Low-cost, long-range open IoT for smarter rural African villages

IEEE International Smart Cities Conference (ISC2'2016)

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

IoT domain in Africa

Irrigation & Agriculture

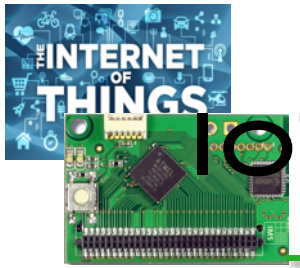
Livestock farming

Fish farming & aquaculture

Storage & logistic

Health

Water quality



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
- to deploy IoT in Sub-Saharan Africa, it is necessary to target three major issues
  - longer range for rural access
  - cost of hardware and services
  - limit dependancy to proprietary infrastructures and provide local interaction models

Rural Sensing

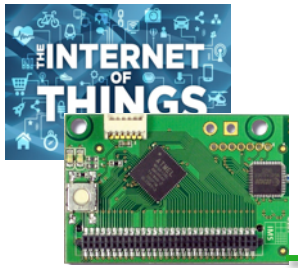
Moisture/
Temperature
of storage
areas

10-15kms

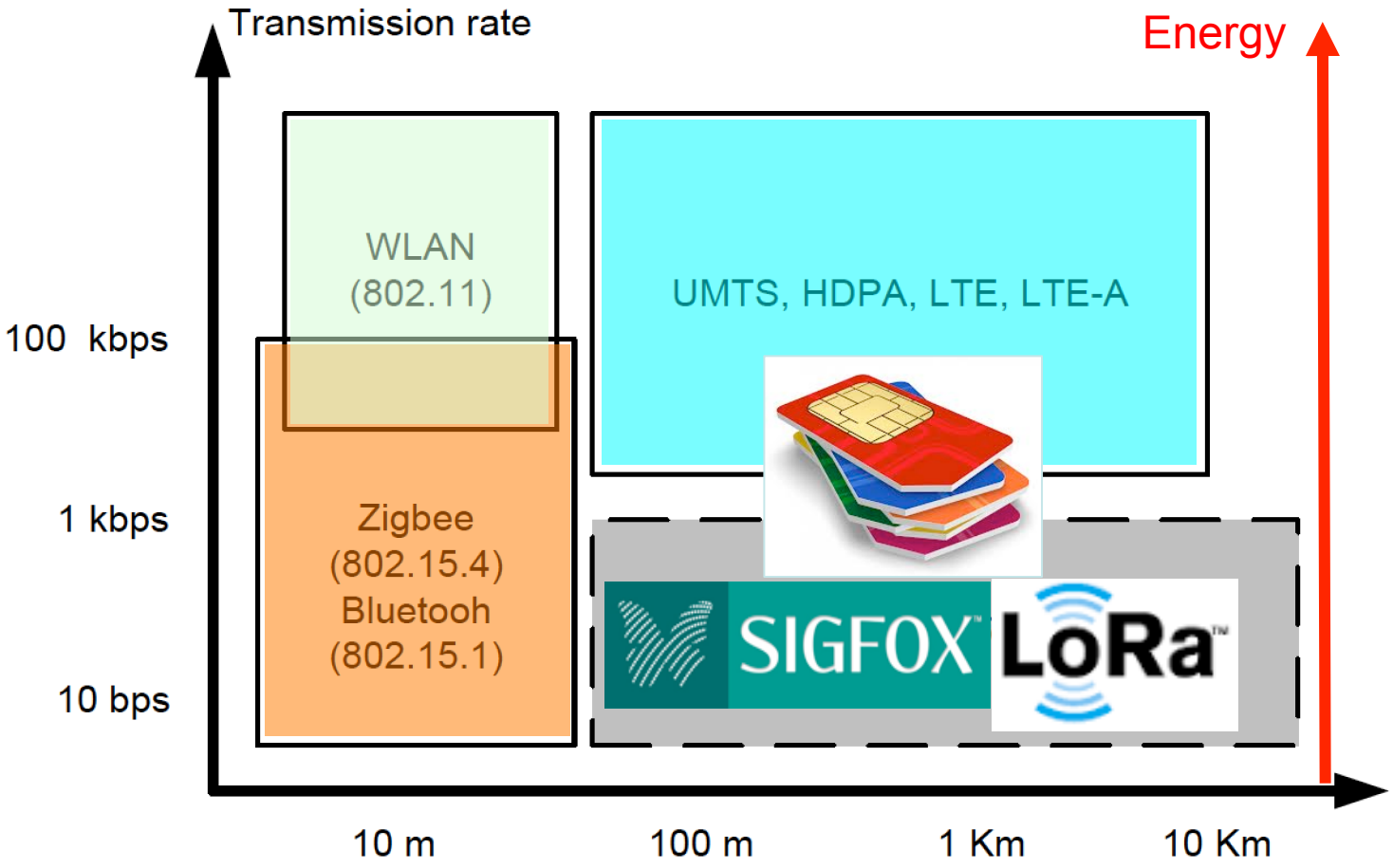
GSM GPRS

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



Low-power and long-range?

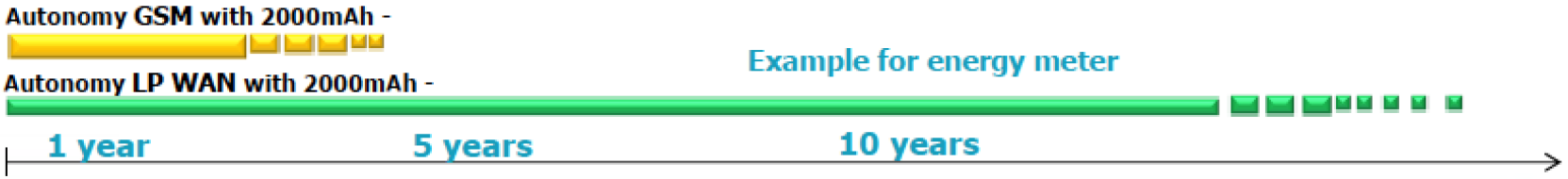


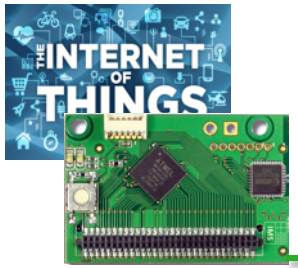
Enhanced from M. Dohler "M2M in SmartCities"

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 $





Long-range Rural Sensing

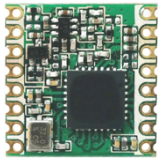
Moisture/ Temperature of storage areas

10-15kms

LoRa™

No subscription
Deploy own network
Low energy consumption

Add LoRa radio module to your preferred dev platform



Install a LoRa gateway and start collecting data

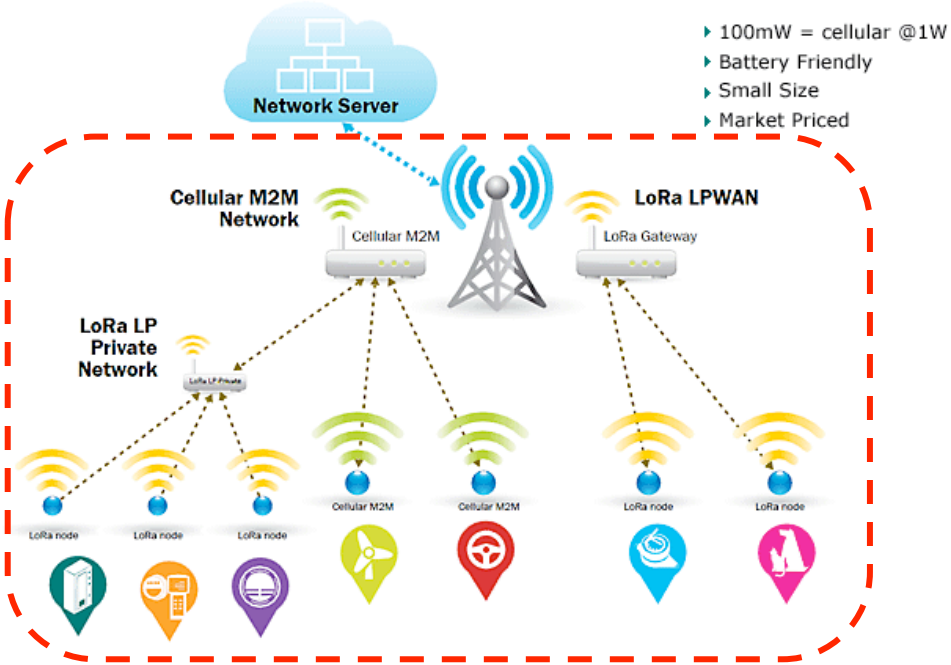
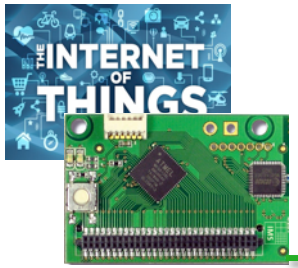


Figure from Semtech



MATURATION OF THE IoT MARKET…

Waste Container connected sensor

… BUT NOT ADAPTED FOR RURAL AFRICA CONTEXT

- Too expensive, too integrated, not flexible
- Do-It-Yourself approach with off-the-shelves components more adapted

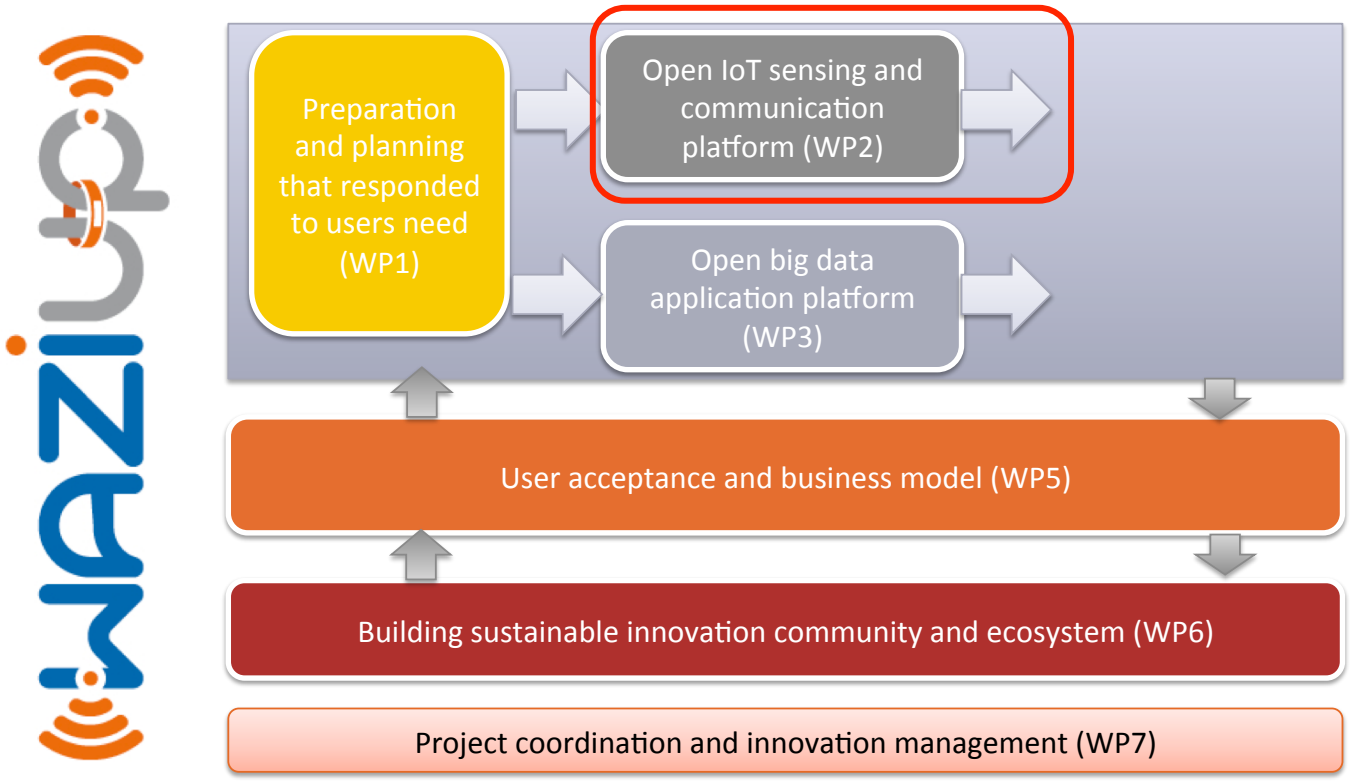
Theairboard on kickstarter

Tinyduino

SODAQ autonomo

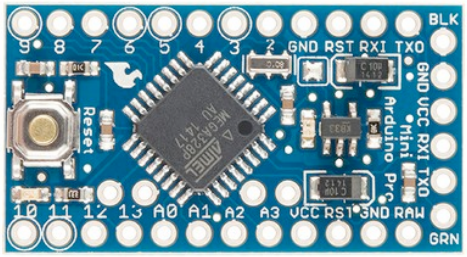
IoT FOR RURAL APPLICATIONS IN DEVELOPPING COUNTRIES

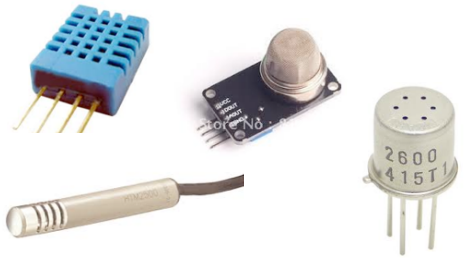
- WAZIUP is an EU H2020 project (2016-2019)
- contributes to long-range networks for rural applications with WP2

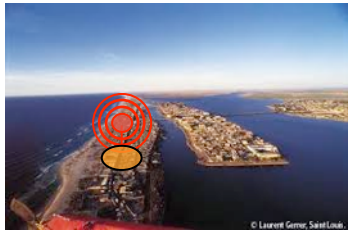


Generic sensing IoT device

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





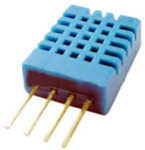


Ready-to-use templates

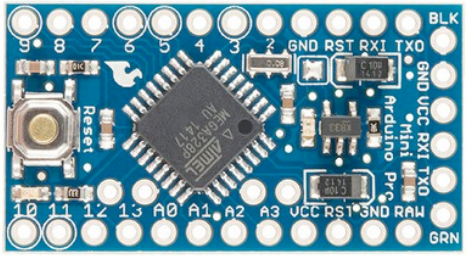
Physical sensor reading

Physical sensor reading

Physical sensor reading



Physical sensor management

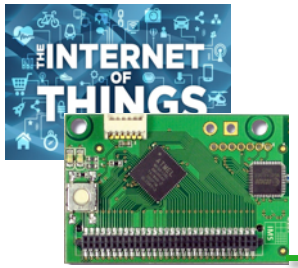


Activity duty-cycle, low power

Security

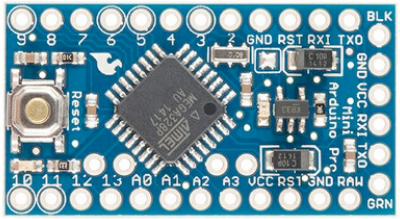
Long-range transmission

Logical sensor management

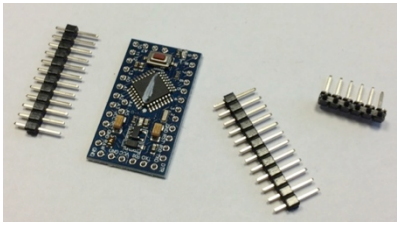


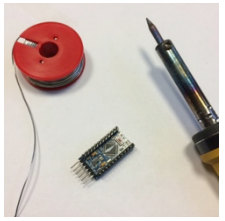
Easy integration and customization

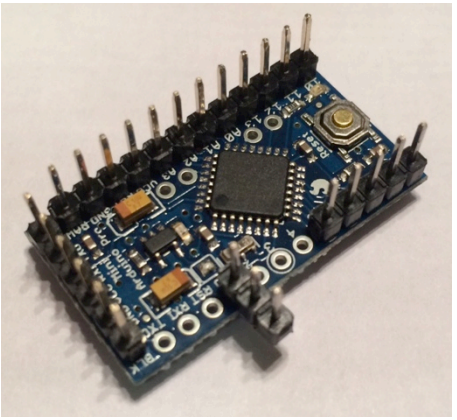
Arduino Pro Mini

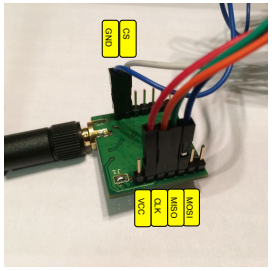


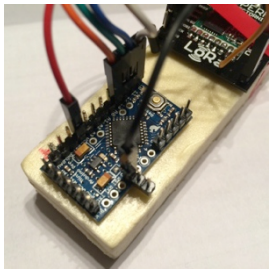
3.3v and 8MHz version

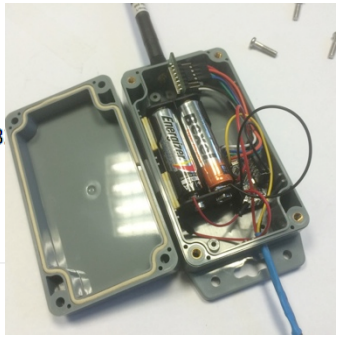


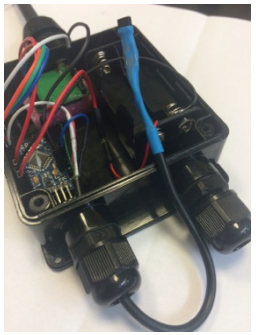


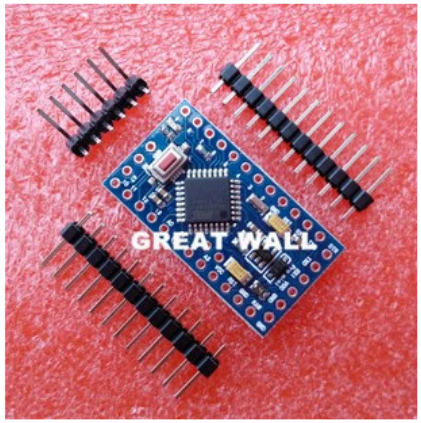












Avec la bootloader 1 pcs Pro Mini ATMEGA328 Pro Mini 3
MHz pour Arduino

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)

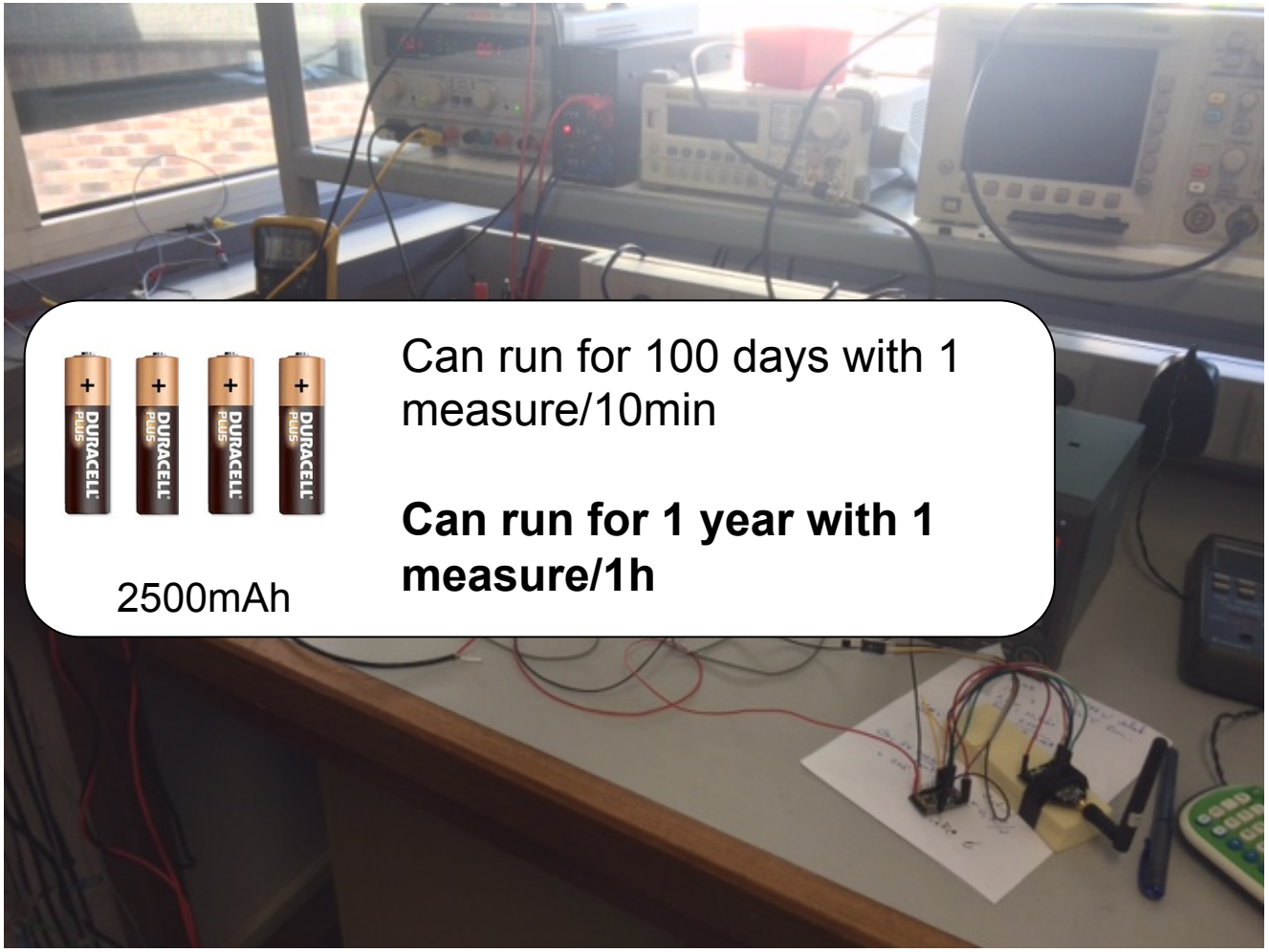
Quantité : – 1 + Kit (55350 Kits available)

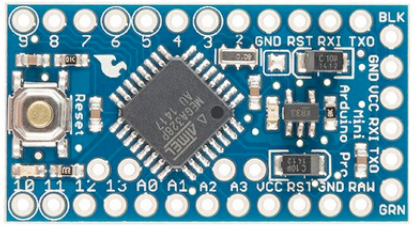
Montant total : € 1,78

Acheter maintenant | Ajouter au panier

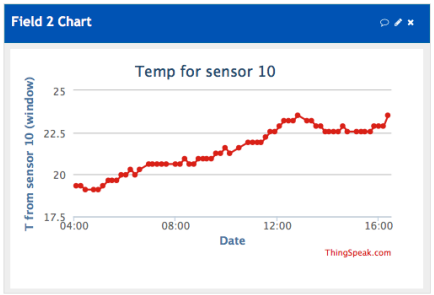
Running for 1 year with low-power mode!

Low-Power library from RocketScream



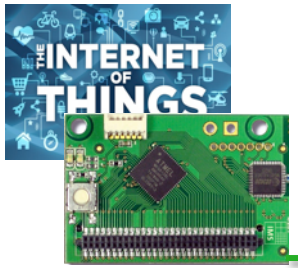


Wakes-up every 10min, take a measure (temp) and send to GW



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

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

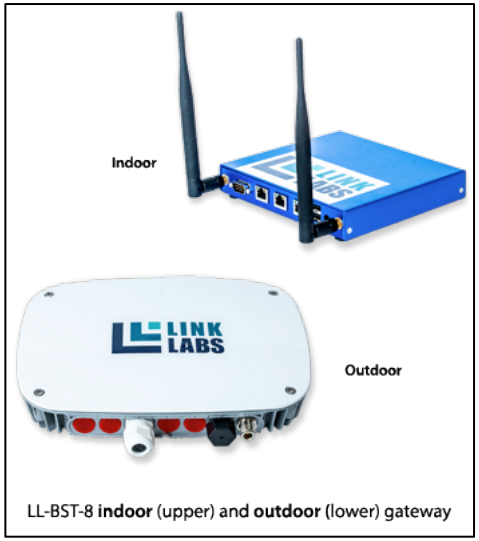


LoRa Gateways
(non exhaustive list)

Multi-Tech Conduit

Embedded Planet
EP-M2M-LORA

Ideetron Lorank 8



LinkLabs Symphony

Kerlink IoT Station

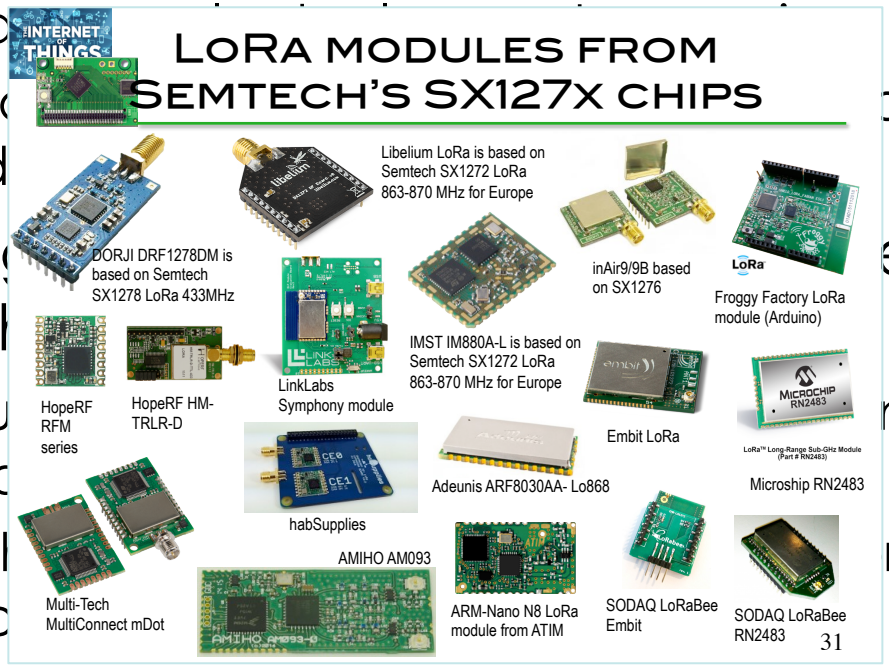
PicoWAN from
Archos

TheThingNetwork

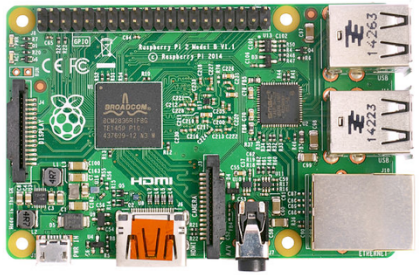
Or build your own one:
Arduino, Rasperry PI, …

Low-cost LoRa gateways

- Commercial gateways
  - Target lo
  - Use adv ost hundred
- Low-cost g edium-scale ad-h
  - Use regu nection » from enc
  - Use off-th rms for much lower-co
  - Use standard UNIX tools and high-level language for maximum flexibility and evolution



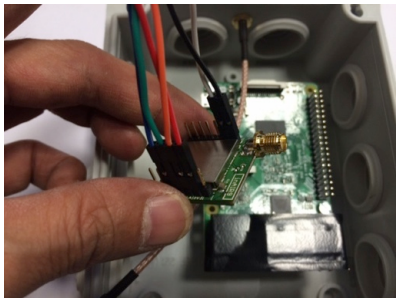
Raspberry-based LoRa gateway



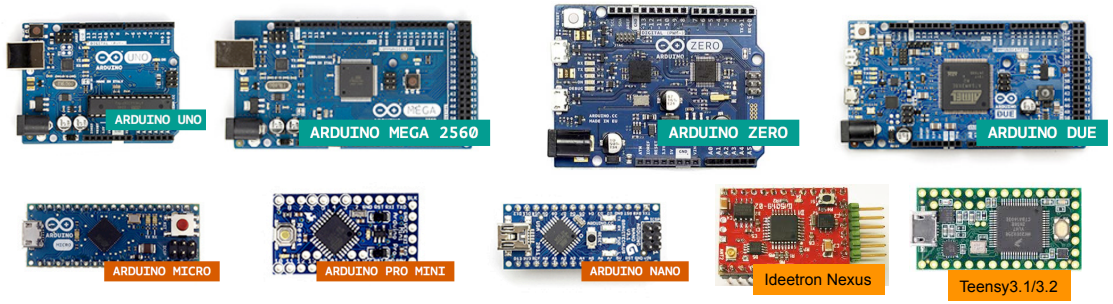
We can use all model of Raspberry. The most important usefull feature is the Ethernet interface for easy Internet connection. Then WiFi and Bluetooth can be added with USB dongles. RPI3 provides built-in Ethernet, WiFi and Bluetooth!



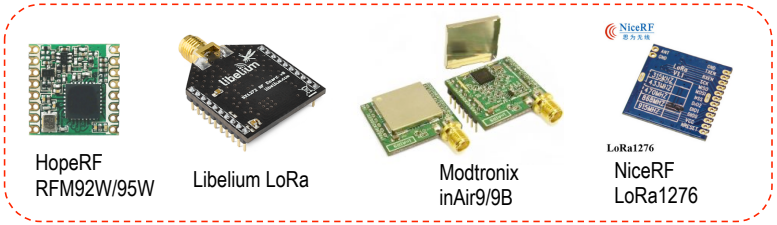





SW/HW BUILDING BLOCKS



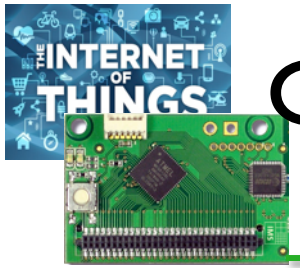
LoRa radios that our library already supports



Long-Range communication library

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

1 send function!



Our Low-Cost gateway architecture

Kept as simple as possible

high-level lang. e.g. python

Most of user or application specific logics is done here! We provide some basic features, up to you to enhance them

radio bridge program

stdout

post processing

stdout

stdin

mongoDB

post-processing

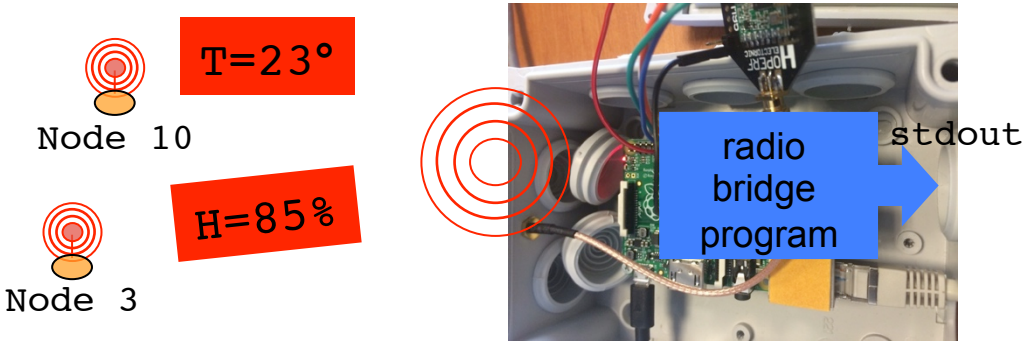
user/app-specific

lora_gateway program

Long-range radio lib

Raspbian

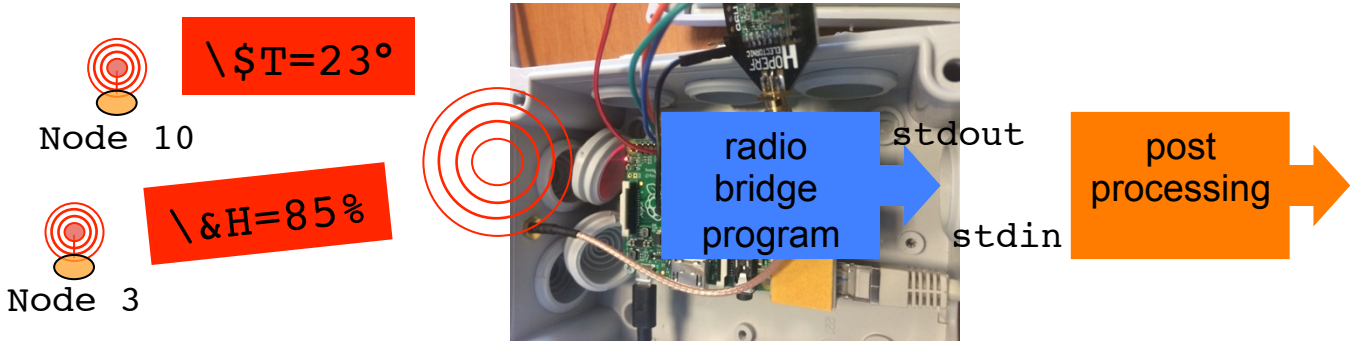
Transparent LoRa bridge




```
> 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%
```

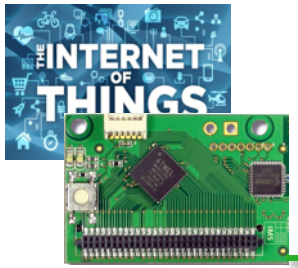
LOG RECEIVED MESSAGES USING CLOUD SERVICES




```
> 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



Need IoT cloud?

Dropbox

Firebase

FIWARE

Axēda®

ioBridge®
Connect things.

ThingSpeak

GroveStreams

SensorCloud™

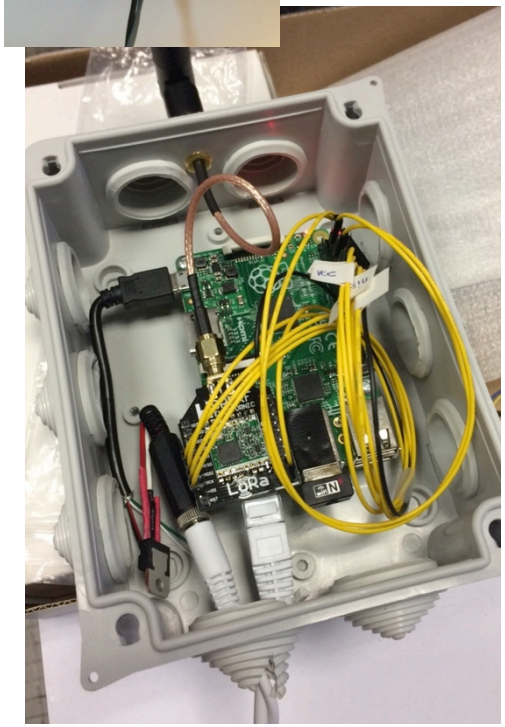
freeboard

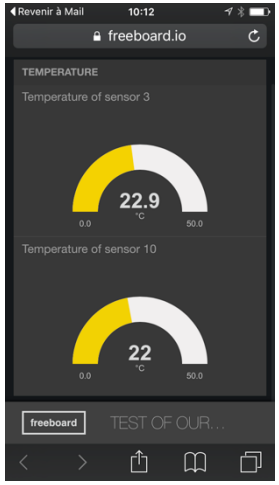
dweet.io

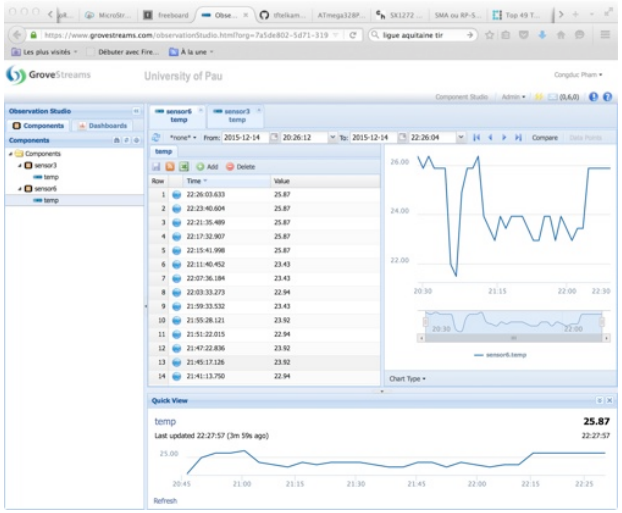
OpenRemote

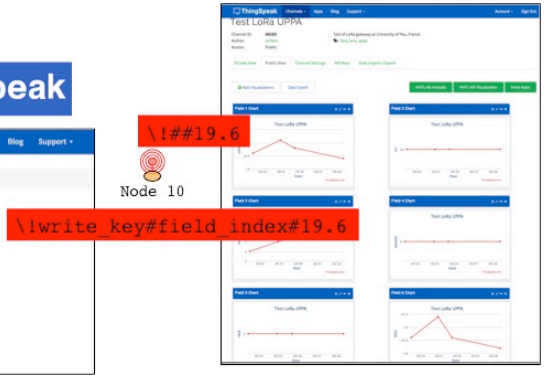
TempoIQ

Templates for various clouds









\!##19.6

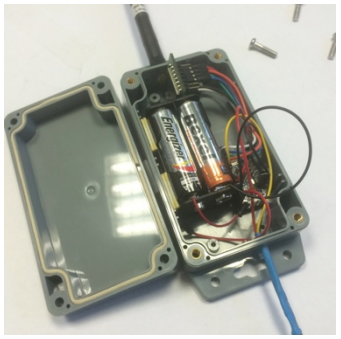
Node 10

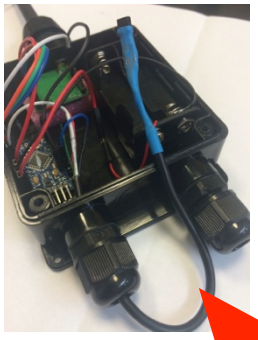
\!write_key#field_index#19.6

GroveStreams

SensorCloud™

Do it yourself !

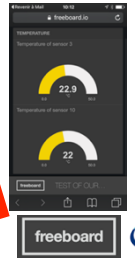


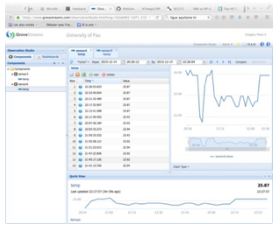


Step-by-step tutorial and source code available

Step-by-step tutorial and source code available

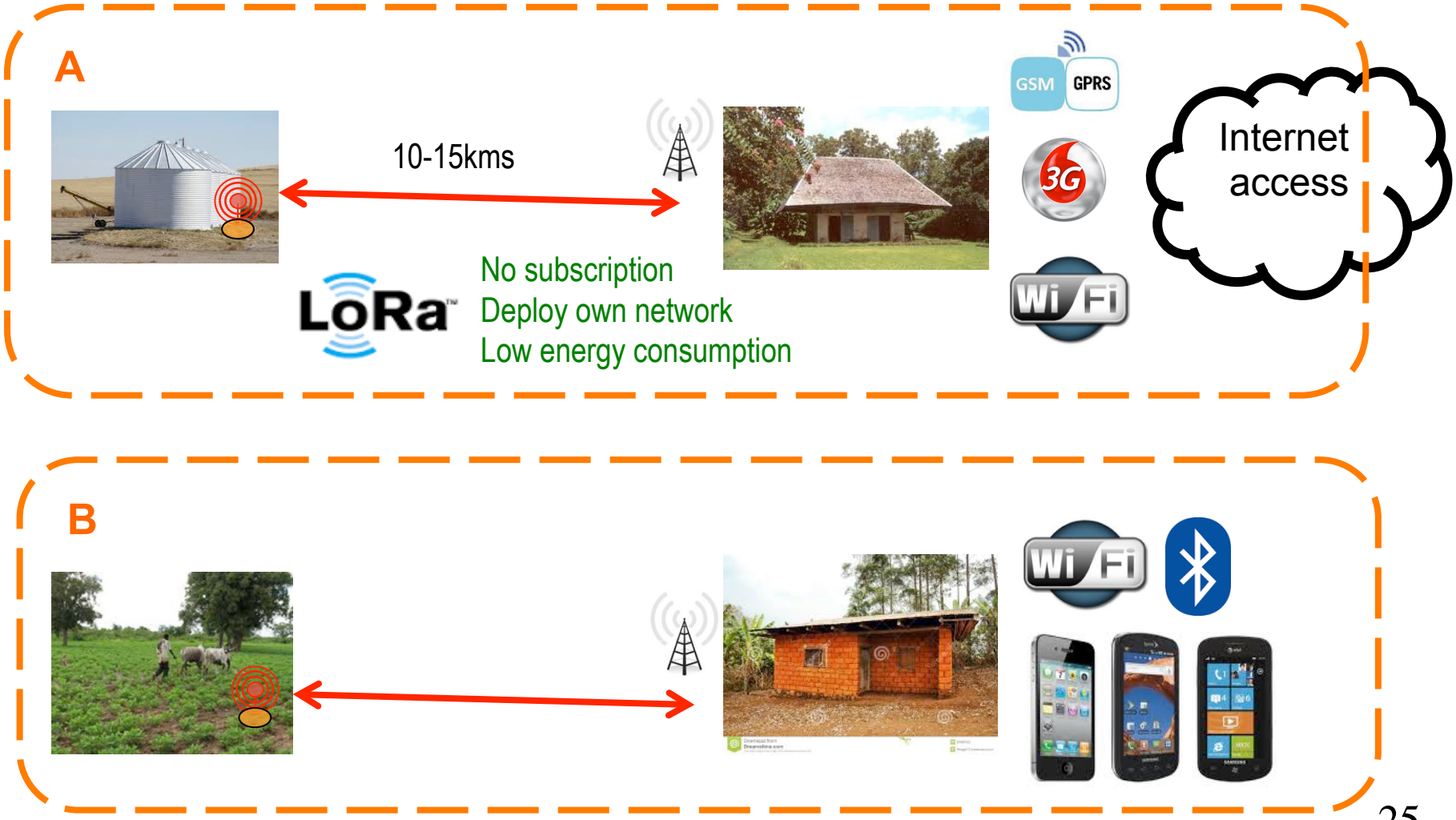
Python scripts available



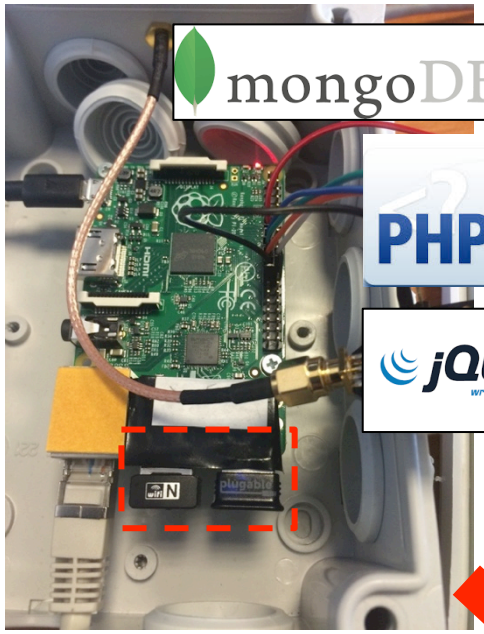


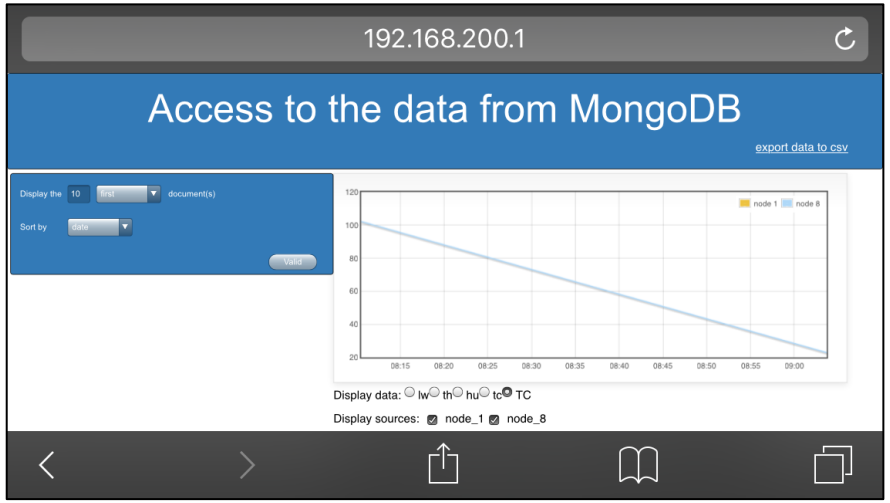
https://github.com/CongducPham/LowCostLoRaGw

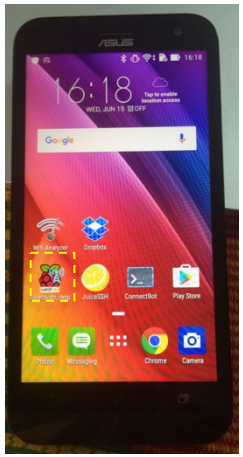
Working without Internet access

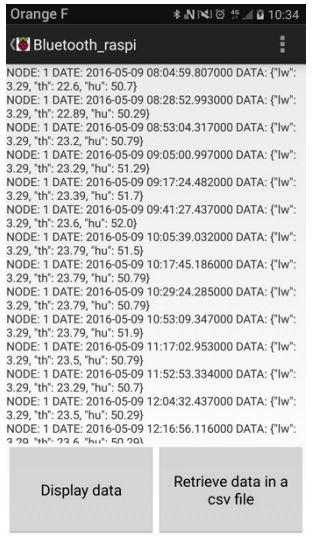


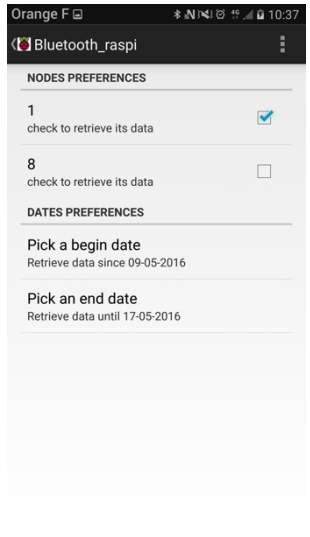
Standalone gateway

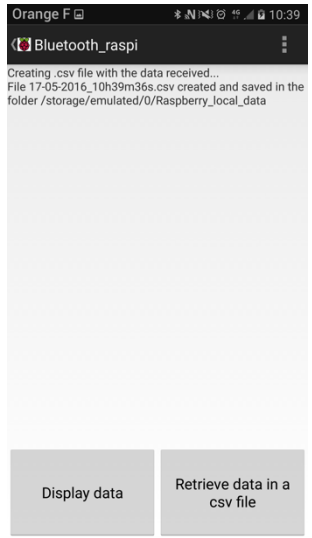


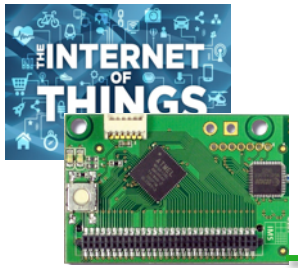






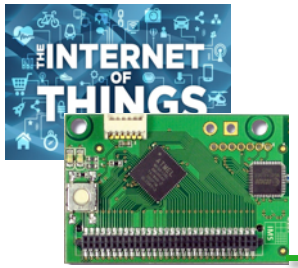






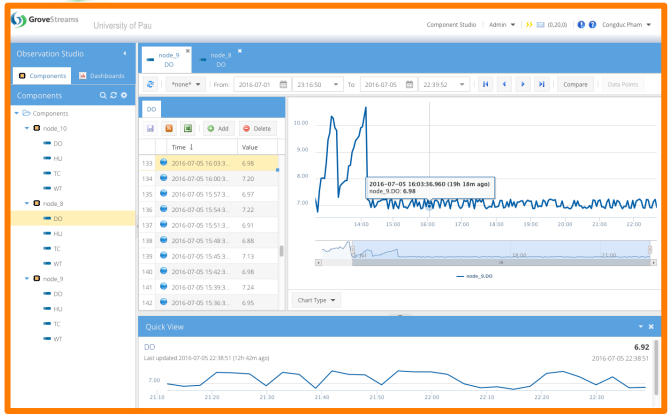
Use case: fish pond monitoring

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



Out-of-the-box !

GroveStreams

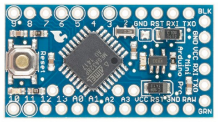


Waziup

Physical sensor reading

Waziup

Physical sensor management



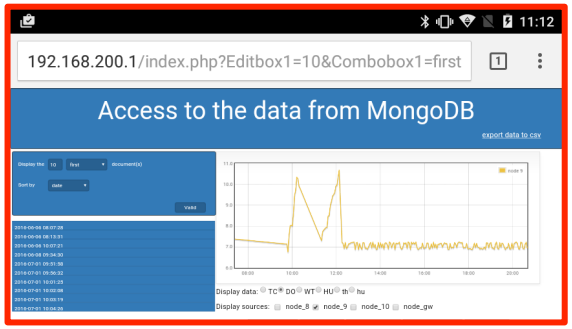
Activity duty-cycle, low power

Security

Long-range transmission

Logical sensor management

Wi Fi



THINGS WE ARE DOING FOR RESEARCH

- To leverage the « single » connection gateway approach
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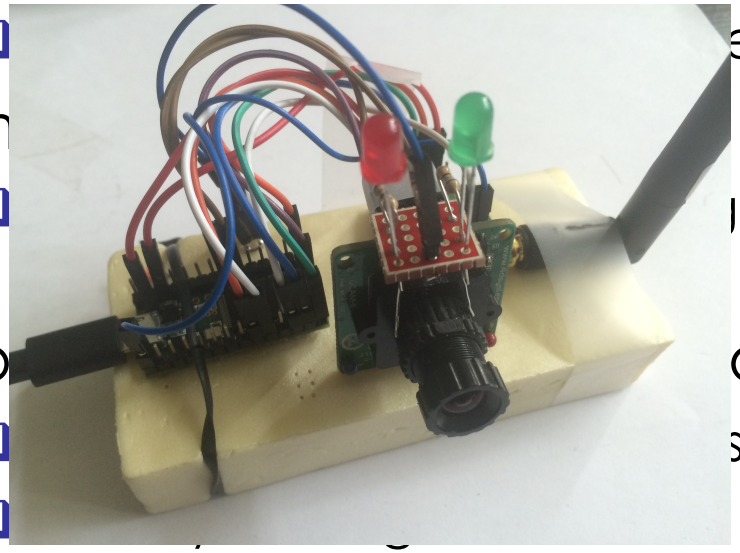
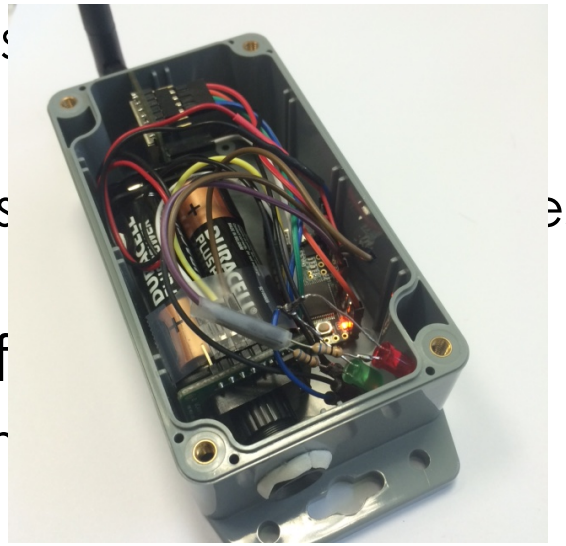
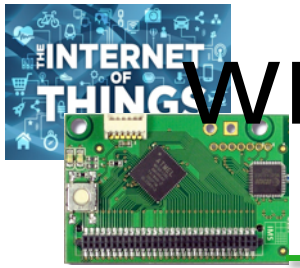
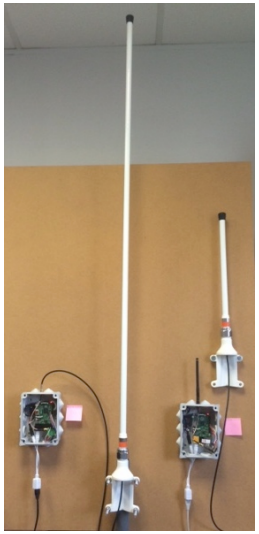
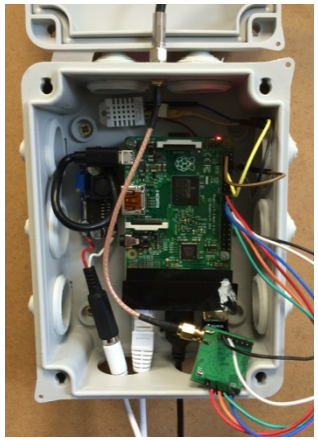
  - 
  - 
- The proposed framework can be used to set-up your own LoRa test-bed for implementing advanced mechanisms



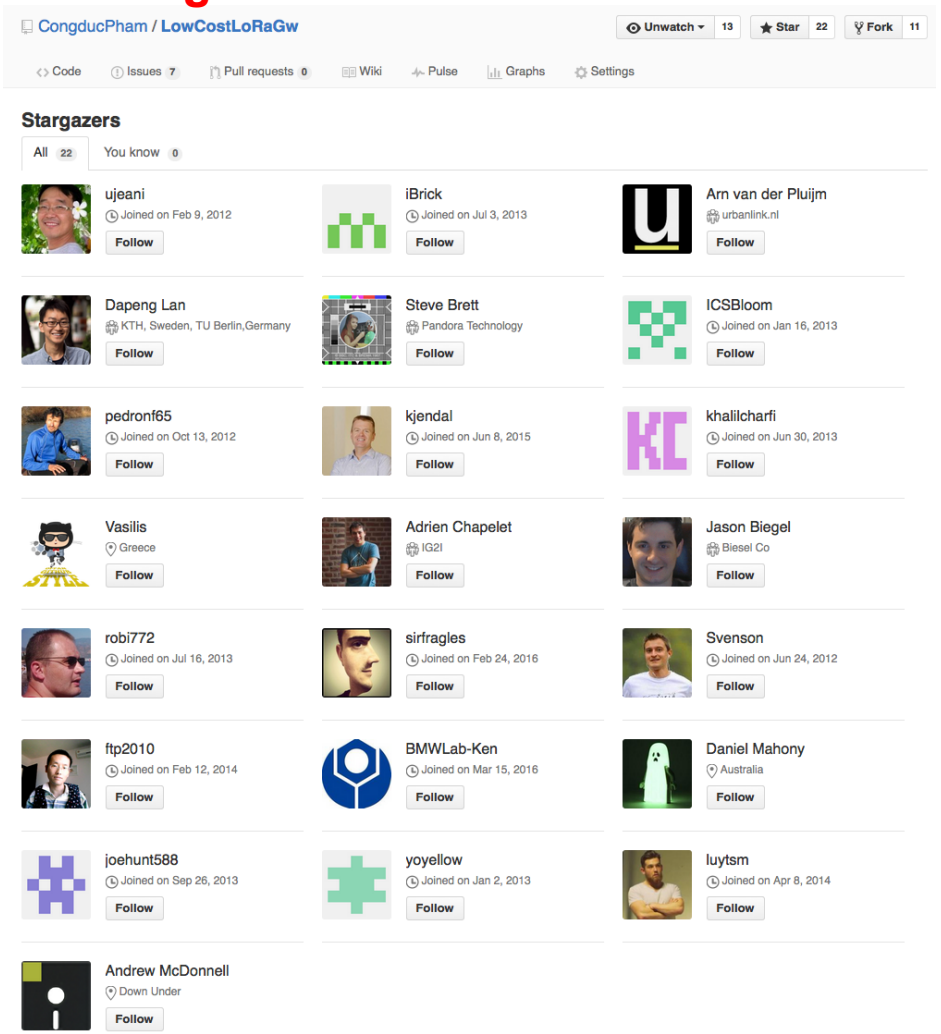
WHO IS DEPLOYING TEST–BEDS?

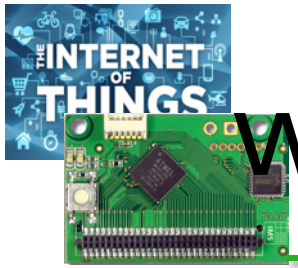
https://github.com/CongducPham/LowCostLoRaGw





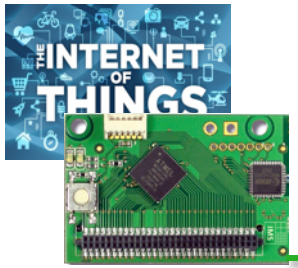
University Gaston Berger, Saint-Louis, Senegal The gateway will be used to deploy low-cost IoT solutions in the context of the H2020 WAZIUP project.	
Easy Global Market, Nice, France The gateway will be used to deploy LoRa service for various demonstration purposes	
As part of the WAZIUP project, a starter kit with a gateway will be deployed at project's partner's site: 1- Farmerline (Ghana) 2- iSpace (Ghana) 3- CTIC (Senegal)	
IIDRE SAS The gateway will be used to deploy LoRa service for various demonstration purposes	
Connecting Nature The gateway will be used to deploy and test LoRa-based telemetry services for various agriculture applications	
Chuck Swiger from West Virginia (US)... has a ds18b20 temp probe ThinkSpeak channel using our gateway	
The Oceanographic Observatory of Banuyls/mer (part of University of Paris 6) The gateway will be used to deploy and test LoRa-based telemetry services for various environmental surveillance applications	
Matthew Way from New Zeland Develops great LoRa-based pest surveillance system. He is testing our solution as well as his own custom design solutions.	





Why not using LoRaWAN

- Cost of gateway concentrator chip
- No custom behavior at gateway level, every thing is at application server level
- No P2P (senso-sensor) communications, prevent defining elaborated interaction models
- LoRaWAN channels are well defined and shared on larger scale, thus increasing probability of interferences
- Difficult (impossible?) to add additional mechanisms for advanced channel access, QoS, shared activity time,…



Conclusions

- Low-power, long-range transmission is a break-through technology for large-scale IoT deployment
- With low-cost, off-the-shelves hardware, IoT is entering the DIY era without giving up for performance and functionalities
- The whole IoT eco-system is becoming mature with availability of IoT clouds and advanced big data analytic platforms/frameworks
- We presented our IoT framework with design orientations to meet Sub-Saharan Africa needs