

# LESSONS LEARNED FROM PRACTICAL DEPLOYMENT OF WIRELESS SENSING SYSTEMS IN RURAL AREAS

**JOURNÉES RESSACS 2018  
UBO, BREST, 30 AOÛT 2018**



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



# QUELQUES RETOURS D'EXPÉRIENCES SUR LE DÉPLOIEMENT PRATIQUE DE RÉSEAUX DE CAPTEURS

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# IoT: development for rural areas



Irrigation



Aquaculture



Storage & logistic



Agriculture

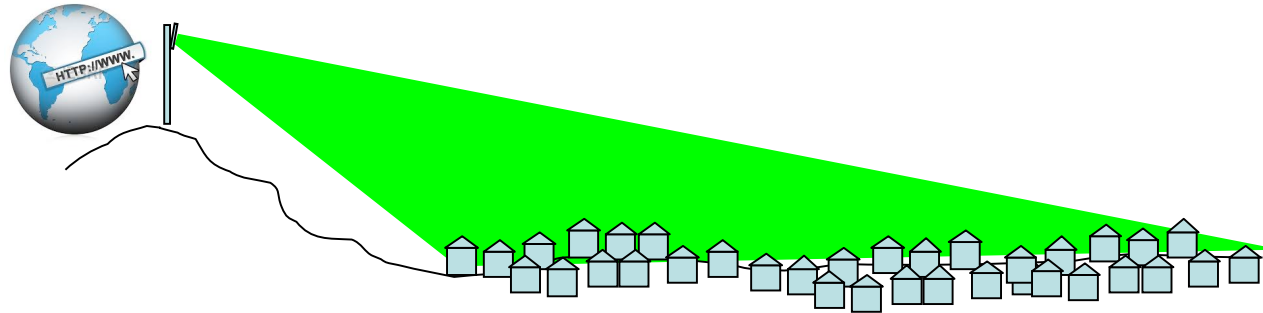


Environment

# Long-range Sensing Applications



Moisture/  
Temperature of  
storage areas



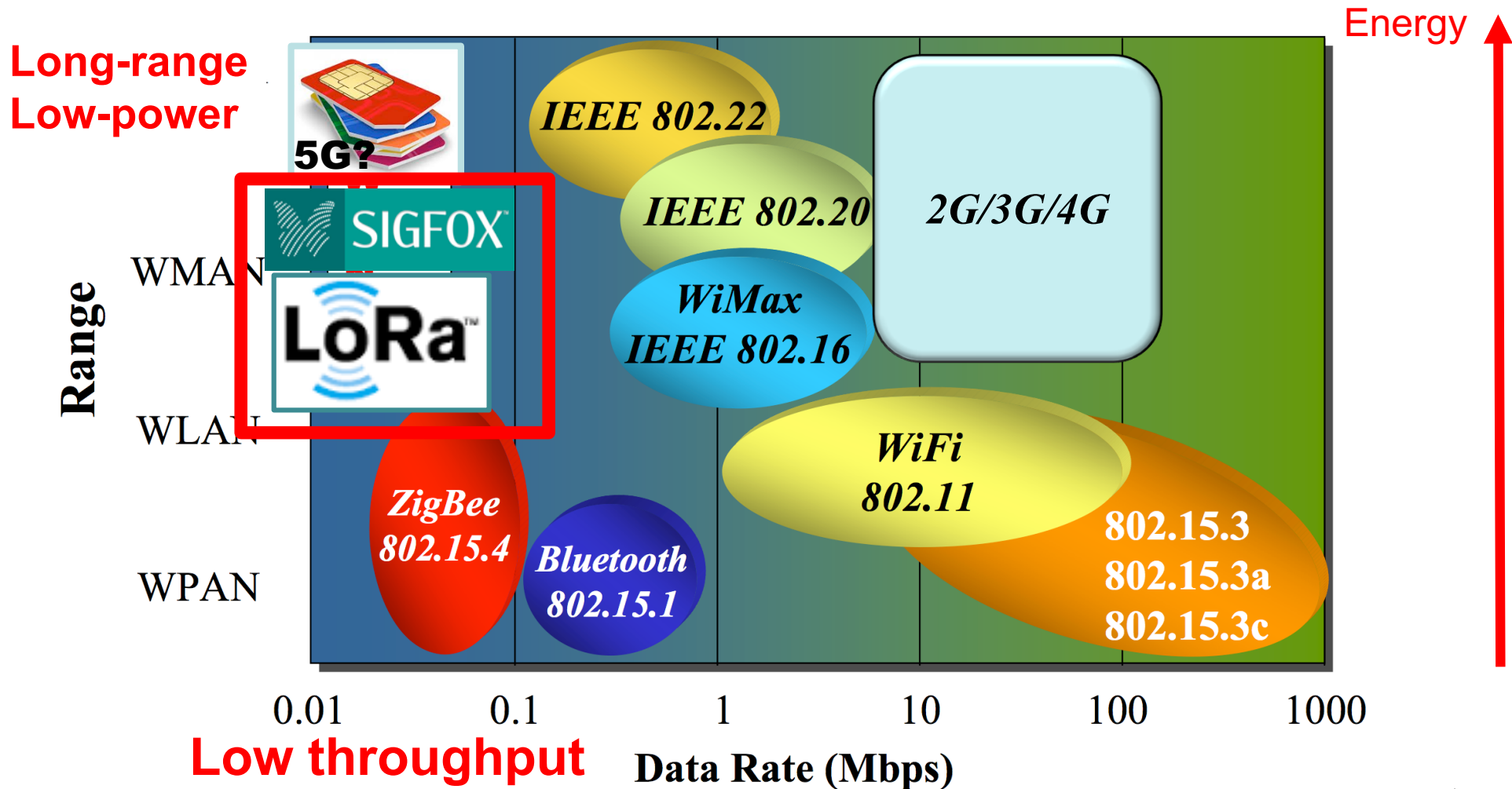
Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200-500mA	500-1000mA	100-300mA
Standby current	2.3mA	3.5mA	NC



# Low-power & long-range radio technologies (LPWAN)



## Energy-Range dilemma



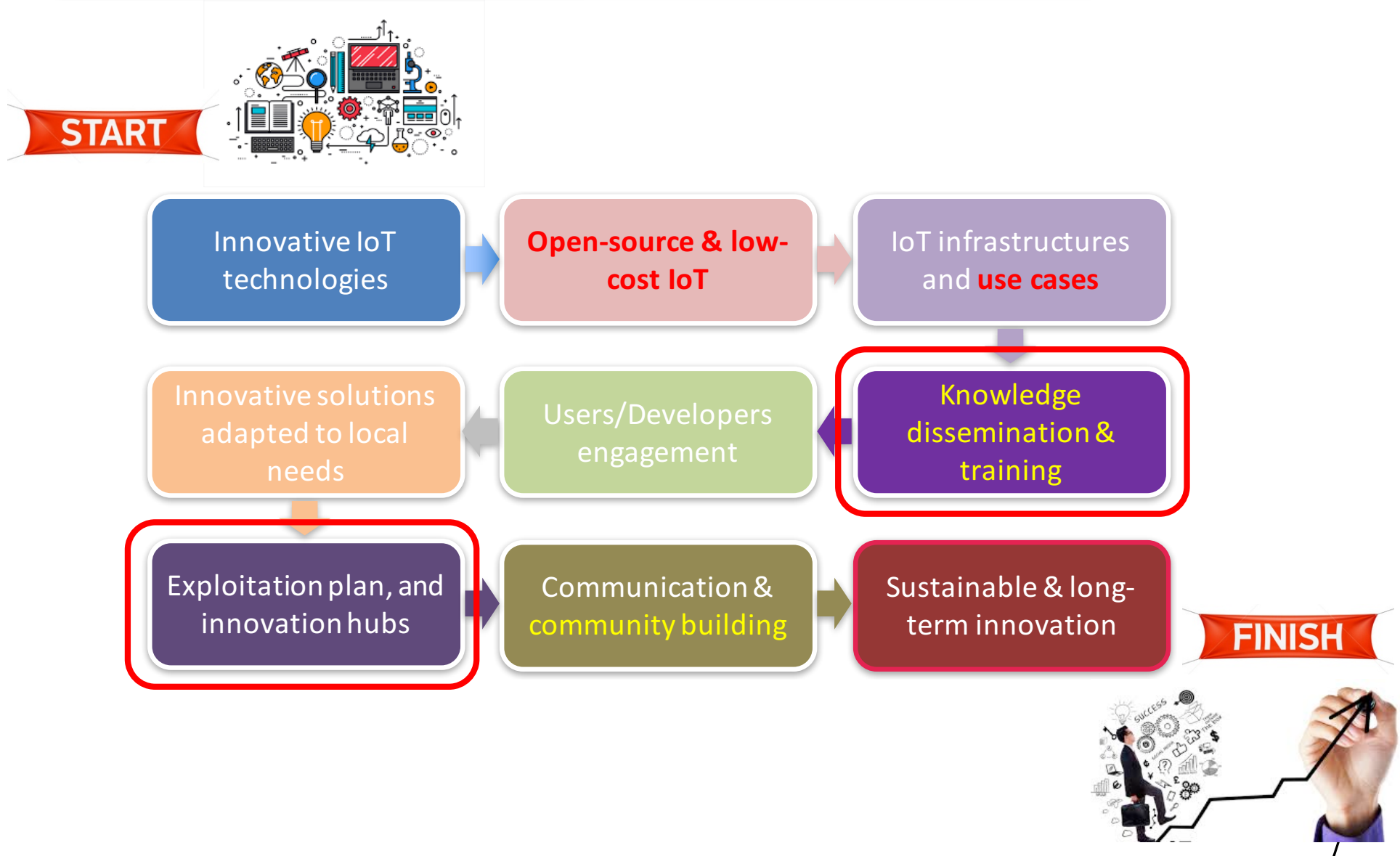


Needs, constraints, cost, design approach, control mechanism

Challenge: Bridging the digital divide

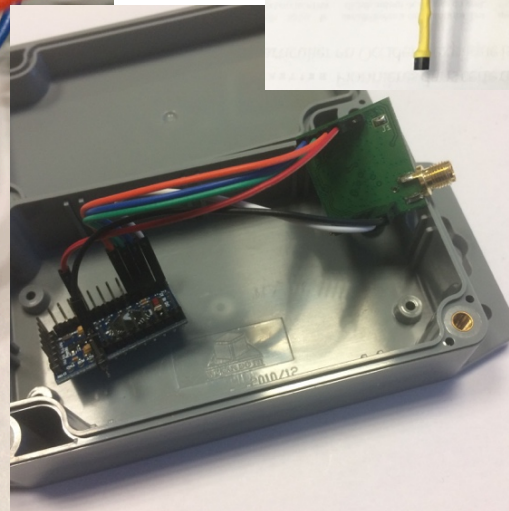
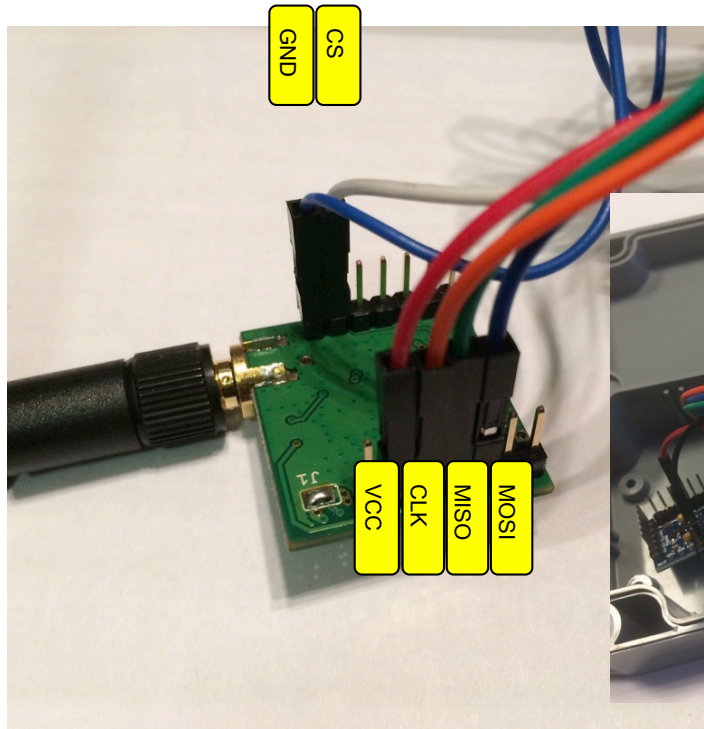
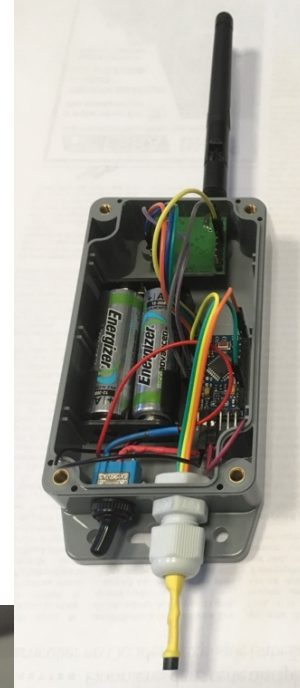
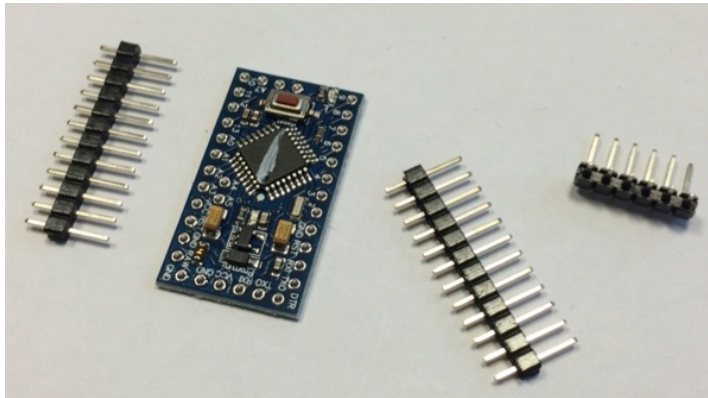


# What/Who are we targeting?



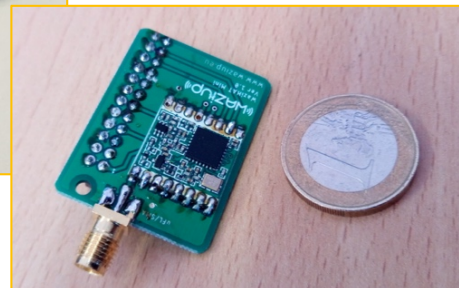
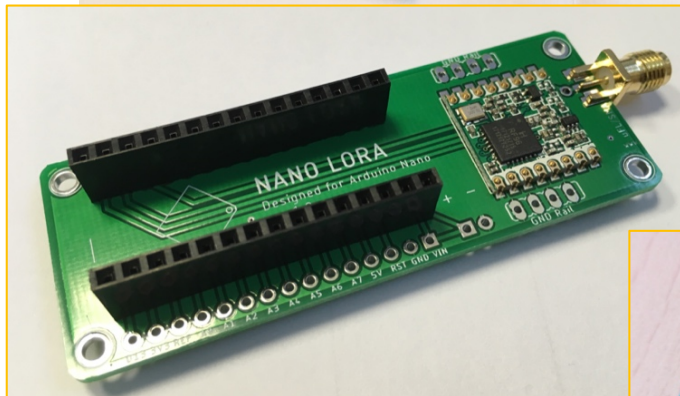
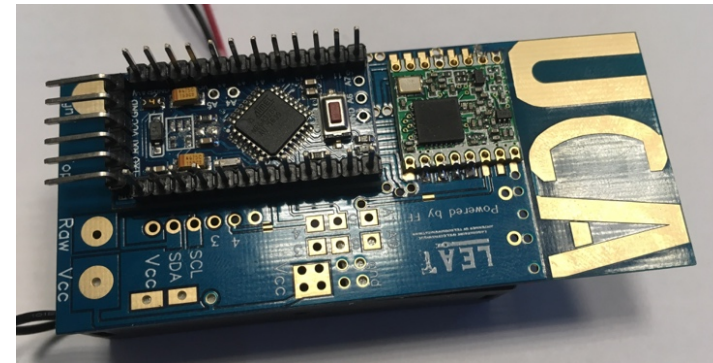
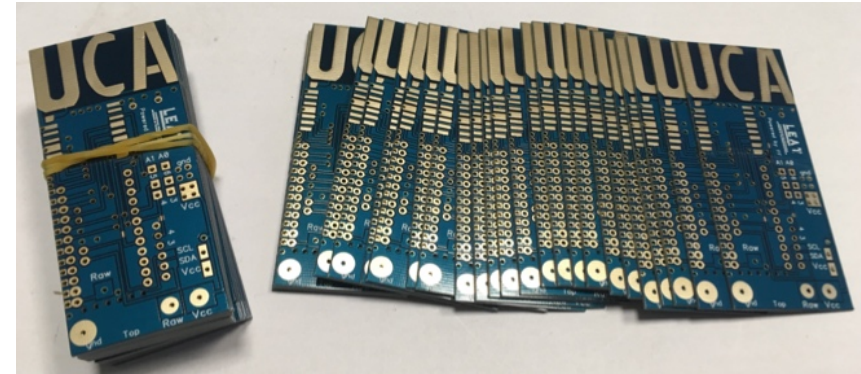
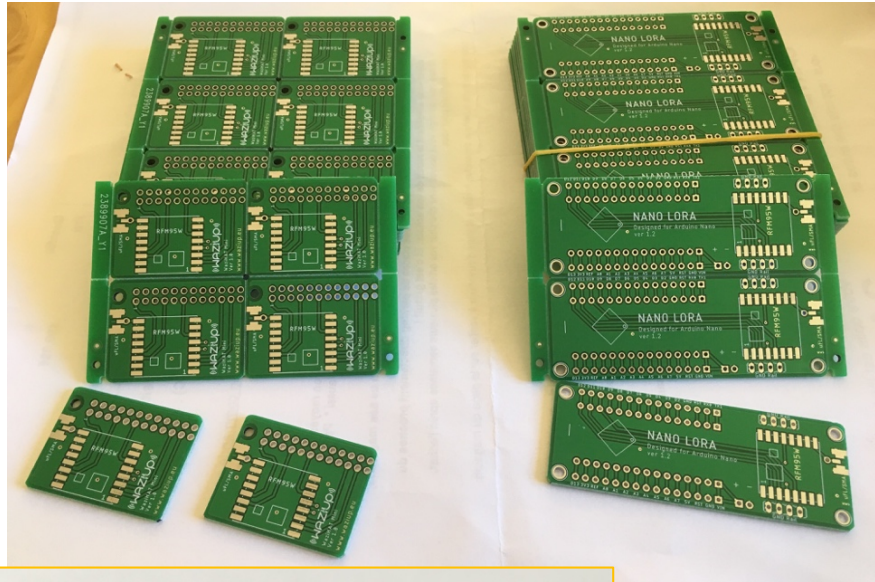


# Full Do-It-Yourself approach





# Still DIY but simple PCBs make it simpler

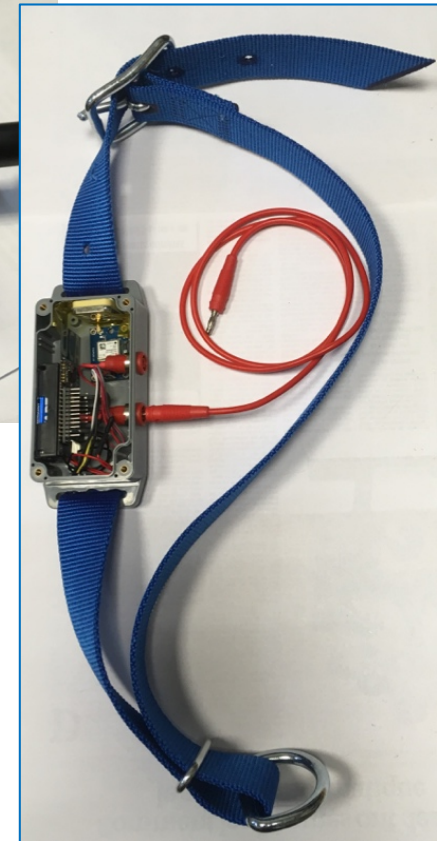
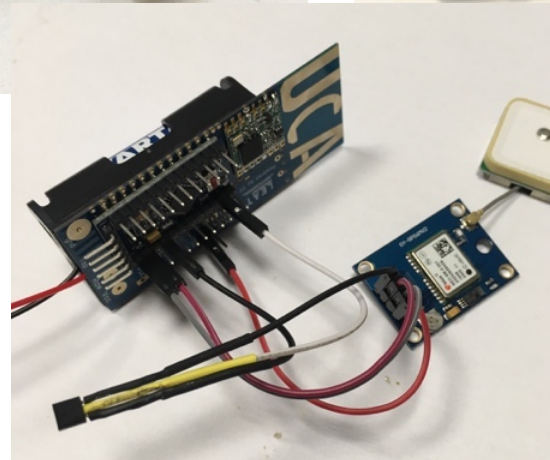
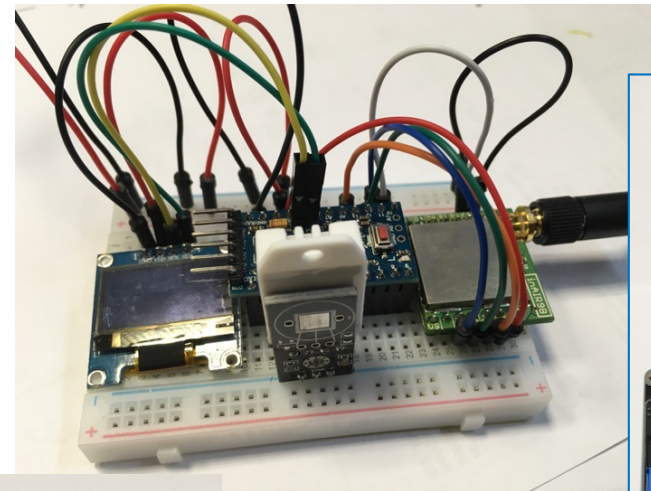
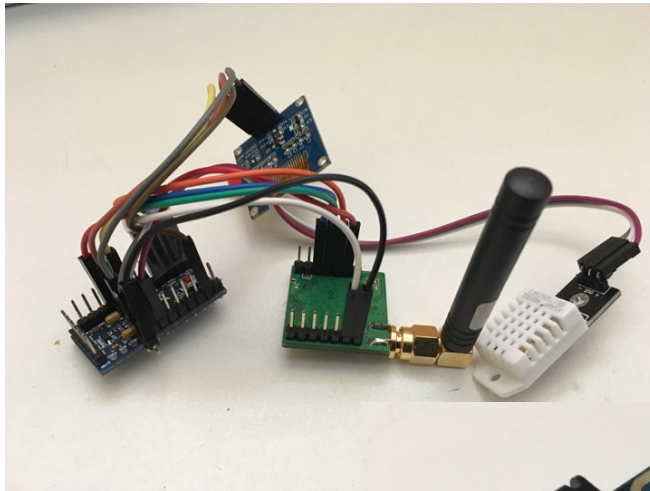






# Using the IoT kit

- ❑ For both training (knowledge dissemination) and device integration (exploitation plan, entrepreneurs)



# Ready-to-use templates

Moisture/  
Temperature of  
storage areas



10-15kms



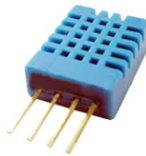
Physical sensor



Physical sensor



Physical sensor

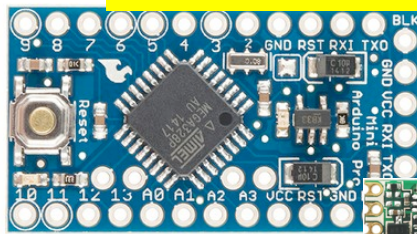


Physical sensor mgmt

AES encryption

Long-range transmission

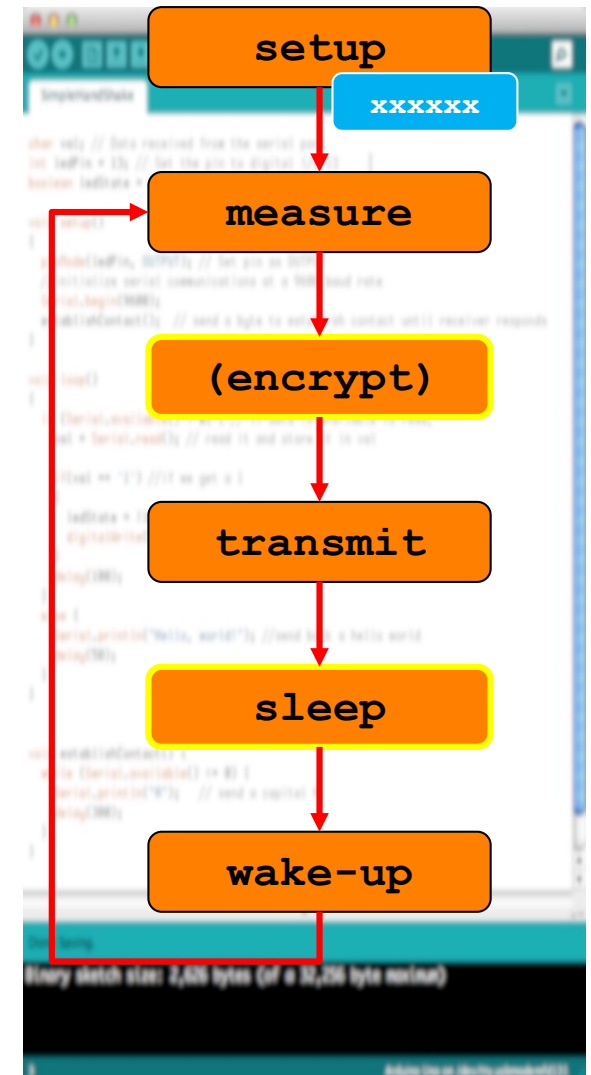
Arduino Pro Mini @3.3V



**VERY IMPORTANT**

Activity duty-cycle, low power

Logical sensor mgmt

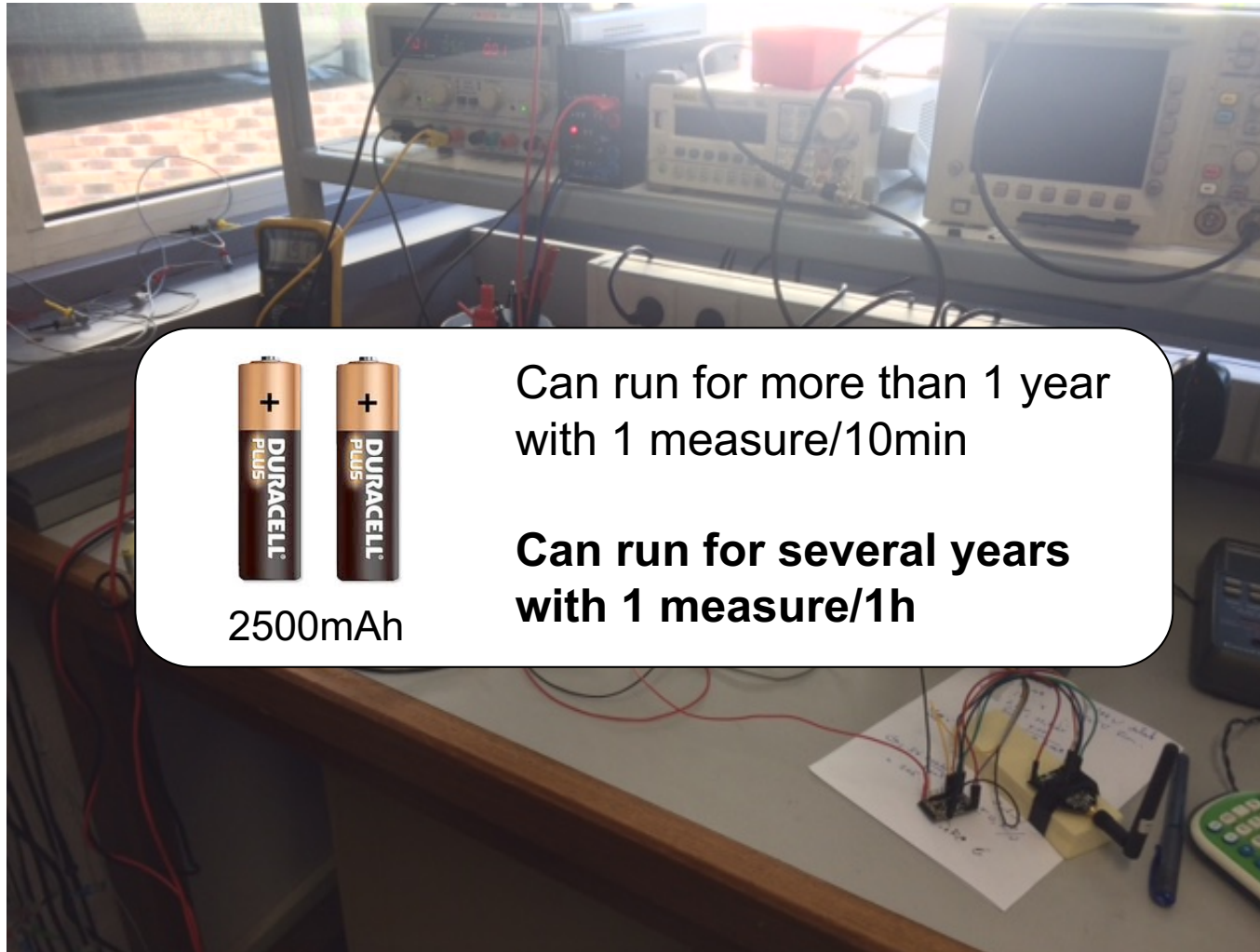




# Running for several years!



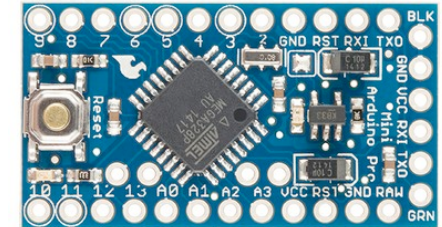
## Low-Power library from RocketScream



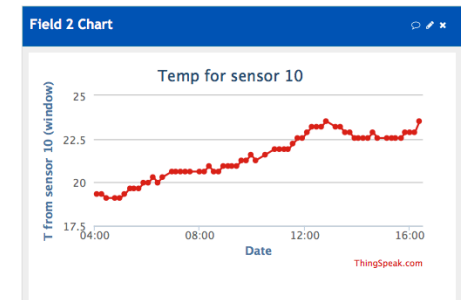
2500mAh

Can run for more than 1 year with 1 measure/10min

Can run for several years with 1 measure/1h



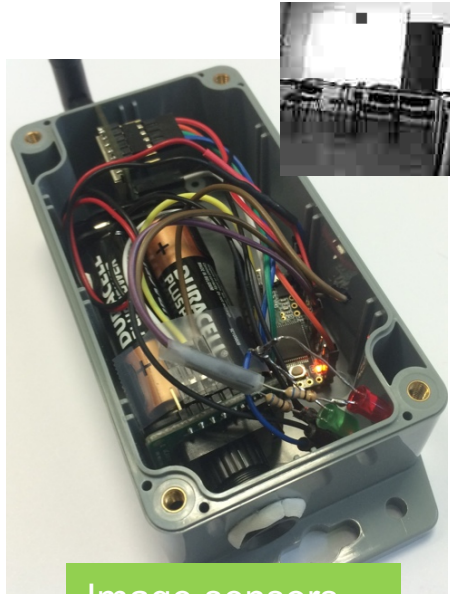
Wakes-up every 10min, take a measure (temp) and send to GW



**5 $\mu$ A in deep sleep mode, about 40mA when active and sending!**

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

# From generic to specific applications



GPS collar

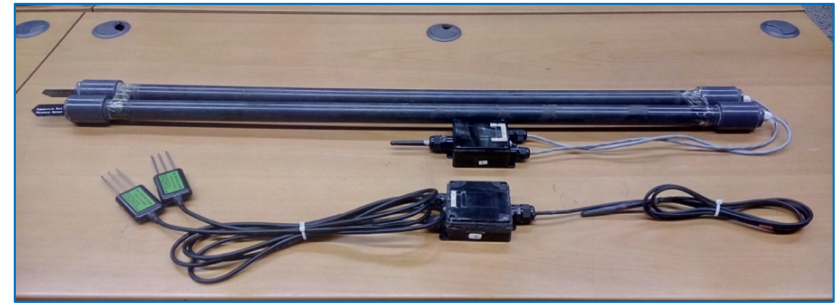
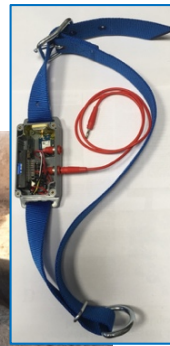


Image sensors



Photo from EGM

Buoy for water quality



Weather Station



Soil Moisture

Photo from Unparallel



Bin presented at Woelab

Waste Mngt



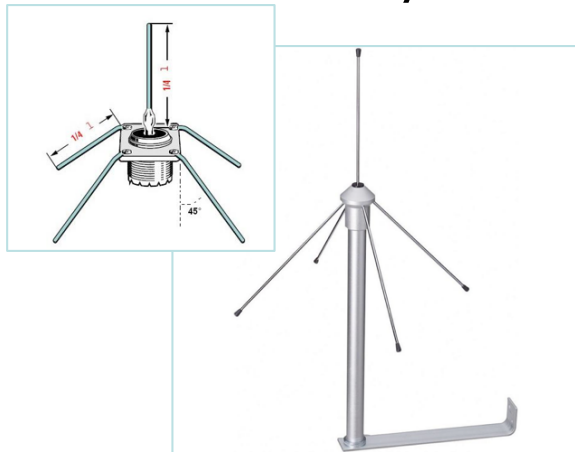
# Main difficulty is ...

- ...to get a good transmission system!



# Antennas when using a coaxial extension cable

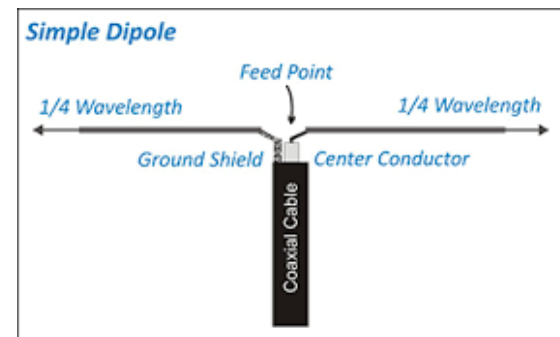
- At the end of a coaxial cable, it is possible to connect a ground plane antenna (usually  $\frac{1}{4}$  wave) or a  $\frac{1}{2}$  wave dipole antenna.



Ground plane



Sleeve dipole



Simple dipole



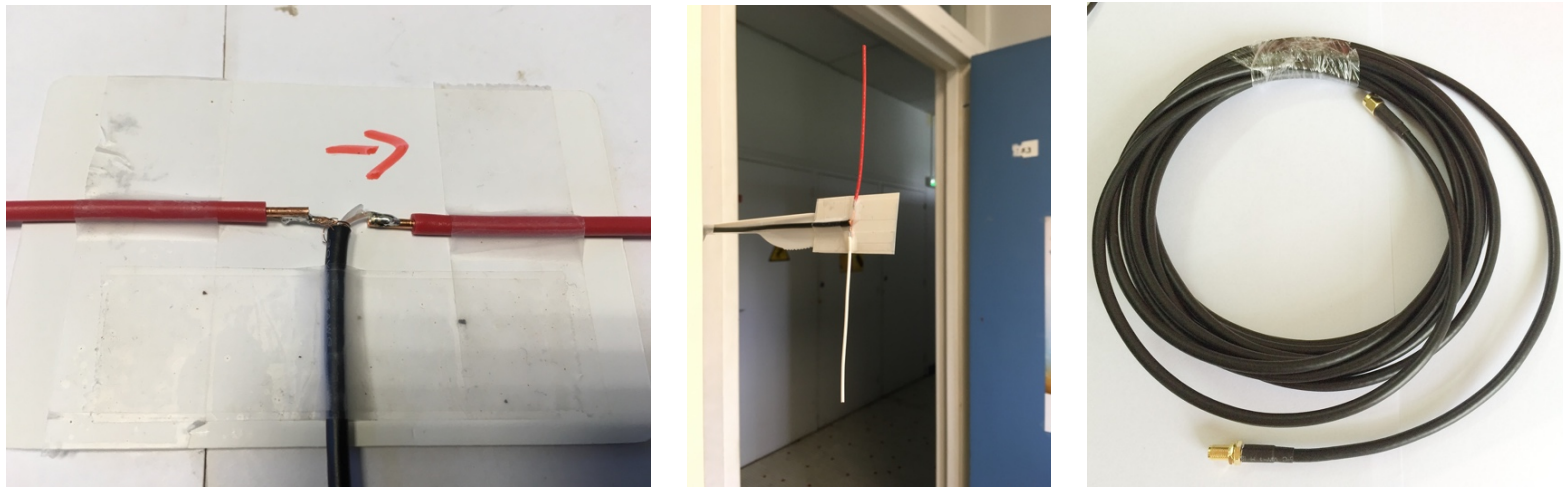
More complex:  
collinear,  
array,...

- Some of them are easy to build (ground plane and simple dipole) and there are many tutorials.



# Simple $\frac{1}{2}$ wave dipole antenna

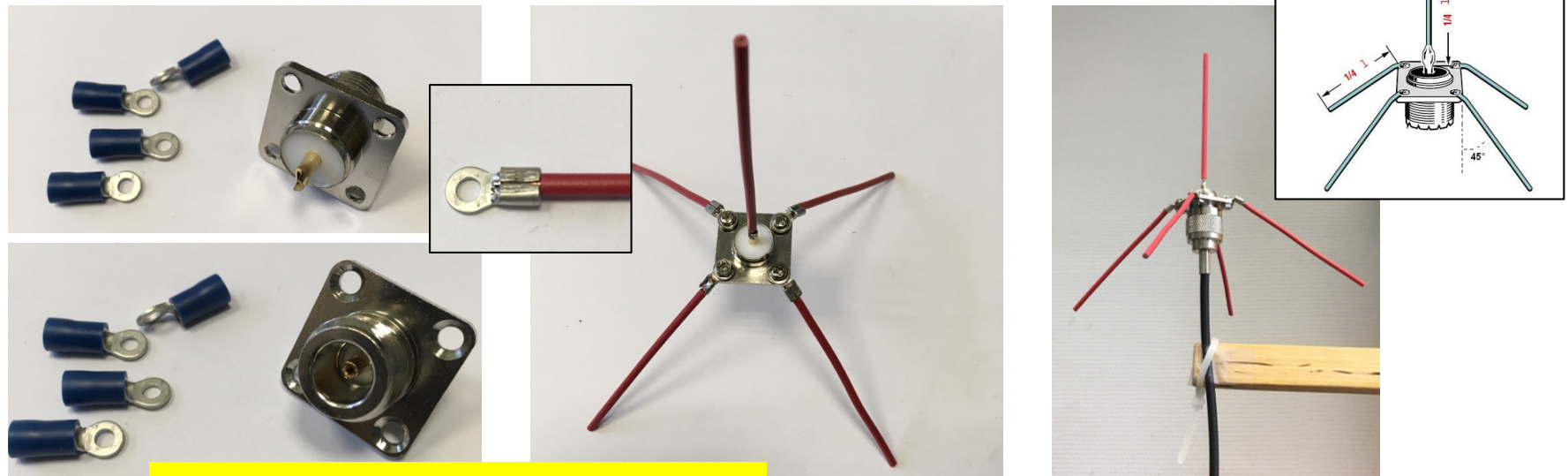
- Very simple dipole can be made with 2 pieces of  $\frac{1}{4}$  wave wires.  $\frac{1}{4}$  wave in 868 is about 8.2cm (16.4cm for 433MHz).



- There is no balun here but it is still better than the  $\frac{1}{4}$  wave monopole if a coaxial cable is used.
- You can buy a 3m **RG58** cable (SMA-m to SMA-f for instance), keep the male side, cut the female side and solder the core conductor and the braid as shown.

# Simple $\frac{1}{4}$ wave ground plane antenna

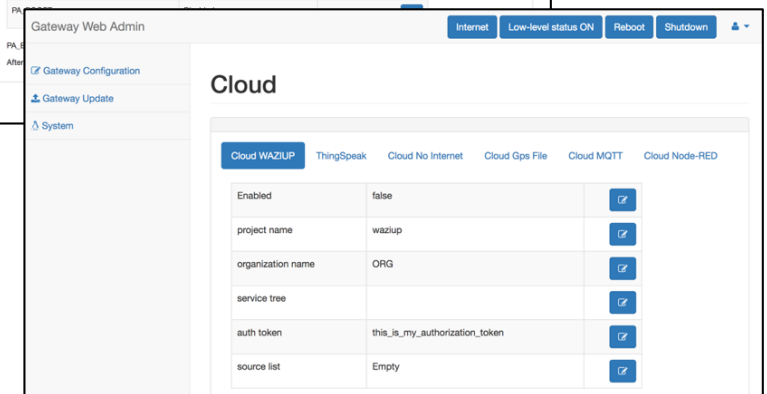
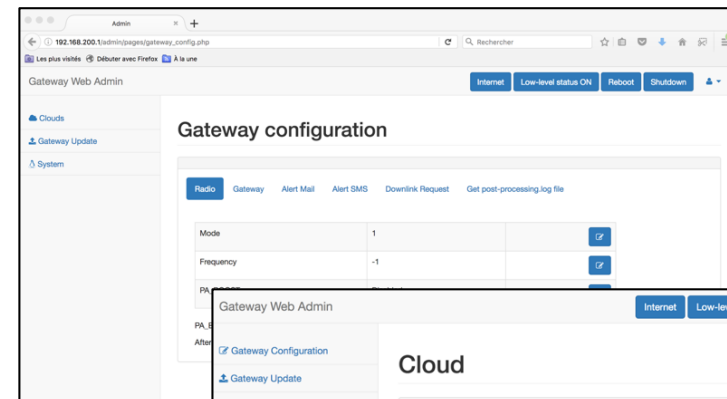
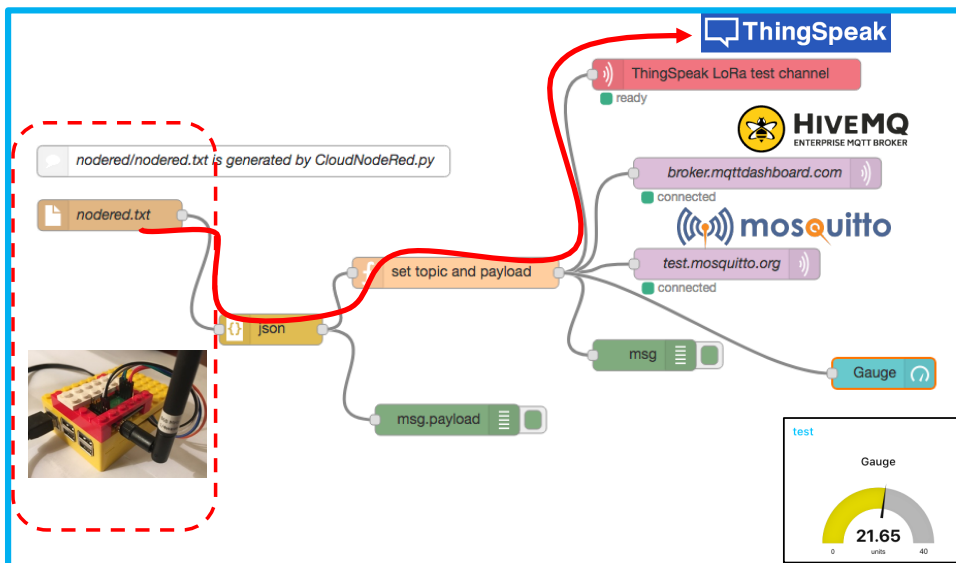
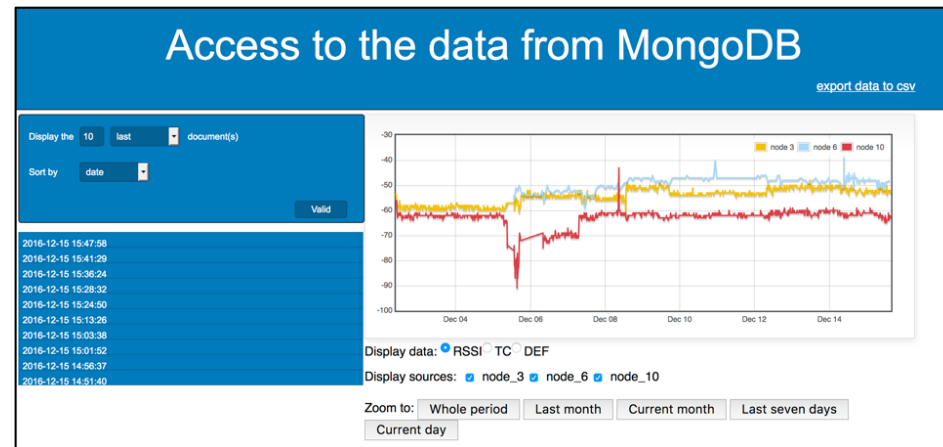
- The ground plane antenna can be made with 5 pieces of  $\frac{1}{4}$  wave wires.

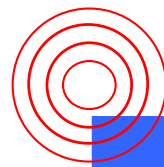
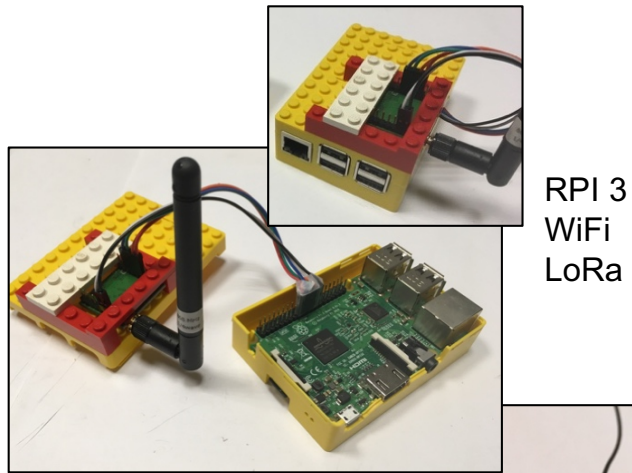


N Female Panel Mount Chassis

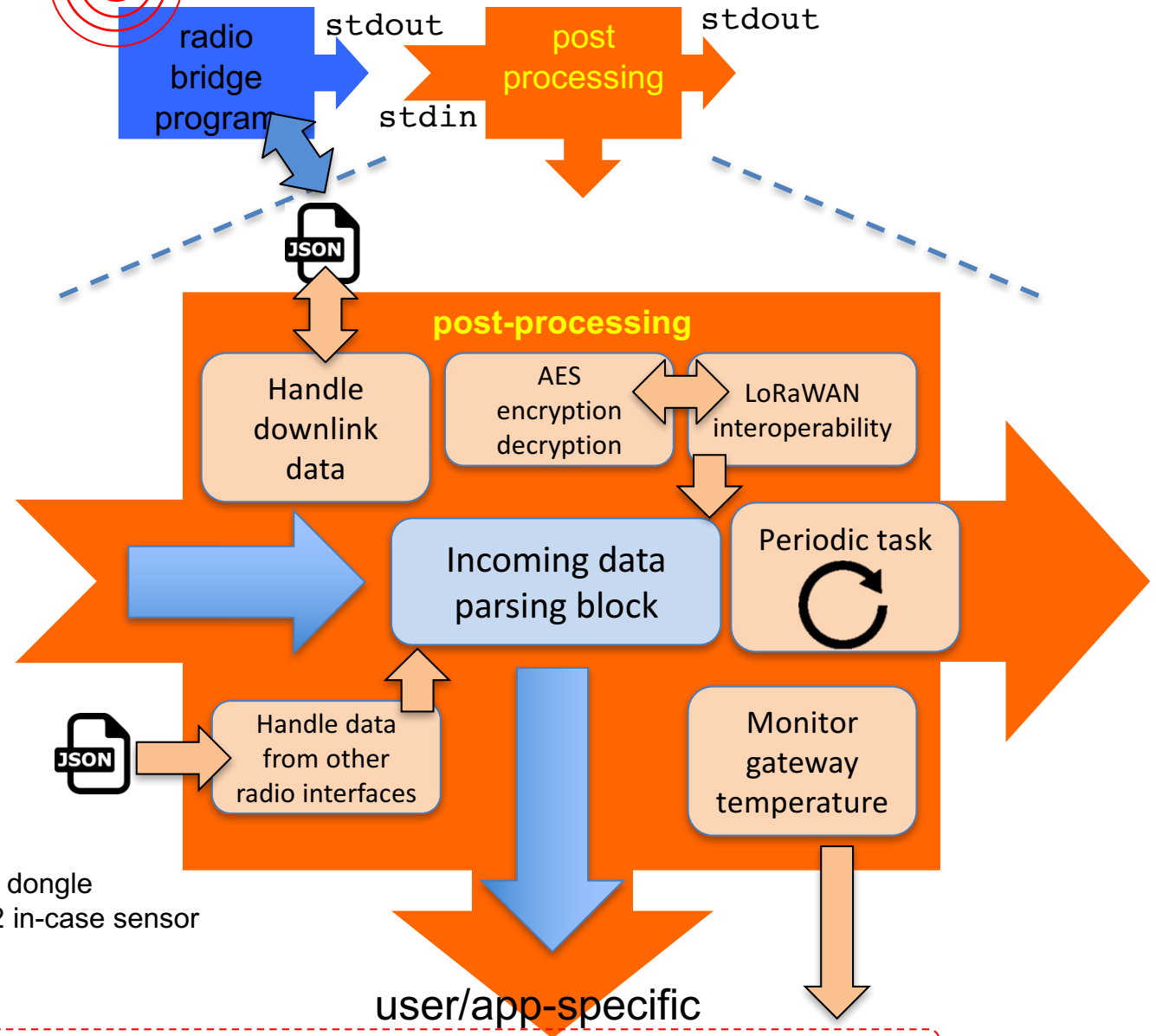
- You can buy a 3m RG58 cable with an SMA-male at one end and a male N-connector at the other end. Or build your own cable.

# Open, versatile gateway

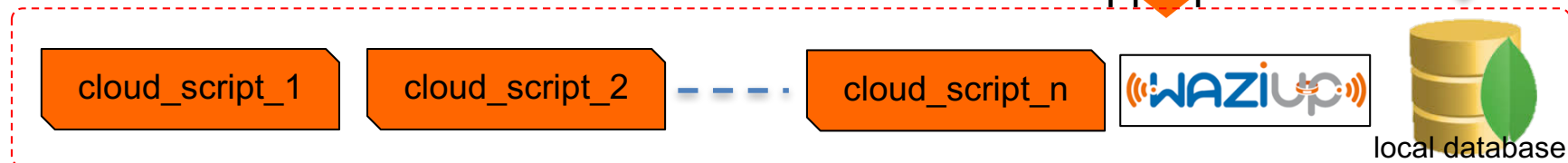




# Data post-processing stage



## Cloud definition





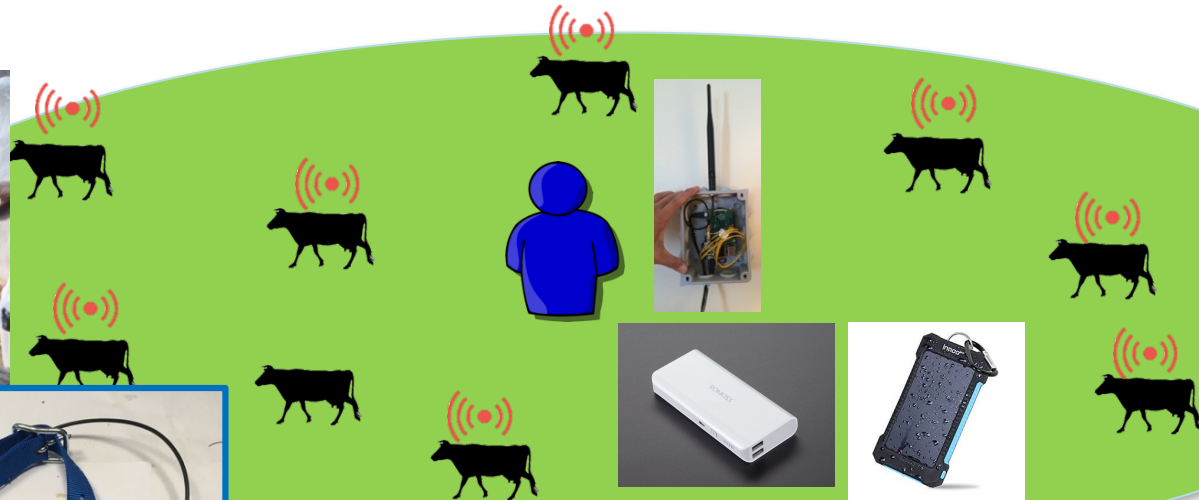
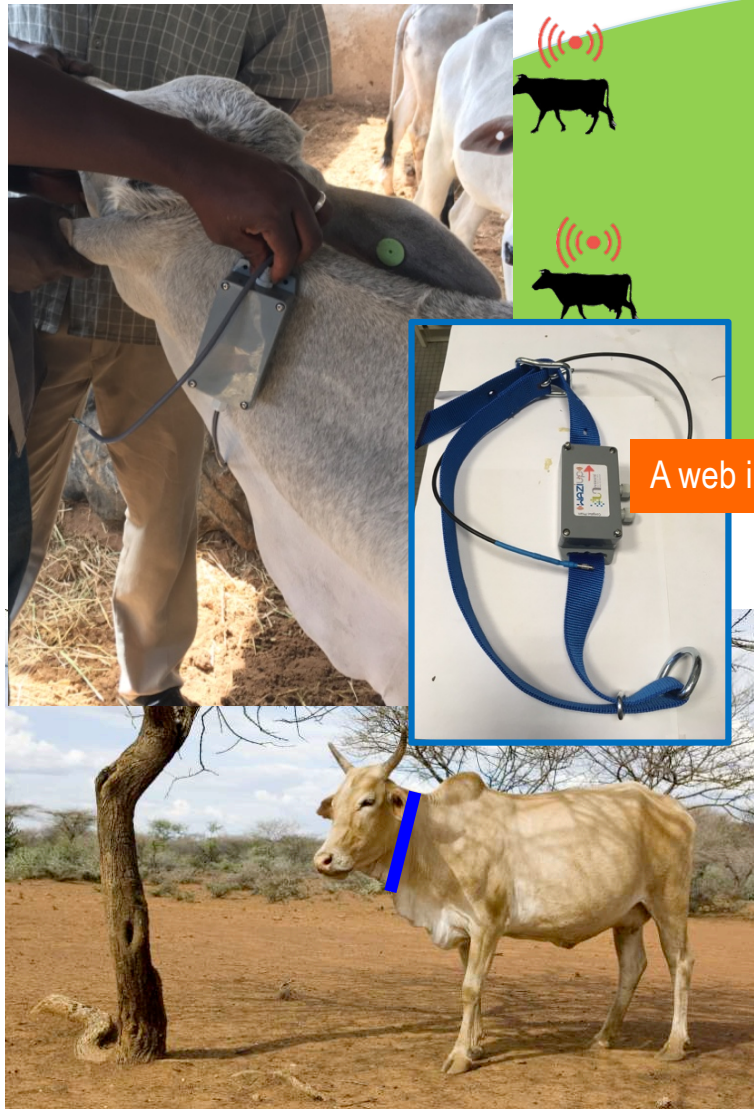
# IoT in Africa usually means...



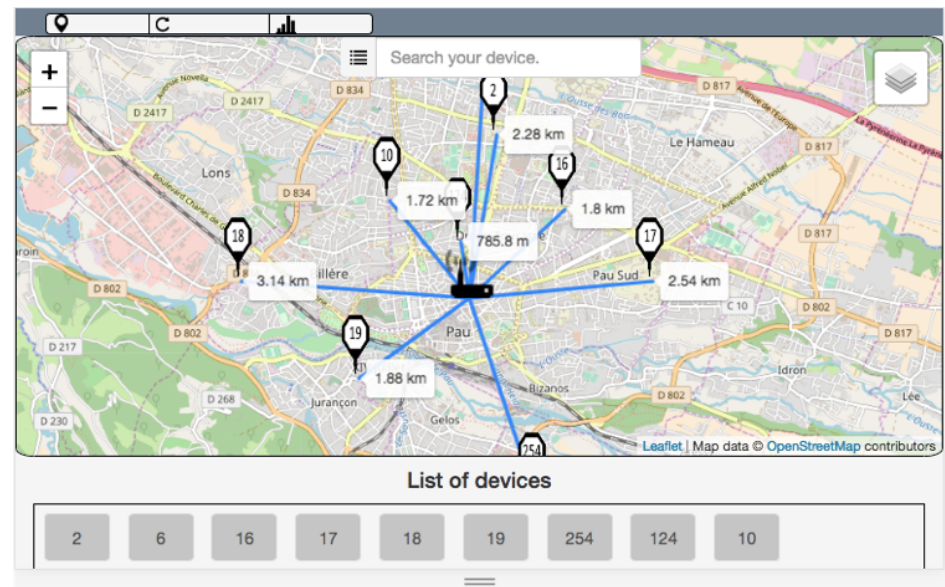
- ❑ ... deploying IoT in very isolated areas...
- ❑ ... where internet and electricity are not stable!



# Embedded applications: GPS for cattle localization



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





# Cellular Internet and SMS



- ❑ Internet connection can be obtained from cellular networks
- ❑ Instead of uploading to clouds, the gateway can also send SMS to the end-user



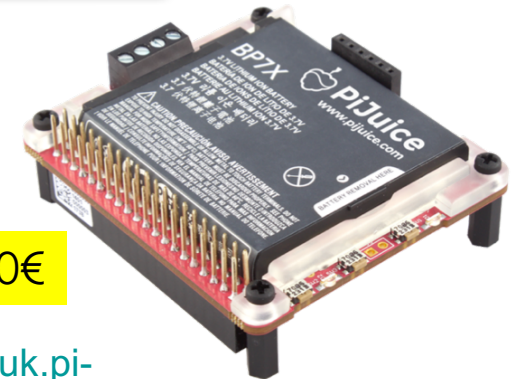


# UPS hats for RPI



- ❑ There are UPS hats for Raspberry that can be a good alternative to office UPS if you only need to protect your gateway
- ❑ The PIJuice with its 1820mAh battery shipped with the hat can power your gateway for about 2 hours
- ❑ There are also cheaper, simpler UPS hats from China manufacturer (2500mAh battery included)

About 50€



<https://uk.pi-supply.com/products/pijuice-standard>



About 15€

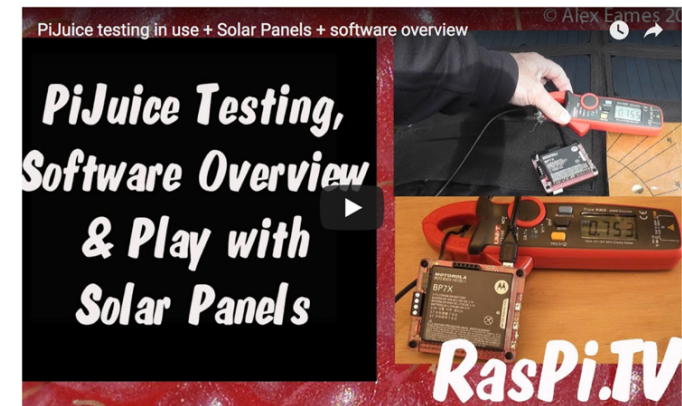
<https://fr.aliexpress.com/item/UPS-HAT-Board-Module-2500mAh-Lithium-Battery-For-Raspberry-Pi-3-Model-B-Pi-2B-B/32882666003.html?spm=a2g0s.9042311.0.0.40696c37G298M7>



# Powering gateway with solar panels



- ❑ The UPS hats can also be used to power your gateway with a solar panel
- ❑ Most portable solar panel (left) have USB output (5V) and can therefore be directly plugged into the hat's onboard micro USB (middle for PiJuice hat) which accepts voltage in the range of 4.2V-10V. See video link.

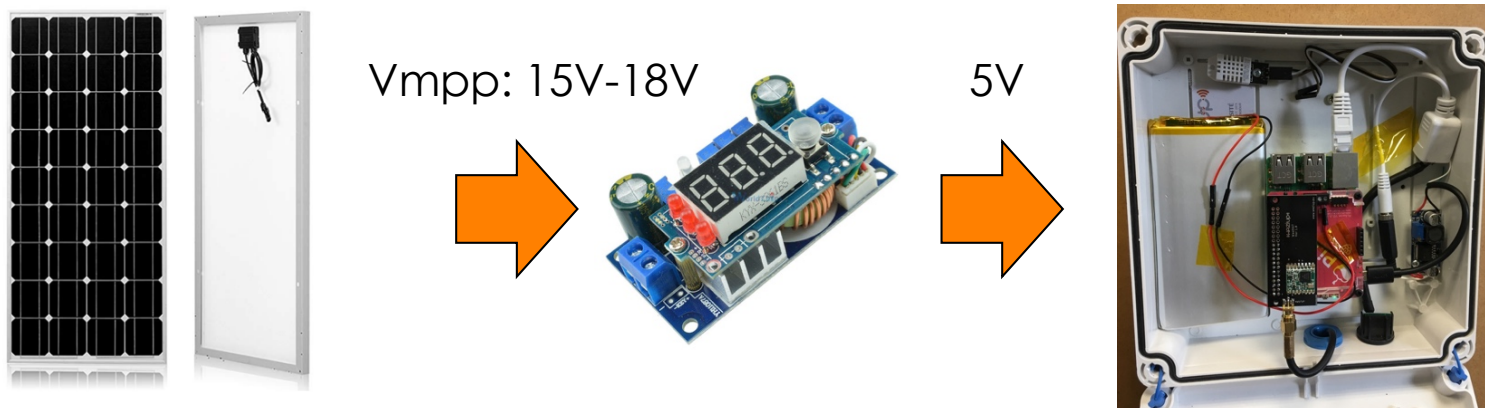


<https://raspi.tv/2017/pijuice-testing-the-software-and-hardware-plus-6w-40w-solar-panels-video>

# Connecting larger solar panels



- ❑ To really achieve a fully uninterruptible power supply, a larger solar panel and a high capacity Lilon/LiPo battery (e.g. 10000mAh) should be used
- ❑ Large solar panels are usually 12V/24V systems (more info on solar panel specifications: <https://www.altestore.com/blog/2016/04/how-do-i-read-specifications-of-my-solar-panel/>)
- ❑ You probably need to regulate output from the solar panel to an acceptable range for your UPS hat, e.g. 4.2V-10V for the PIJuice, by using an MPPT (Maximum Power Point Tracking) controller with an integrated DC-DC stepdown
- ❑ More info on MPPT: [http://www.leonics.com/support/article2\\_14j/articles2\\_14j\\_en.php](http://www.leonics.com/support/article2_14j/articles2_14j_en.php)



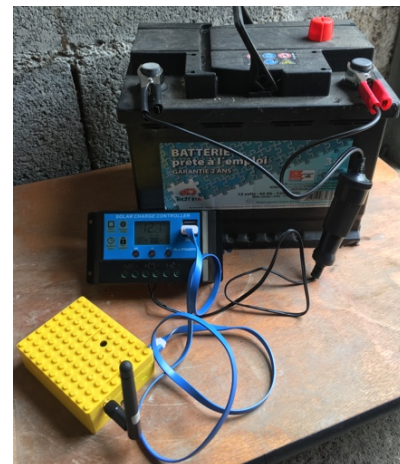
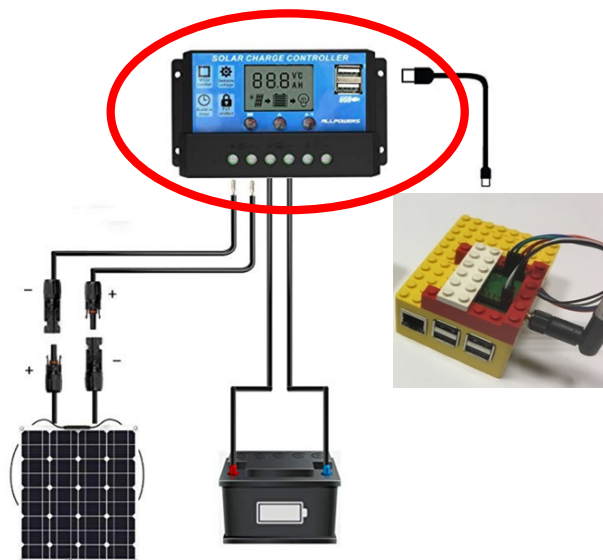


# Using 12V battery and 12V solar panel



- There are very affordable solar charge controller to connect a 12V solar panel to your 12V car battery to power your gateway

<https://fr.aliexpress.com/item/-/32904671590.html?spm=a2g0s.13010208.999999.259.1dd23c00BnOdQd>



<https://fr.aliexpress.com/item/Dokio-Brand-Solar-Panel-China-100W-Monocrystalline-Silicon-18V-1175x530x25MM-Size-Top-quality-Solar-battery-China/32802702078.html?spm=a2g0s.13010208.99999999.259.a8d33c00HQzpLB>

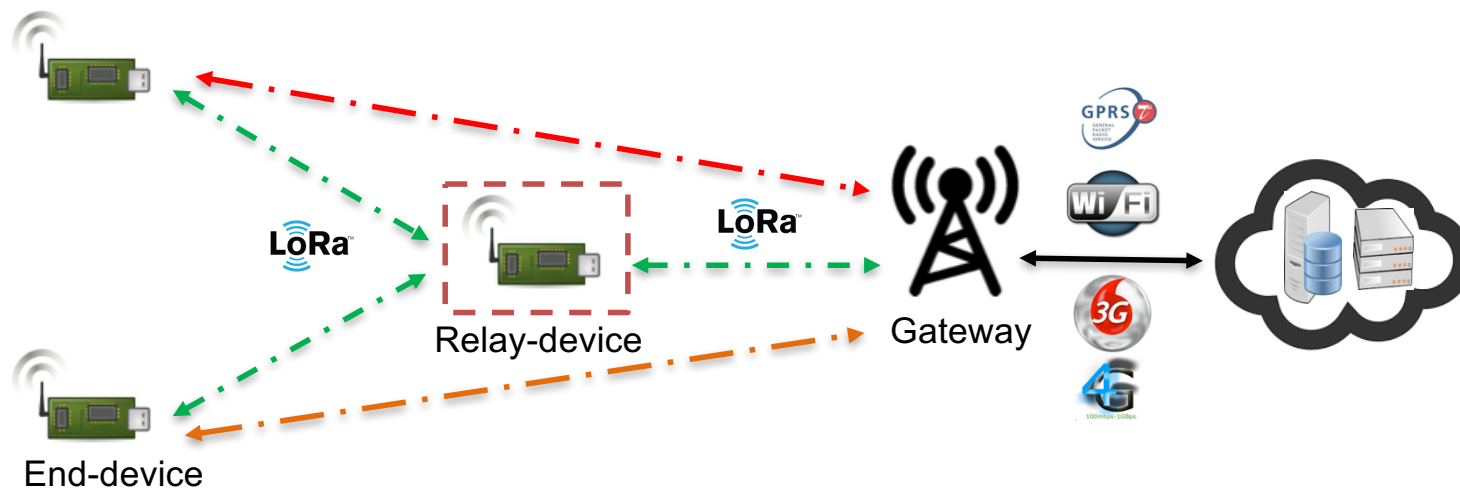
# Real-world deployment

- ❑ 1-hop connectivity to gateway is difficult to achieve in real-world, remote, rural scenarios



# 2-hop long-range approach

- **smart, transparent** relay node should be able to be inserted at anytime between end-devices and gateway to increase range





# Conclusions



- ❑ IoT is growing fast, with new cutting-edge radio technologies and frameworks
- ❑ In the Africa context, operator coverage and Internet access issues must be taken into account
- ❑ WAZIUP has been developing the open, low-cost IoT technologies/frameworks and use-cases
- ❑ WAZIHUB will focus on dissemination, community building and entrepreneurship
- ❑ IoT kits will be hosted on kickstarter to provide an easy solution for African partner to get ready-to-use, yet open and DIY, solutions