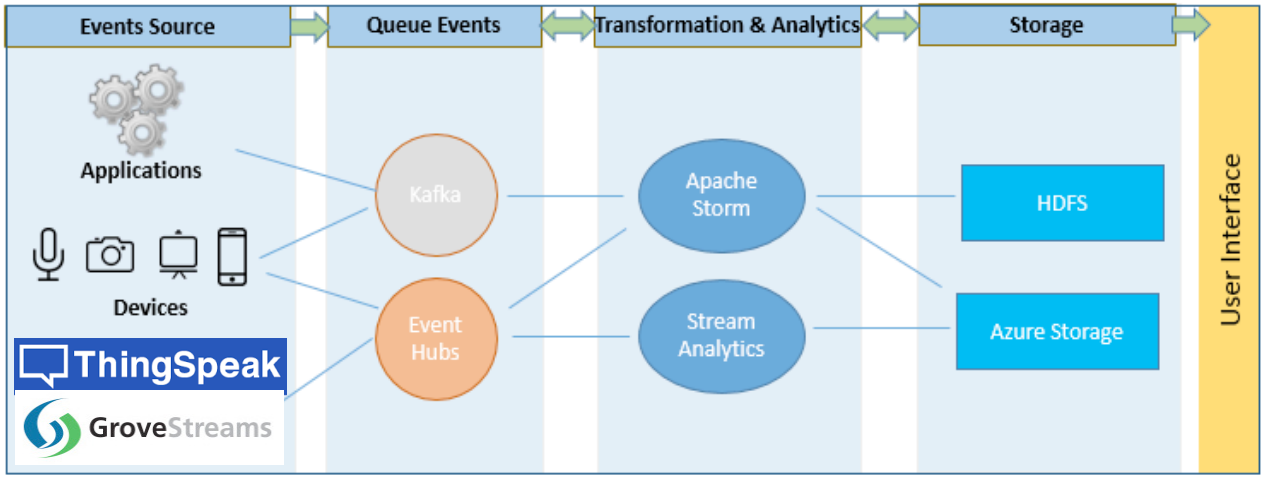
Example



From AlchemyAPI and NodeRED on Bluemix

From PubNub Live Twitter Dashboard (feat. President Trump)

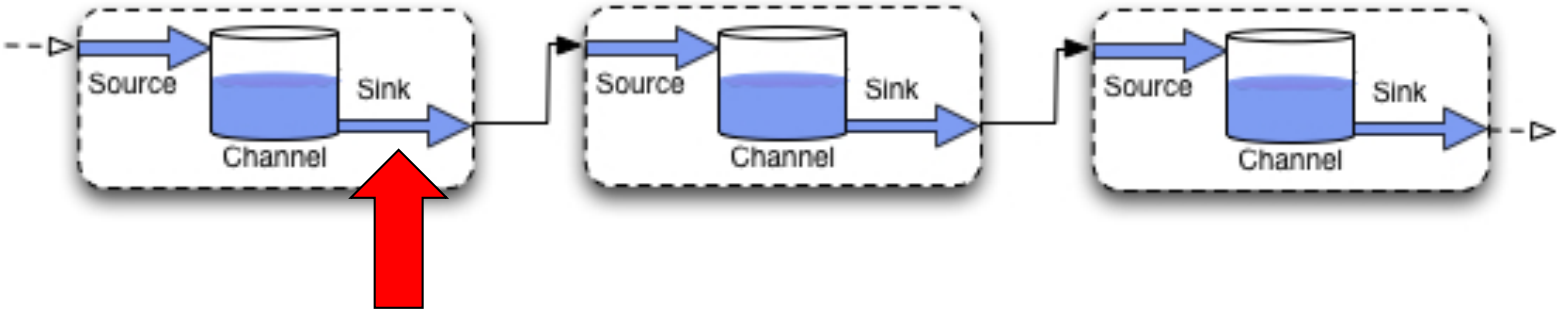
Connecting to advanced data mngt/analytic platforms



SensorCloud

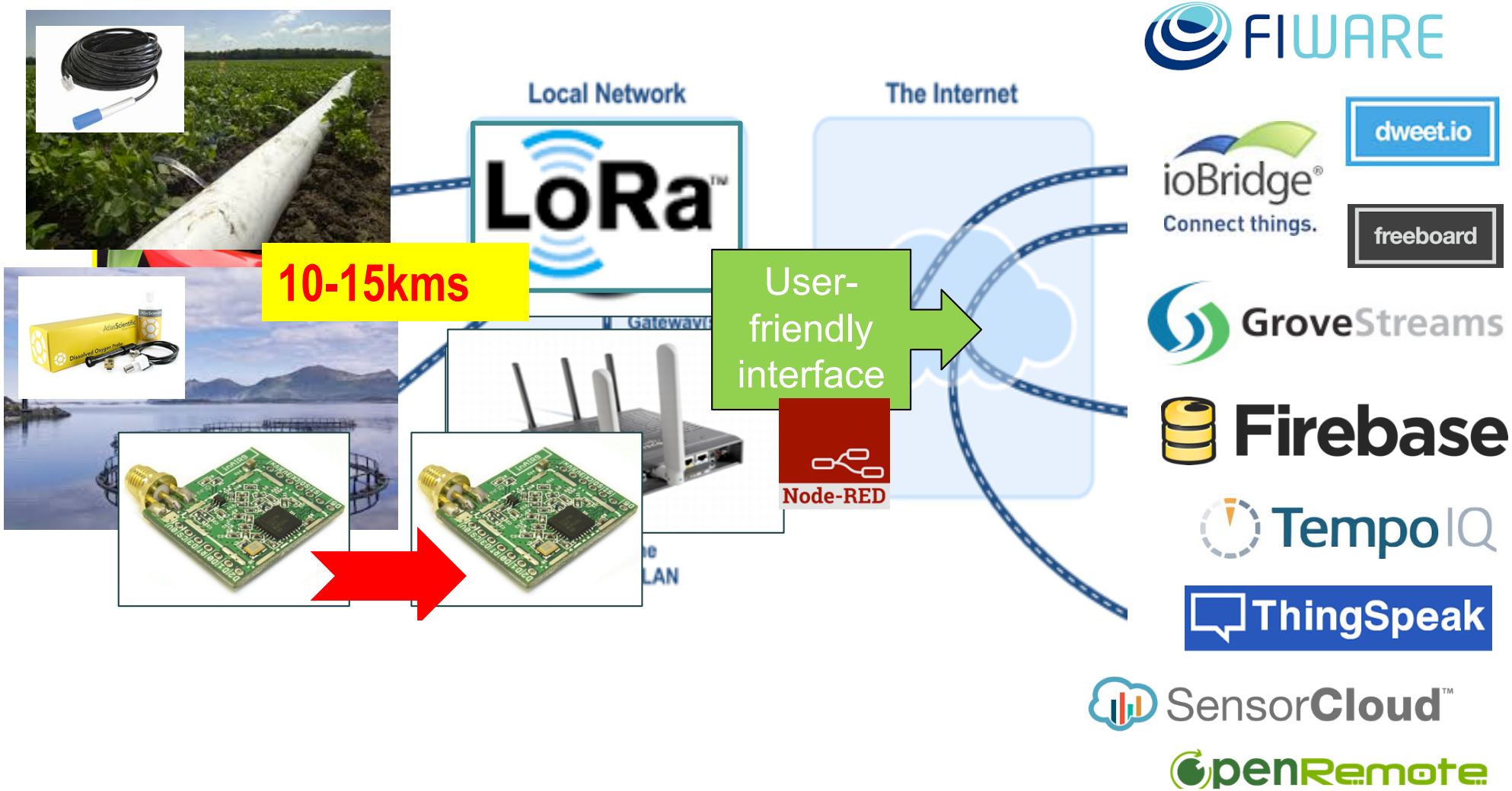
kafka

ThingSpeak

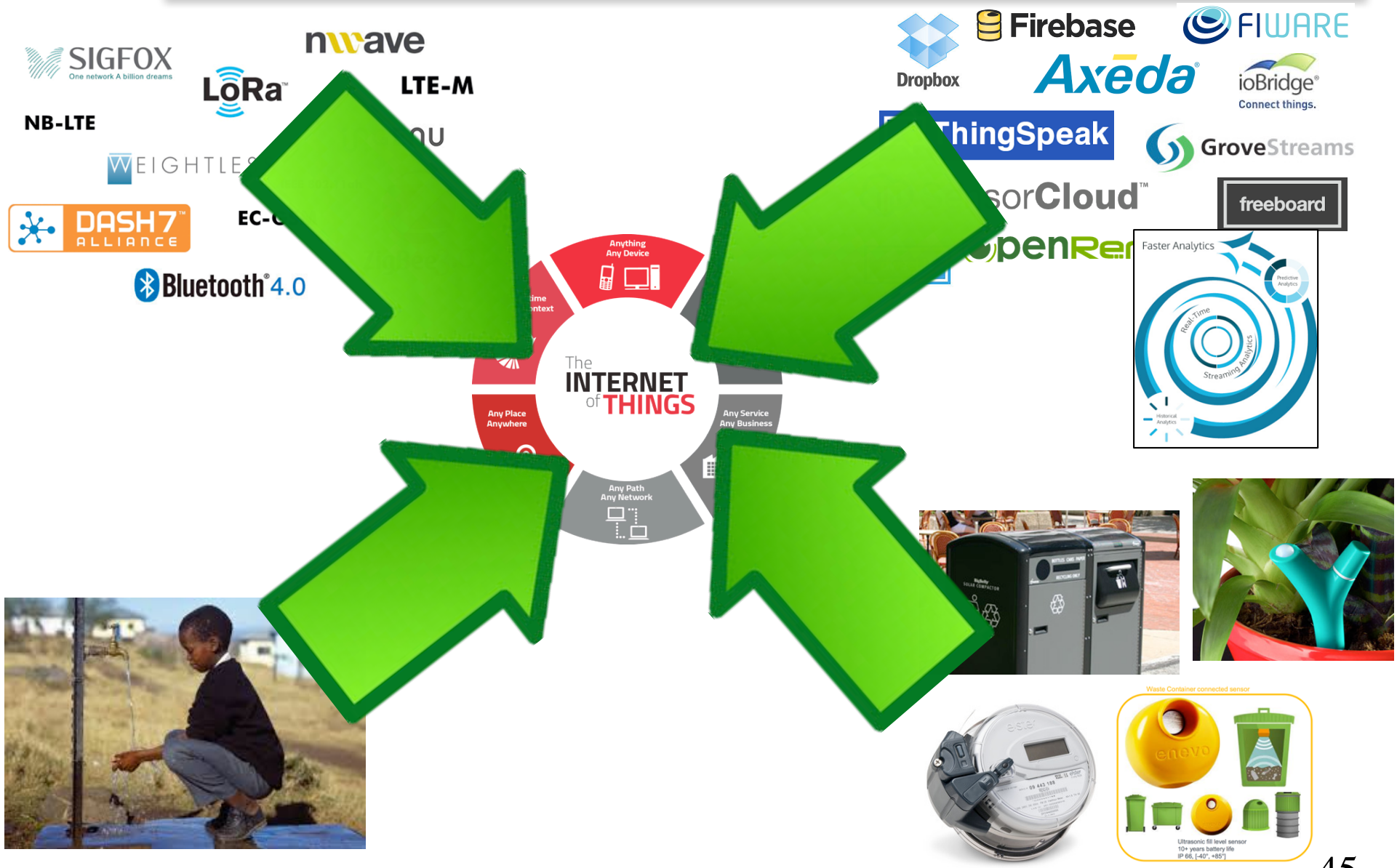


Advanced & customized data management

Global picture of long-range IoT ecosystem



IoT becomes reality!



A REALITY FOR EVERYBODY?

Needs, constraints, cost, design approach, control mechanism

Challenge 2: Bridging the digital divide

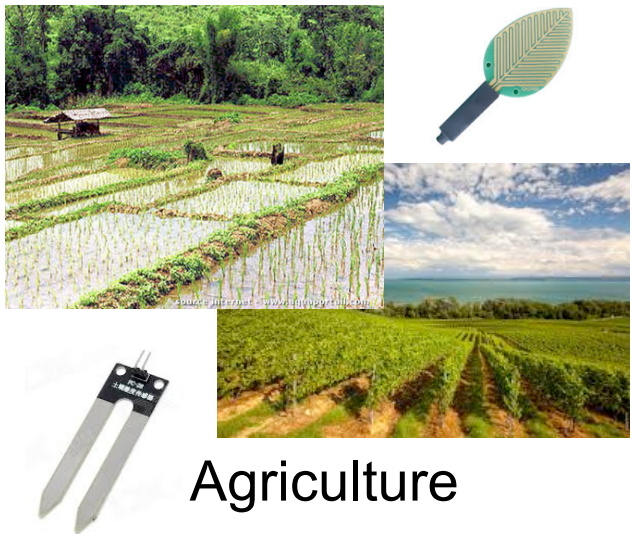
IoT4D
DEVELOPMENT FOR RURAL AREAS

Irrigation

Livestock farming

Fish farming & aquaculture

Storage & logistic



Agriculture

Environment

MATURATION OF THE IoT MARKET…

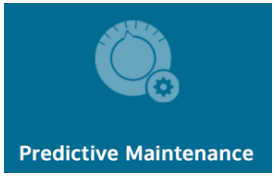
… but not adapted for rural developing countries context & environment

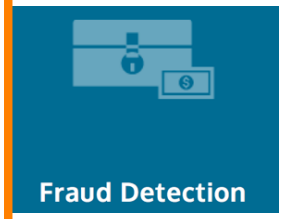
Too expensive
Too integrated
Highly specialized
Difficult to customize
Difficult to upgrade

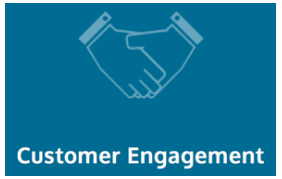
Internet, Cloud & big data analytics

Internet connectivity is weak and expensive!

Nearly impossible in remote/rural areas







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

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

HORIZON 2020

Affordable technologies to empower rural economics

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

Develop IoT solutions and applications meeting African needs

DO MORE with LESS

www.waziup.eu

Waziup IoT

Waziup IoT

Waziup

Waziup

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

waziup.community@create-net.org

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 personaly & 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)

Community building for sustainable innovation

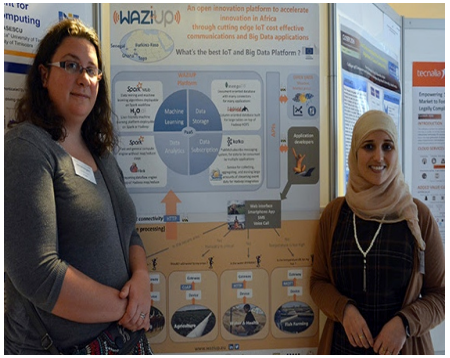
International Events
+ 20 organized & attended

Launch event (Senegal, CTIC Dakar)

Launch event (Ghana, iSpace)

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

IoTWeek2016 (Belgrade, EGM)

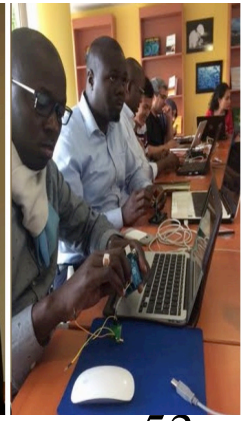


IoTBigData2016 (Italy, EGM)

IoTCareConference (Budapest, CNET)

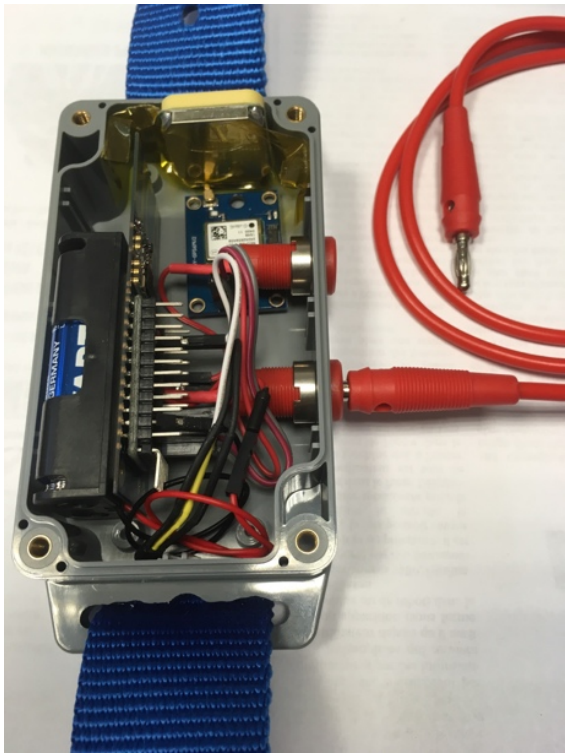
WAZIUP Workshop on IoT (Togo, L'Africaine d'Architecture)

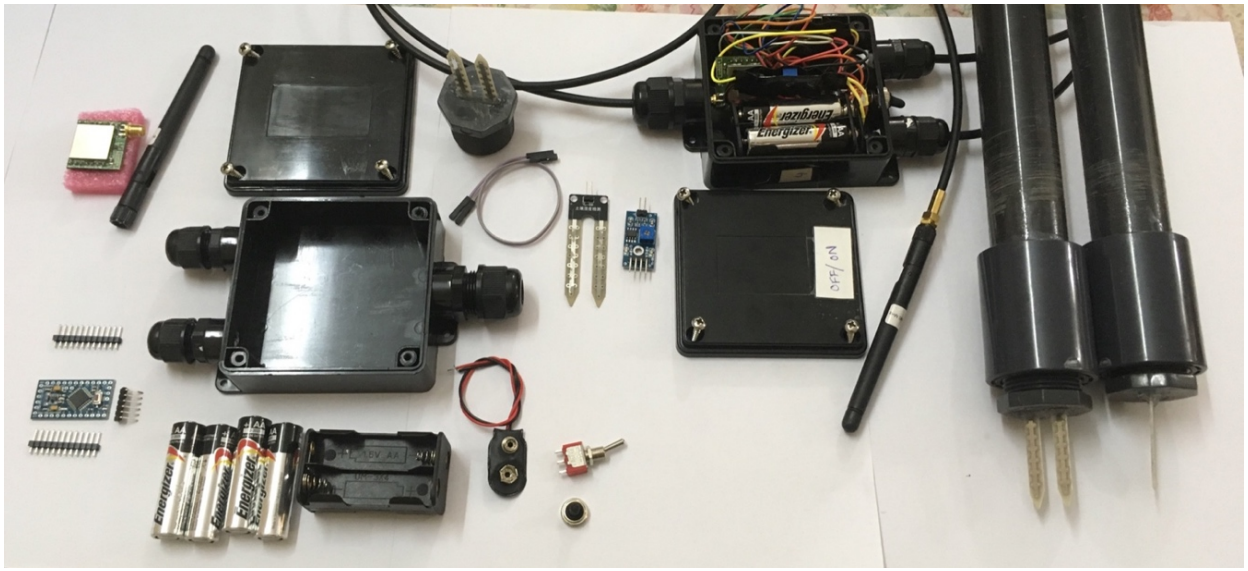
Credit: C. Vavasseur, CTIC Dakar



Workshop at the RESSACS 2016 (France, UPPA)

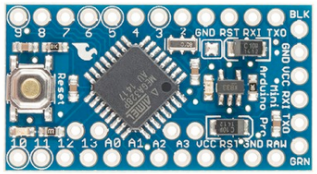
Low-cost IoT devices





Low-cost hardware

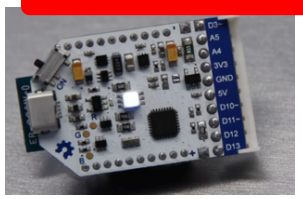
Arduino Pro Mini



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/

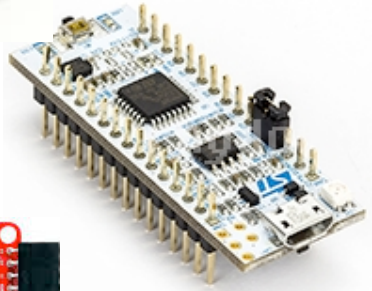


Theairboard

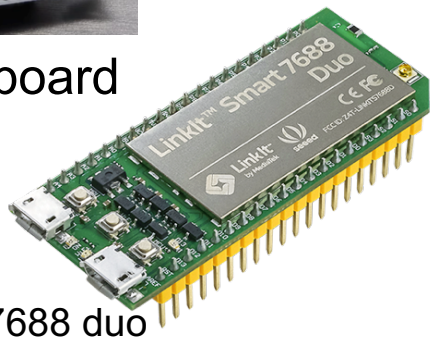
Teensy 3.2

Expressif ESP32

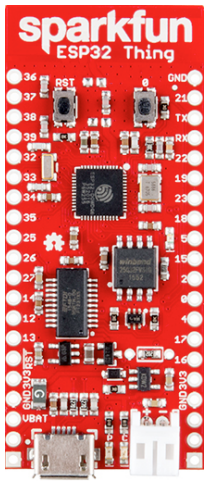
STM32 Nucleo-32



Heltec ESP32 + OLED



LinkIt Smart7688 duo

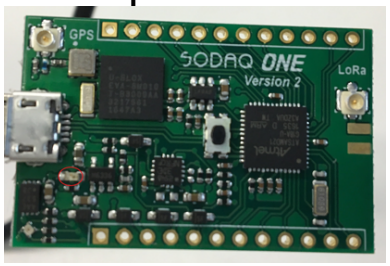


Adafruit Feather

Sparkfun ESP32 Thing

Tessel

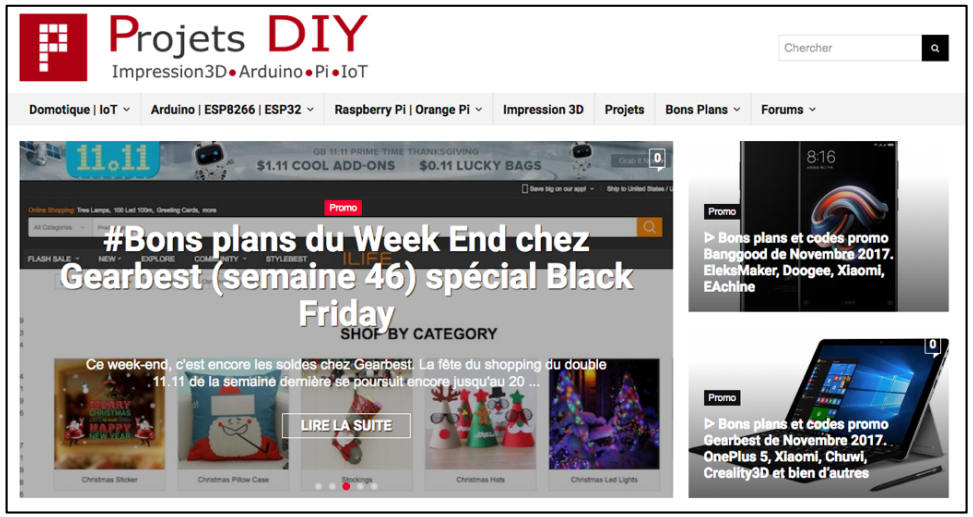
SodaqOnev2

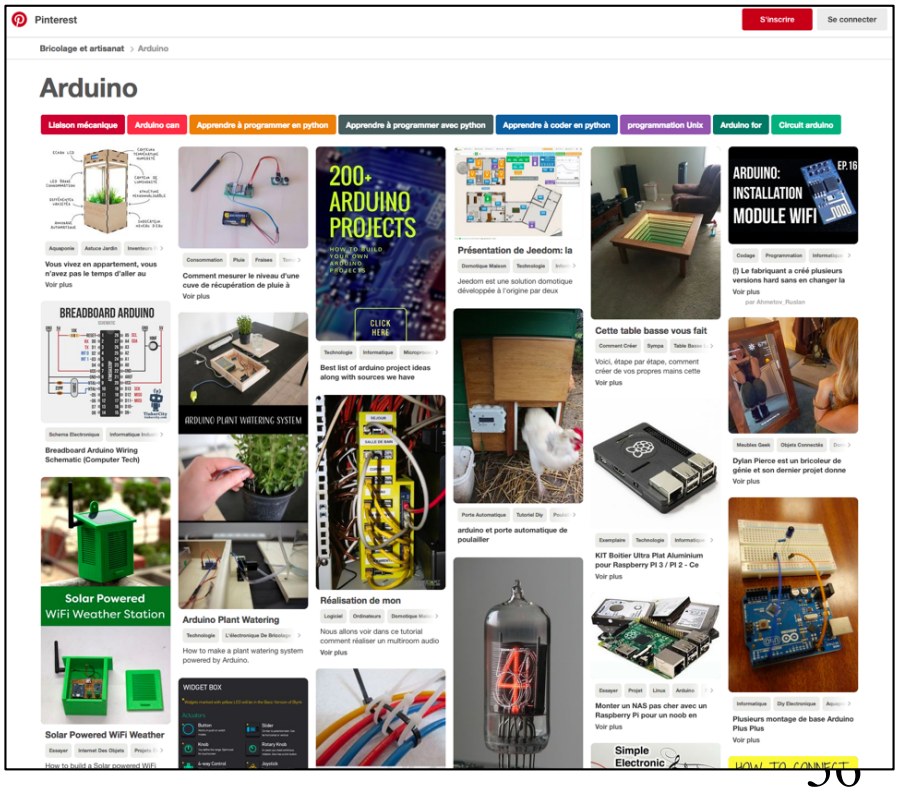


Tinyduino

… stimulating "Do-it-Yourself" worldwide

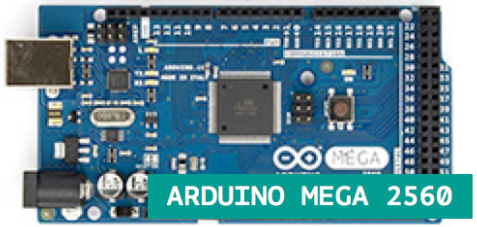
- DIY usually means
  - More open-source software from larger community
  - More flexibility

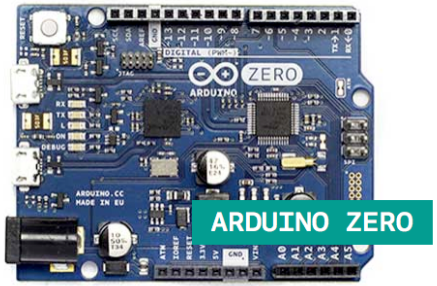


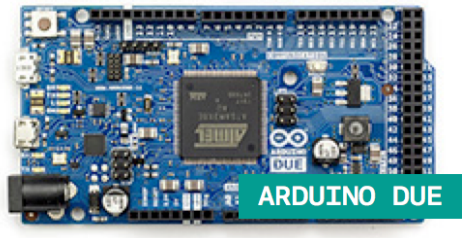


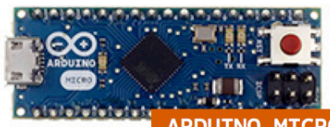
WAZIUP PROVIDES SW/HW BUILDING BLOCKS INTEGRATION

ARDUINO UNO

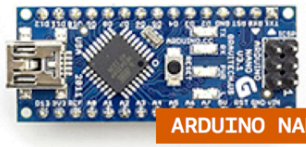

ARDUINO MEGA 2560

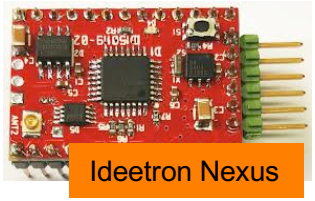

ARDUINO ZERO


ARDUINO DUE


ARDUINO MICRO

ARDUINO PRO MINI


ARDUINO NANO


Ideetron Nexus

TeensyLC/3.1/3.2

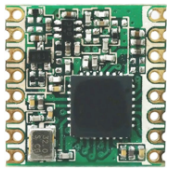
Adafruit Feather 32u4/M0

Expressif ESP8266/ESP32

More to come…

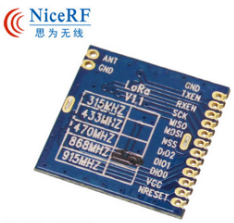
LoRa

LoRa radios that our library already supports


HopeRF RFM92W/95W

Libelium LoRa

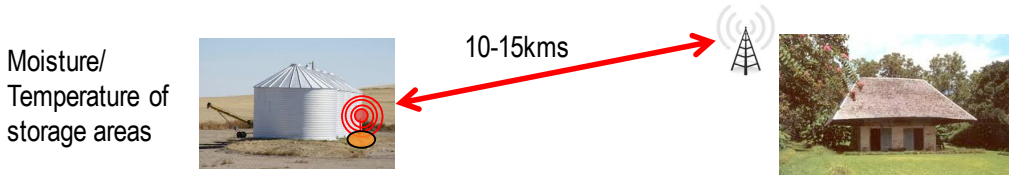
Modtronix inAir9/9B

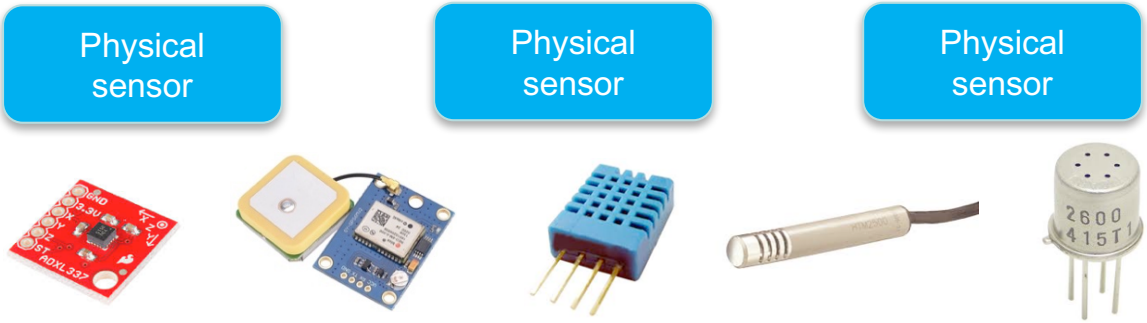


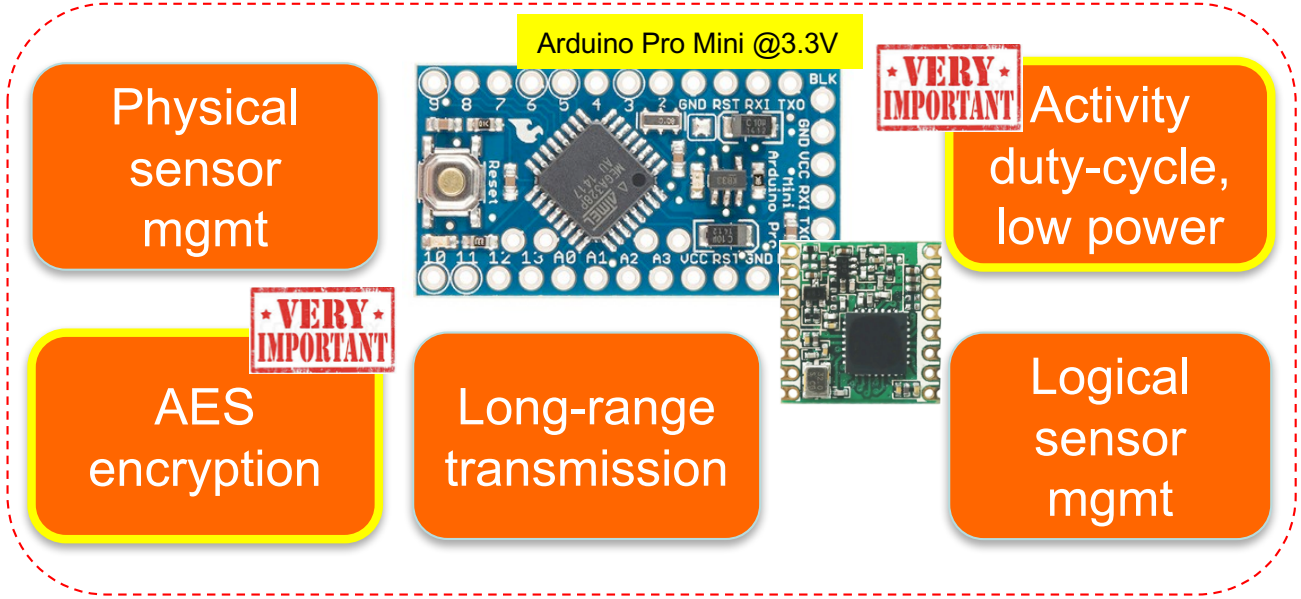
NiceRF LoRa1276

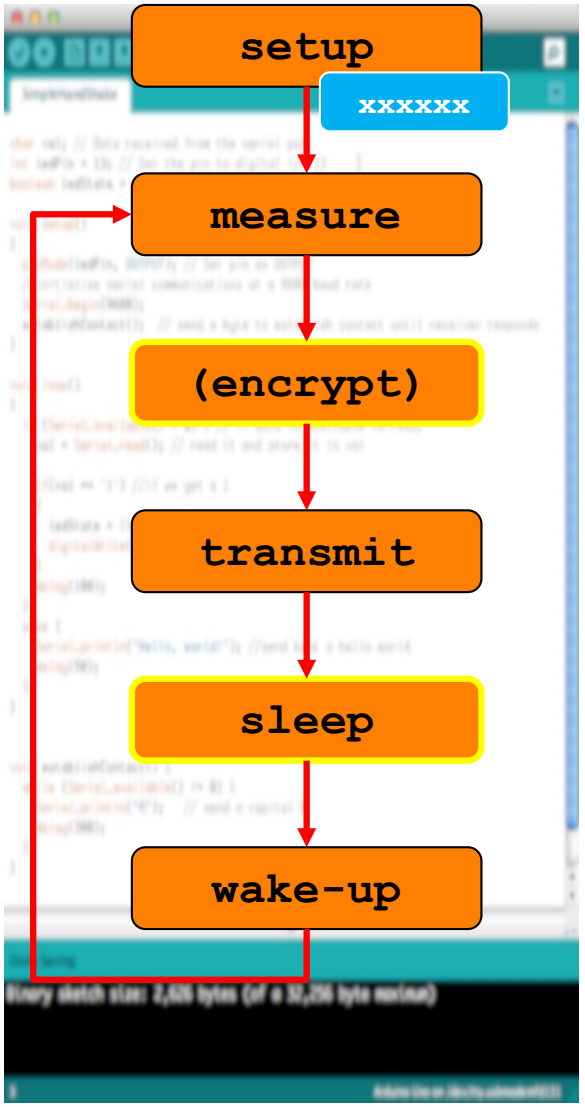
Long-Range communication library

Ready-to-use templates



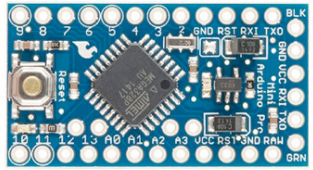






A simple temperature sensor example

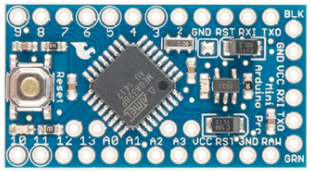
Arduino Pro Mini @3.3V



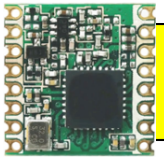
Modtronix inAir9

TMP36

Low-cost integration

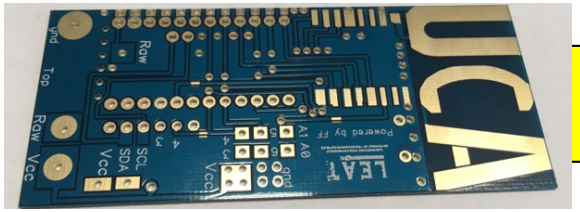


1.5€

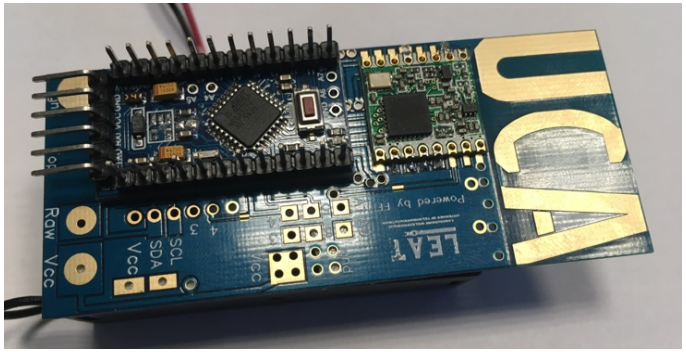


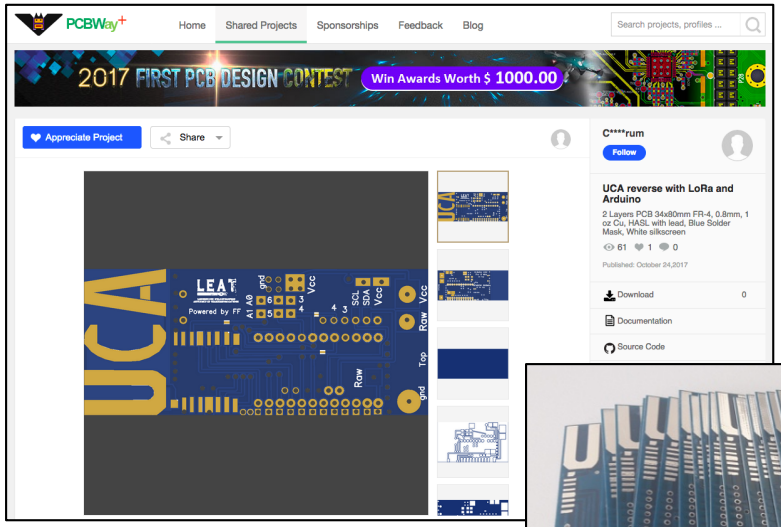
5€

https://github.com/FabienFerrero/UCA_Board



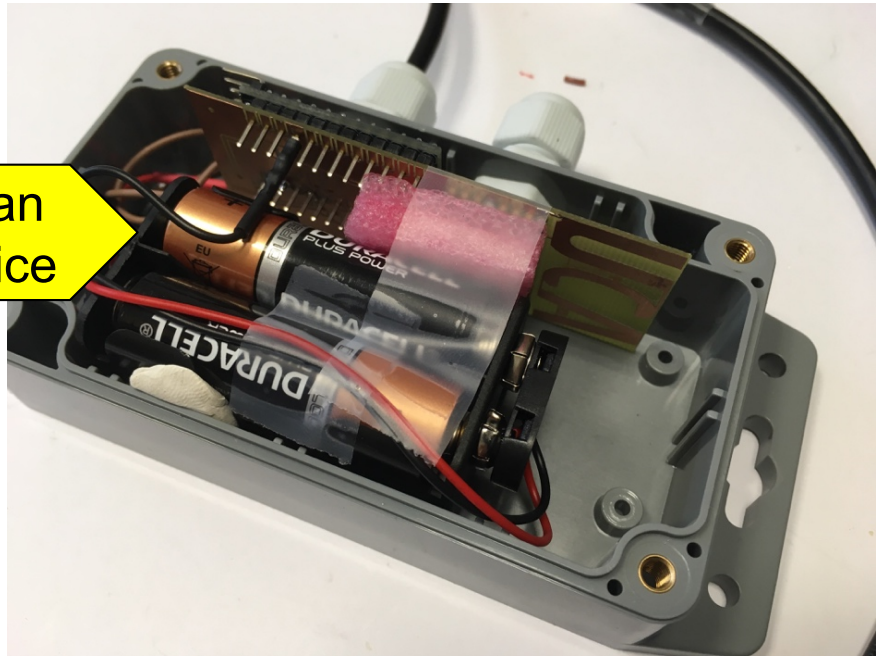
1€





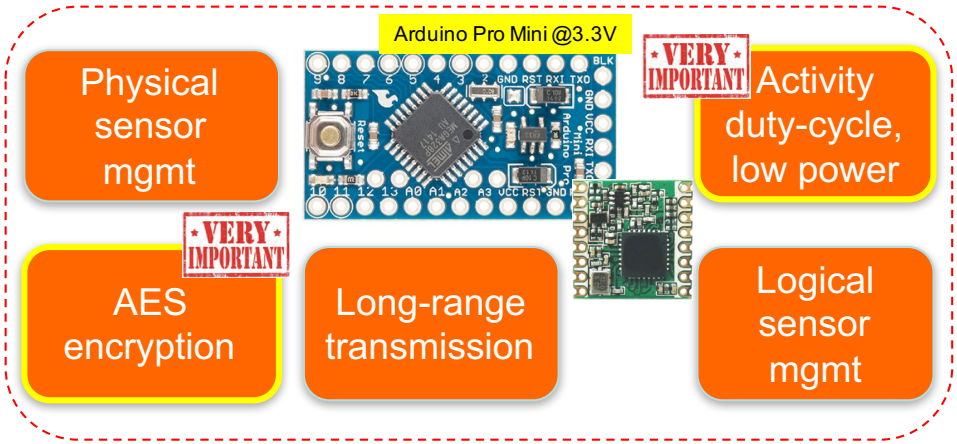
1-click order

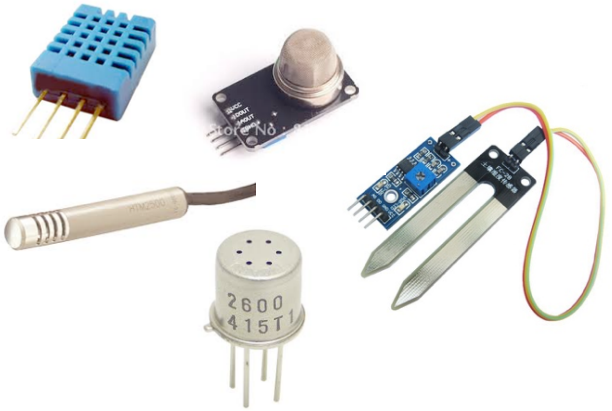
Less than 10€/device



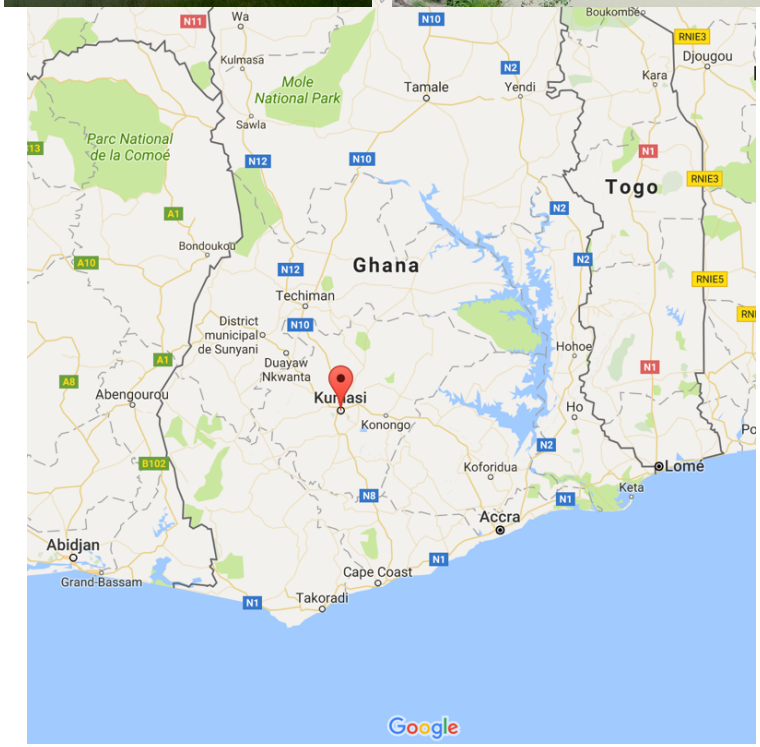
Generic sensing IoT device vs Highly specialized

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

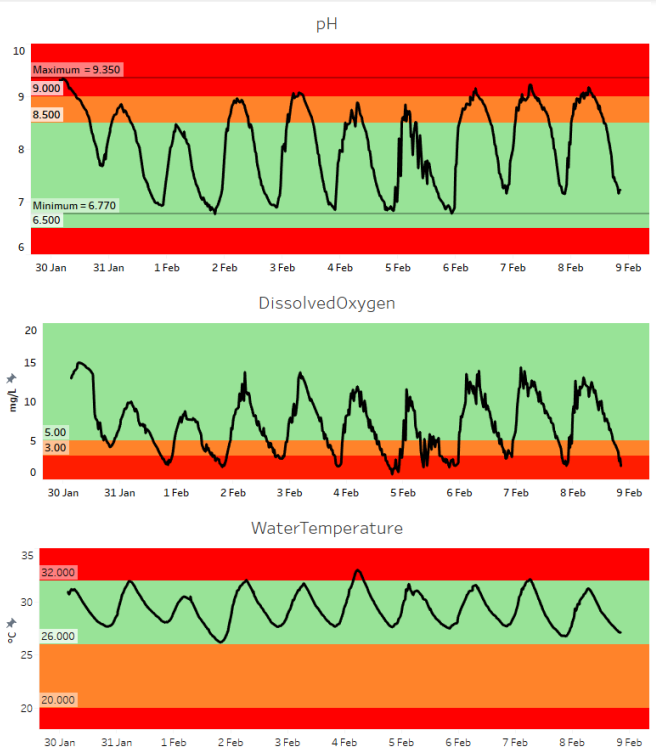




Fish Farming in Kumasi, Ghana



Low-cost buoy for fish farming MVP



Physical sensor reading

Credit: EGM

Physical sensor management

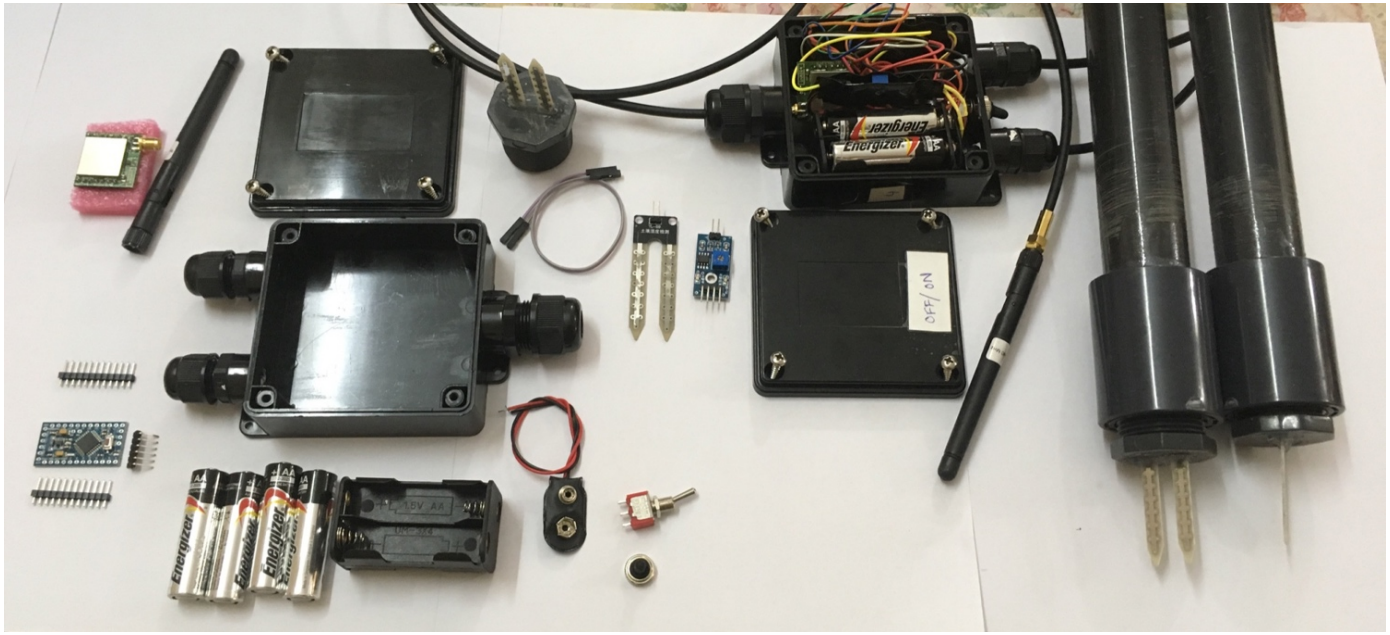
Activity duty-cycle, low power

Security

Long-range transmission

Logical sensor management

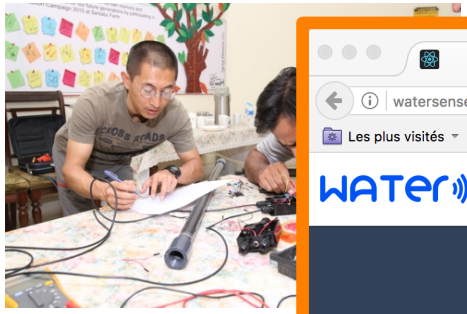
Soil humidity sensors for agri MVP

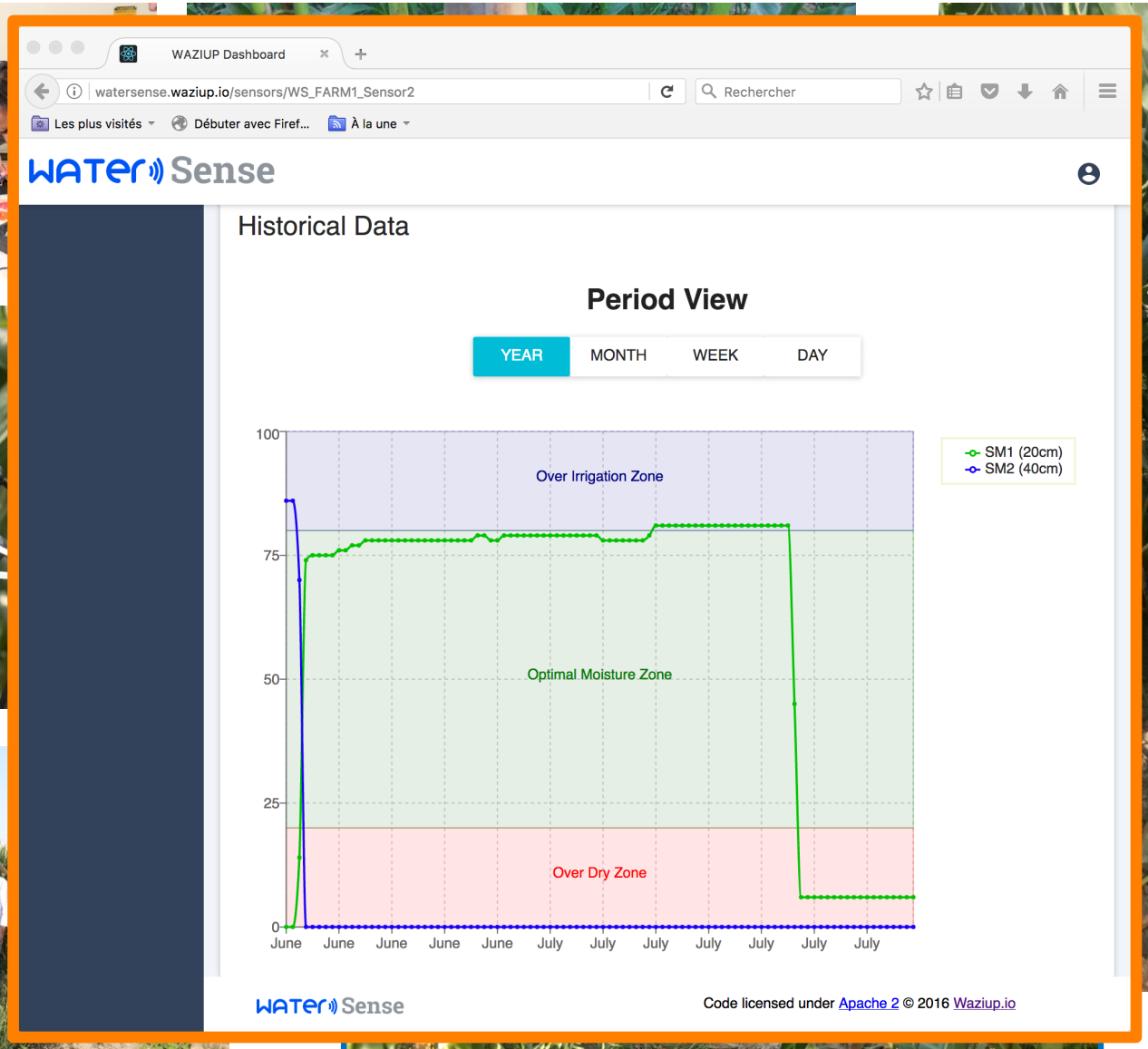


- Physical sensor management
- Activity duty-cycle, low power
- Security
- Long-range transmission
- Logical sensor management

Deployment for Nestlé's WaterSense project

Deployment for Nestlé's WaterSense project

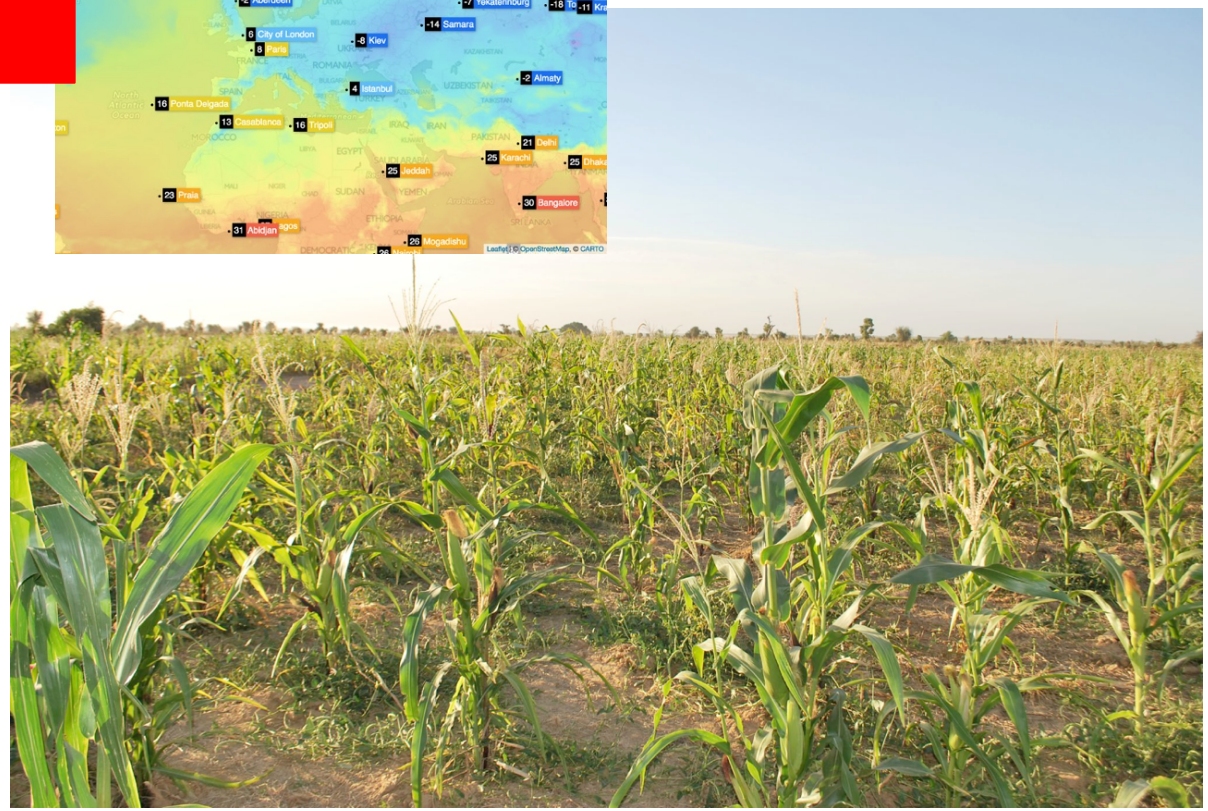




Local weather station for AGRI MVP

https://openweathermap.org/

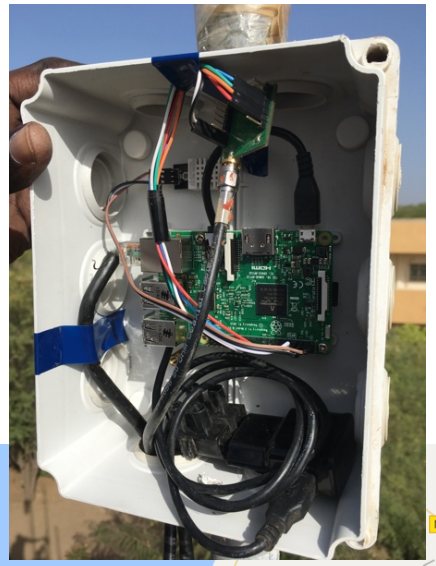
Photo from Unparallel

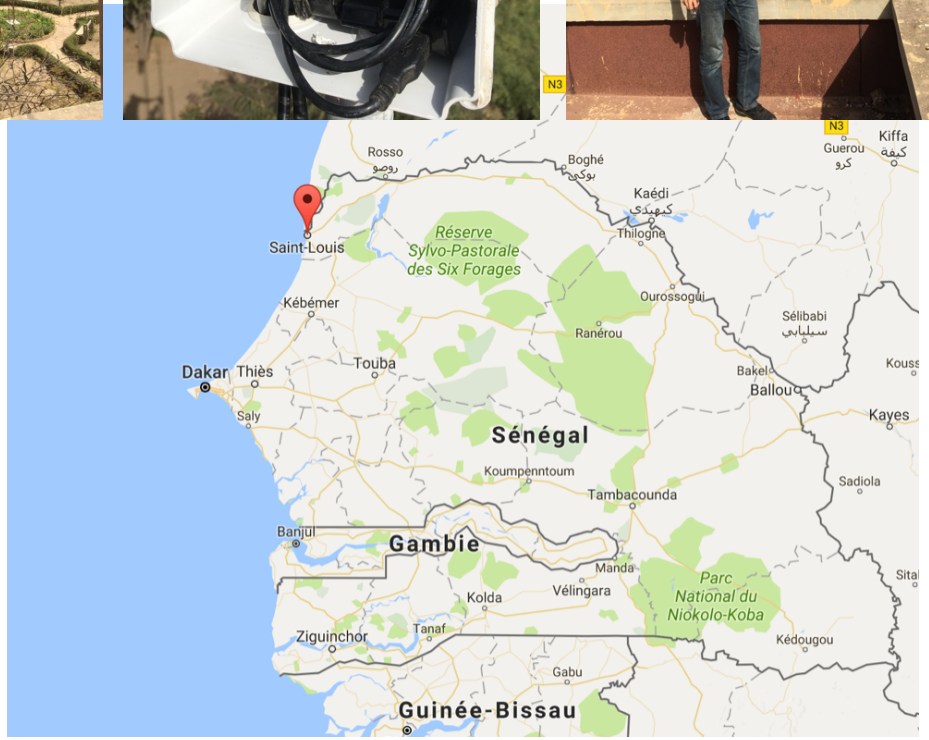


Get local weather measuments

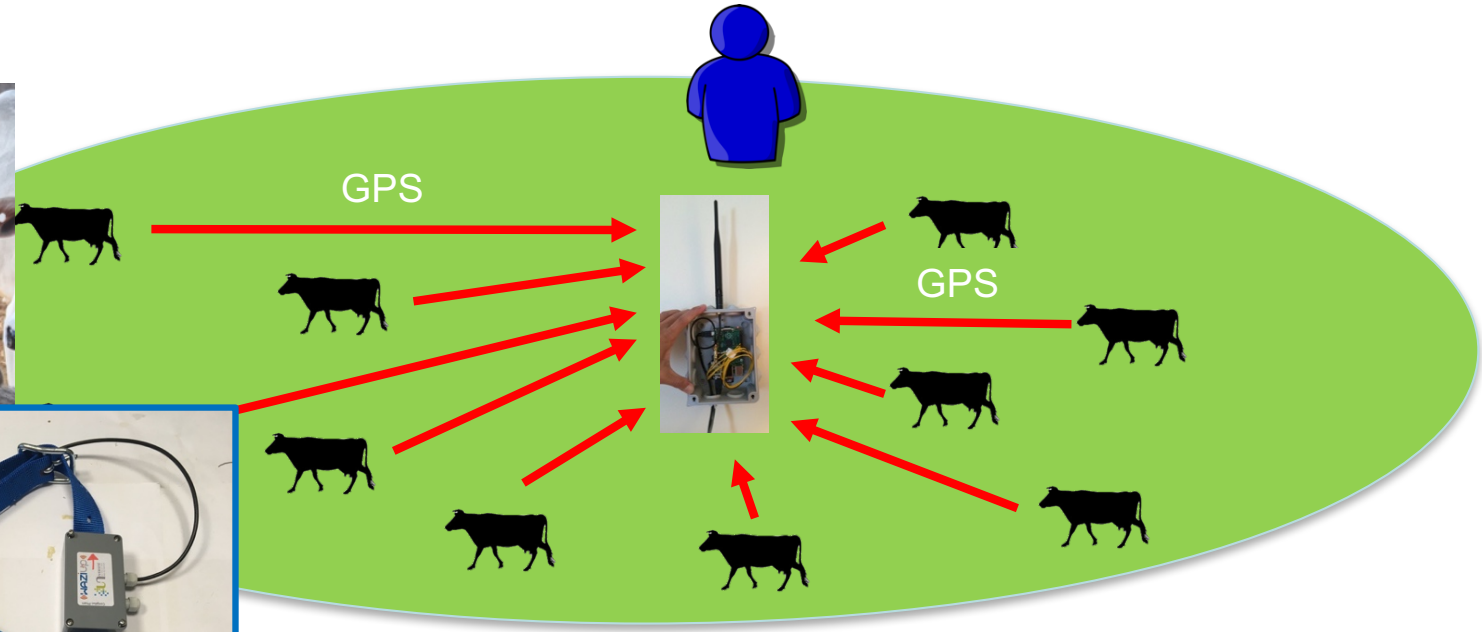
Combine with open weather data to get more accurate predictions

Cattle Rustling in Saint-Louis, Senegal





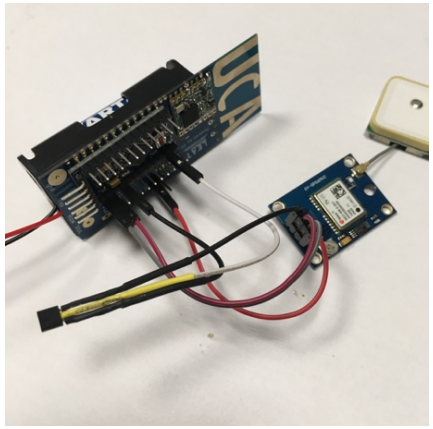
Collar for Cattle Rustling MVP

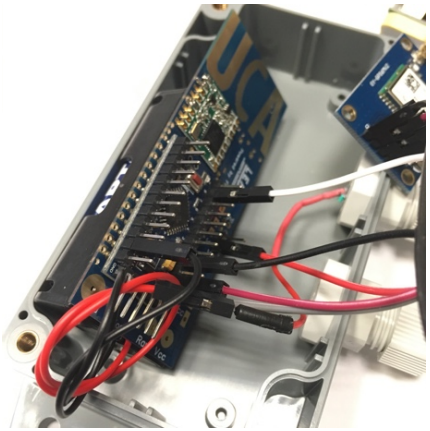


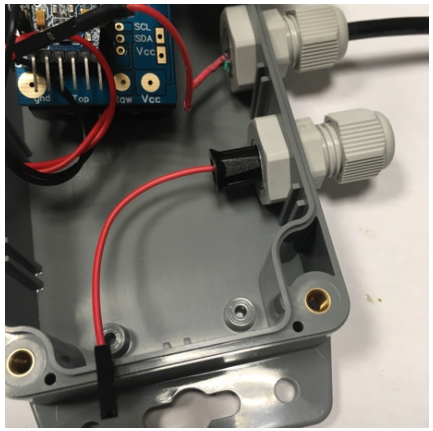
In Africa, the practice of animal husbandry has always been and still remain farmers' livelihood and incomes

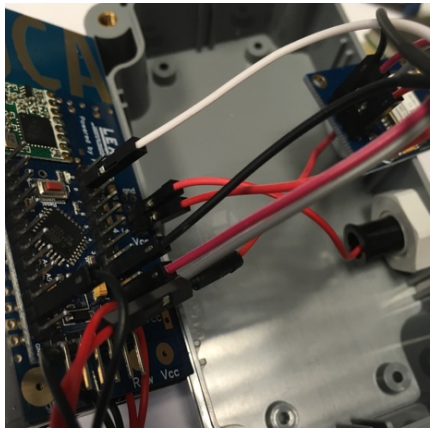
Their main problem in this activity remain the cattle rustling and some families are put in dramatic situation after a theft (reported 2 billions CFA losses)

Easy integration and customization

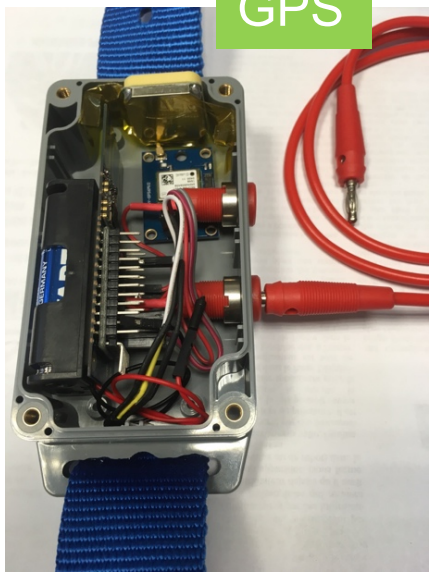


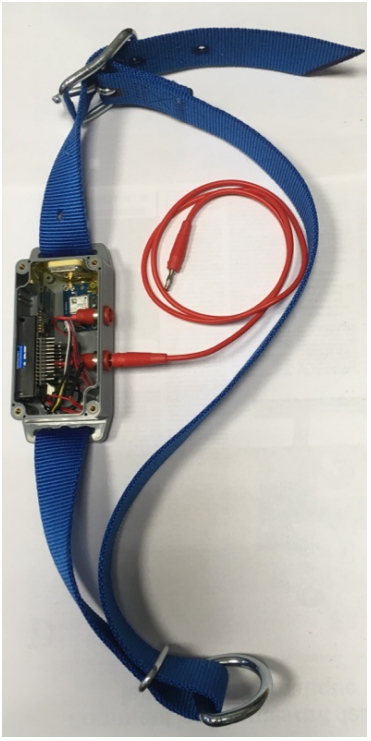






GPS





A web interface can be developped to display the position of the gateway and the position of the remote GPS devices

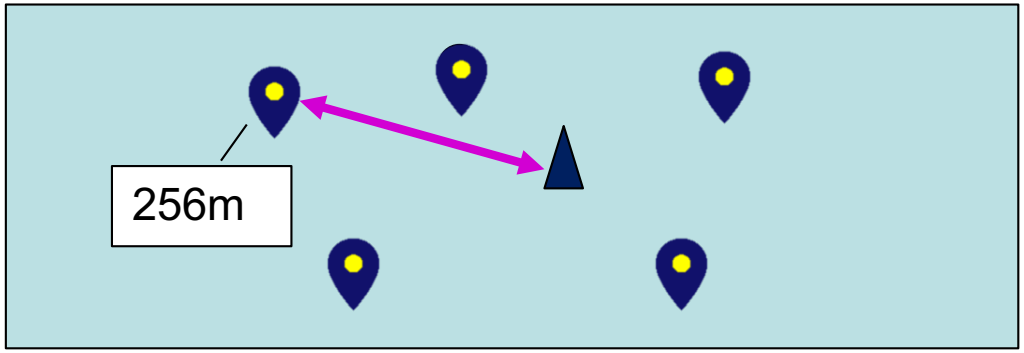
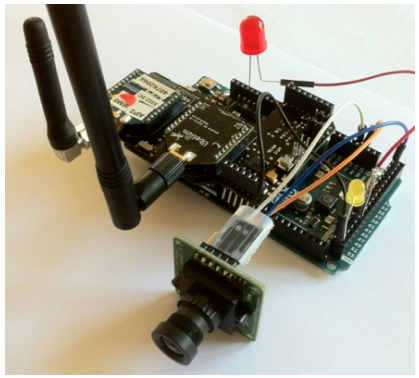
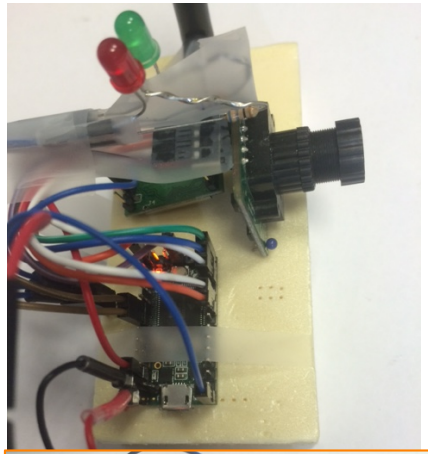
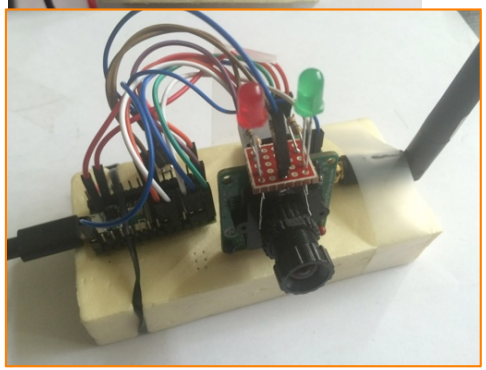
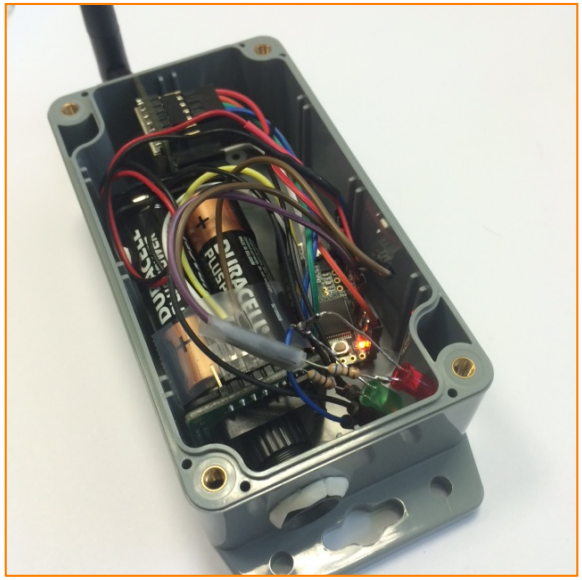


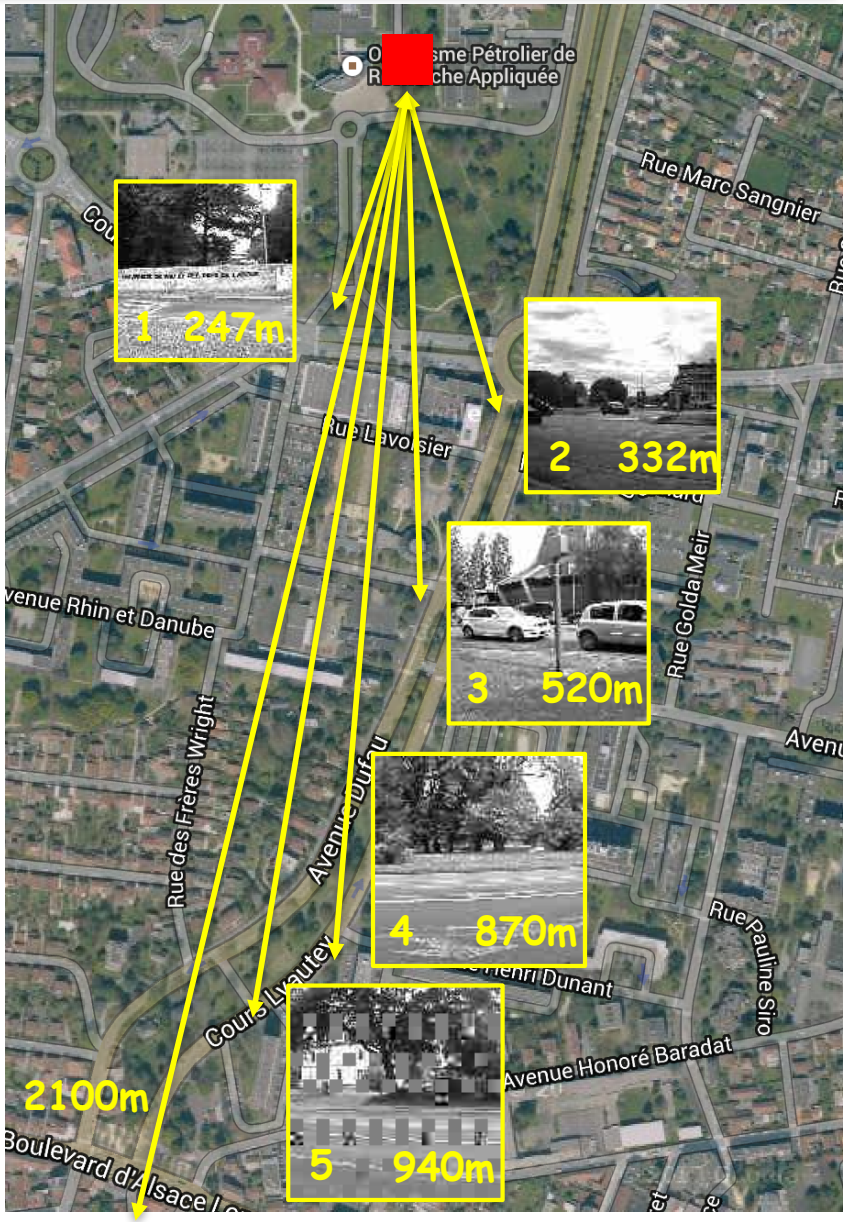
IMAGE SENSOR FOR SPECIFIC SURVEILLANCE CASES





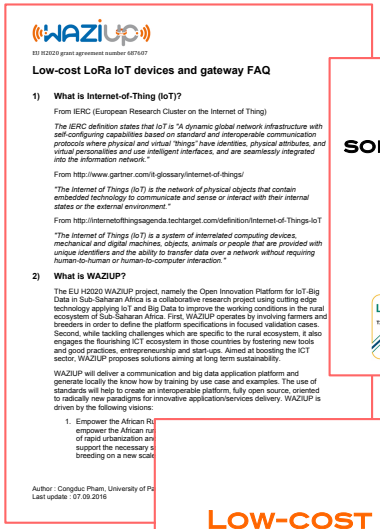






Tutorials/resources

https://github.com/CongducPham/tutorials


EU H2020 grant agreement number 687607

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-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network."

From http://www.gartner.com/it-glossary/internet-of-things/

"The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment."

From http://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT

"The Internet of Things (IoT) is a system of interrelated 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-human or human-to-computer interaction."

2) **What is WAZIUP?**

The EU H2020 WAZIUP project, namely the Open Innovation Platform for IoT-Big Data in Sub-Saharan Africa is a collaborative research project using cutting edge technology applying IoT and Big Data to improve the working conditions in the rural ecosystem of Sub-Saharan Africa. First, WAZIUP operates by involving farmers and breeders in order to define the platform specifications in focused validation cases. Second, while tackling challenges which are specific to the rural ecosystem, it also engages the flourishing ICT ecosystem in those countries by fostering new tools and good practices, entrepreneurship and start-ups. Aimed at boosting the ICT sector, WAZIUP proposes solutions aiming at long term sustainability.

WAZIUP will deliver a communication and big data application platform and generate locally the know how by training by use case and examples. The use of standards will help to create an interoperable platform, fully open source, oriented to radically new paradigms for innovative application/services delivery. WAZIUP is driven by the following visions:

1. Empower the African R… empower the African rur… of rapid urbanization ar… support the necessary … breeding on a new scal…

Author : Congduc Pham, University of Pa…
Last update : 07.09.2016

Tutorial on hardware & software for low-cost long-range IoT

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

Low-cost LoRa IoT device: a step-by-step tutorial

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

Building an IoT device for outdoor usage: a step-by-step tutorial

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

Low-cost LoRa IoT device: supported physical sensors

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

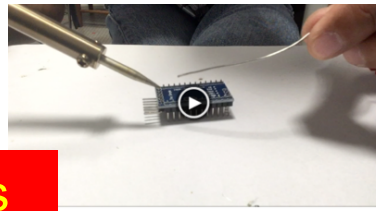
Low-cost LoRa gateway: a step-by-step tutorial

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

Low-cost LoRa IoT: using the WAZIUP demo kit

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

Low-cost IoT device



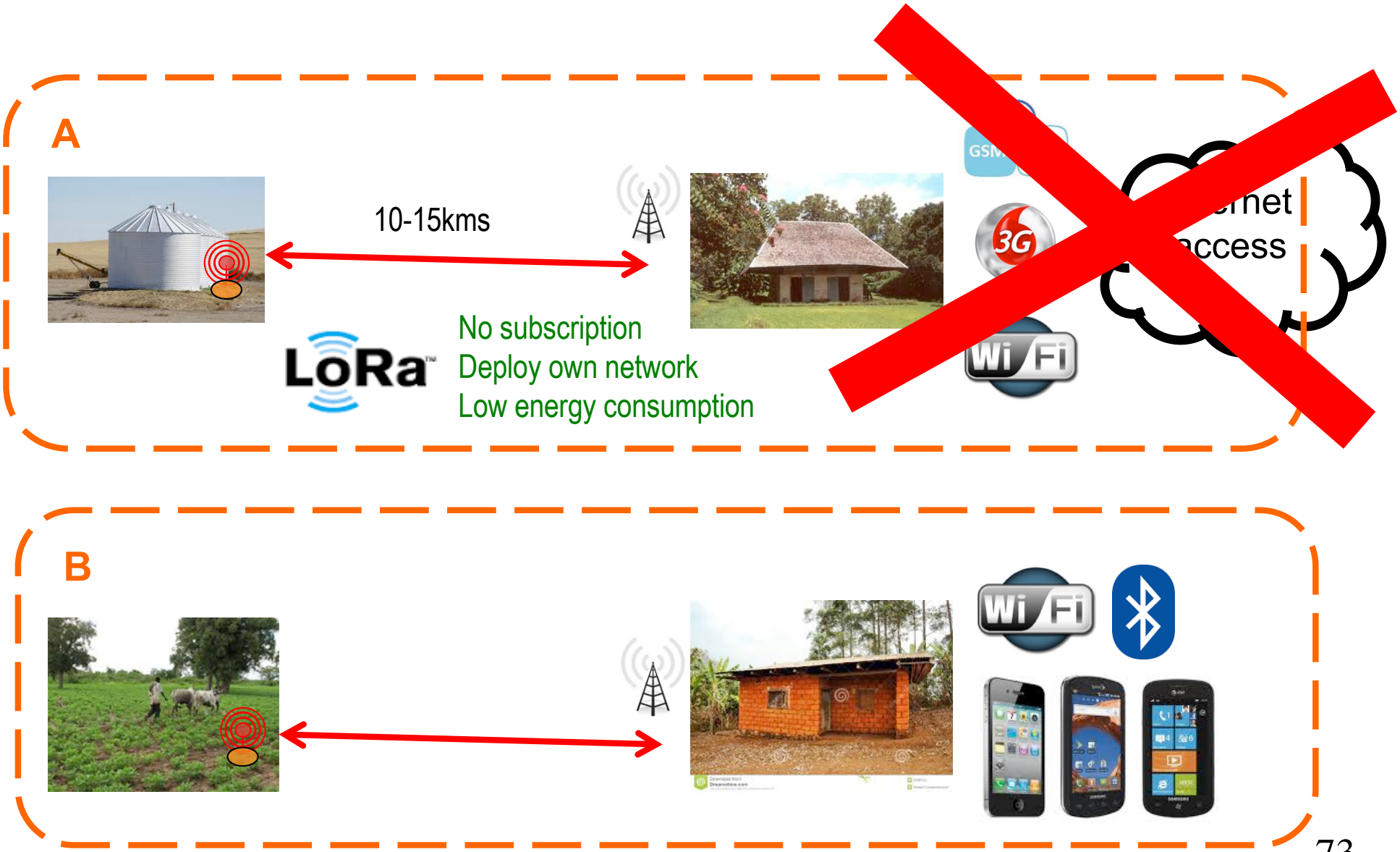
+53000 views

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

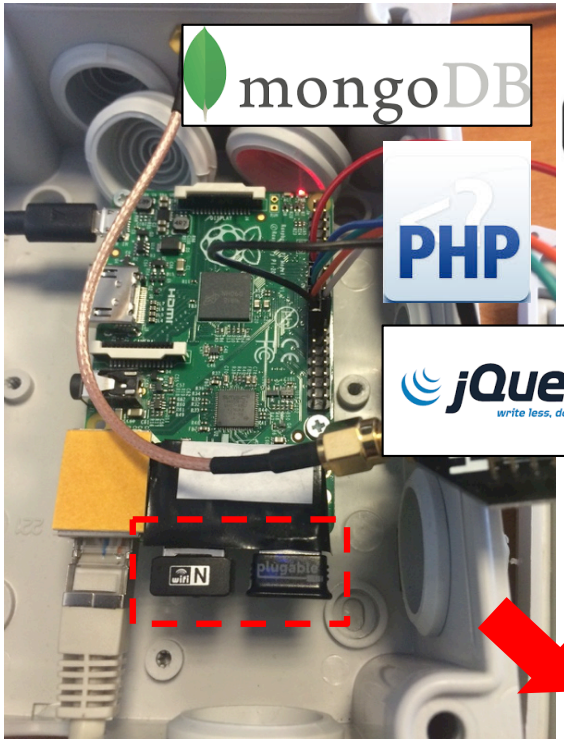
Low-cost IoT gateway

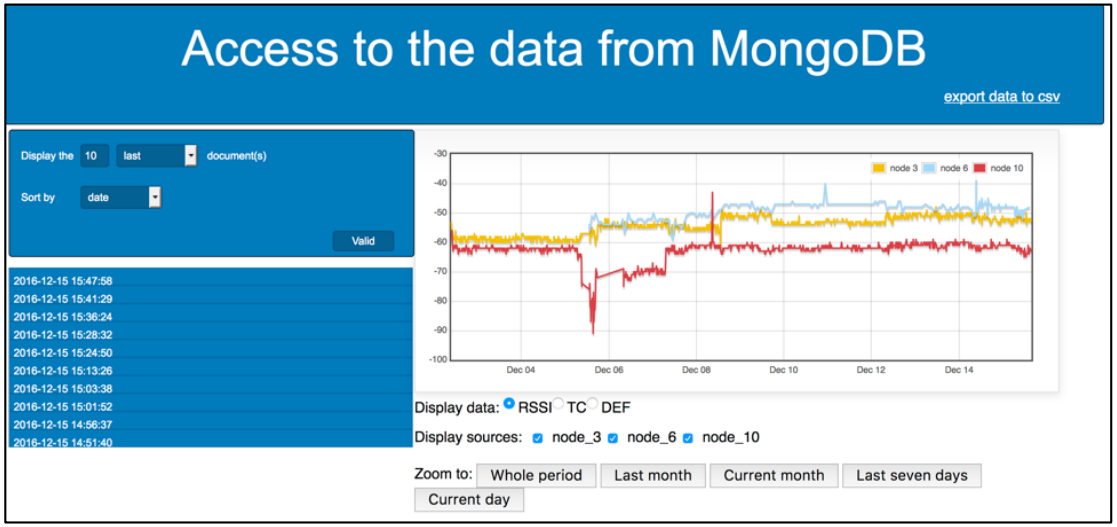
https://www.youtube.com/watch?v=mj8ItKA14PY

Working without Internet access

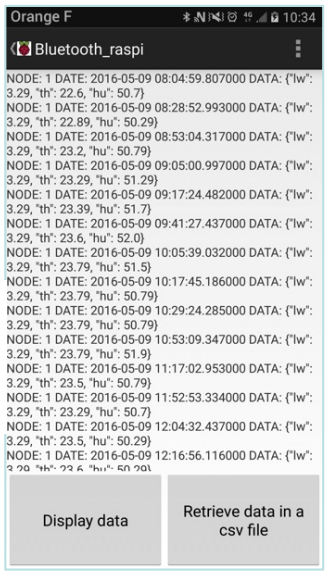


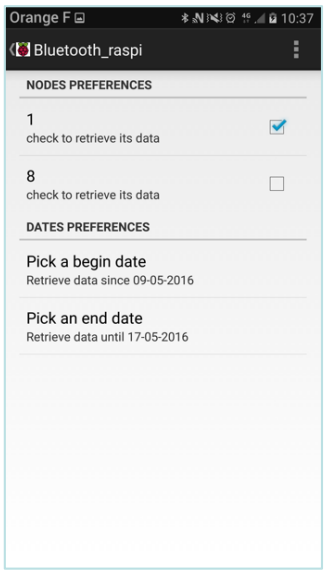
STANDALONE GATEWAY

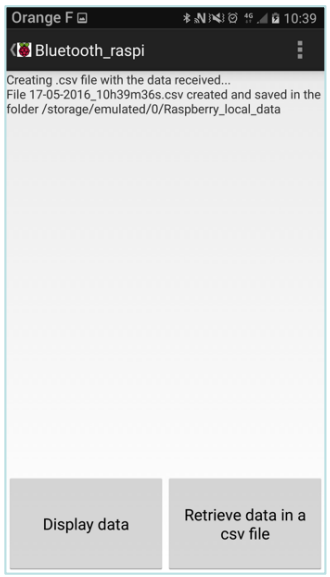




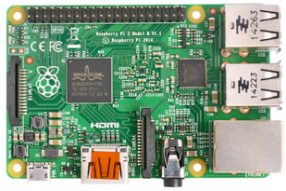
Isolated areas

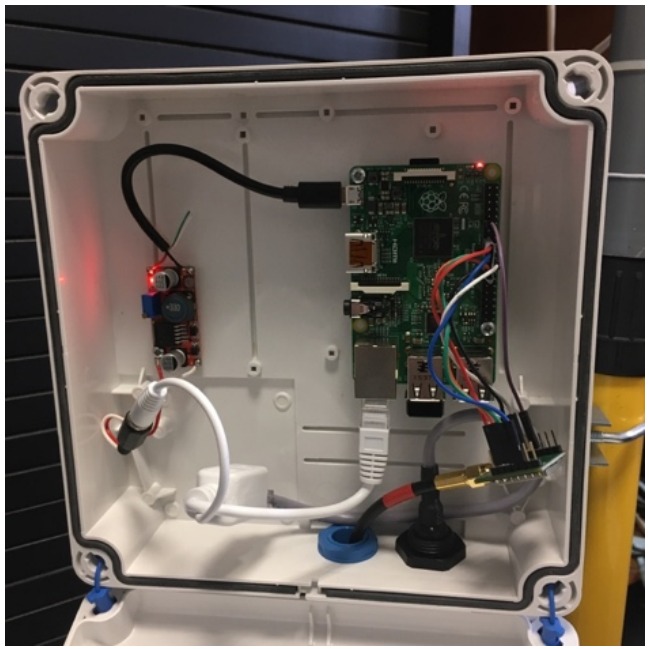


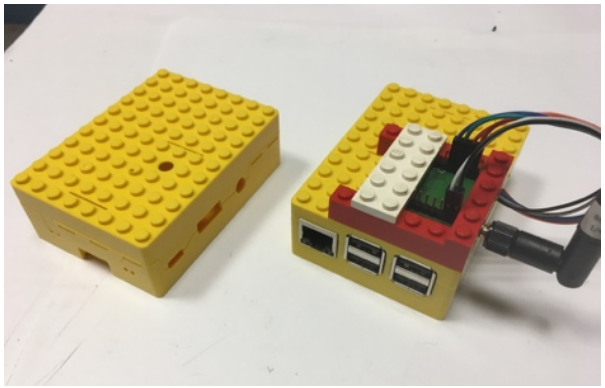




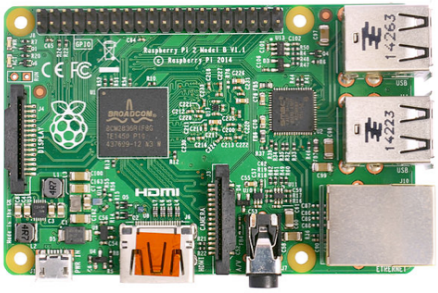
The versatile IoT gateway



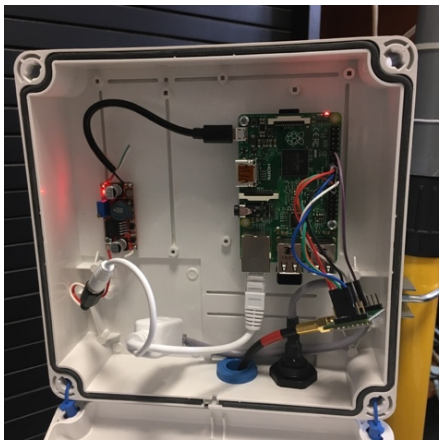




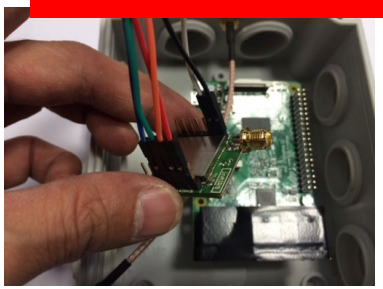
Raspberry-based low-cost LoRa gateway

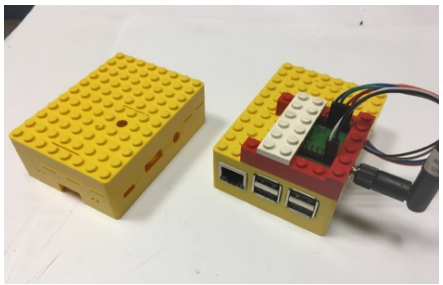


We can use all model of Raspberry. The most important usefull feature is the Ethernet interface for easy Internet connection. Then WiFi and Bluetooth can be added with USB dongles.
RPI3 provides built-in Ethernet, WiFi and Bluetooth!



Less than 50€

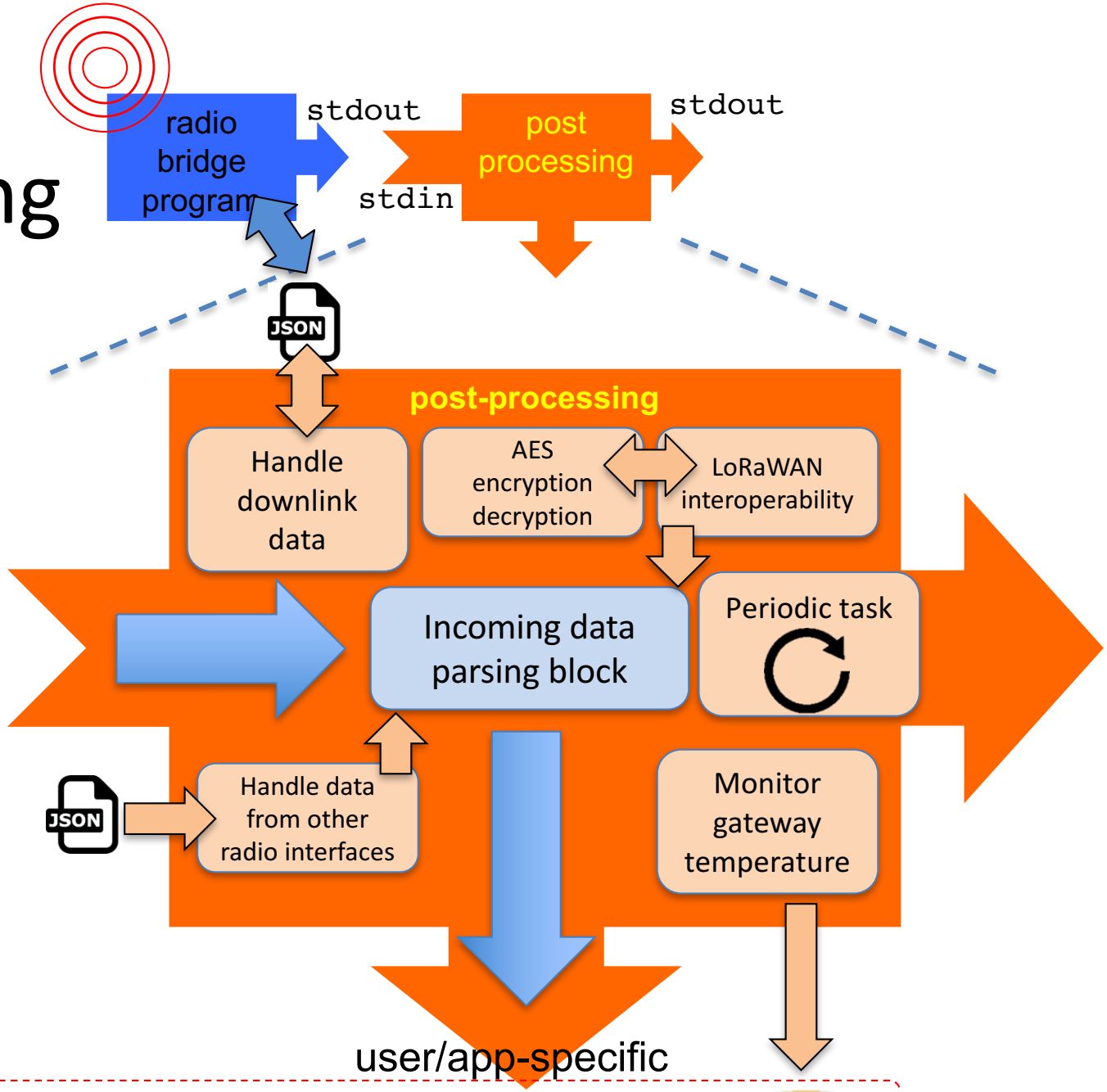




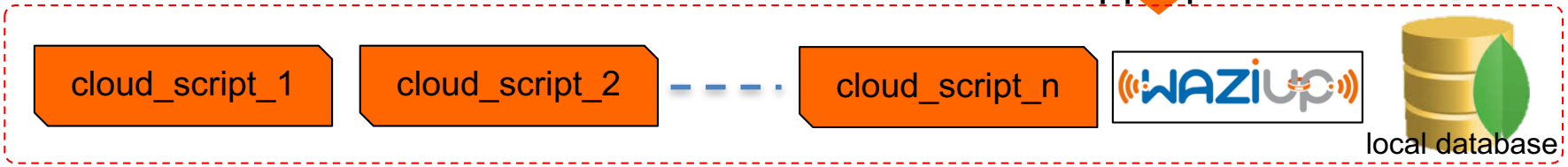
Get the ready-to-use SD card image

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

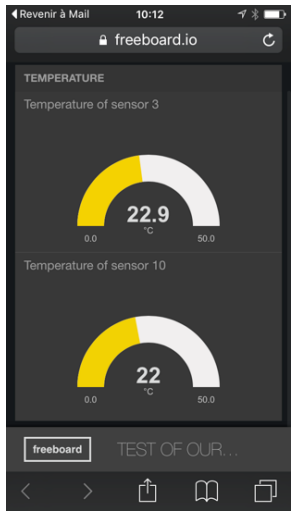
Post-processing stage

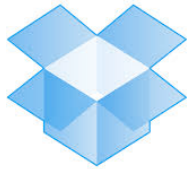


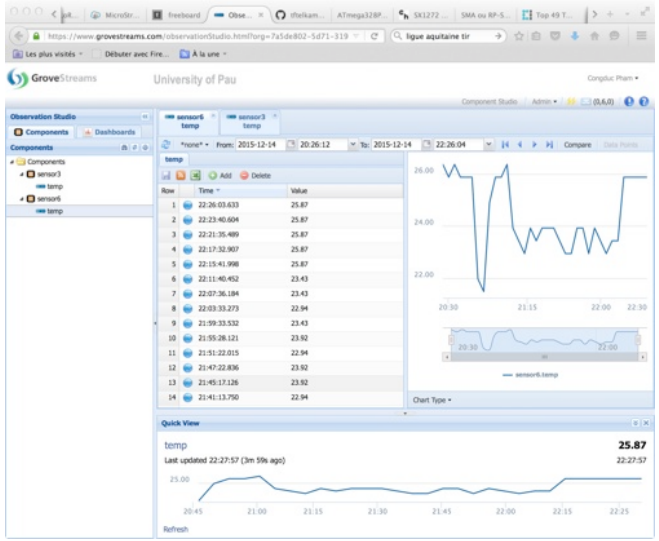
Cloud definition



Templates for various clouds



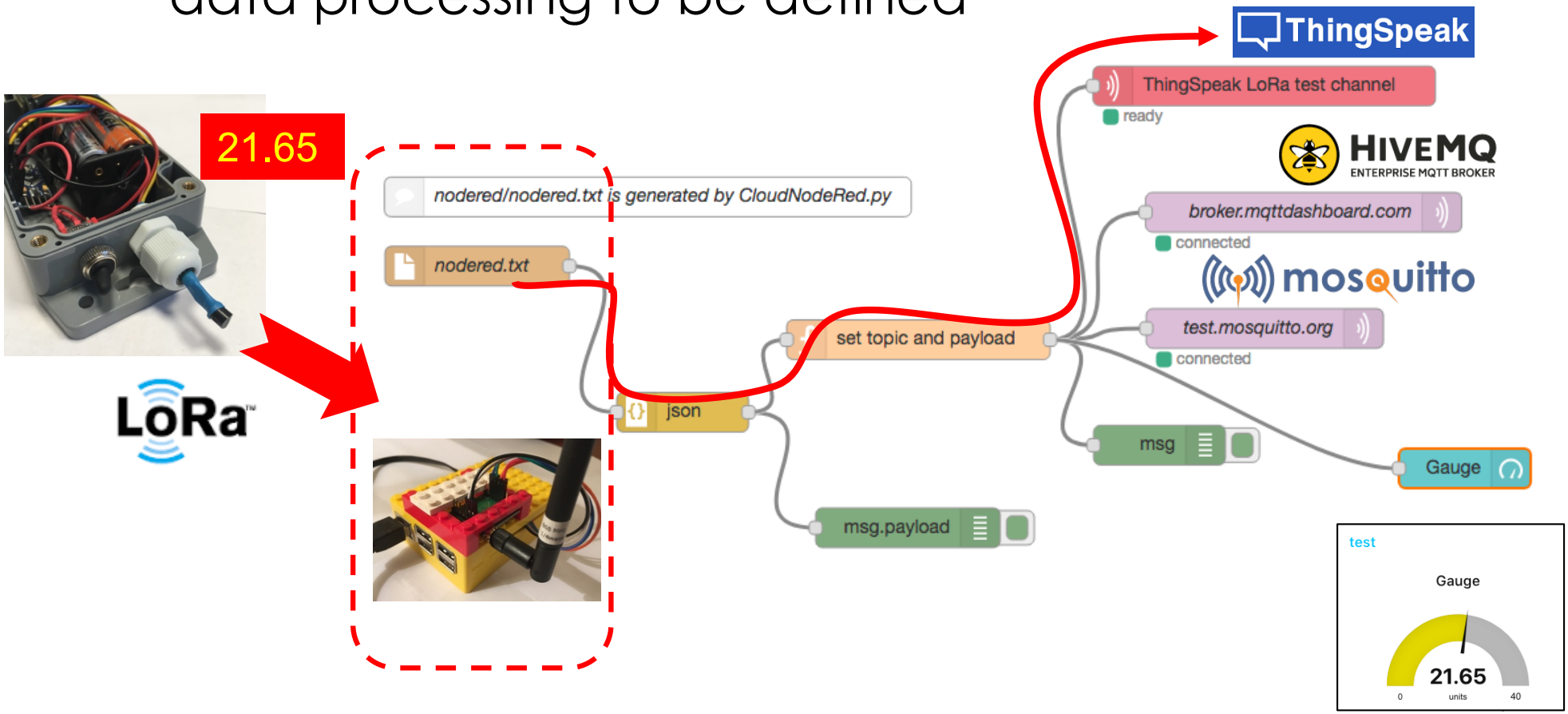




And much more: HTTP, FTP, MQTT, Node-Red…

Node-red enabled gateway

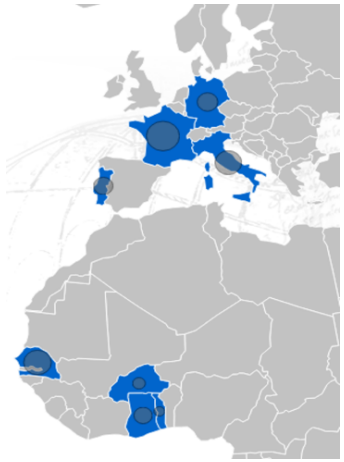
- Messages received on the gateway can be injected into a Node-Red flow, allowing complex data processing to be defined



Scaling up!

Feb 2016 - 2019

WAZIup



May 2018 - 2021

WAZIhub

Thanks.

Let's keep in touch

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