Deploying low-cost and long-range Internet of Things in developing countries

the challenges of the WAZIUP H2020 project

smyle event on

SMART SYSTEMS FOR A BETTER LIFE

"Understand the issues and challenges of the connected world"

September 23rd, 2016
Neuchâtel, Switzerland

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

IoT domain (in Africa)

Irrigation & Agriculture

Livestock farming

Fish farming & aquaculture

Storage & logistic

Health

Water quality

Rural Sensing

Moisture/
Temperature
of storage
areas

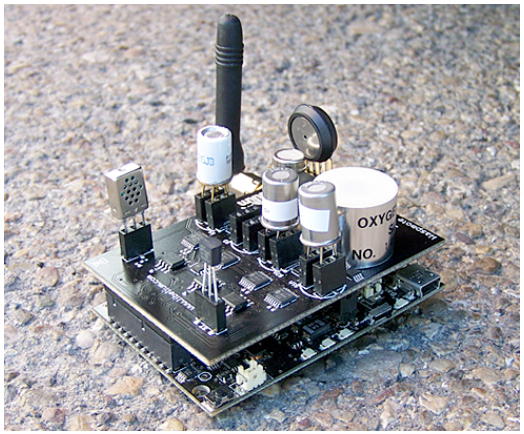
10-15kms

GSM GPRS

Pay subscription
Limitation of coverage
High energy consumption

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



18720 Joules

TX power: 500mA

P = I x V = 500 x 3.3 = 1650mW

E = P x t -> t = E/P

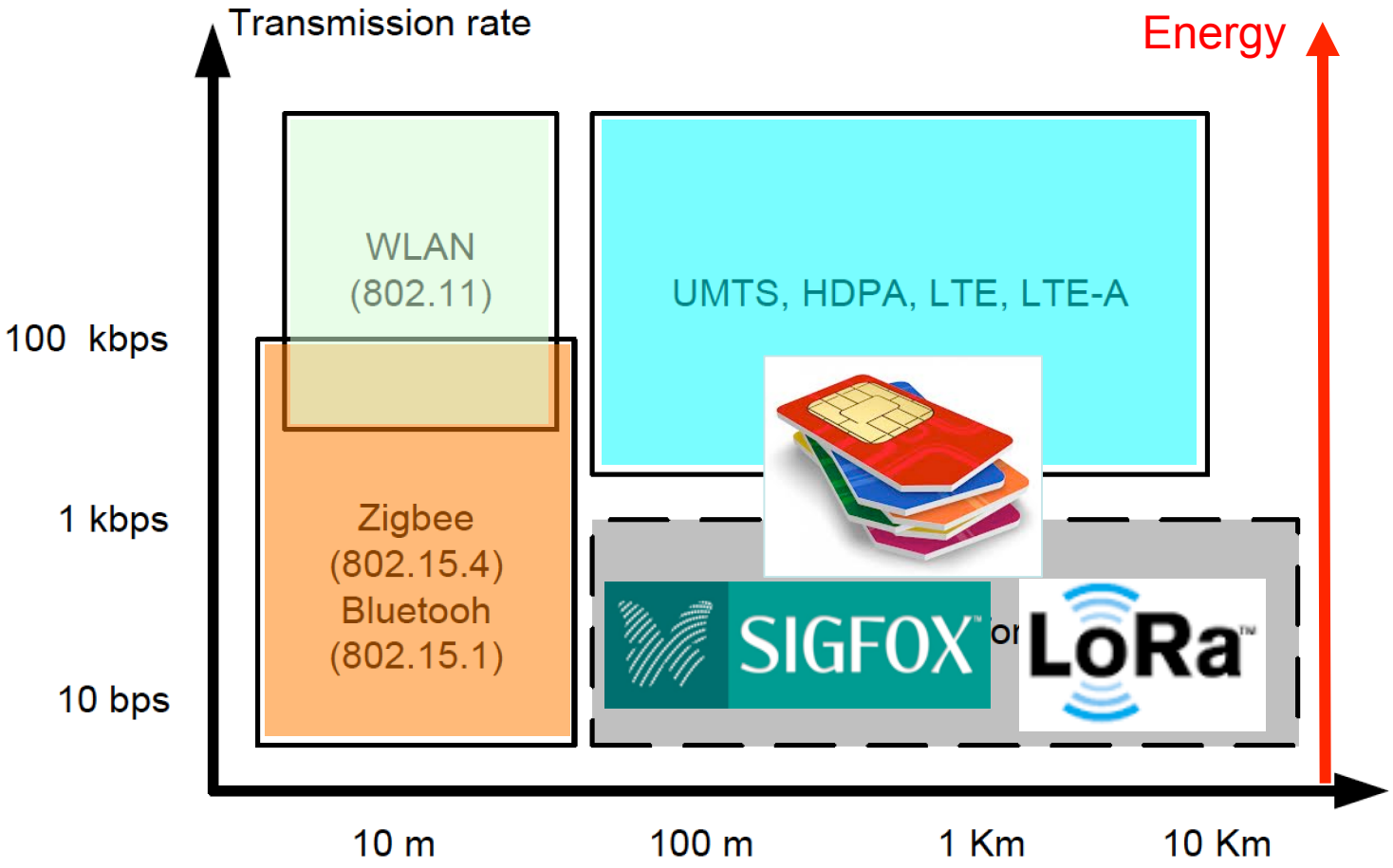
11345s or 3h9mins

Technology	2G	3G
Range (I=Indoor, O=Outdoor)	N/A	N/A
Tx current consumption	200mA-500mA	500mA – 1000mA
Standby current	2.3mA	3.5mA

Haven't considered:

- Baseline power consumption of the sensor board
- RX consumption!
- Event capture consumption
- Event processing consumption

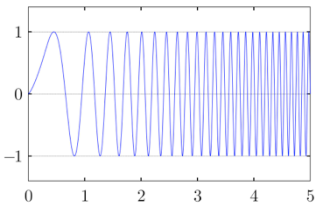
Low-power and long-range?



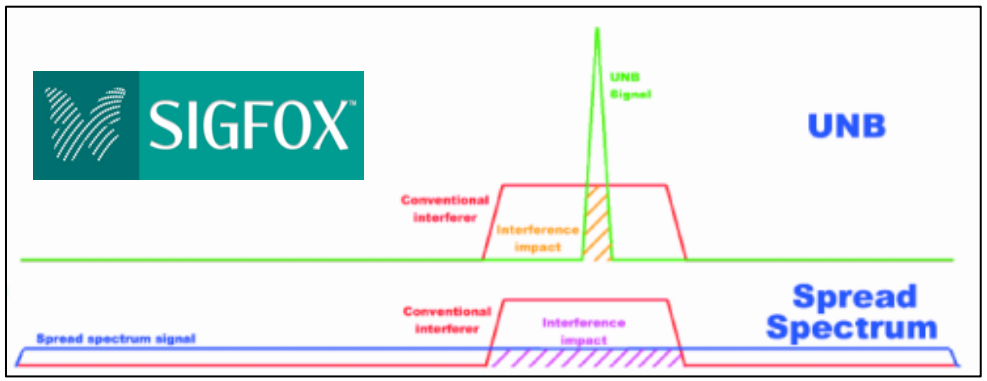
Enhanced from M. Dohler "M2M in SmartCities"

Increasing range?

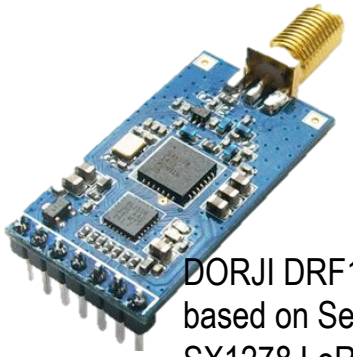
- Generally, robustness and sensitivity can be increased when transmitting (much) slower
- A[Sigfox message is sent relatively slowly in a very narrow band of spectrum (hence ultra-narrow-band) using Gaussian Frequency-Shift Keying modulation]. Max throughput=~100bps
- LoRa also increases time-on-air when maximum range is needed. But LoRa uses spread spectrum instead of UNB. 300bps-37.5kbps



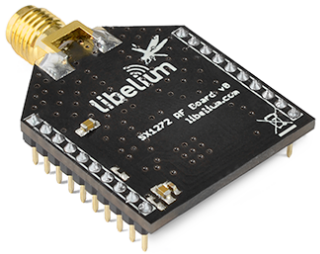
LoRa™



LoRa modules from Semtech's SX127x chips



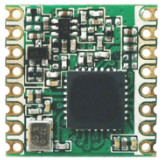
DORJI DRF1278DM is based on Semtech SX1278 LoRa 433MHz



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

inAir9 based on SX1276

Froggy Factory LoRa module (Arduino)

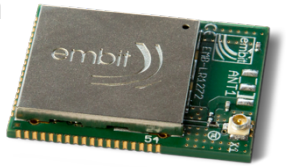


HopeRF RFM series

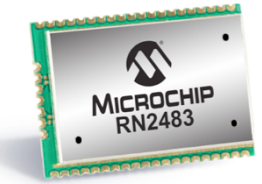
HopeRF HM-TRLR-D

LinkLabs Symphony module

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



Embit LoRa

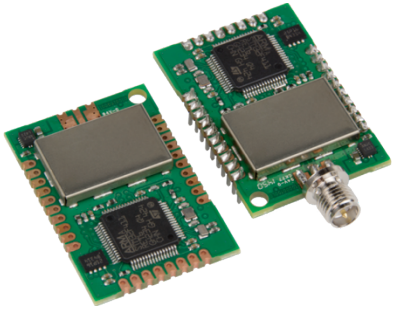


LoRa™ Long-Range Sub-GHz Module (Part # RN2483)

Microship RN2483

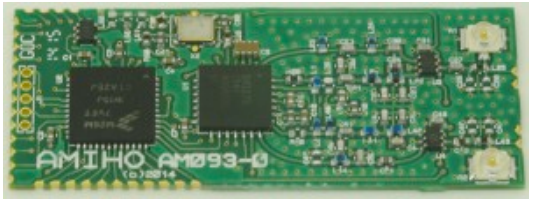
habSupplies

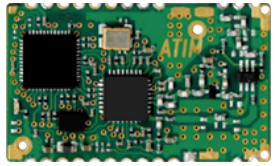
Adeunis ARF8030AA- Lo868



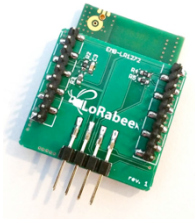
Multi-Tech MultiConnect mDot

AMIHO AM093





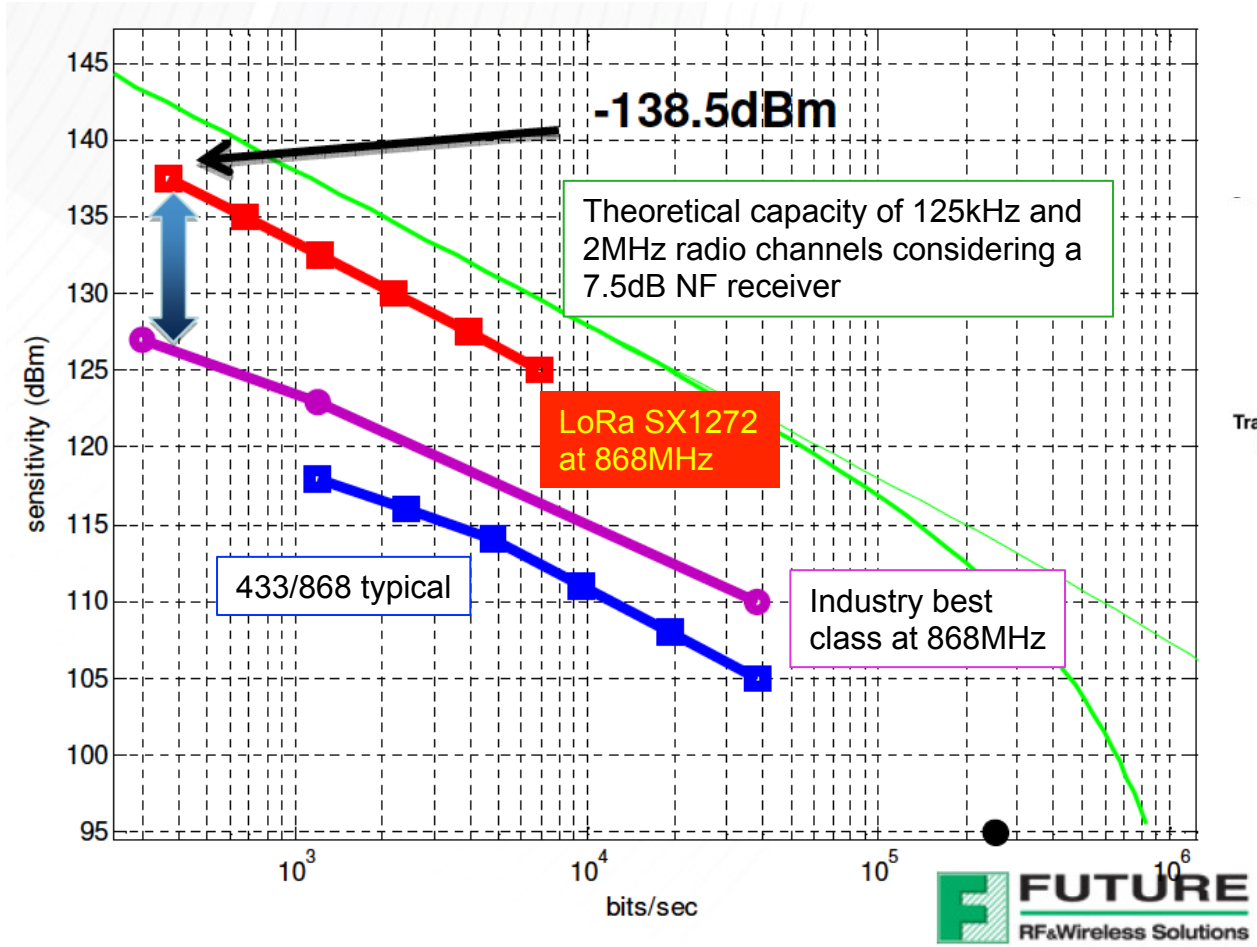
ARM-Nano N8 LoRa module from ATIM



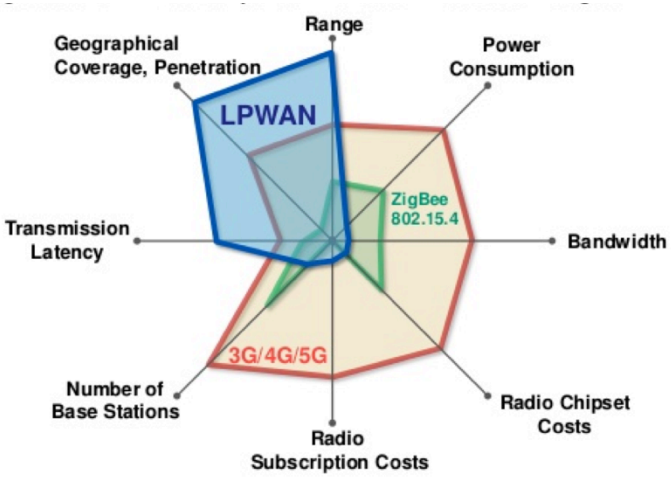
SODAQ LoRaBee Embit

SODAQ LoRaBee RN2483

The long-range revolution



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

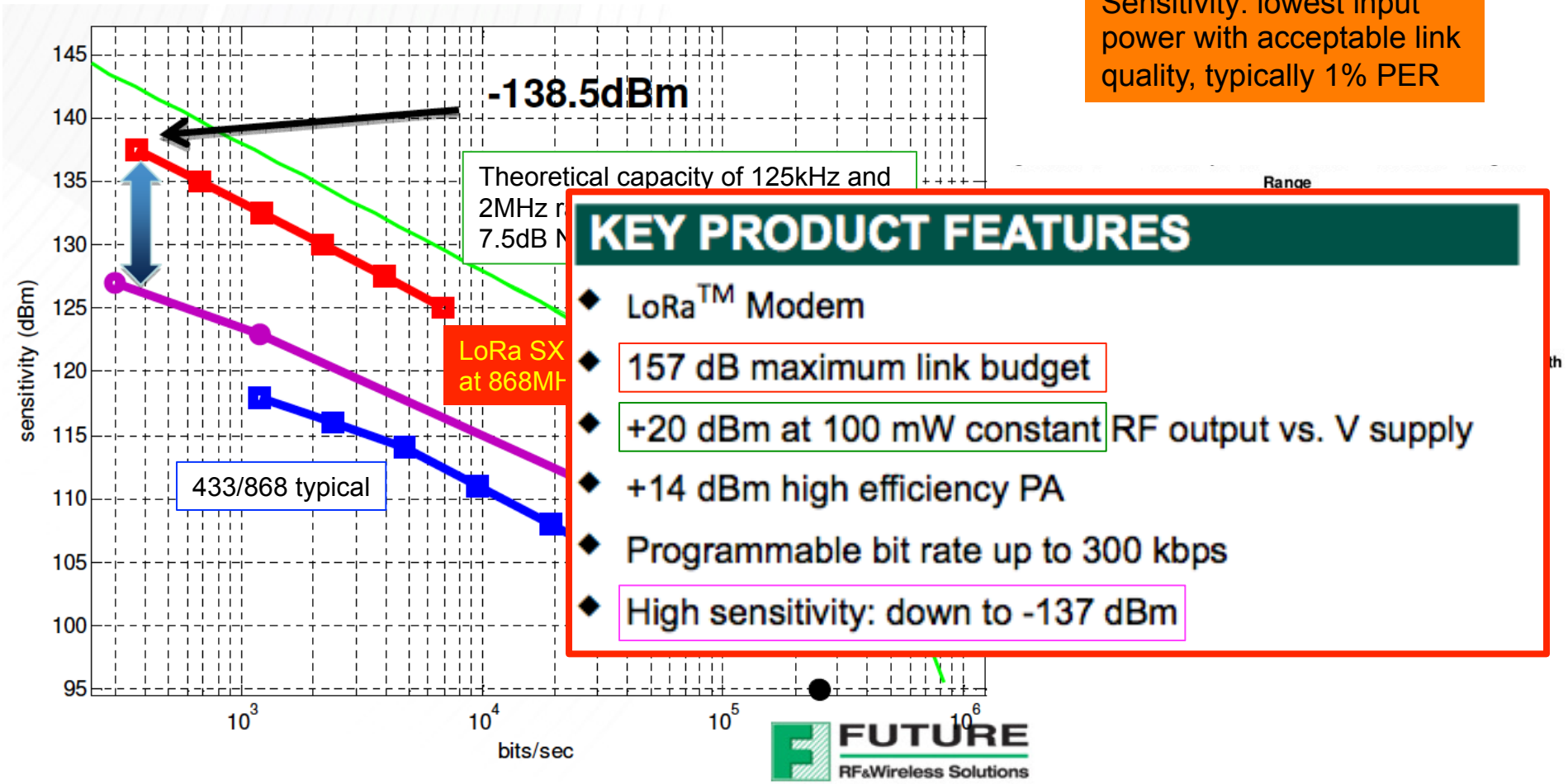


From Peter R. Egli, INDIGOO.COM

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

The long-range revolution

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

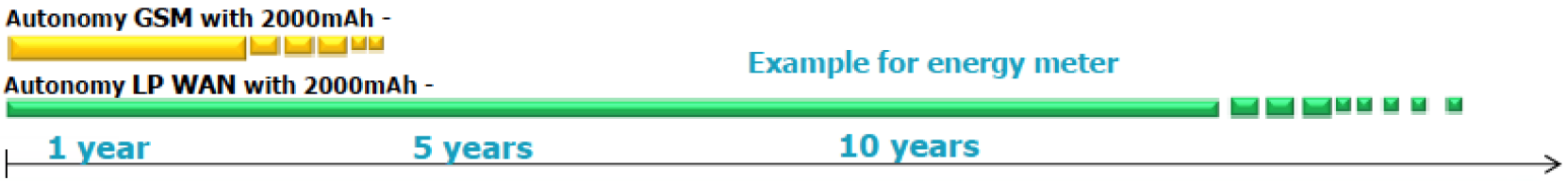


The lower the receiver sensitivity, the longer is the range!

Low Power WAN (LPWAN) ?

Tables from Semtech

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



LPWAN ARCHITECTURE

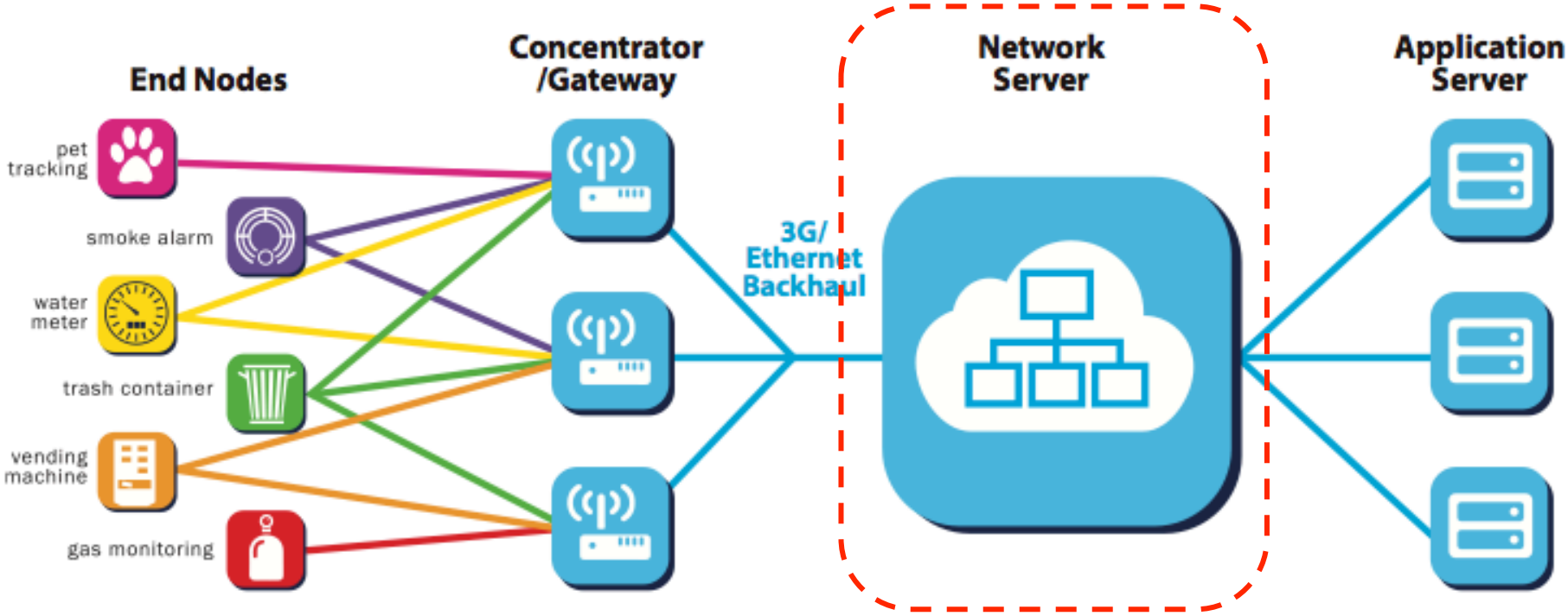
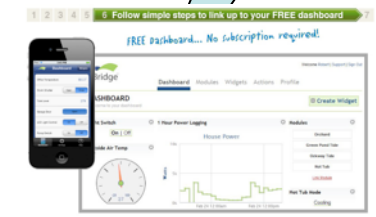


Figure from Semtech

MATURATION OF THE IoT MARKET…

Waste Container connected sensor

CONTROL, OPTIMIZE & INSTRUMENT !



DATA [illegible] TION &

SENSING

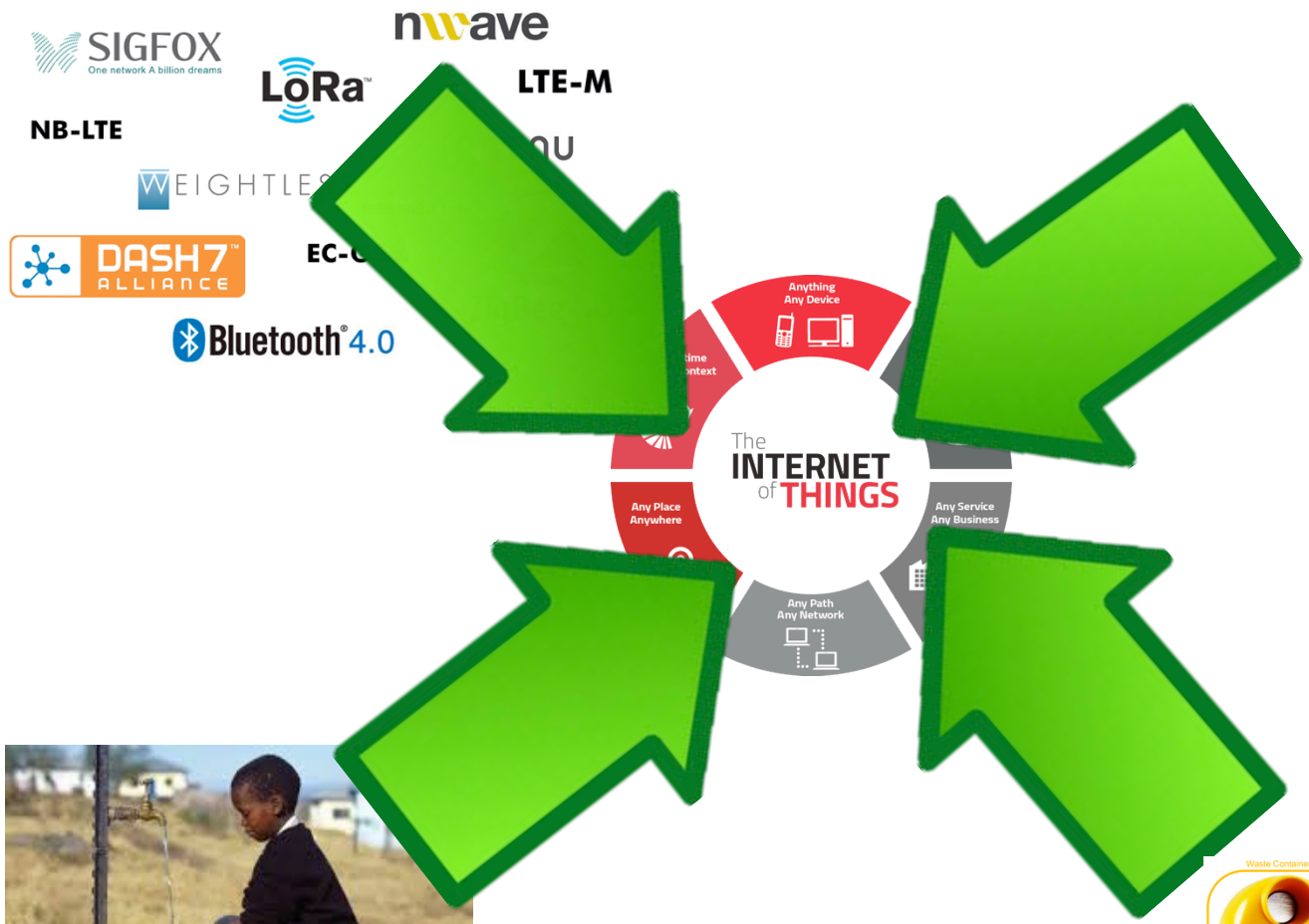
PEOPLES, INFRASTRUCTURES, BUILDINGS, VEHICULES

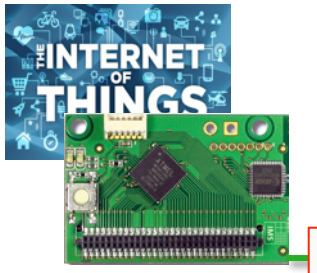
BIG DATA ANALYTICS

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

- Predictive Maintenance
- Outage Management
- Fraud Detection
- Demand/Supply Optimization
- Customer Engagement

IoT BECOMES REALITY!





From SCOOP IT

LoRa™ technology to be integrated into FLASHNET's street lighting management solution

From intelil

" Brasov, 2015

SIGFOX and Glen Canyon Corp. to 1 Million Smart Meters to of Things

From www.businesswire.com

Tata Communication world's largest IoT n India

devic

The c of Lo conne Benga

Semtech and STMicroelectronics Collaborate to Scale LoRa Technology to Meet High-Volume Demands of Internet of Things Applications

From www.st.com - December 14, 2015 7:27 AM

ST to offer complete line of solutions including LoRa systems on chips (SOCs) to accelerate deployments of low-power wide-area networks by mobile network operators (MNOs)

Cofely Services, a subsidiary of ENGIE (SUEZ group), integrates SIGFOX solution to expand services it provides for buildings

COFEL

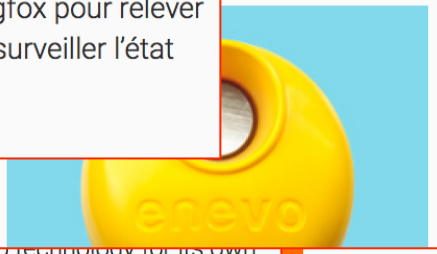
Sogedo et Sigfox lancent les compteurs d'eau intelligents

From www.sudouest.fr - December 16, 2015 2:24 PM

" Gestionnaire de réseaux dans les Landes, en Gironde et en Dordogne, Sogedo utilise les ondes radio de Sigfox pour relever les compteurs et surveiller l'état des canalisations

Le compteur..."

Mobile World Congress in Enevo



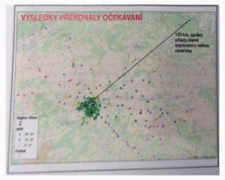
From www.enevo.com - March 6, 4:12 PM

network, a narrow-band technology which guarantees connectivity at a reduced energy consumption rate and at a lower cost. Orange has chosen to rely on LoRa (Long Range) technology to deploy this network that will cover the whole of metropolitan France.

METERI SMART

determine the

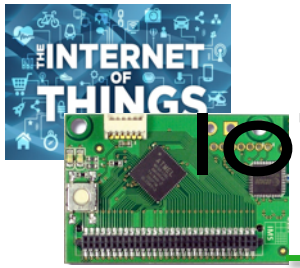
T-Mobile to cover Republic with the for the Internet of



From www.theinternetofthin September 10, 4:41 PM

Following a pilot opera Czech Republic that ex expectations, T-Mobile SimpleCell Networks w SIGFOX's Internet of Th network throughout the country.

" French Telecom LoRa radio technology for its own domestic IoT and M2M network."



IoT in sub-saharan Africa

- Africa's 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

IoT IN SUB-SAHARAN AFRICA

- Africa's countries are still far from being ready to enjoy the smallest benefit of IoT
  - lack of infrastructure
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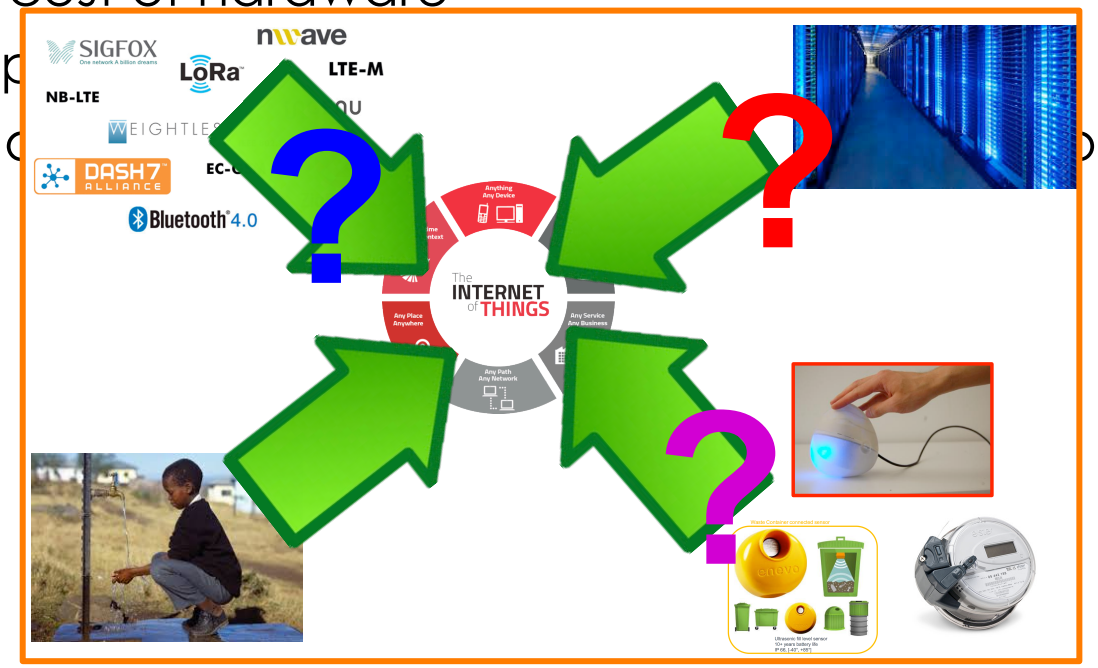
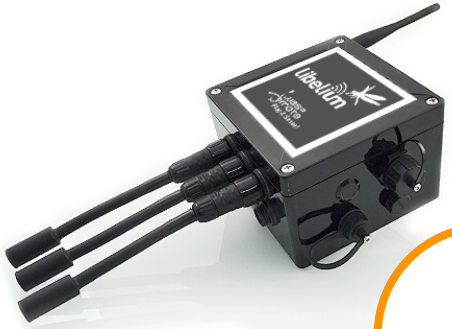
  - lack o ound



MATURATION OF THE IOT MARKET…



… but not adapted for rural africa context

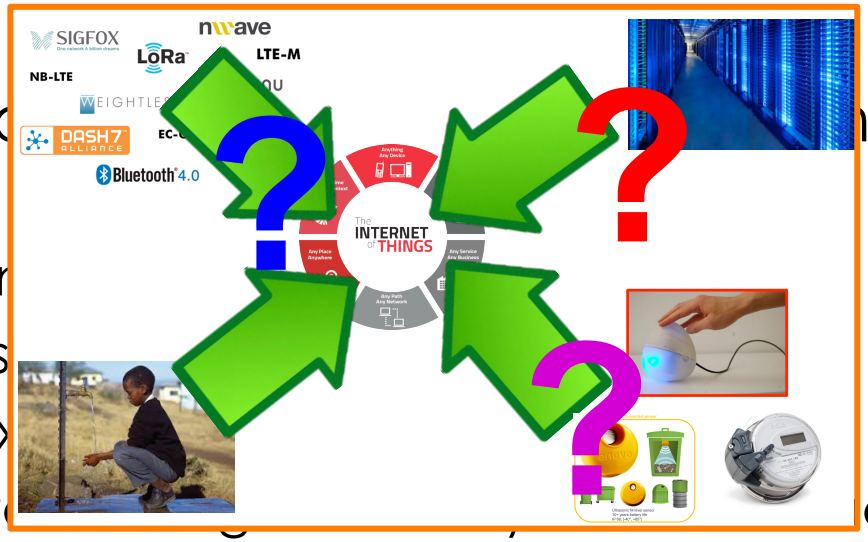
Too expensive
Too integrated
Highly specialized
Difficult to customize
Difficult to upgrade

BIG DATA ANALYTICS

Internet connectivity is weak and expensive

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

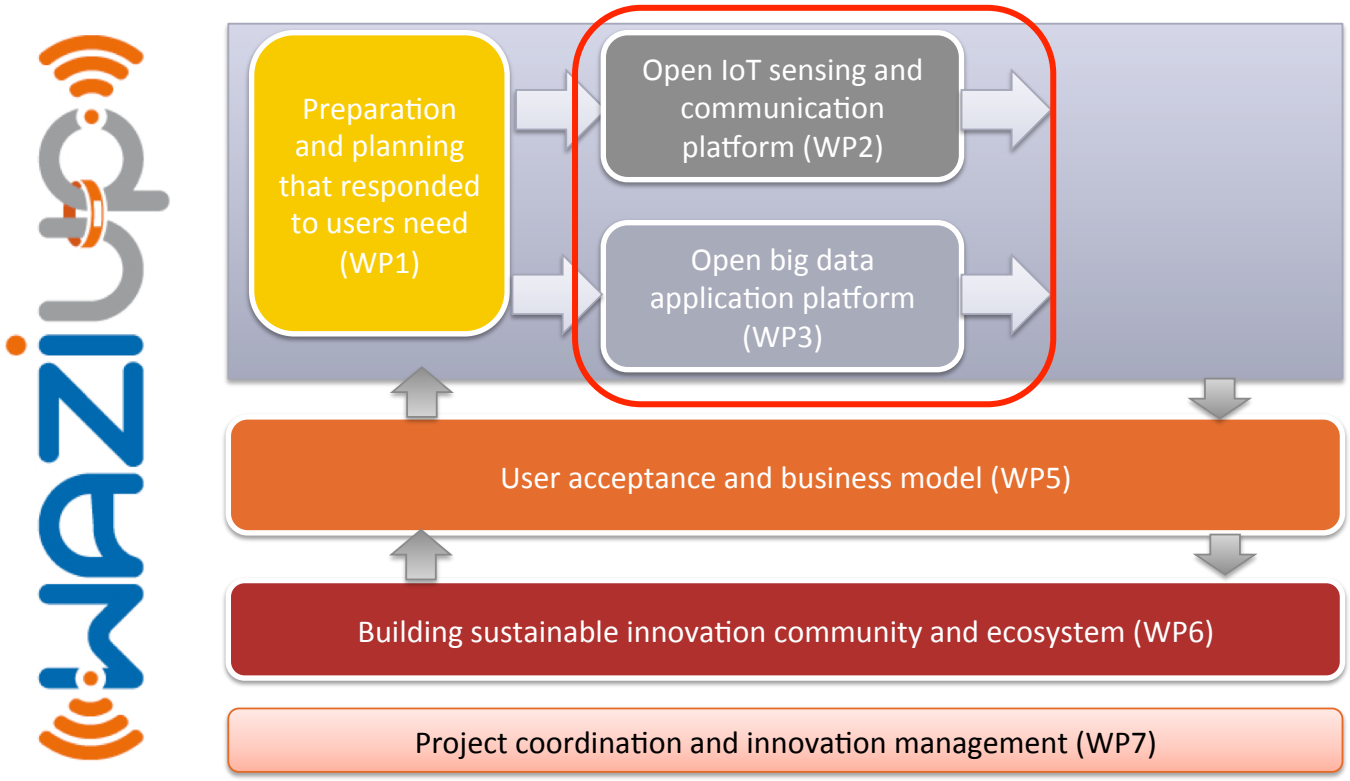
IoT IN SUB-SAHARAN AFRICA



- Africa's co… …g ready to enjoy the …
  - lack of in…
  - high cos…
  - complex…
  - lack of t… …ckground
- **to deploy IoT in Sub-Saharan Africa, it is necessary to target three major issues**
  - **reduce cost of infrastructures, hardware and services**
  - **limit dependancy to proprietary infrastructures and provide local interaction models**
  - **target technology appropriation, push for local business models**

IoT FOR RURAL APPLICATIONS IN DEVELOPPING COUNTRIES

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



Low-cost hardware

WHAT IS ARDUINO?

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

ARDUINO BOARD

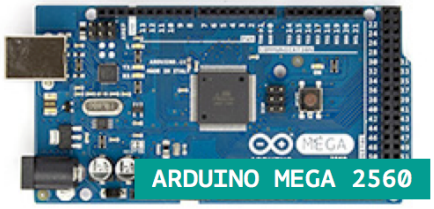
Arduino senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators.

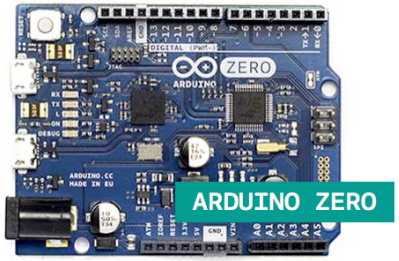
ARDUINO SOFTWARE

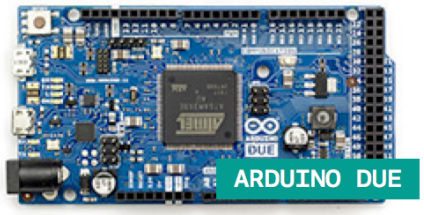
You can tell your Arduino what to do by writing code in the Arduino programming language and using the Arduino development environment.

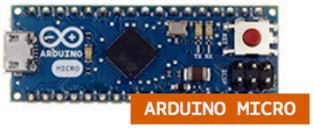
```
void setup() {
}

void loop() {
}
```





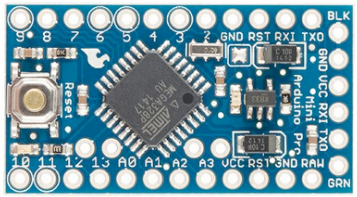




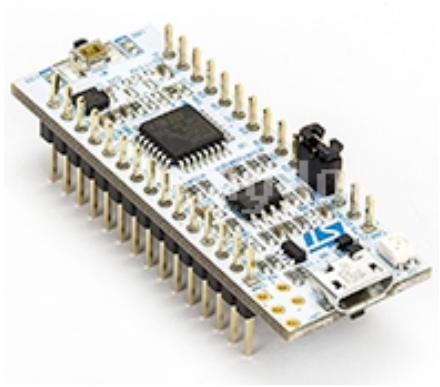
The DIY ecosystem

- Many powerfull microcontroller boards available
- Do-It-Yourself approach with off-the-shelves components more adapted

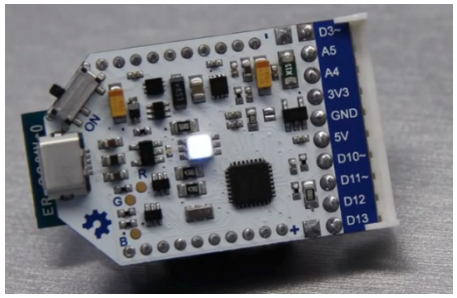
Arduino Pro Mini



Teensy 3.2



STM32 Nucleo-32



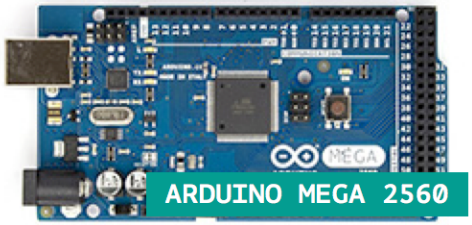
Theairboard on kickstarter

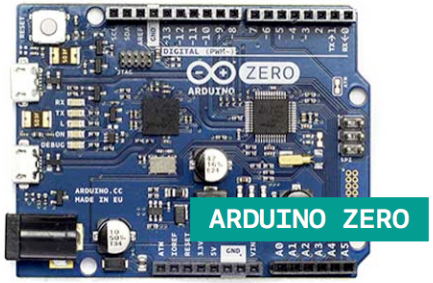
Tinyduino

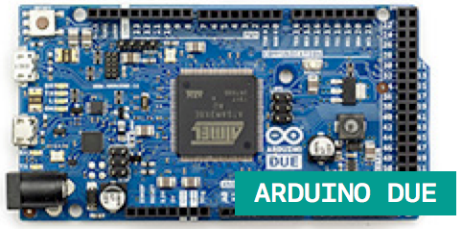
Why go for Arduino?

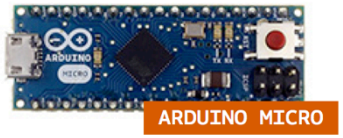
- Cheap, open, and easy to use/program
- huge developer communities
  - Hardware is not the main important issue
  - Software is!

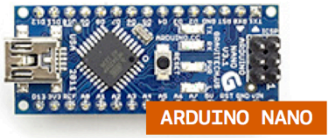
SW/HW BUILDING BLOCKS INTEGRATION

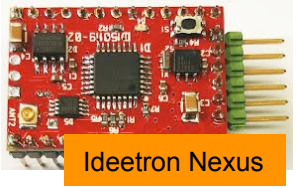




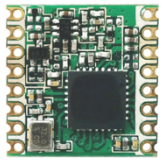








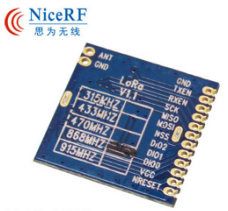
LoRa radios that our library already supports



HopeRF RFM92W/95W

Libelium LoRa

Modtronix inAir9/9B

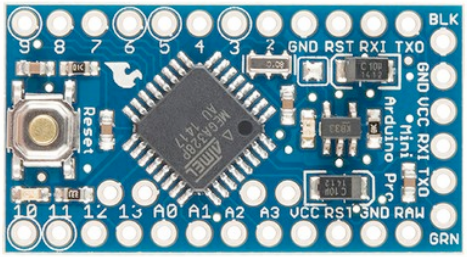


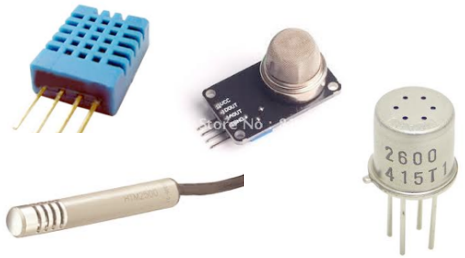
NiceRF LoRa1276

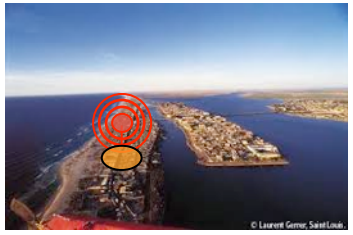
Long-Range communication library

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,…

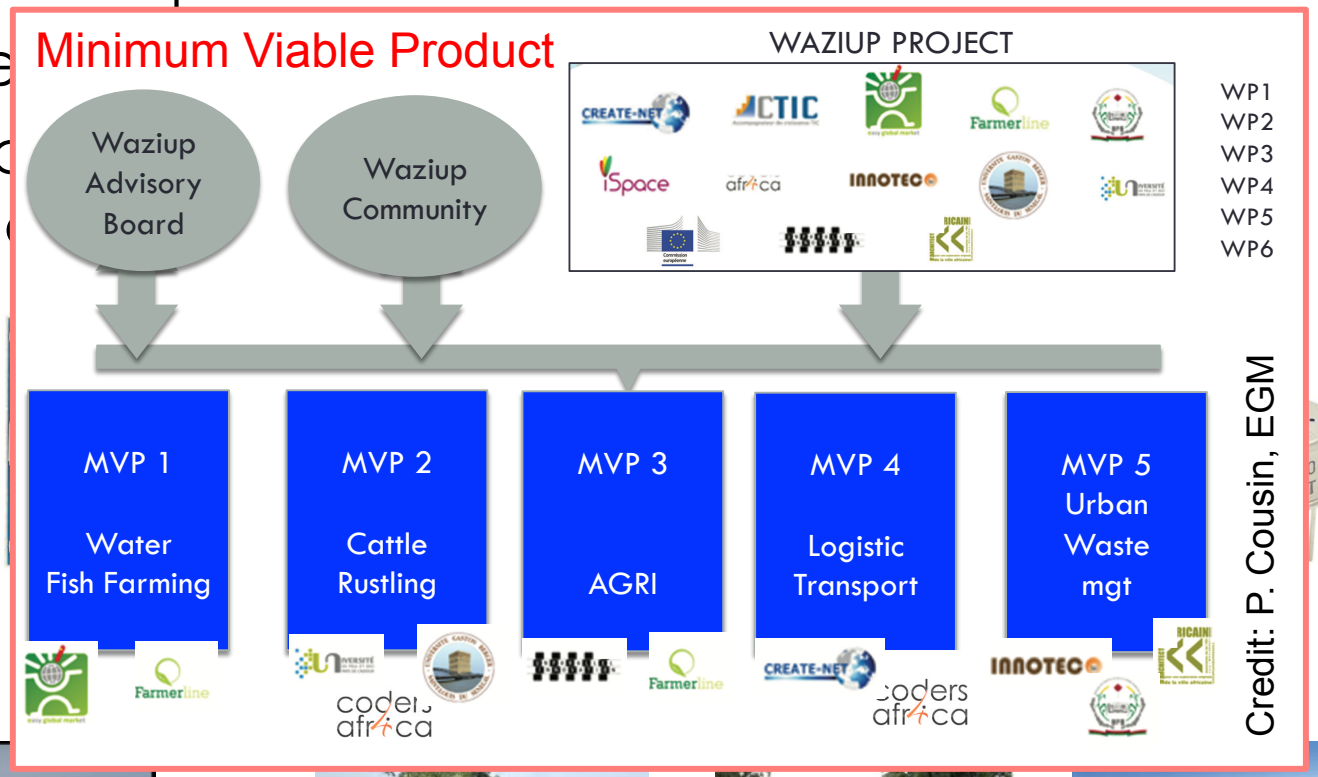


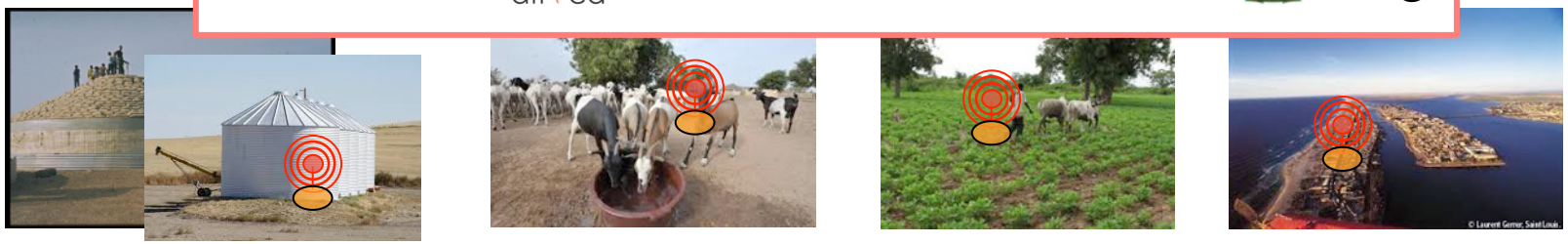




Generic sensing IoT device

- Build low-cost, low-power, Long-range enabled generic platform
- Me
- Tec
  ec





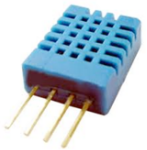
READY-TO-USE TEMPLATES

Physical sensor reading

Physical sensor reading

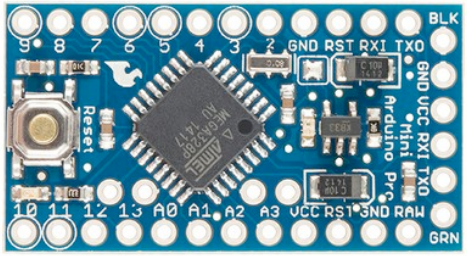
WAZIUP

Physical sensor reading



WAZIUP

Physical sensor management



Activity duty-cycle, low power

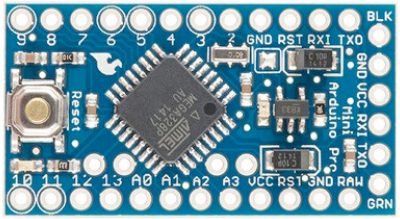
Security

Long-range transmission

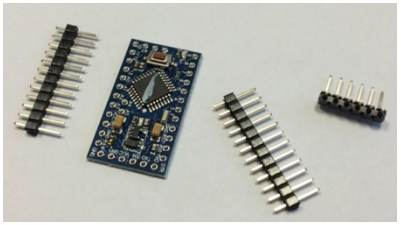
Logical sensor management

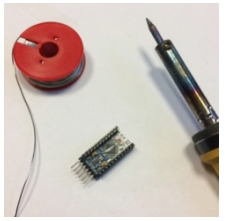
Easy integration and customization

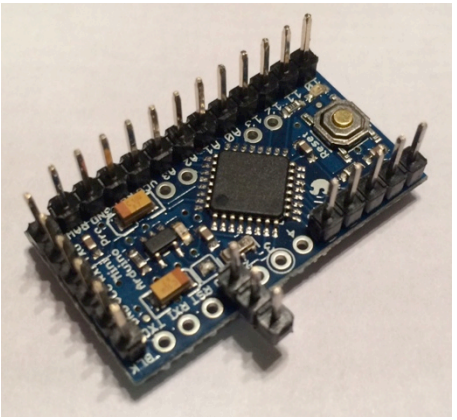
Arduino Pro Mini

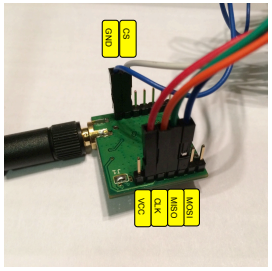


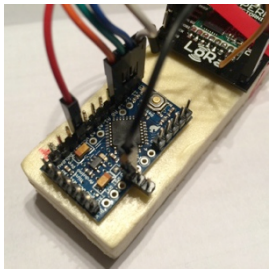
3.3v and 8MHz version

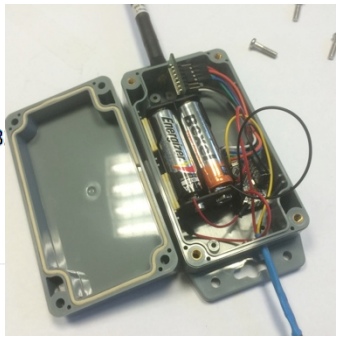


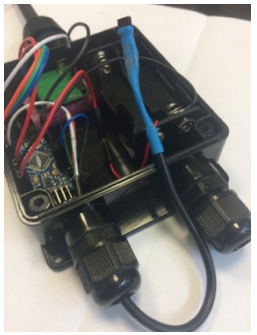


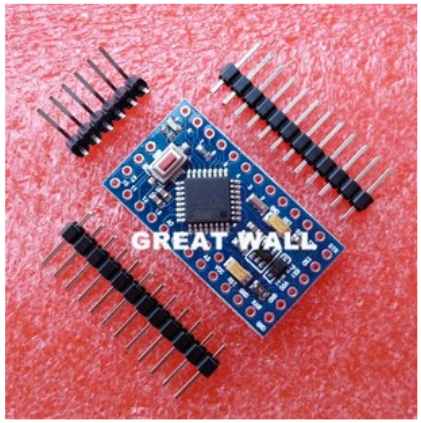












Avec la bootloader 1 pcs Pro Mini ATMEGA328 Pro Mini 3
MHz pour Arduino

View original title in English

4.9 (417 Votes) | 434 Commandes

Prix : € 1,49 / Kit

Trouvez plus de deals sur l'App

Livraison : € 0,29 vers France via China Post Ordinary Small Pac

Livraison : 15-34 jours (envoyé en 7 jours ouvrables)

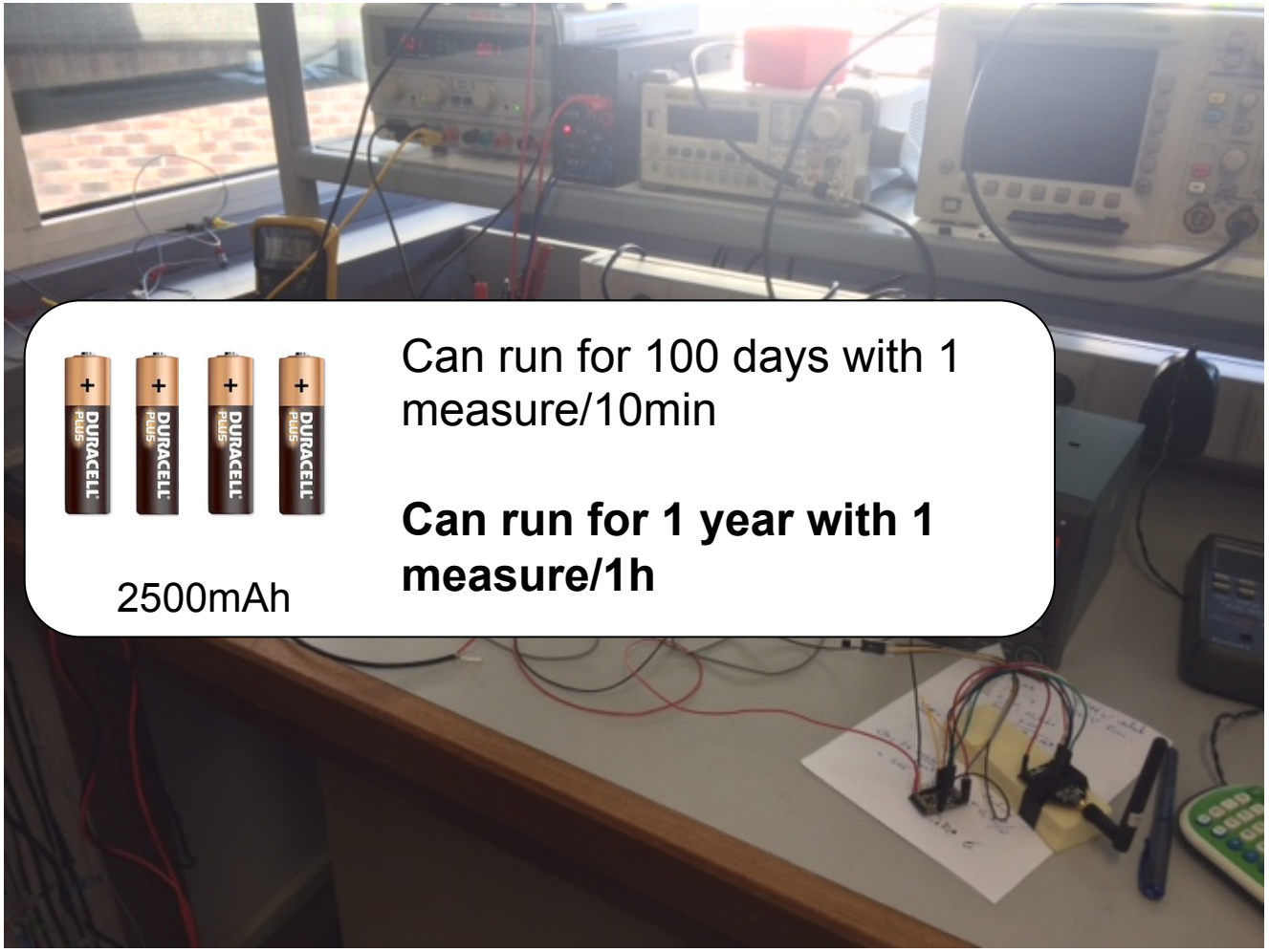
Quantité : – 1 + Kit (55350 Kits available)

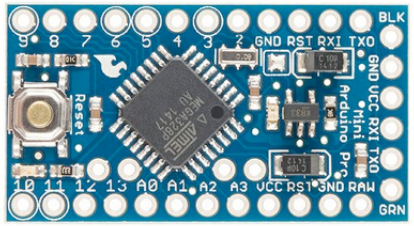
Montant total : € 1,78

Acheter maintenant | Ajouter au panier

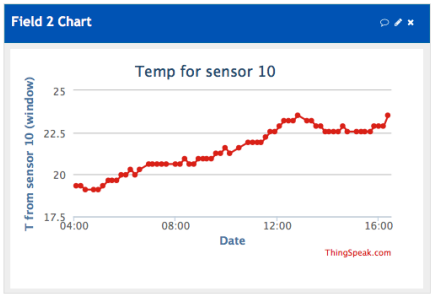
Running for 1 year with low-power mode!

Low-Power library from RocketScream





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



146µA in deep sleep mode, 93mA when active and sending

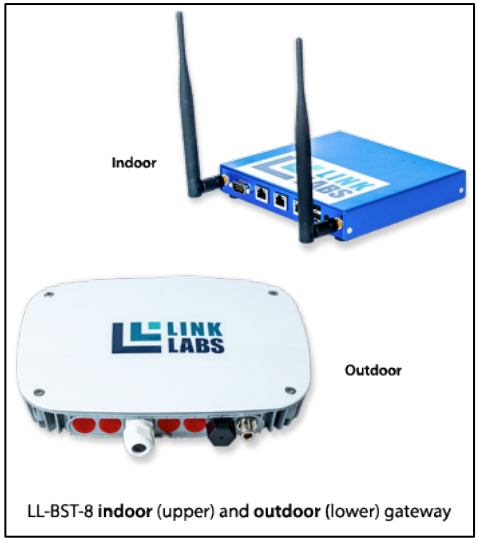
Thanks to T. Mesplou and P. Plouraboué for their help

LoRa Gateways
(non exhaustive list)

Multi-Tech Conduit

Embedded Planet
EP-M2M-LORA

Ideetron Lorank 8



LinkLabs Symphony

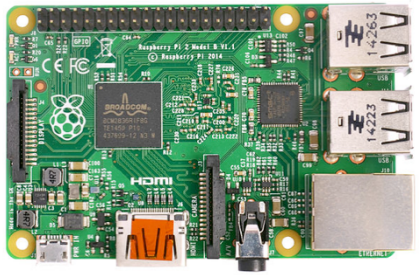
Kerlink IoT Station

PicoWAN from
Archos

TheThingNetwork

From 250€ to 1500€

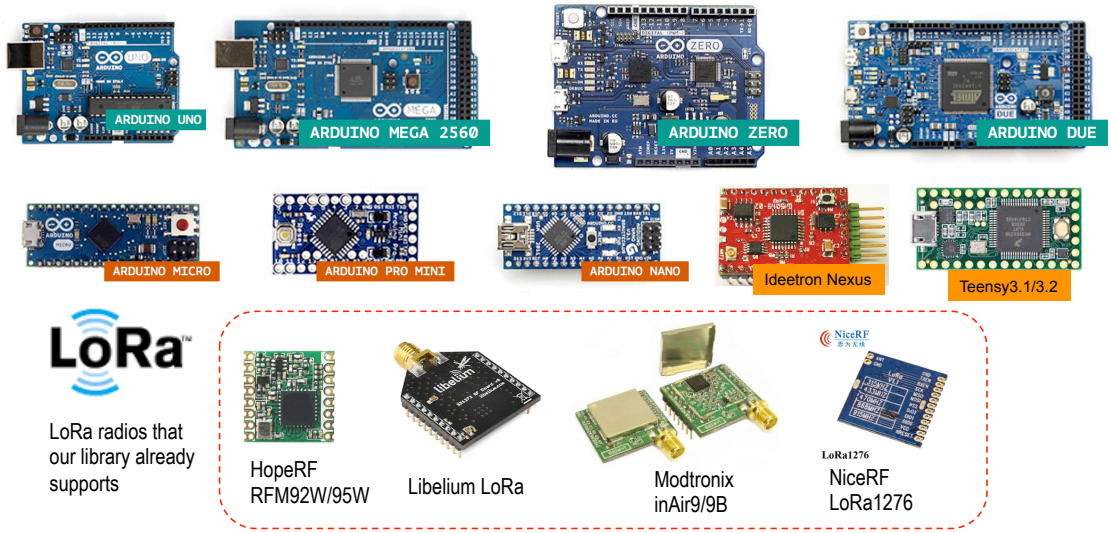
Raspberry-based LoRa gateway



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

Less than 50€

SIMPLICITY!



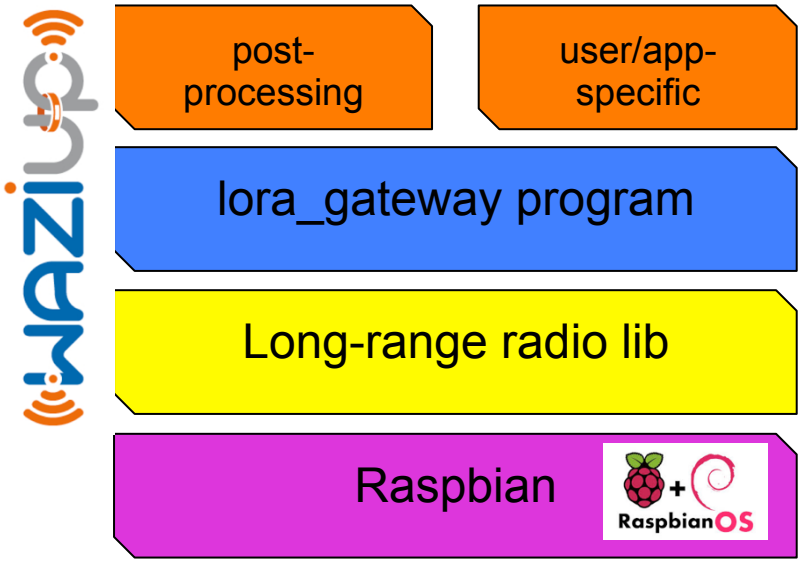
LoRa radios that our library already supports

Long-Range communication library

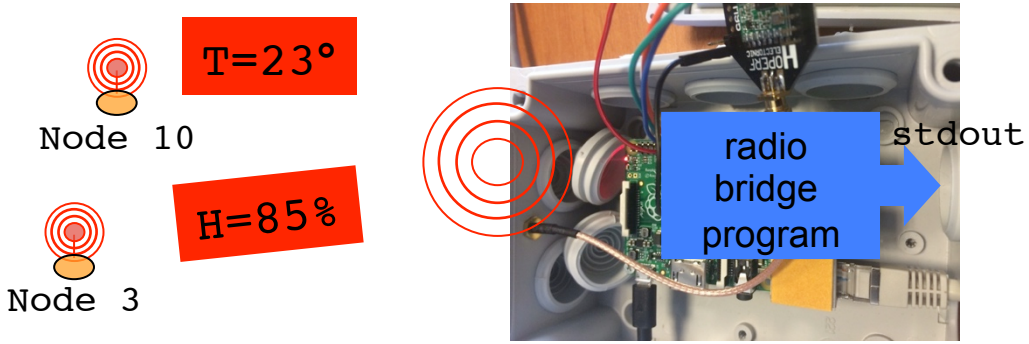
```
sendPacketTimeout("18.5");
// sends to gateway
// 18.5 : temperature message
```

1 send function!

Our Low-Cost gateway architecture

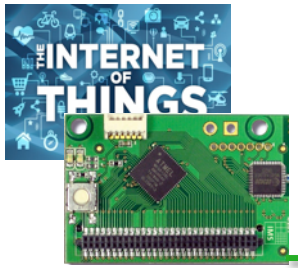


TRANSPARENT LORA BRIDGE




```
> sudo ./lora_gateway
Power ON: state 0
LoRa mode: 4
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge

--- rxlora. dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSIpkt=-54
^p1,16,10,0,5,9,-54
T=23°
--- rxlora. dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSIpkt=-54
^p1,16,3,0,5,8,-54
H=85%
```



IoT cloud?

Dropbox

Firebase

FIWARE

Axēda®

ioBridge®
Connect things.

ThingSpeak

GroveStreams

SensorCloud™

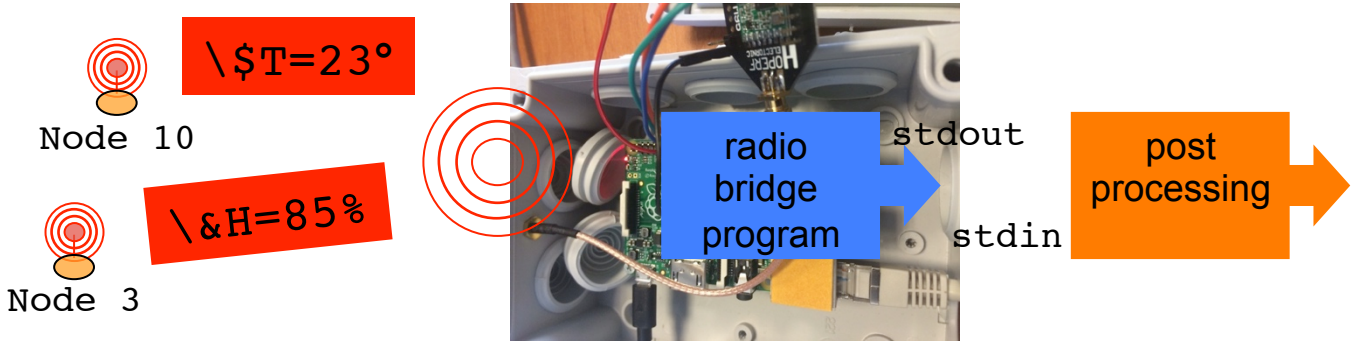
freeboard

dweet.io

openRemote

TempoIQ

LOG RECEIVED MESSAGES USING CLOUD SERVICES

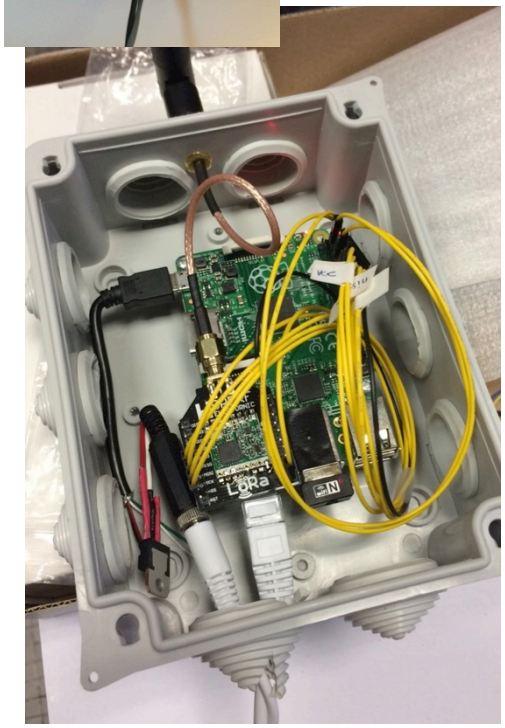


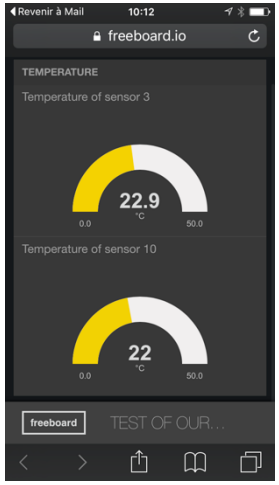

```
> sudo ./lora_gateway | python ./post_processing_gw.py
Power ON: state 0
LoRa mode: 4
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge

--- rxlora. dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSIpkt=-54
Rcv ctrl packet info 1,16,10,0,5,9,-54
(dst=1 type=0x10 src=10 seq=0 len=5 SNR=9 RSSI=-54)
rcv msg to log (\$) on dropbox : T=23°
--- rxlora. dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSIpkt=-54
Rcv ctrl packet info 1,16,3,0,5,8,-54
(dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSI=-54)
rcv msg to log (\&) on firebase : H=85%
```

\$ or \& before the data indicates that the data should be logged on a file or server. It is up to the end-device to decide which option

Templates for various clouds

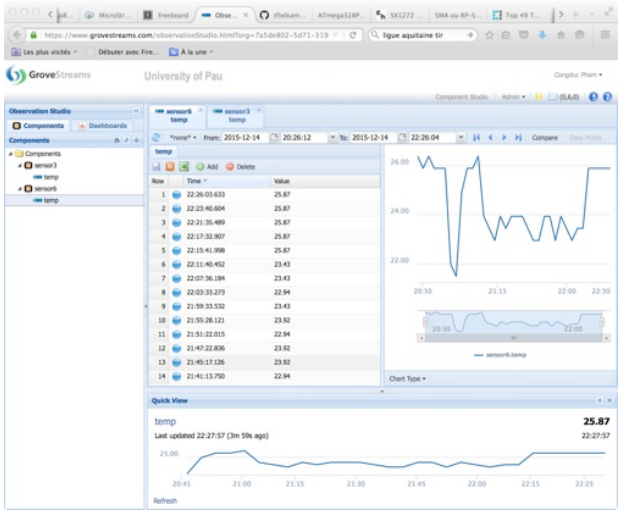




Dropbox

freeboard

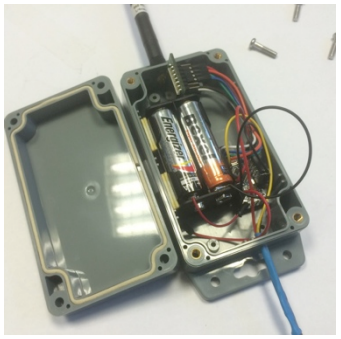
FIWARE

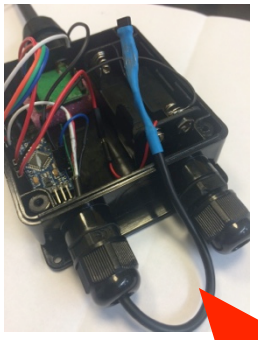


GroveStreams

SensorCloud™

Do it yourself !

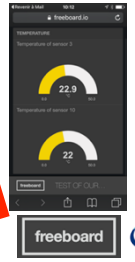


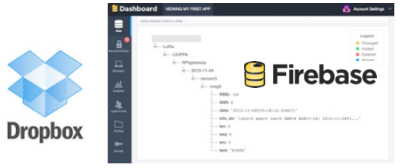


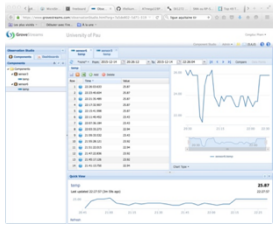
Step-by-step tutorial and source code available

Step-by-step tutorial and source code available

Python scripts available







https://github.com/CongducPham/LowCostLoRaGw

Working without Internet access

A

10-15kms

GSM GPRS

3G

Wi Fi

Internet access

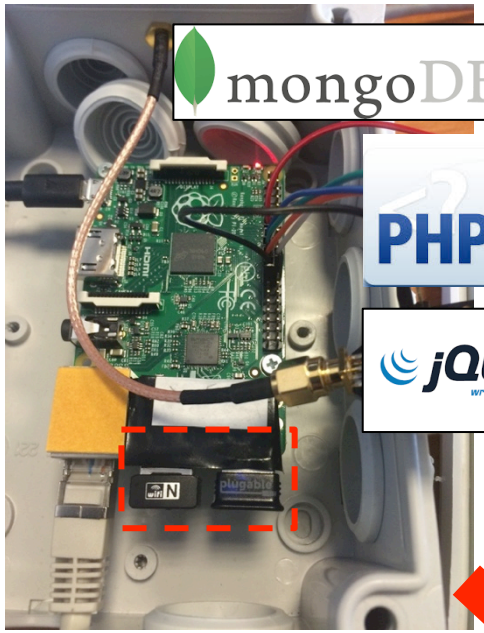
LoRa™

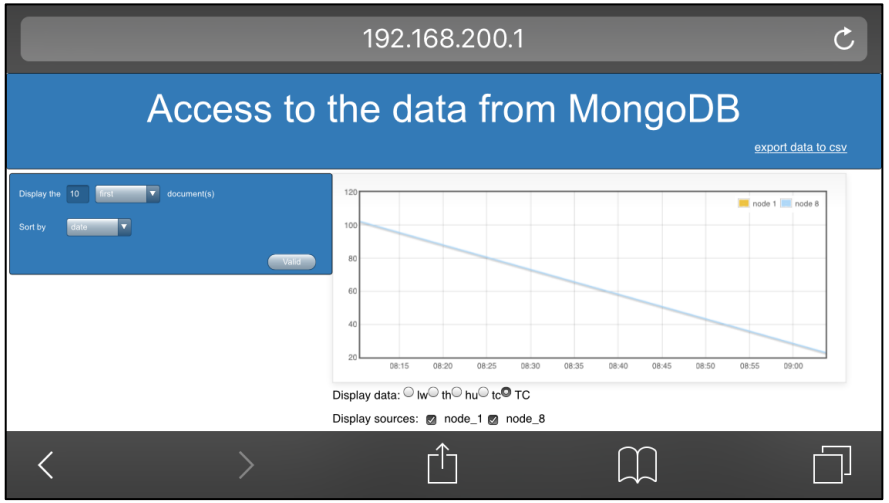
No subscription
Deploy own network
Low energy consumption

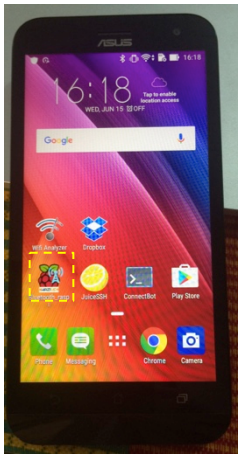
B

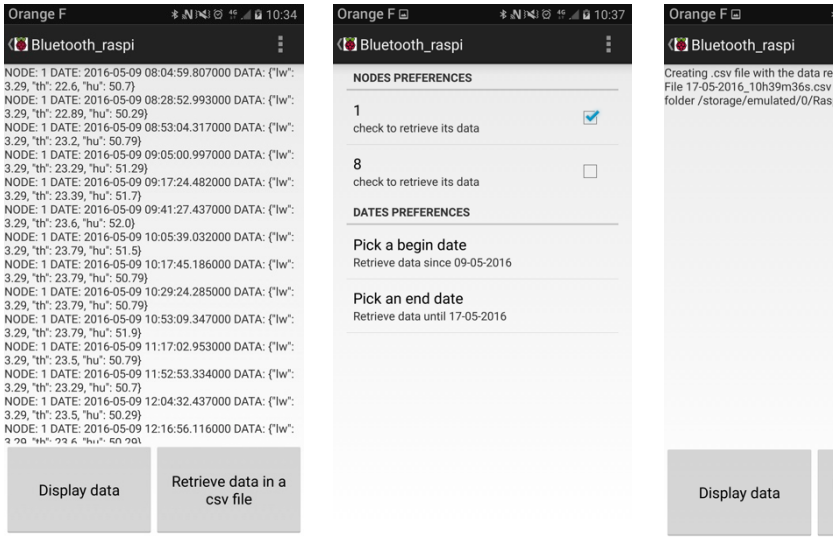
Wi Fi

STANDALONE GATEWAY

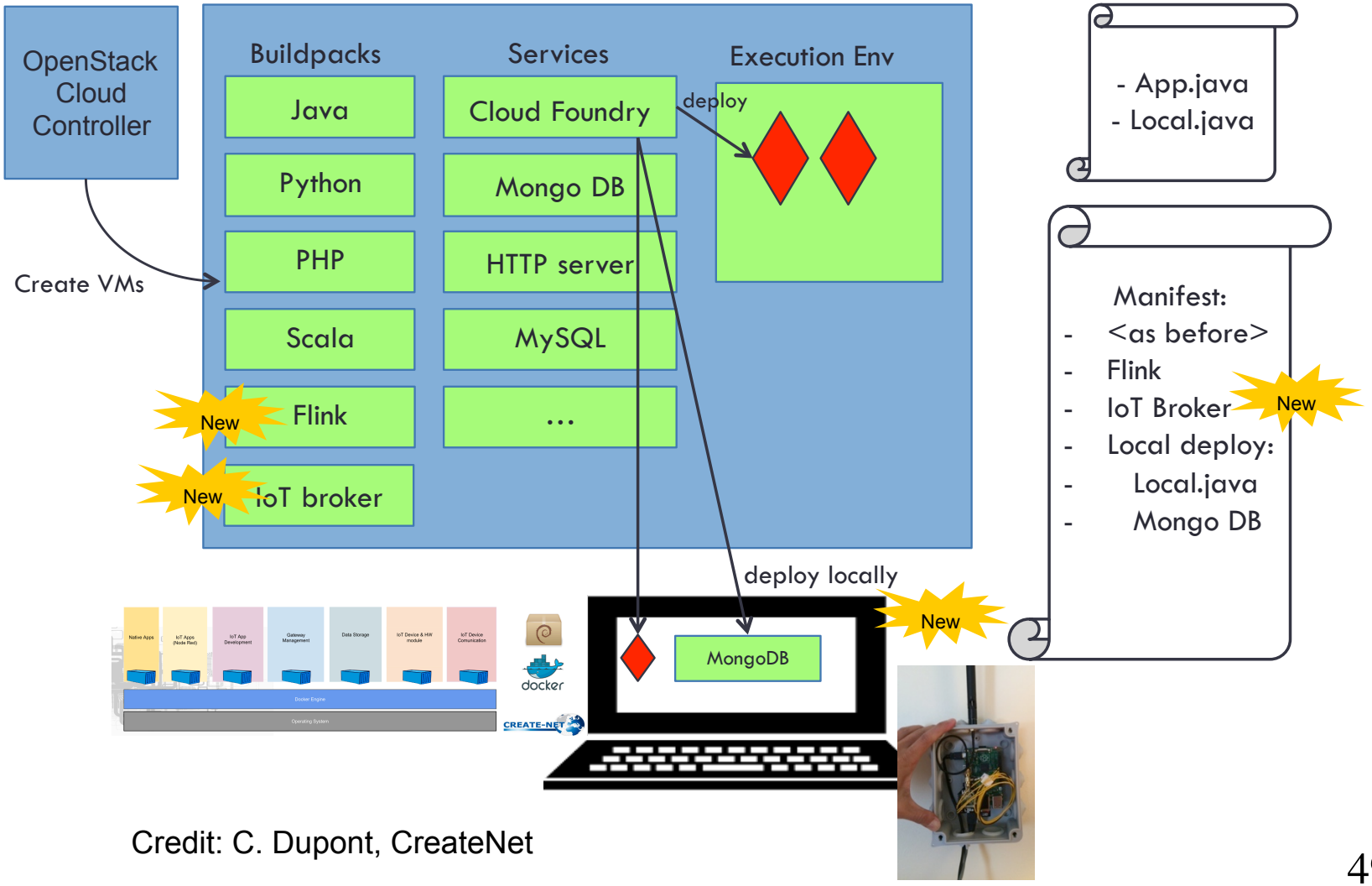






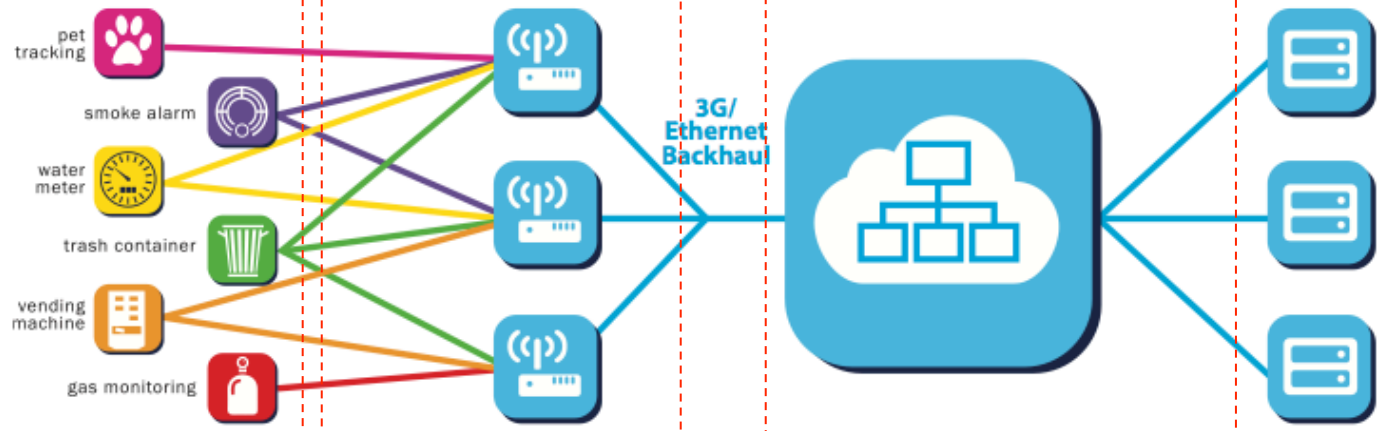


LOCAL DATA ANALYTICS



Credit: C. Dupont, CreateNet

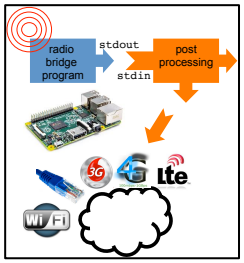
Figure from Semtech



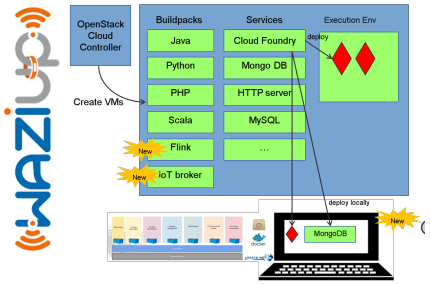
A

Application, MVP

WAZIUP Sensor platform

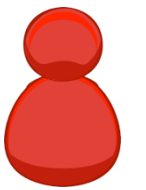


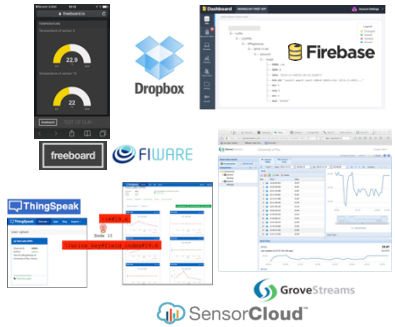
WAZIUP gateway platform

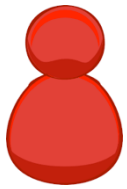


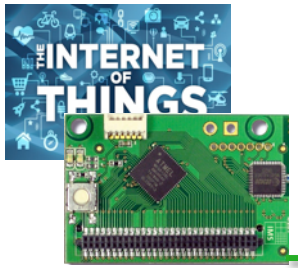
WAZIUP platform

B

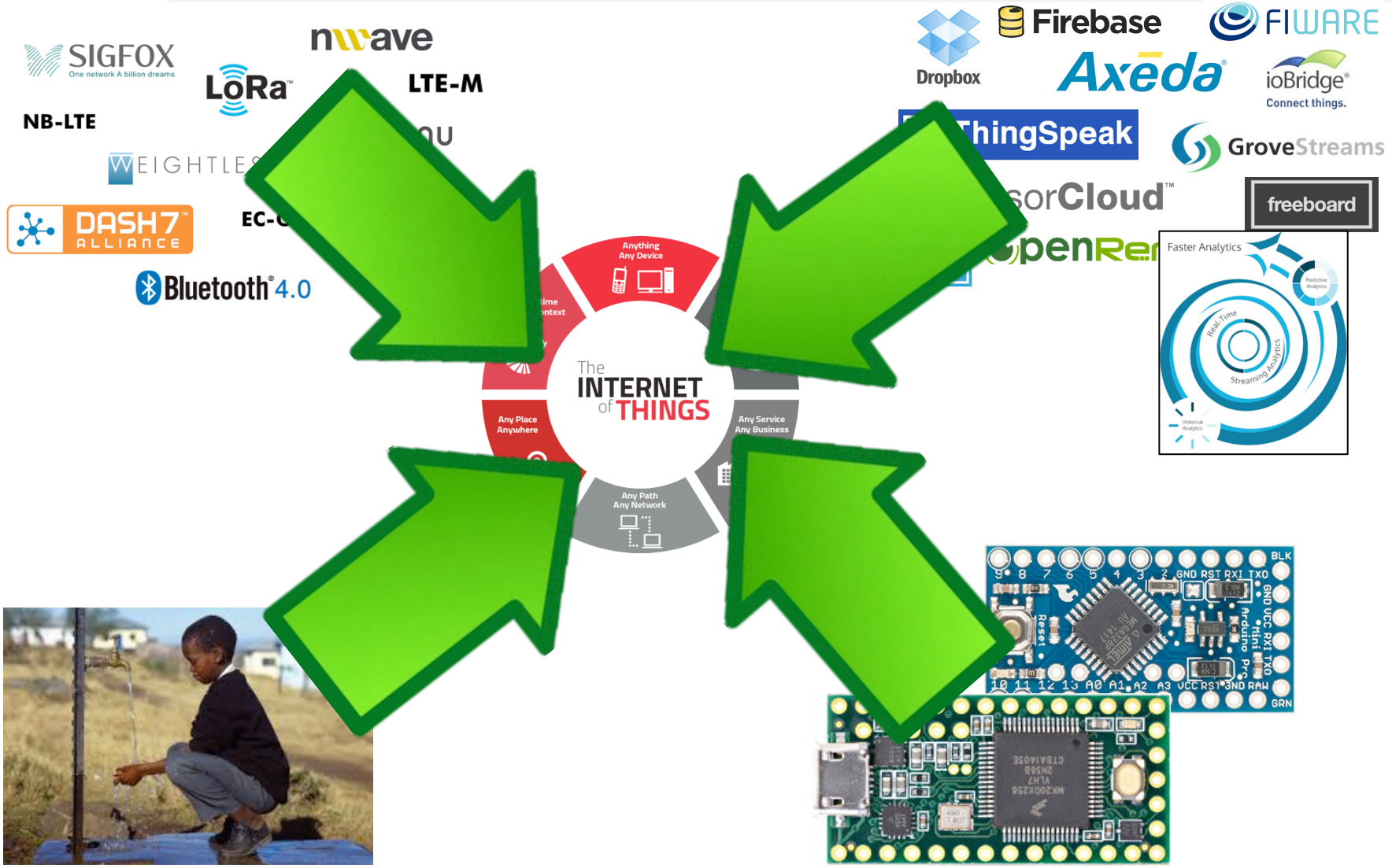








Now,
IoT becomes reality!

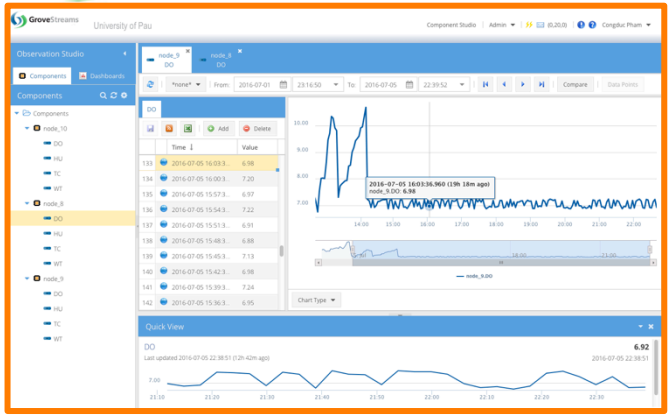


Use case: fish pond monitoring

- Farmerline in Ghana
- Water temperature and dissolved oxygen for monitoring fish ponds

Out-of-the-box !

GroveStreams



Physical sensor reading

Physical sensor management

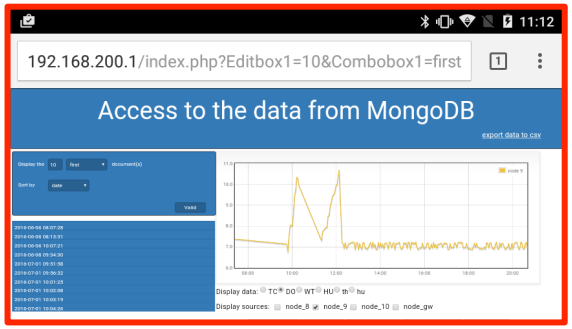
Activity duty-cycle, low power

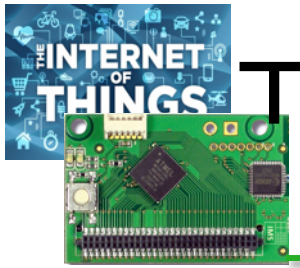
Security

Long-range transmission

Logical sensor management

Wi Fi





THINGS WE ARE DOING FOR RESEARCH

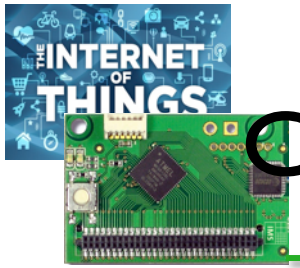
- To leverage the « single » connection gateway approach
  - Smarter radio channel access mechanism
- Image sensor
  - Transfer low-resolution images for context-awareness applications
- To handle larger amount of data (image)
  - Quality of Service mechanism
  - Activity sharing mechanism
- The proposed framework can be used to set-up your own LoRa test-bed for implementing advanced mechanisms

Added-value

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)

Credit: C. Vavasseur, CTIC Dakar



COMMUNITY ENGAGEMENT

	Hackathons	Innovation Lab Weeks	Startup weekends	Webinars	Conferences	Workshop	Participation to international events	Presentation events	Publications
Scientific researchers	☑	☑		☑	☑		☑	☑	☑
Developers	☑	☑	☑	☑	☑	☑	☑	☑	
Entrepreneurs	☑	☑	☑		☑	☑	☑	☑	☑
End-users	☑	☑				☑		☑	
Standardisation and policy makers					☑		☑	☑	☑
Application industries					☑	☑	☑	☑	☑
Investors					☑		☑	☑	☑

Credit: C. Vavasseur, CTIC Dakar

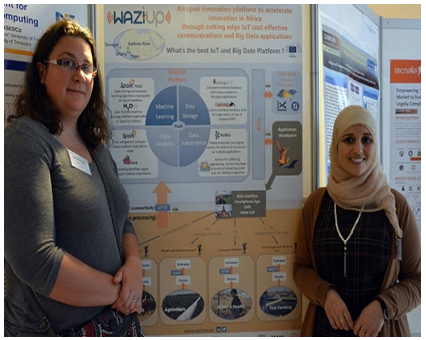
Building WAZIUP community and ecosystem

International Events
+ 20 organized & attended

Launch event (Ghana, iSpace)

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

IoTWeek2016 (Belgrade, EGM)



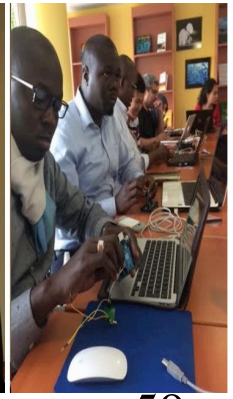
IoTBigData2016 (Italy, EGM)

Launch event (Senegal, CTIC Dakar)

IoTCareConference (Budapest, CNET)

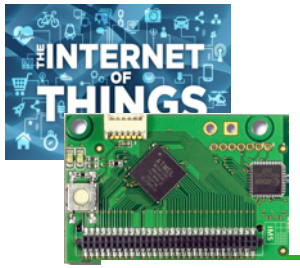
WAZIUP Workshop on IoT (Togo, L'Africaine d'Architecture)

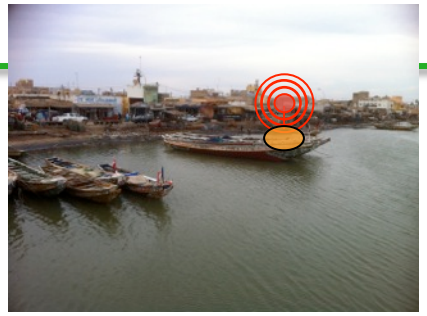
Credit: C. Vavasseur, CTIC Dakar

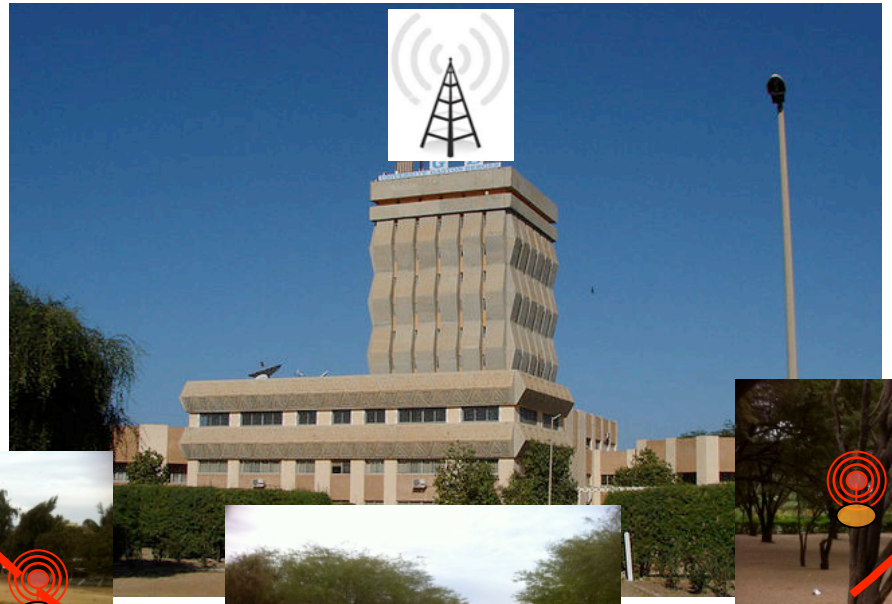


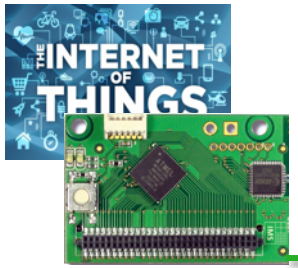
Workshop at the RESSACS 2016 (France, UPPA)

Open Long-range test-bed & benchmark

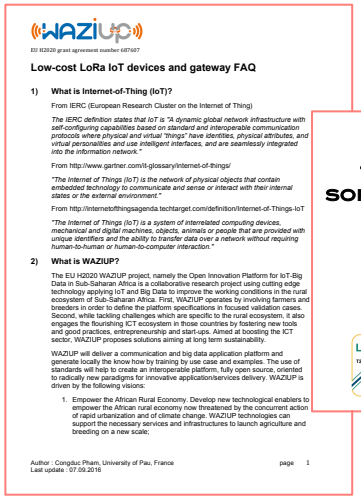








TUTORIALS/RESOURCES



WAZIUP

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 Rural Economy. Develop new technological enablers to empower the African rural economy now threatened by the concurrent action of rapid urbanization and of climate change. WAZIUP technologies can support the necessary services and infrastructures to launch agriculture and breeding on a new scale;

Author : Congduc Pham, University of Pau, France page 1
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TUTORIAL ON HARDWARE & SOFTWARE FOR LOW-COST LONG-RANGE IOT

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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 IOT: USING THE WAZIUP DEMO KIT

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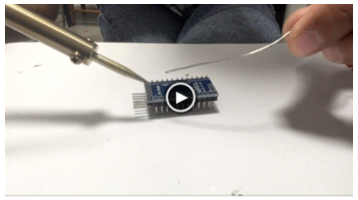

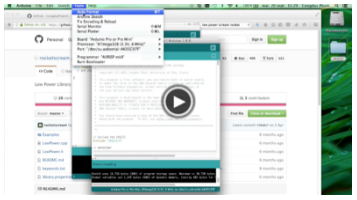

Thanks.

Let's keep in touch

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