

UNDERSTANDING INTERNET-OF-THING TECHNOLOGIES



DISRUPTIVE
INTERNET
OF THINGS
APPLICATIONS
IN AFRICA

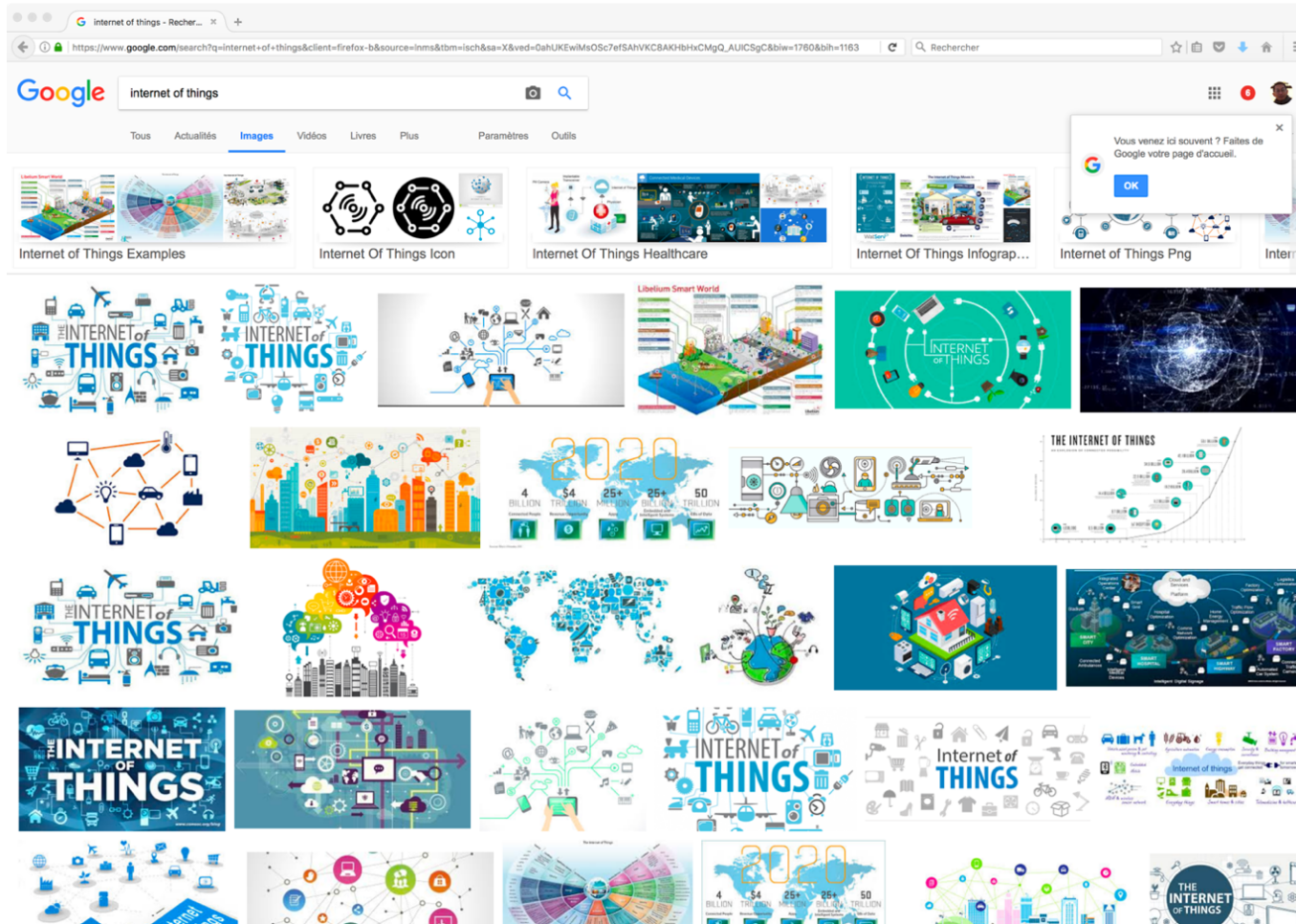


Total Booster Learning Capsule – May 25th, 2021

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

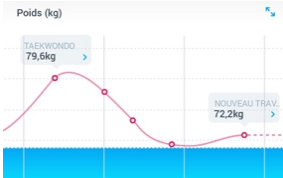
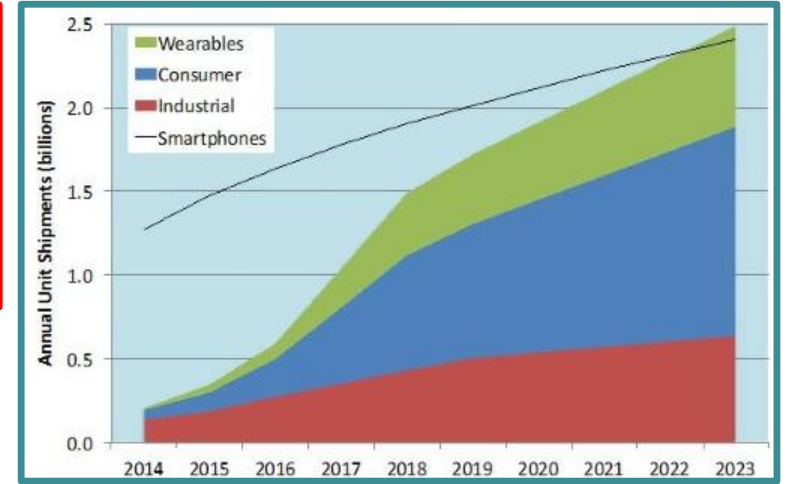


Googling for « Internet of Things »

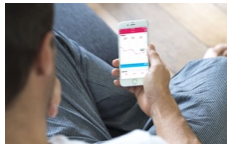


Q: What is IOT for you?

...shows communicating objects



© P. Junquera



All communicating objects?

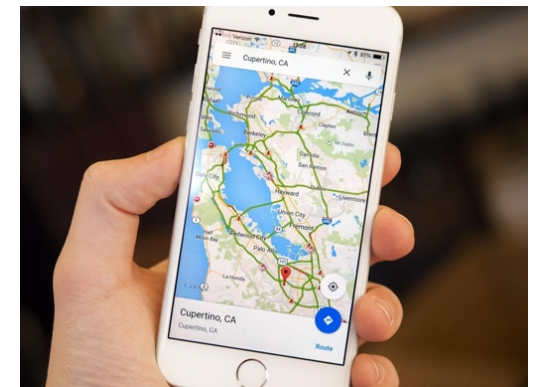
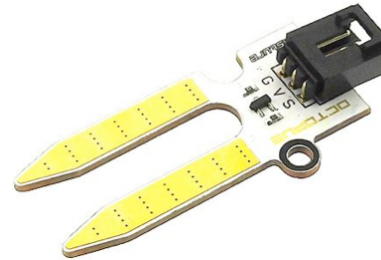


IoT = interactions with physical world



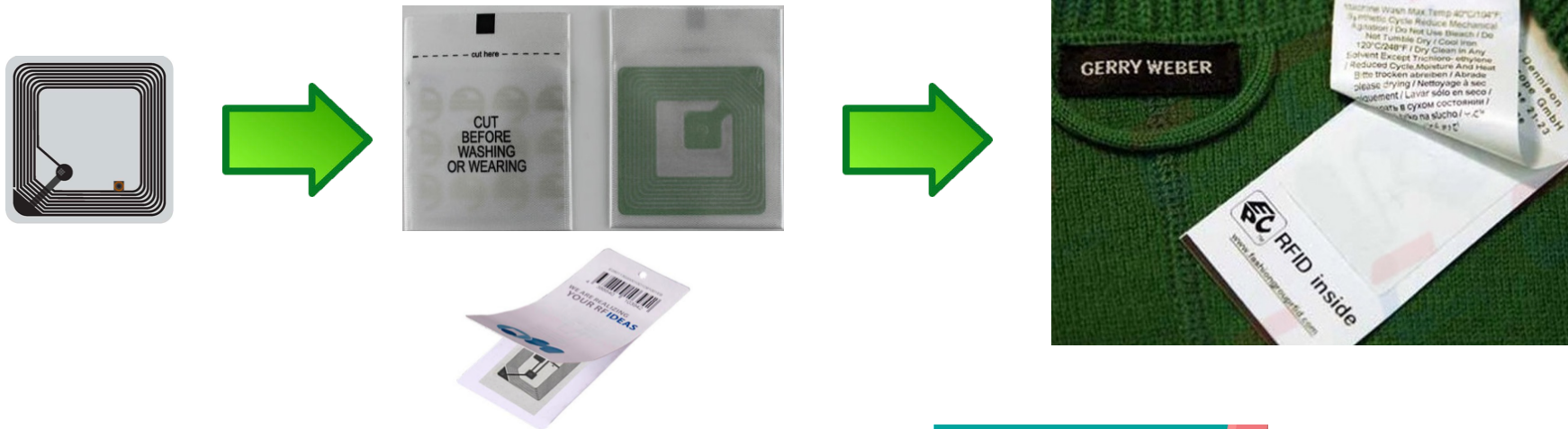
Q: Interactions? How?

Sensing the physical world



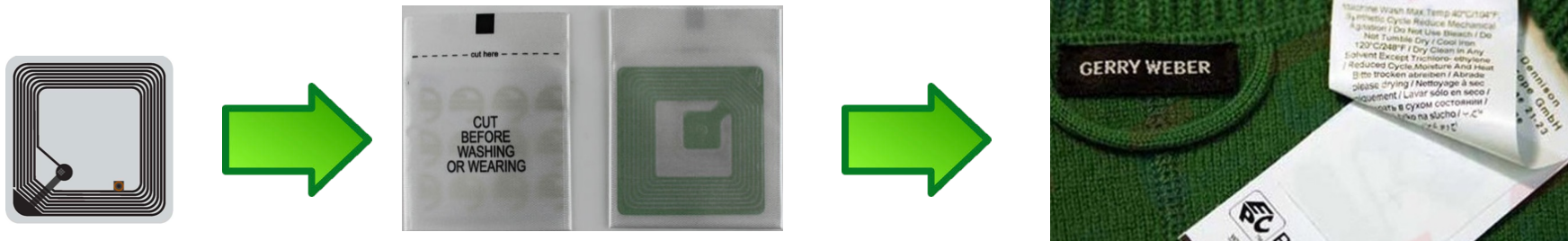
RFID, NFC, active, passive?

- Radio-Frequency Identification (RFID)
- Near Field Contact (NFC)



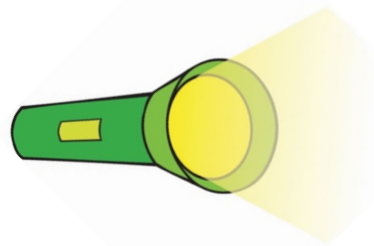
RFID, NFC, active, passive?

- Radio-Frequency Identification (RFID)
- Near Field Contact (NFC)

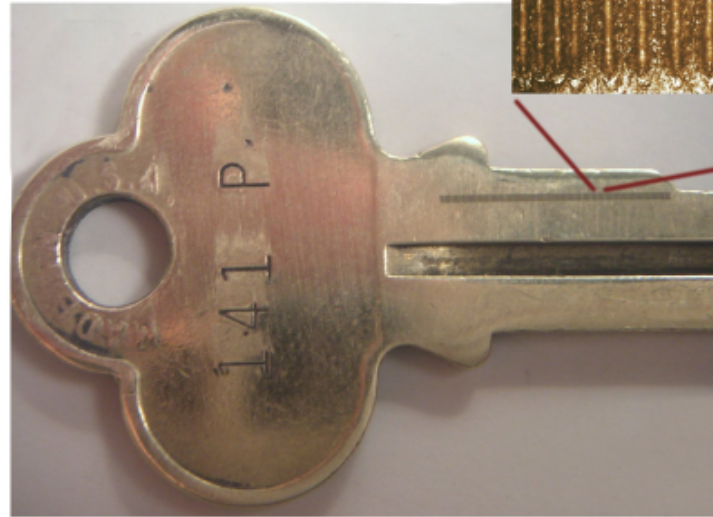


Q: How RFID works?

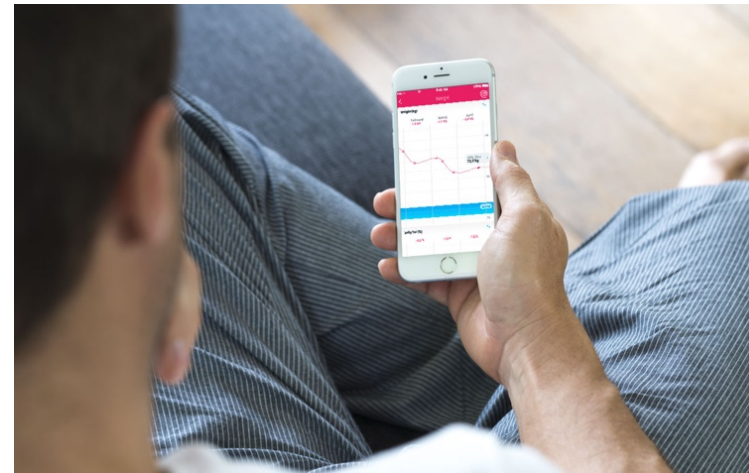
hint



Need sophisticated communication?

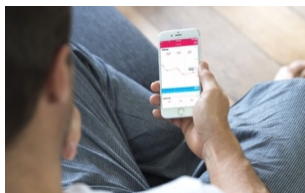


Home/consumer IoT products



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

Local interaction is possible...



Q: Where is the real power of data?

... but IoT usually means cloud data

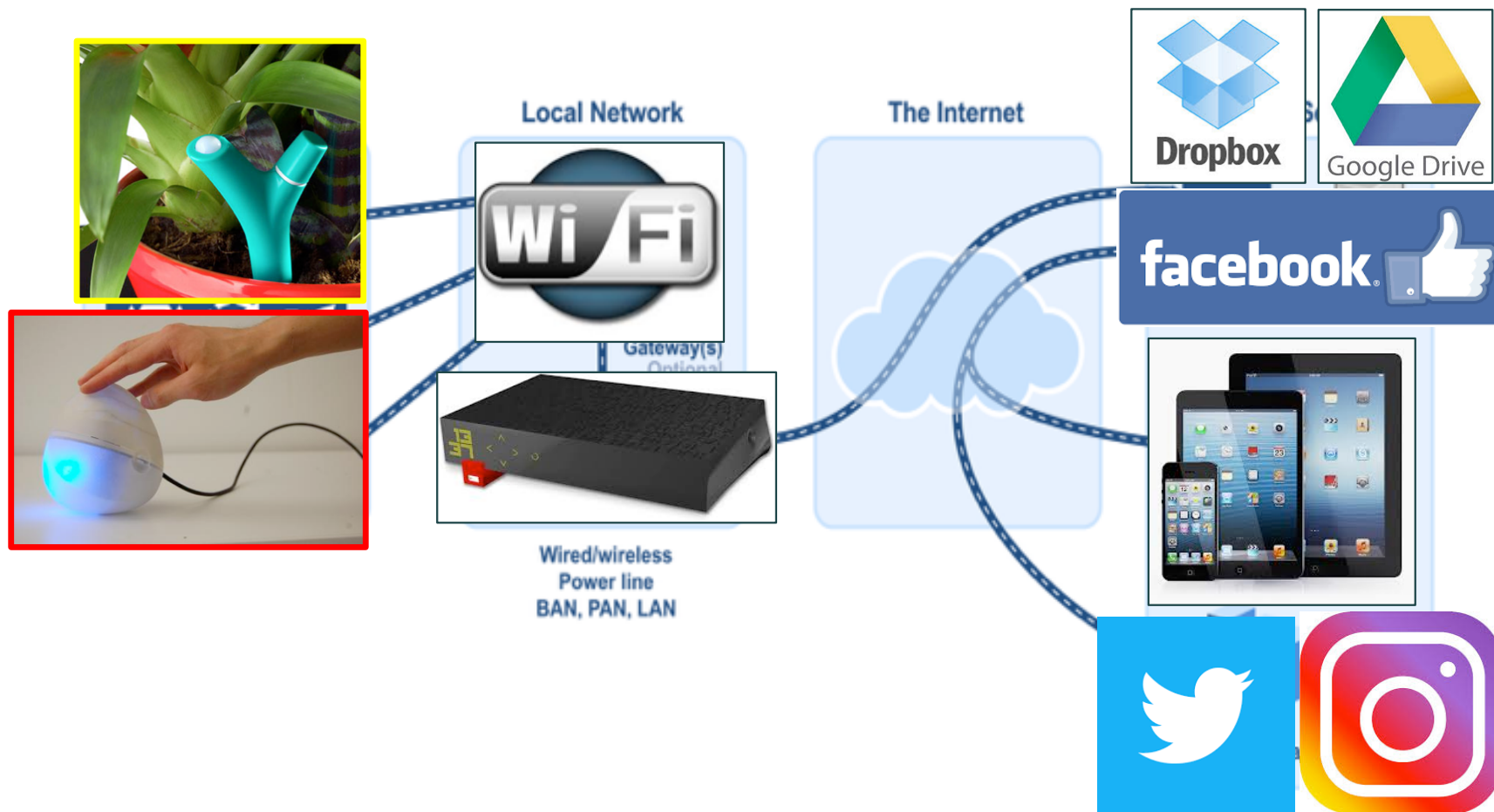
Lot's of data !



IoT added-values come from interactions and linked data!



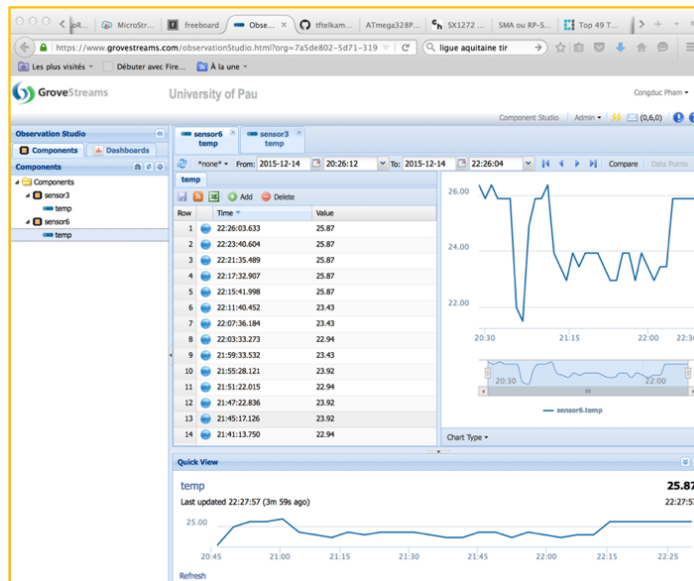
General public IoT architecture



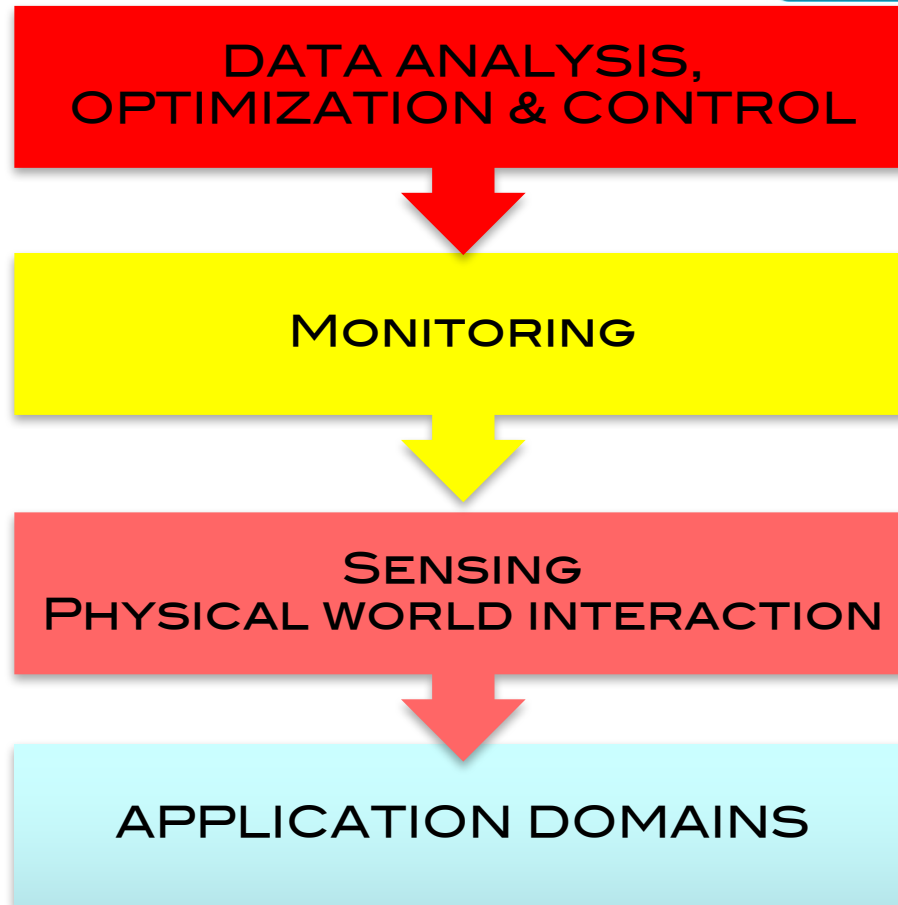
Pictures from ArchitectCorner



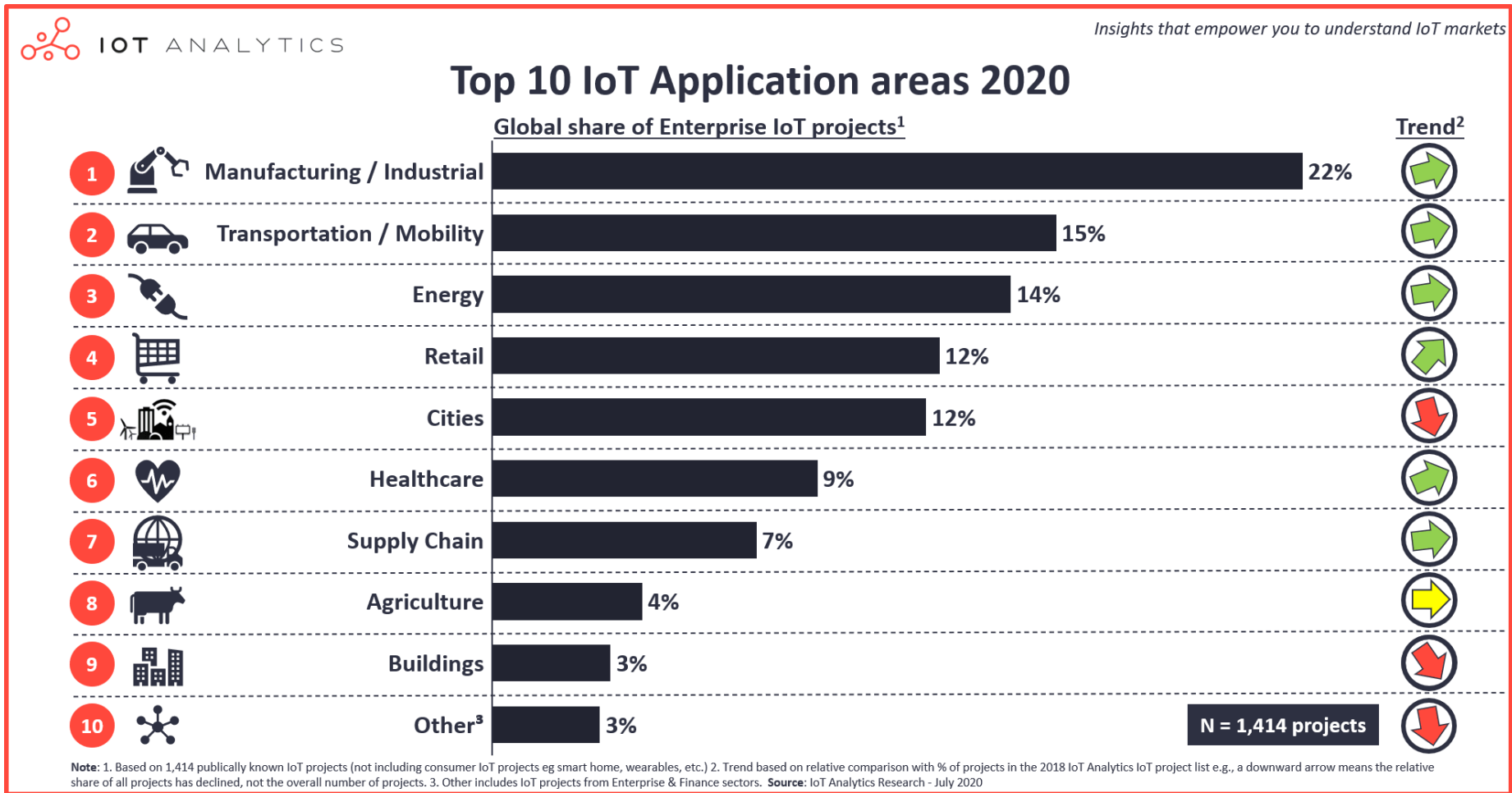
IoT cloud and visualization tools



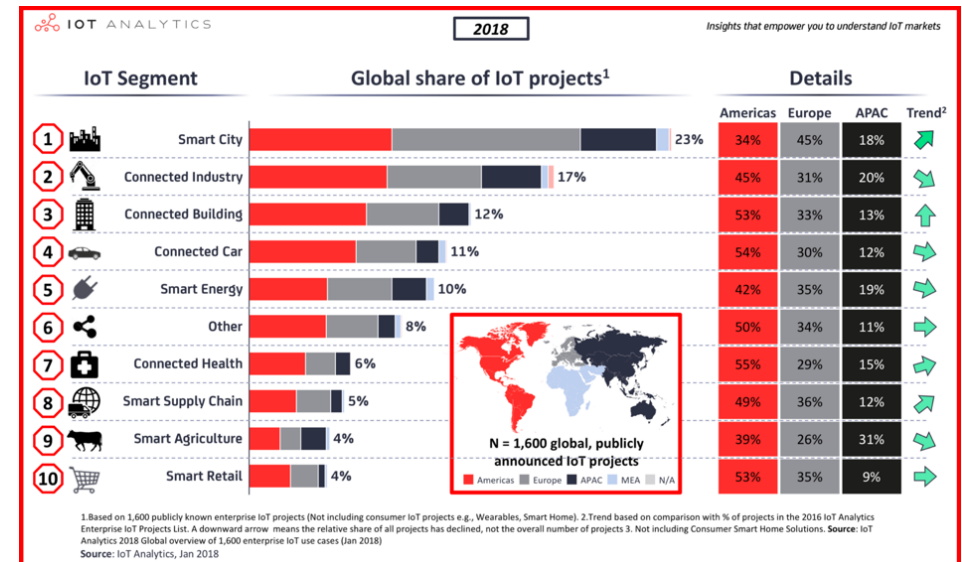
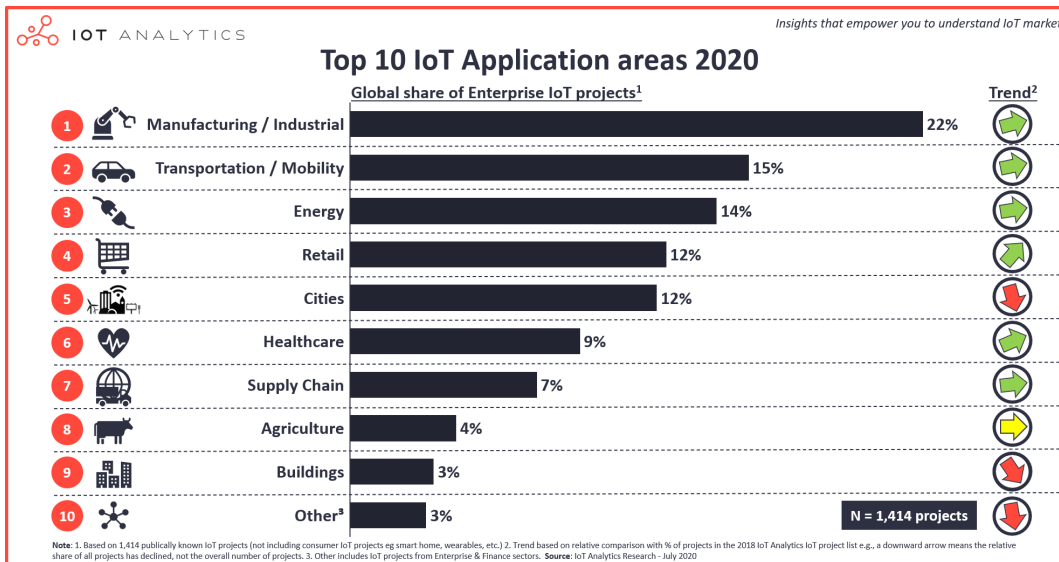
Sense, Monitor, Optimize & Control



Top IoT applications, 2020



IoT: 2020 vs 2018



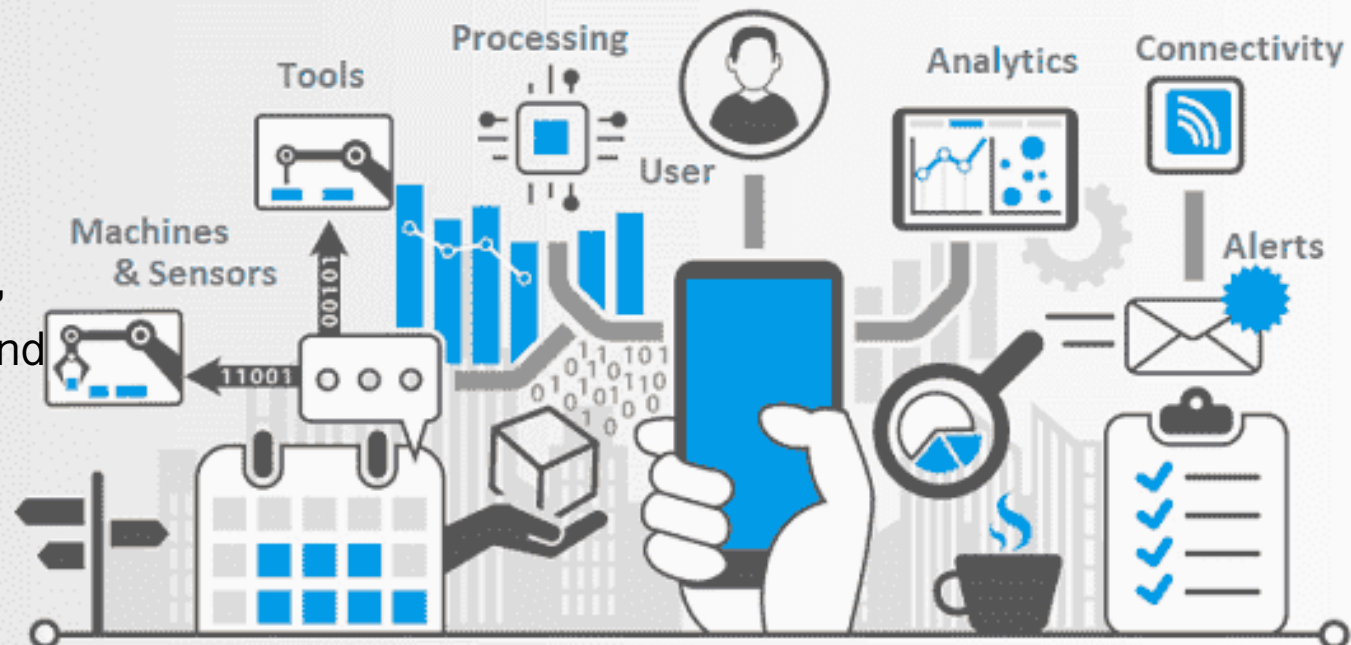
Q: Where are the differences?

IoT in industry



- ⦿ Infrastructure monitoring, Security & Safety
- ⦿ Continuous process improvement, Process automation, Process optimization
- ⦿ Smart logistics management, remote management, tracking,
- ⦿ Connectivity to back-end system, integration of smart tools, Interoperability
- ⦿ Data analysis, Supply Chain Optimization, Predictive maintenance

Industrial Internet of Things



IoT for development!



Irrigation



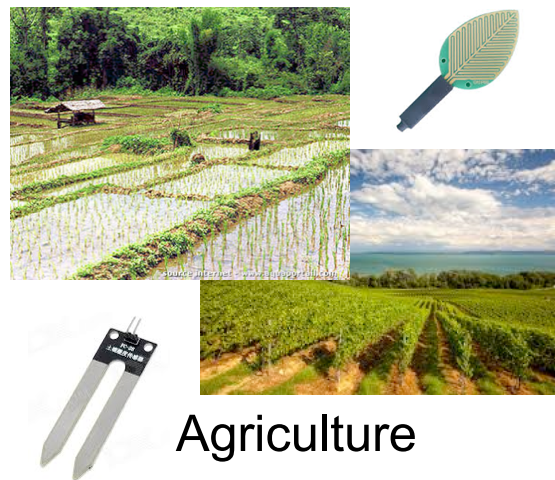
Livestock farming



Fish farming & aquaculture



Logistic, Storage,
Asset Tracking



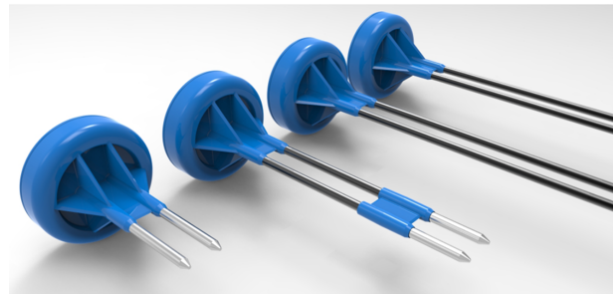
Agriculture



Fresh water

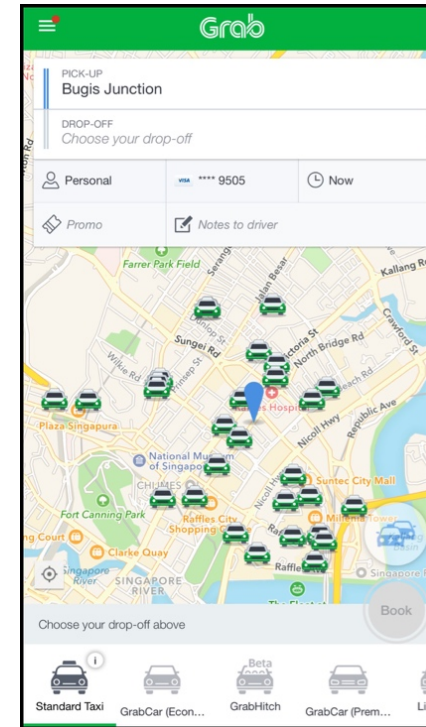


e.g. Smart Agriculture



Is IoT the solution for your problem?

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



Is IoT the solution for your problem?

Q: How to enable municipal street sweepers to report illegal dumping, leaking pipes and emergencies

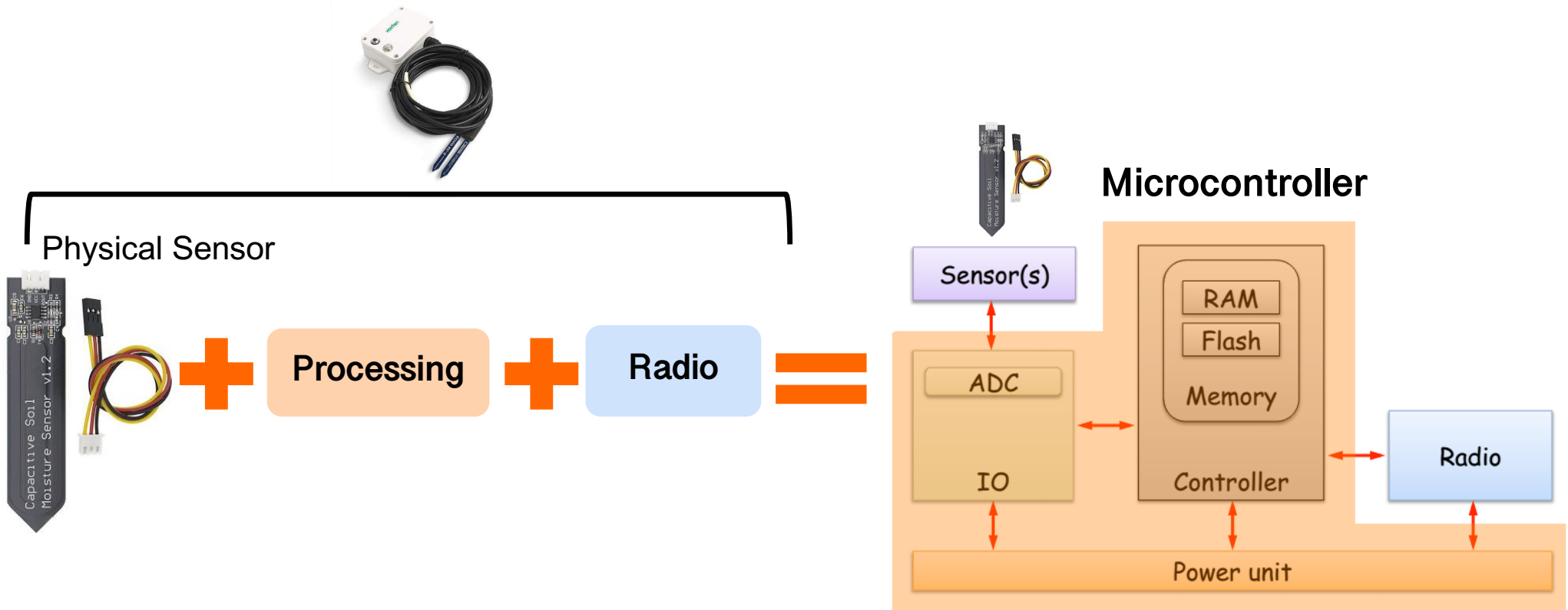


ITU Telecom World 2018
Phathwa Senene at MTN booth



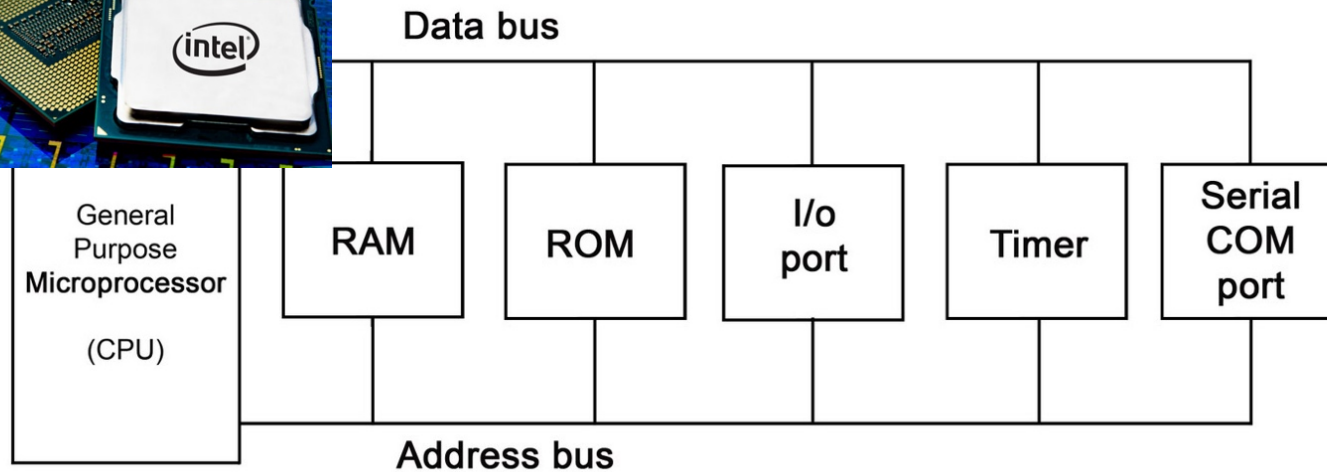
Typical IoT device

- IoT device can be viewed as a simple Embedded System

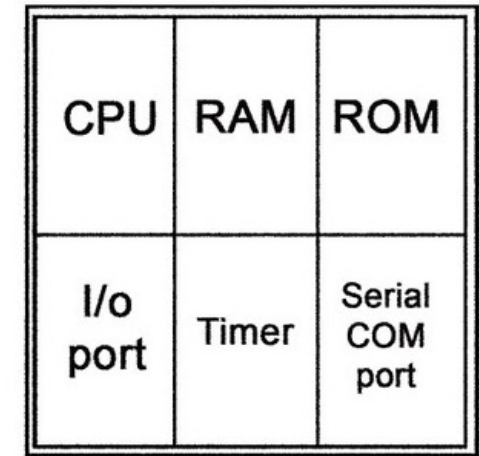


Q: uprocessor vs ucontroller?

- ⦿ A microprocessor unit (MPU) is a processor on one silicon chip
- ⦿ A microcontroller unit (MCU) is a microprocessor with some added circuitry on one silicon chip
- ⦿ Microcontrollers are used in embedded computing and **most IoT devices are based on microcontrollers**



VS



(Single chip)

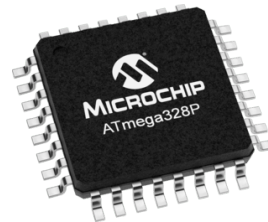
From "An Embedded System Overview" by Dr. Eng. Amr T. Abdel-Hamid

From μ controller to μ controller board

- ⦿ A μ controller can be standalone...

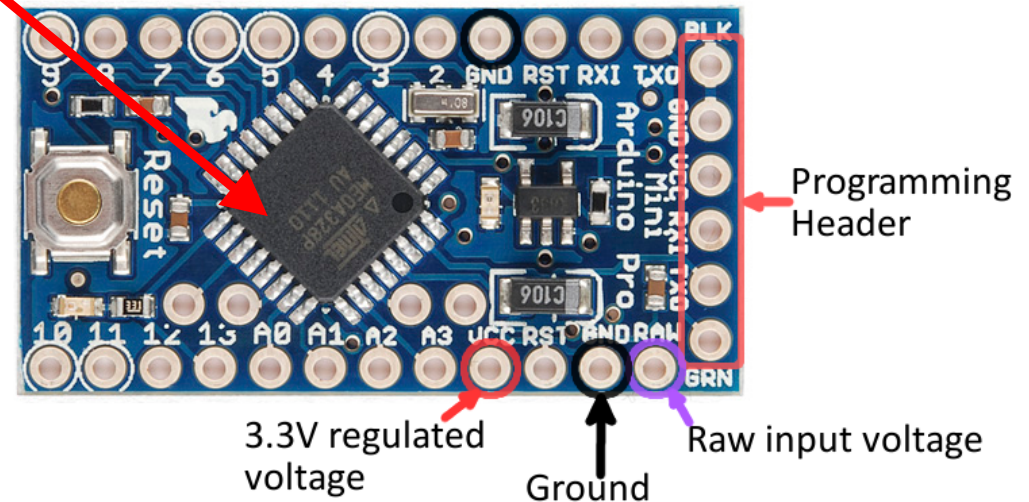
CPU	RAM	ROM
I/o port	Timer	Serial COM port

(Single chip)

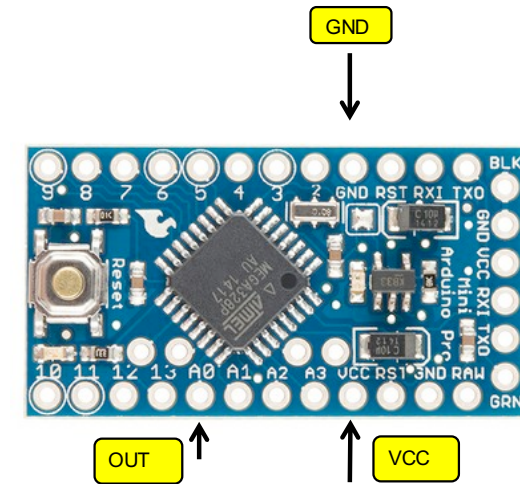
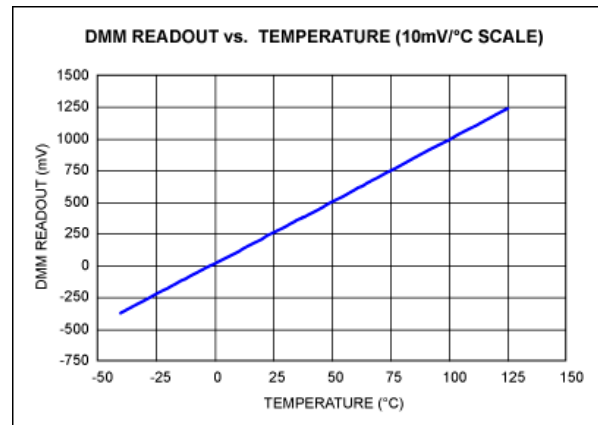
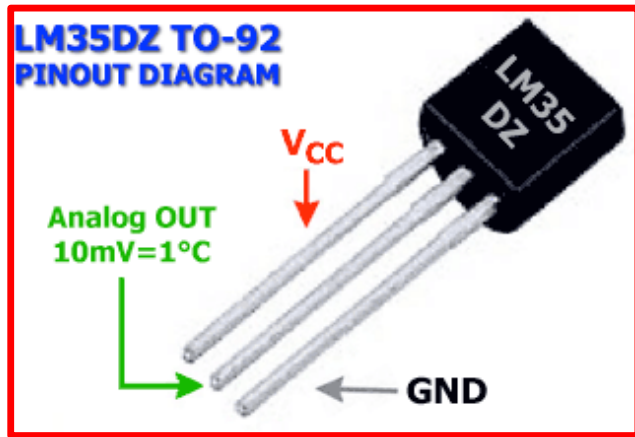


- ⦿ But, it is usually mounted on a board with additional electronics parts

- ⦿ Leds, Voltage regulators
- ⦿ Easy access to pins
- ⦿ Reset button
- ⦿ Serial-USB interface



Digitalizing the real world!



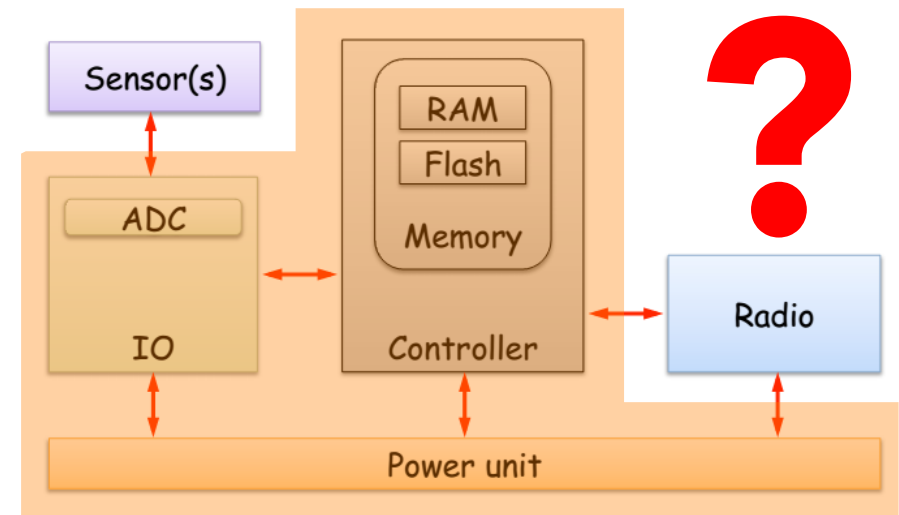
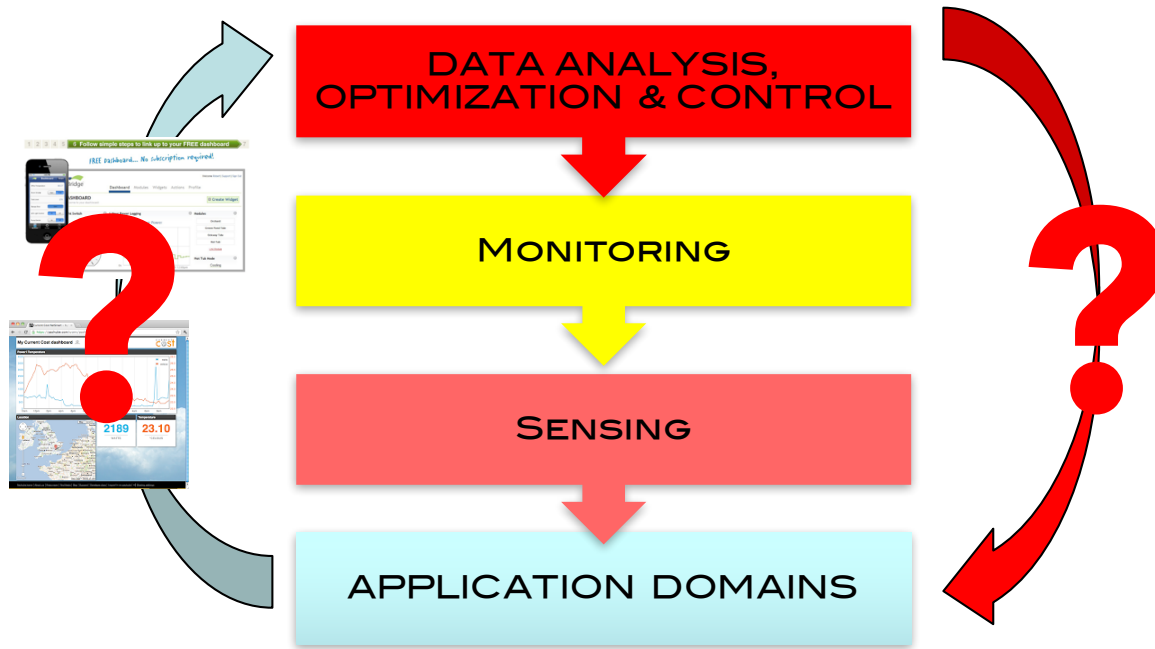
V_{cc} is typically 3.3V. Microcontrollers have Analog/Digital (A/D) converter to map a voltage to a numerical value. **A/D with 10-bit resolution give values in $[0, 2^{10}-1] = [0, 1023]$**

If 0=0V and 1023=3300mV then **$3300\text{mV}/1024=3.22\text{mV}$ is the granularity of the measure**

A digital value of 100 means $100 \times 3.22\text{mV}=322\text{mV}$

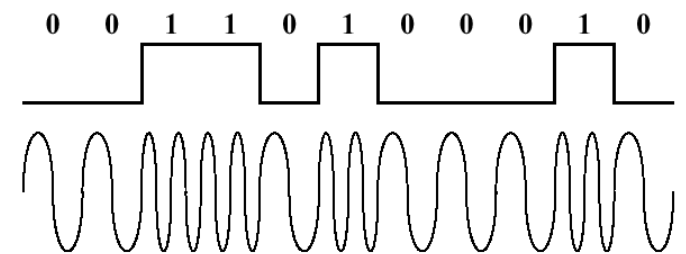
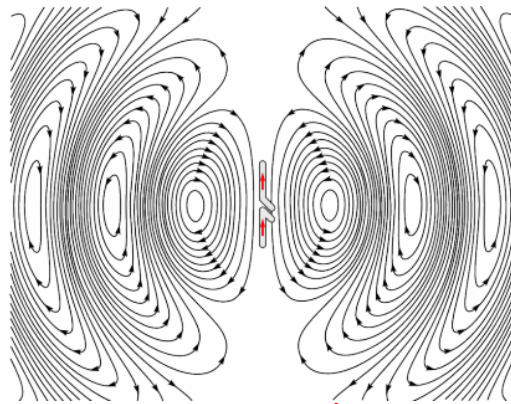
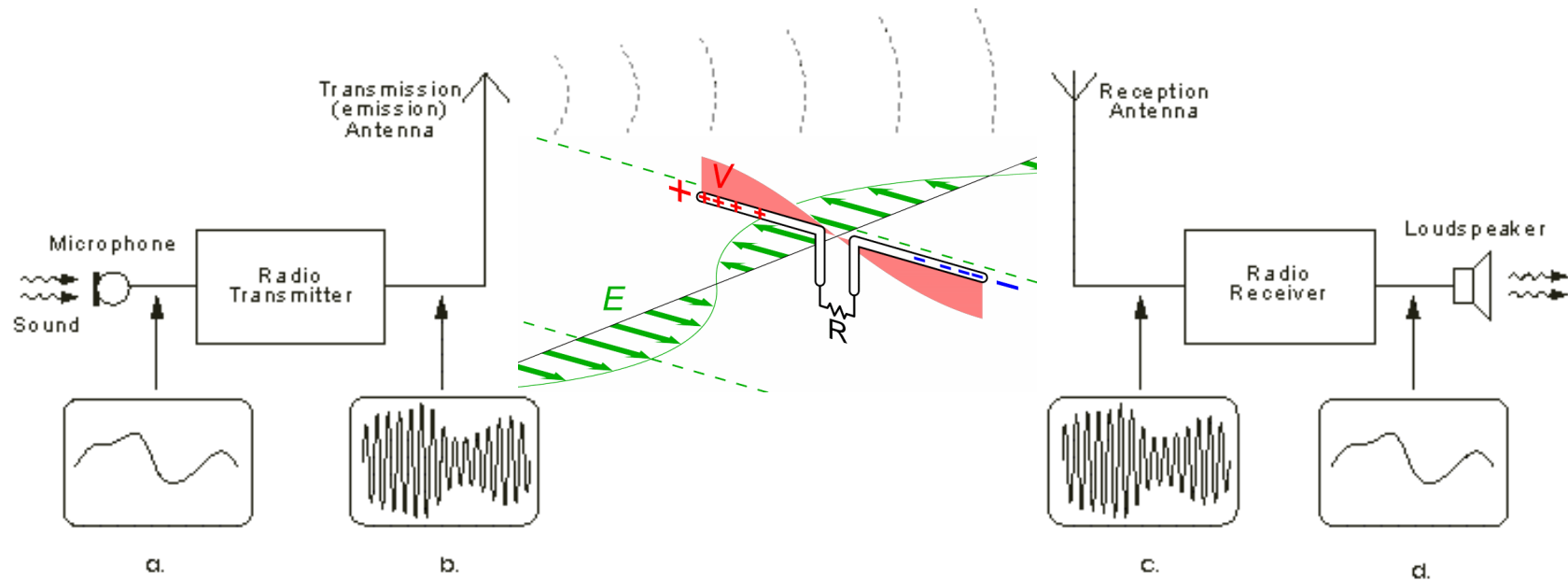
If the sensor output is 10mV/1°C then the physical temperature is $322\text{mV}/10\text{mV}=32.2^\circ\text{C}$

How to collect data?



Microcontroller

Wireless (radio) transmission basics

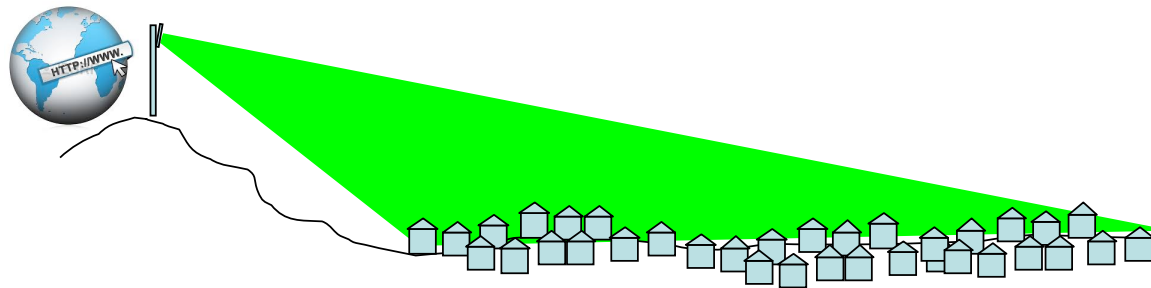


(b) Frequency-shift keying

Q: Can we have Gbps in wireless?

The real limitation in wireless

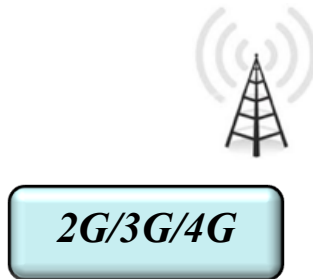
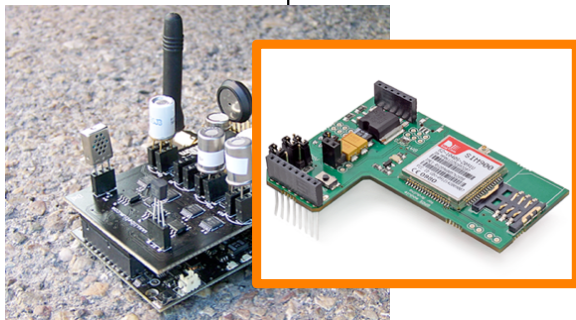
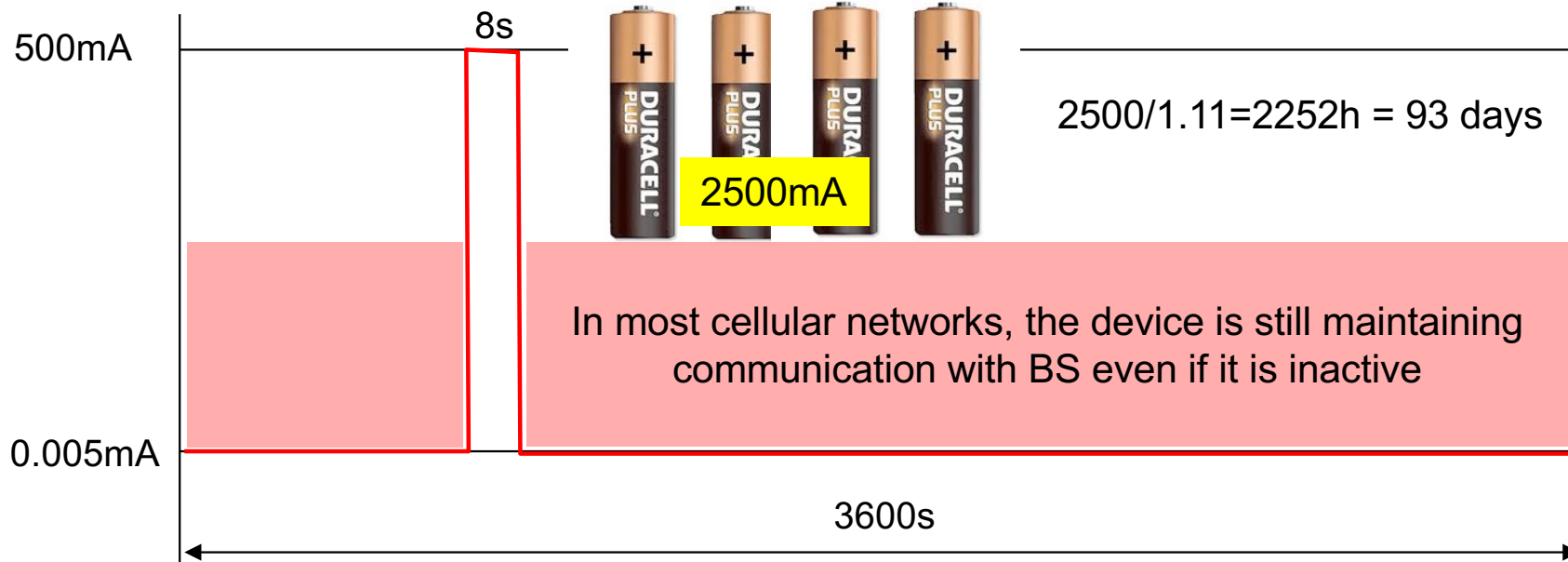
Moisture/
Temperature of
storage areas



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

Energy consideration

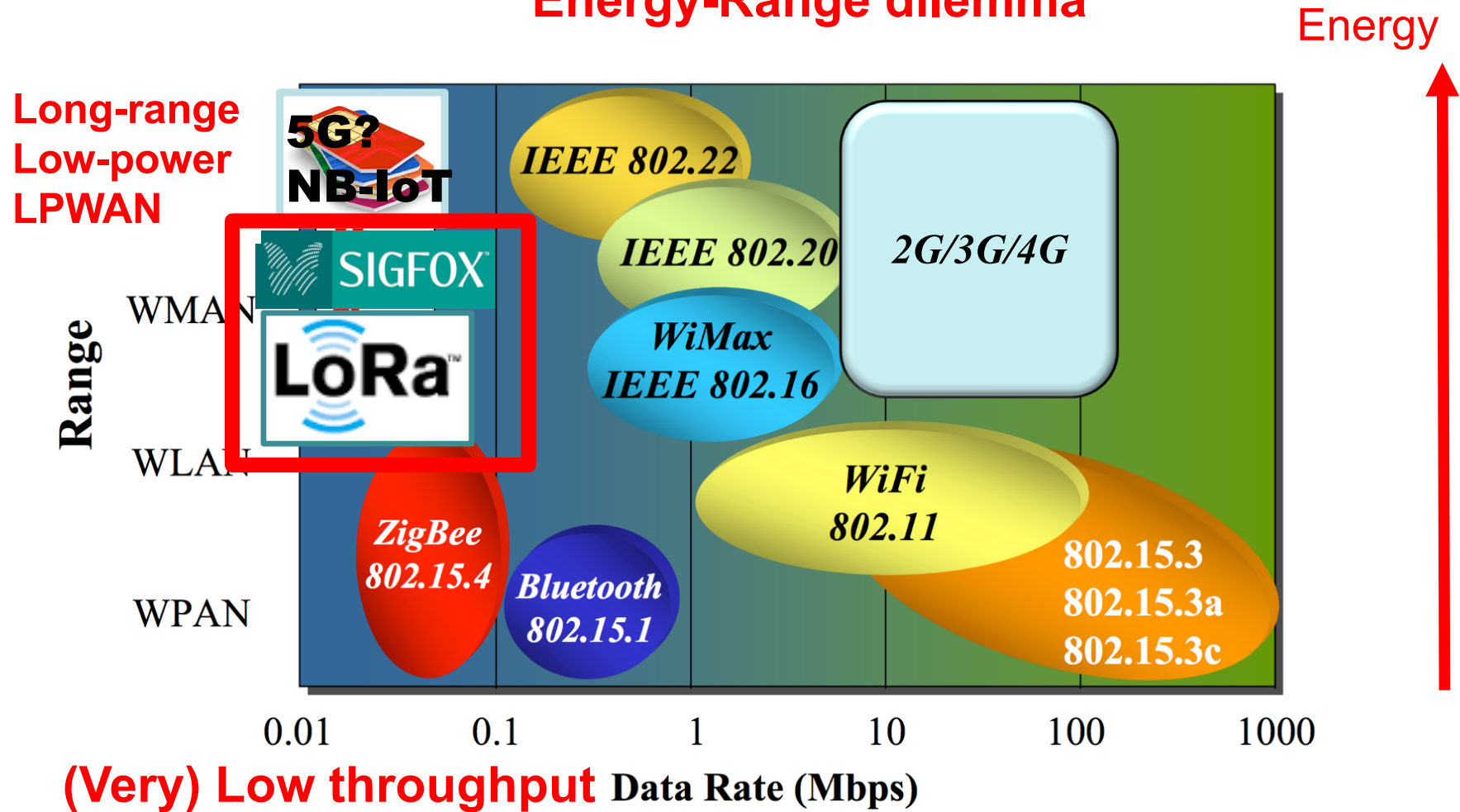
TX power: 500mA. Mean consumption: $(8s \times 500 + 3592s \times 0.005) / 3600 = 1.11mA$



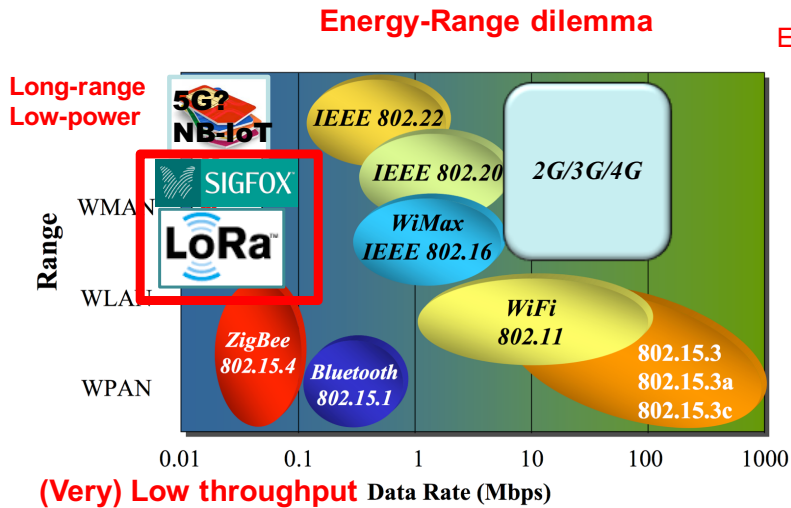
Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200-500mA	500-1000mA	100-300mA
Standby current	2.3mA	3.5mA	NC

Low-power & long-range radios

Energy-Range dilemma



Energy consumption comparaison

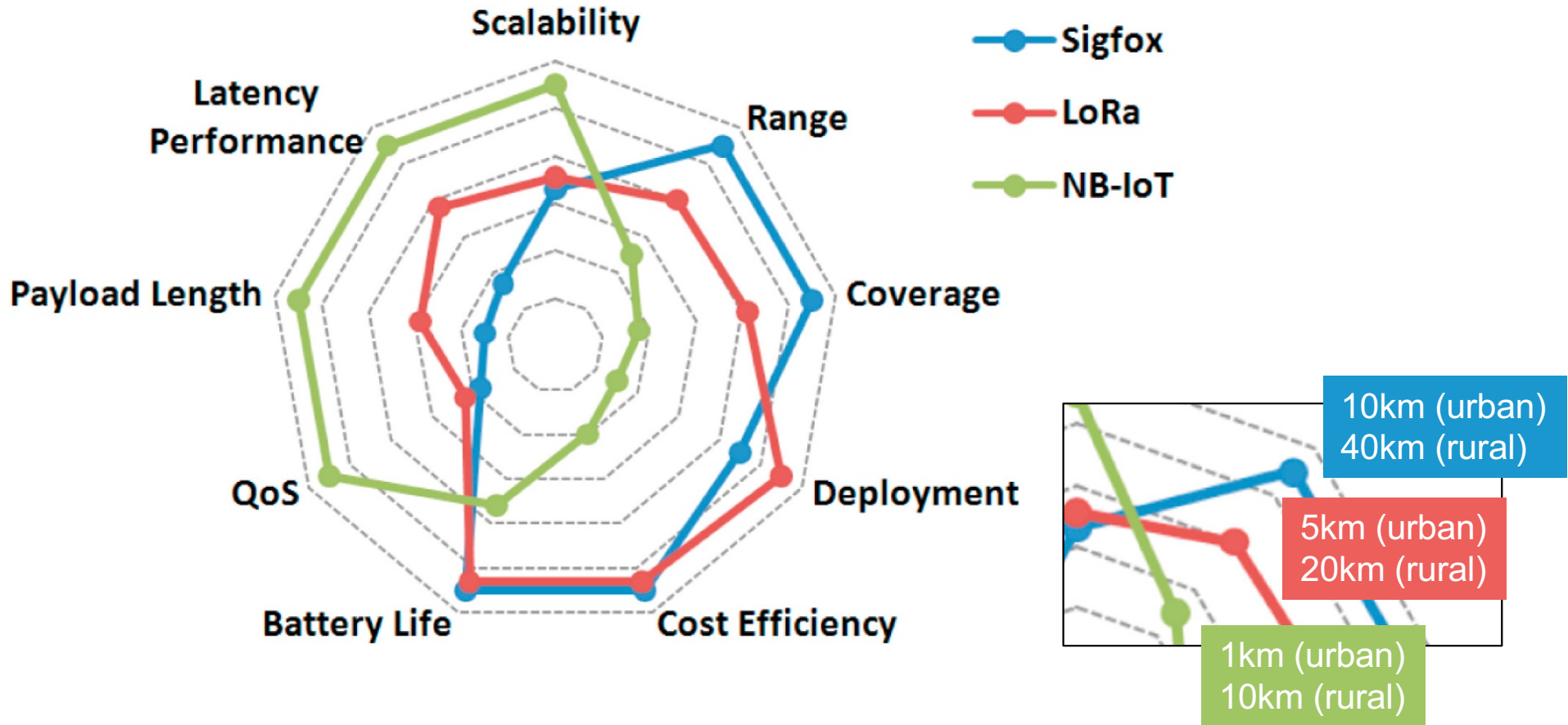


	2G	3G	LAN	ZigBee	Lo Power WAN
	N/A	N/A	O: 300m I: 30m	O: 90m I: 30m	Same as 2G/3G
Energy	200-500mA	500-1000mA	100-300mA	18mA	18mA-40mA
	2.3mA	3.5mA	NC	0.003mA	0.001mA

TX power: 40mA. Mean consumption: $(2s \times 40 + 3598s \times 0.005) / 3600 = 0.027mA$

$2500 / 0.027 = 92592h = 3858 \text{ days} = 10 \text{ years}$

LPWAN Expected range?



Attenuation in general

- ⦿ Depends mainly on distance

$$P_r = P_e d^{-\alpha}$$

- ⦿ with :
 - P_e = transmitted power
 - P_r = received power
 - d = distance between antennas
 - α from 2 to 4

Attenuation in practice

- ⦿ For an ideal antenna (theoretic)

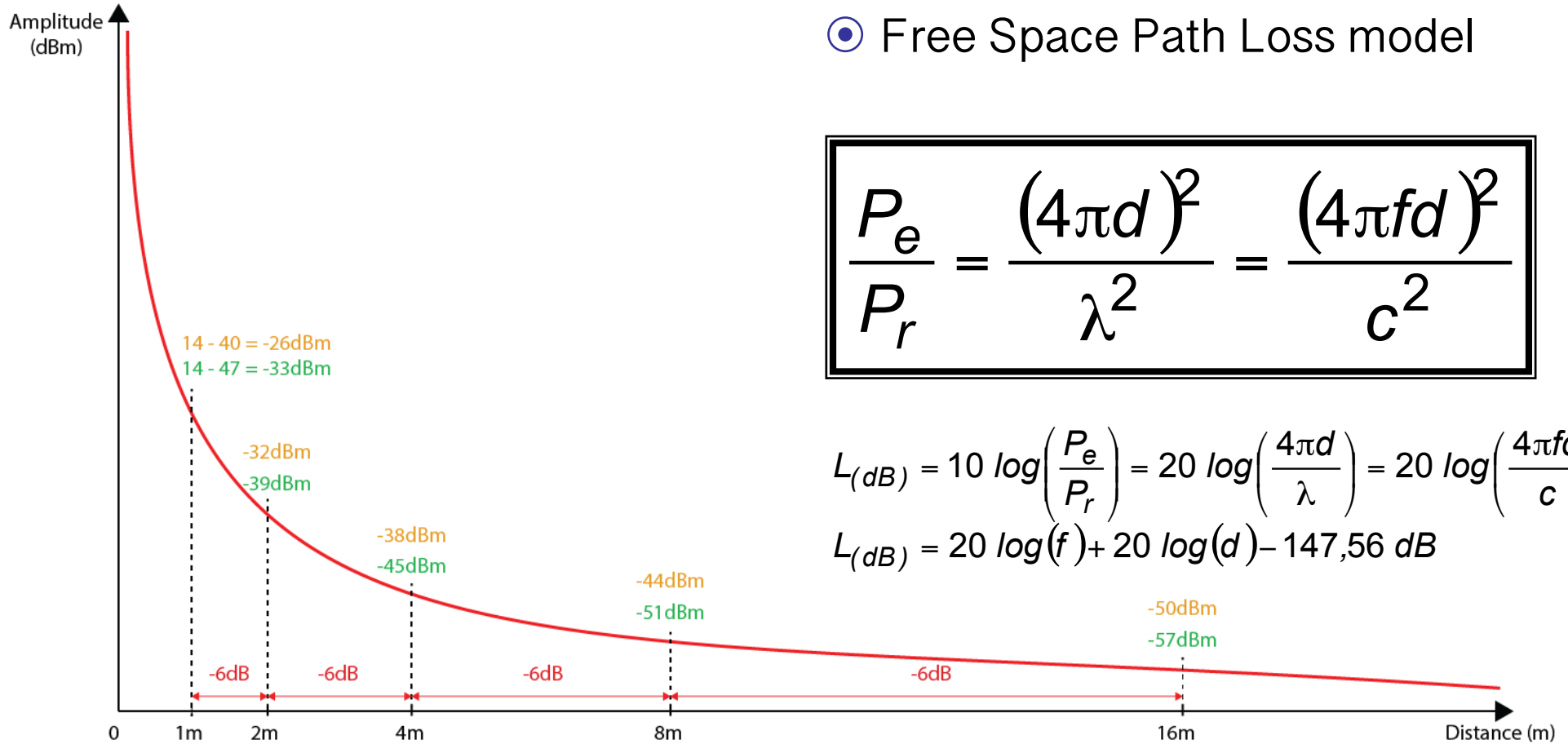
$$\frac{P_e}{P_r} = \frac{(4\pi d)^2}{\lambda^2} = \frac{(4\pi f d)^2}{c^2}$$

- P_e = transmitted power
- P_r = received power
- d = distance between antennas
- c = light speed in space $3 \cdot 10^8$ m/s
- λ = wave length of the signal = c/f

Attenuation in image



2.4GHz EIRP = 14dBm
5GHz EIRP = 14dBm



Free Space Path Loss model

$$\frac{P_e}{P_r} = \frac{(4\pi d)^2}{\lambda^2} = \frac{(4\pi f d)^2}{c^2}$$

$$L_{(dB)} = 10 \log\left(\frac{P_e}{P_r}\right) = 20 \log\left(\frac{4\pi d}{\lambda}\right) = 20 \log\left(\frac{4\pi f d}{c}\right)$$

$$L_{(dB)} = 20 \log(f) + 20 \log(d) - 147,56 \text{ dB}$$

Q: who know what is dB?

Link budget in wireless system

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

- P_{RX} = Received power (dBm)
- P_{TX} = Sender output power (dBm)
- G_{TX} = Sender antenna gain (dBi)
- L_{TX} = Sender losses (connectors etc.) (dB)
- L_{FS} = Free space loss (dB)
- L_M = Misc. losses (multipath etc.) (dB)
- G_{RX} = Receiver antenna gain (dBi)
- L_{RX} = Receiver losses (connectors etc.) (dB)
- S_{RX} = Receiver sensitivity (dBm)

Adapted from Peter R. Egli, INDIGOO.COM



$$L_{(dB)} = 20 \log(f) + 20 \log(d) - 147,56 \text{ dB}$$

Receiver sensitivity is a measure of how well the receiver performs and is defined as the power of the weakest signal the receiver can detect

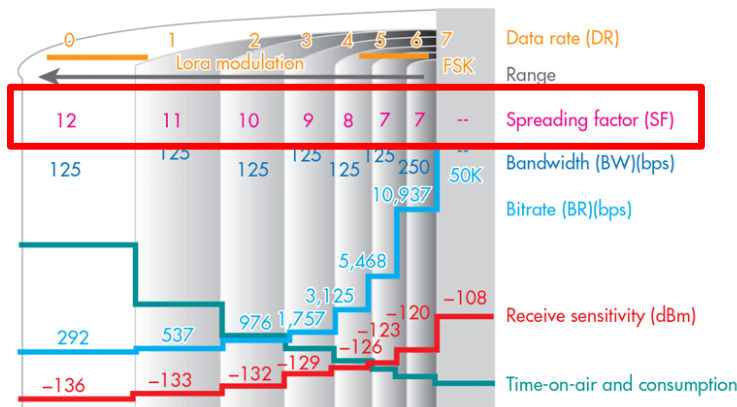
How can we increase range?



I'm not fluent in idiot
could you please speak

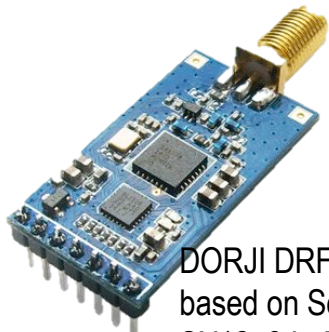


- ⦿ Increase TX power and/or improve RX sensitivity
- ⦿ Generally, RX sensitivity (\sim robustness) can be increased when transmitting (much) slower (like speaking slower!)
- ⦿ LoRa uses spread spectrum approach to increase RX sensitivity
 - ⦿ Spreading Factor defines how many chips will be used to code a symbol. More chip/symbol=longer transmission time \Rightarrow more robustness
- ⦿ **The price to pay for LPWAN**
 - ⦿ LoRa has very low throughput: 200bps-37500bps (0.2-37.5kbps)



- WiFi 802.11n: 450 000 000 bps (450Mbps)
- WiFi 802.11g: 54 000 000 bps (54Mbps)
- Bluetooth3&4: 25 000 000 bps (25Mbps)
- Bluetooth BLE: 2 000 000 bps (2Mbps)
- 3G/4G : 20Mbps-200Mbps
- **LoRa** : 200bps-37500bps (0.0002-0.0375Mbps)
- 3G/LoRa ratio: 20,000,000bps/200bps=100000!

LoRa modules with Semtech's SX127x



DORJI DRF1278DM is based on Semtech SX1278 LoRa 433MHz



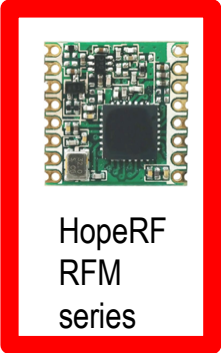
Libelium LoRa is based on Semtech SX1272 LoRa 863-870 MHz for Europe



inAir9 based on SX1276



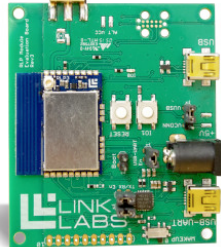
Froggy Factory LoRa module (Arduino)



HopeRF RFM series



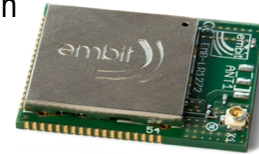
HopeRF HM-TRLR-D



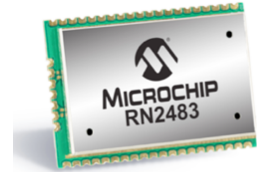
LinkLabs Symphony module



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



Adeunis ARF8030AA- Lo868



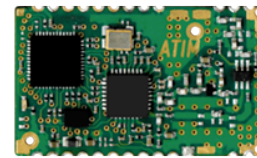
habSupplies



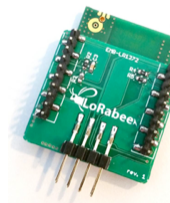
Multi-Tech MultiConnect mDot



AMIHO AM093



ARM-Nano N8 LoRa module from ATIM



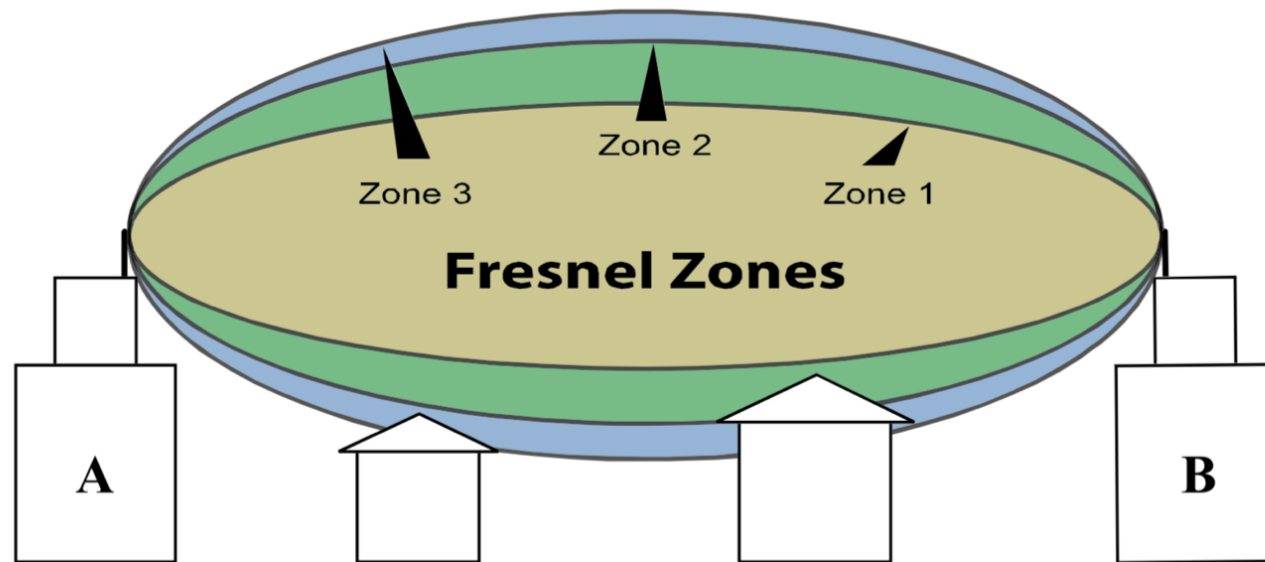
SODAQ LoRaBee Embit



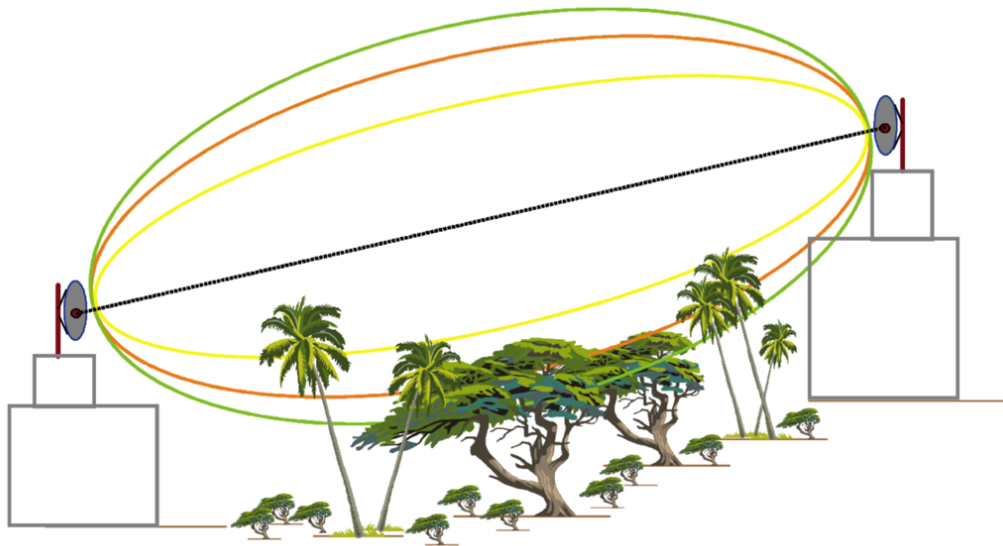
SODAQ LoRaBee RN2483

Line-of-Sight & Fresnel zone

- LoS means clear Fresnel zone
- Football (american) shape
- Acceptable = 60% of zone 1 + 3m

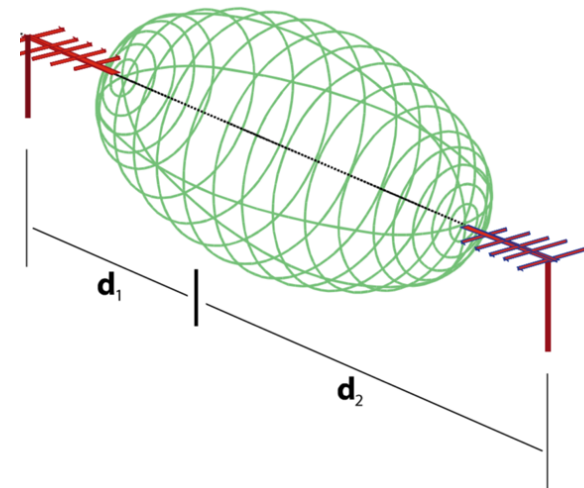


Clearing the Fresnel zone? Raise antennas!



$$r_n = \sqrt{\frac{d_1 d_2}{d_1 + d_2}}$$

Range Distance	900 MHz Modems Required Fresnel Zone Diameter	2.4 GHz Modems Required Fresnel Zone Diameter
1000 ft. (300 m)	16 ft. (5 m)	11 ft. (3.4 m)
1 Mile (1.6 km)	32 ft. (10 m)	21 ft. (6.4 m)
5 Miles (8 km)	68 ft. (21 m)	43 ft. (13 m)
10 Miles (16 km)	95 ft. (29 m)	59 ft. (18 m)



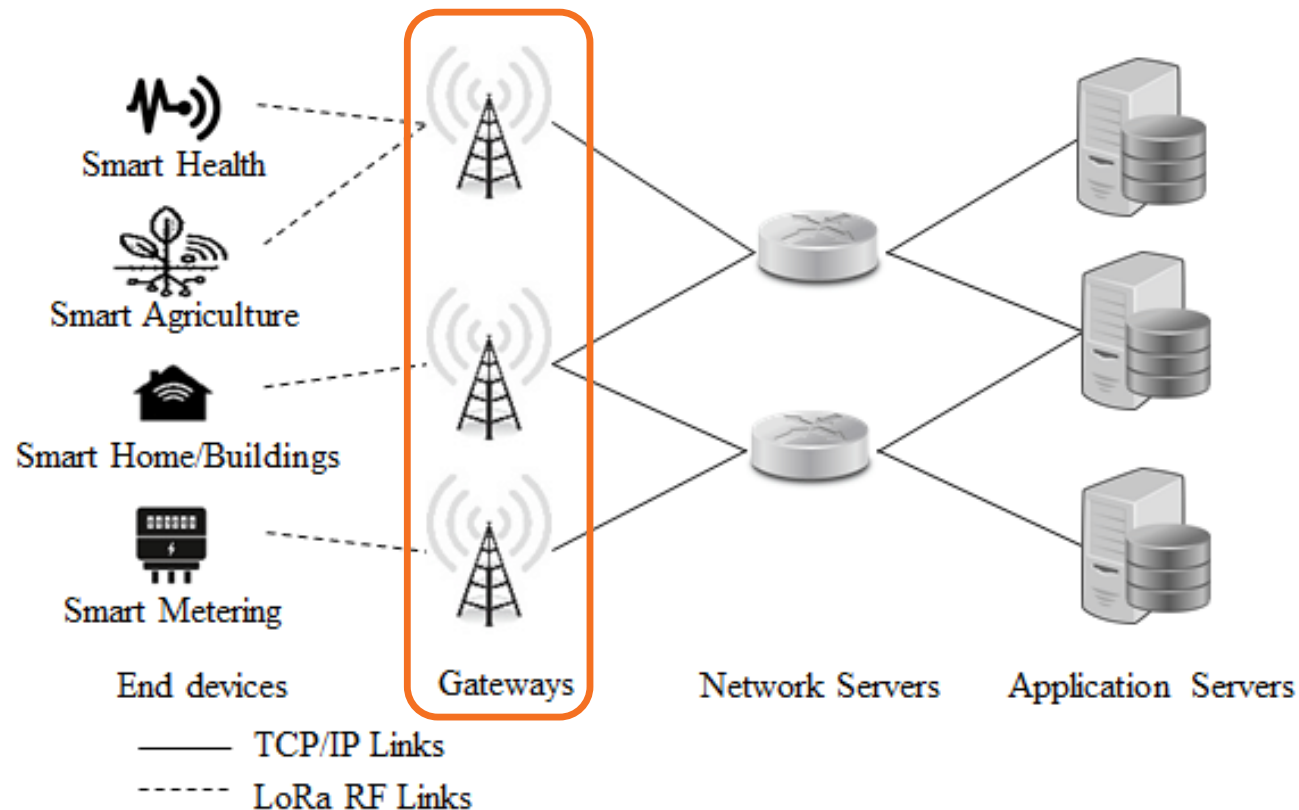
Clearing the Fresnel zone? Let's use satellite!

- Low-orbit, low-cost; compact satellite for global coverage

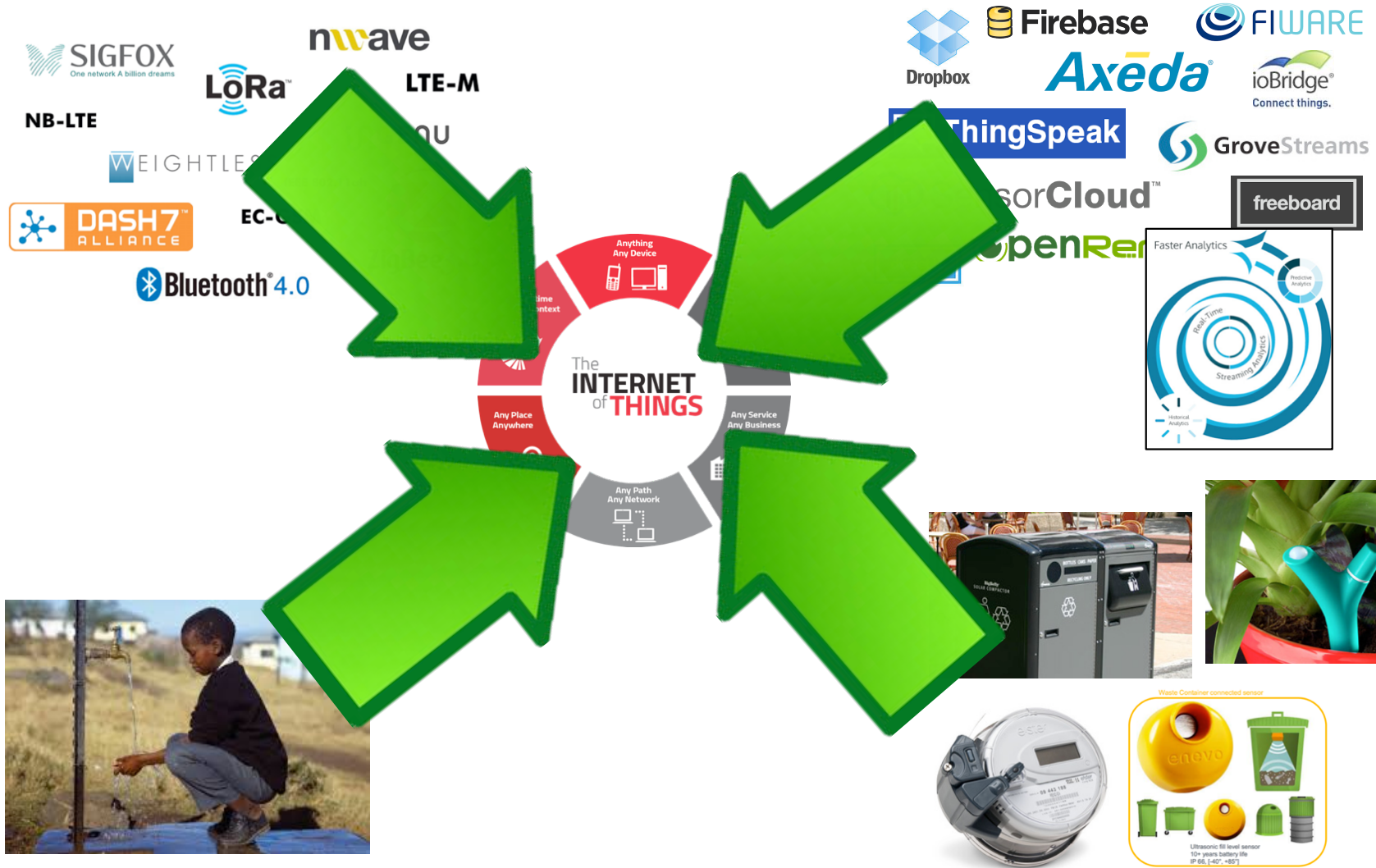


General LPWAN IoT architecture

- LPWAN architecture is gateway-centric
 - IoT gateways are connected to Internet
 - They forward data from IoT device to Internet Servers



IoT becomes reality!



A reality for everybody?



IoT in developing countries?



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



Smallholders: the next decade challenge!



SMALLHOLDERS AND FAMILY FARMERS

DID YOU KNOW?

Eighty percent of the farmland in sub-Saharan Africa and Asia is managed by smallholders (working on up to 10 hectares). While 75 percent of the world's food is generated from only 12 plants and 5 animal species, making the global food system highly vulnerable to shocks, biodiversity is key to smallholder systems who keep many rustic and climate-resilient varieties and breeds alive.

Smallholders are small-scale farmers, pastoralists, forest keepers, fishers who manage areas varying from less than one hectare to 10 hectares. Smallholders are characterized by family-focused motives such as favouring the stability of the farm household system, using mainly family labour for production and using part of the produce for family consumption.

AVERAGE SIZE OF AGRICULTURAL HOLDINGS (ha)

Smallholders are small-scale farmers, pastoralists, forest keepers, fishers who manage areas varying from less than one hectare to 10 hectares. Smallholders are characterized by family-focused motives such as favouring the stability of the farm household system, using mainly family labour for production and using part of the produce for family consumption.

Eighty percent of the farmland in sub-Saharan Africa and Asia is managed by smallholders (working on up to 10 hectares). While 75 percent of the world's food is generated from only 12 plants and 5 animal species, making the global food system highly vulnerable to shocks, biodiversity is key to smallholder systems who keep many rustic and climate-resilient varieties and breeds alive.

The economic lives of smallholder farmers

An analysis based on household data from nine countries

Connecting Smallholder Farmers to Markets

WFP support for agricultural market development

World Food Programme

Agriculture and Development

A summary of the International Assessment on Agricultural Science and Technology for Development

AGRICULTURE is closely linked to many concerns, including biodiversity loss, global warming and water availability. Despite significant increases in productivity, malnutrition and poverty still plague many parts of the world. This International Assessment of Agricultural Science and Technology for Development (IAASTD) focuses on how to make better use of agricultural science, knowledge and technology to reduce hunger and poverty, improve rural livelihoods, and foster equitable and sustainable development.

Prof. Congduc Pham
http://www.univ-pau.fr/~cpham

Linking Smallholders to Markets:

A Supplier Development Program for Vegetable Farmers in Lesotho

THE WORLD BANK

Smallholder ecologies

Food and Agriculture Organization of the United Nations

AGRONOMIC PRACTICES FOR WATER MANAGEMENT UNDER SMALLHOLDER RAINFED AGRICULTURE

Nile Basin Initiative - NELSAP
Regional Agricultural Trade and Productivity Project - RAPT

Training Manual 4

2012

Inclusive Digital Agriculture:

Making Value Chains Work for Farmers with Disabilities

April 2021

FAO DIGITAL SERVICES PORTFOLIO

Working together for Zero Hunger through digital innovation

AGRICULTURAL SERVICES AND DIGITAL INCLUSION IN AFRICA

Four new apps bring agricultural services closer to farmers, providing real-time information on weather, livestock care, markets, and nutrition-related aspects of food production.

ISSUE

Digital services are changing the way farmers do business, build resilience and communicate, and enable an innovative digital ecosystem to improve the impact of existing rural advisory services. However, various and social protection programmes. They also facilitate access to markets, information and enterprise or shop opportunities. Digital services can also help smallholder farmers to include informal activities through infrastructure and policy-related digital literacy and availability of local content. They contribute directly to poverty reduction and food security.

ACTION

FAO and its partners are therefore developing and implementing digital inclusion initiatives and scaling up innovative digital services for smallholders and family farmers, with particular emphasis on women, self-employed entrepreneurs and female-headed households.

Four new mobile-based digital services (W4 Apps) have been developed: W4 apps for crop, livestock and aquaculture, W4 apps for market and extension, W4 apps for weather and crop calendar, and W4 apps for nutrition and food security. These services are available in multiple languages and are user-friendly, easy to use and accessible to people with low literacy skills.

FAO and its partners are therefore developing and implementing digital inclusion initiatives and scaling up innovative digital services for smallholders and family farmers, with particular emphasis on women, self-employed entrepreneurs and female-headed households.

Four new mobile-based digital services (W4 Apps) have been developed: W4 apps for crop, livestock and aquaculture, W4 apps for market and extension, W4 apps for weather and crop calendar, and W4 apps for nutrition and food security. These services are available in multiple languages and are user-friendly, easy to use and accessible to people with low literacy skills.

Many commercial systems are not adapted for developing countries, rural areas, smallholders



Needs, cost, design approach, constraints & control mechanisms

Challenges:
Low-cost, adaptation, digital inclusion, local economy



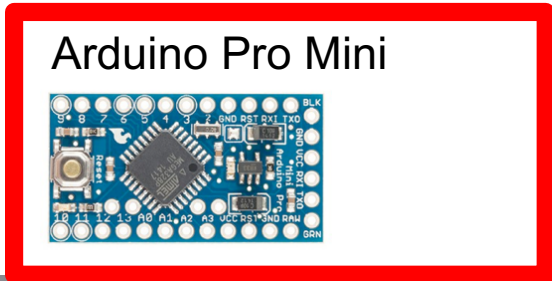
WAZIUP Low-cost IoT!



The banner features the WAZIUP logo at the top left, followed by a navigation menu with links: ABOUT, TECHNOLOGIES, COMMUNITY, NEWS & EVENT, DOWNLOADS, DEV KIT, FAQ, and CONTACT. The main visual is a computer monitor and keyboard on a bed of soil with carrots. The monitor screen is filled with various icons representing IoT and agriculture, such as a tractor, a cow, a leaf, a watering can, and various electronic devices. In the top left corner of the banner, there is a smaller version of the Horizon 2020 logo. The text 'AFFORDABLE TECHNOLOGIES TO EMPOWER RURAL ECONOMIES' is overlaid on the bottom left of the banner.

Prof. Congduc Pham
<http://www.univ-pau.fr/~cpham>

Low-cost microcontroller boards



Arduino Pro Mini



LoPy

<http://blog.atmel.com/2015/12/16/rewind-50-of-the-best-boards-from-2015/>

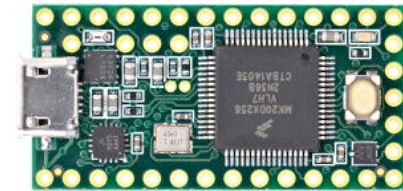
<http://blog.atmel.com/2015/04/09/25-dev-boards-to-help-you-get-started-on-your-next-iot-project/>



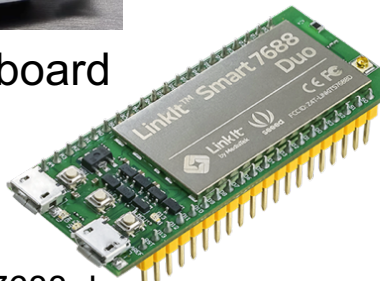
Theairboard



Expressif ESP32

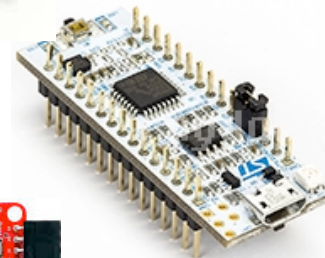


Teensy 3.2



LinkIt Smart7688 duo

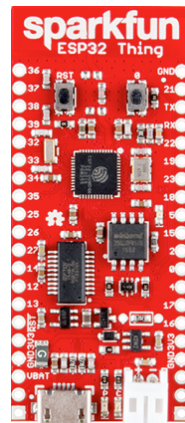
STM32 Nucleo-32



Heltec ESP32 + OLED



Adafruit Feather



Sparkfun ESP32 Thing



Tessel

SodaqOnev2



Tinyduino

Arduino's success story starting in 2005



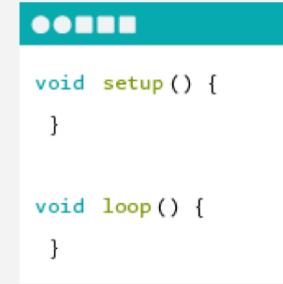
WHAT IS ARDUINO?

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



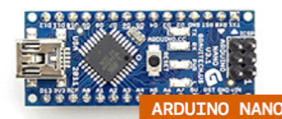
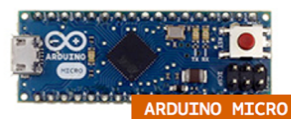
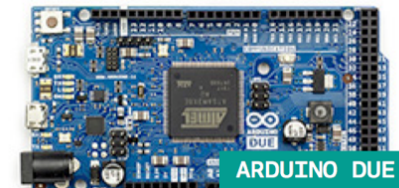
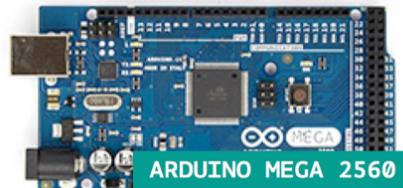
ARDUINO BOARD

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

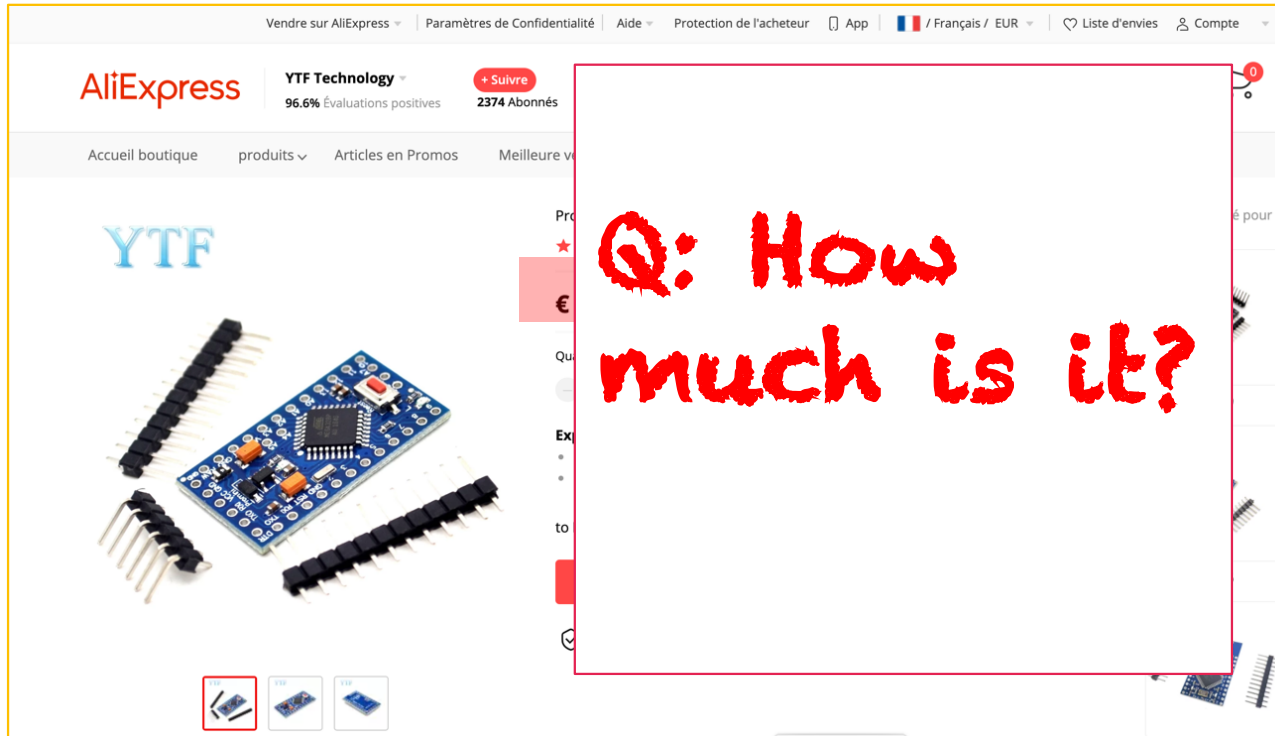


ARDUINO SOFTWARE

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

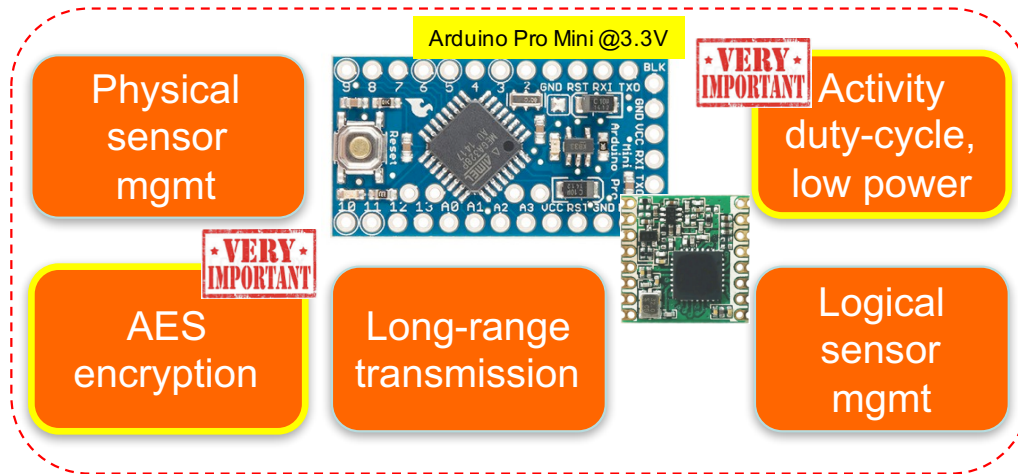
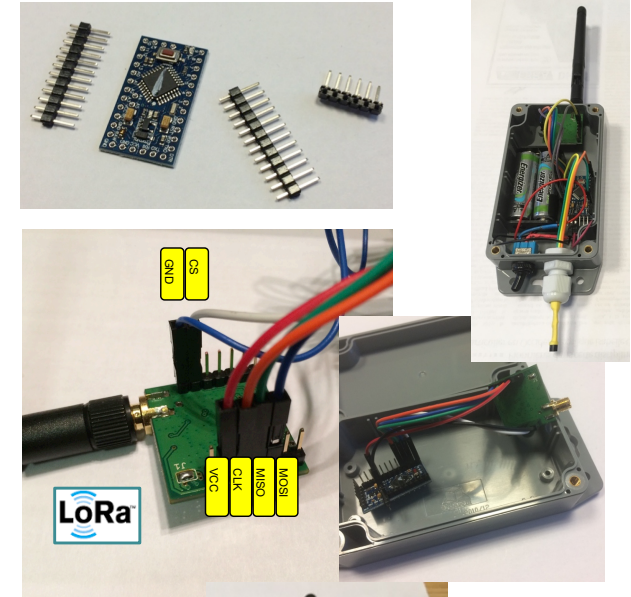
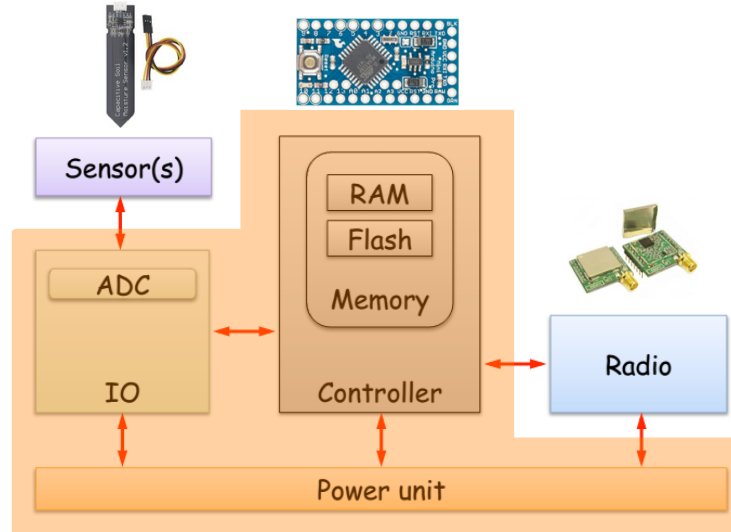
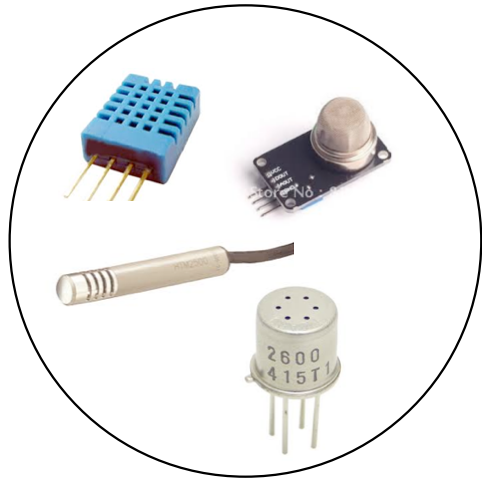


Why go for Arduino?



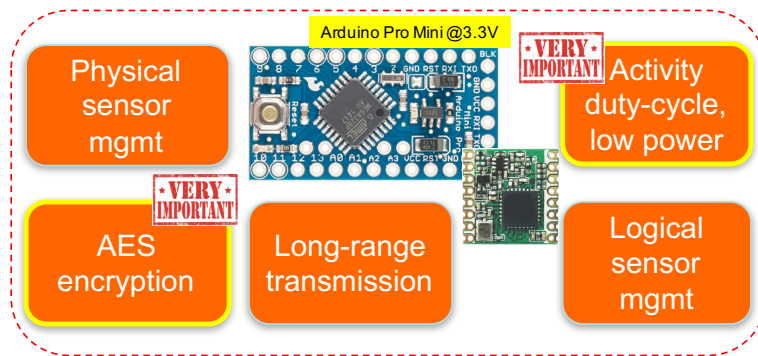
- ⦿ Cheap, open, and easy to use/program
- ⦿ **Huge developer communities**
- ⦿ Hardware is not the main important issue
- ⦿ Hardware is nothing without software libraries!

Do-It-Yourself IoT



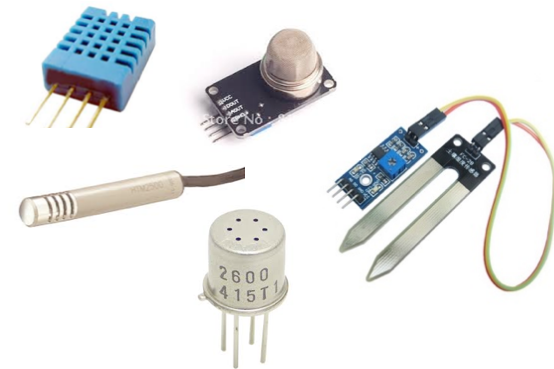
Generic IoT v.s. highly specialized

- Build **low-cost**, **low-power**, **generic** IoT platform
- Methodology for low-cost platform design
- Technology transfers to user communities, economic actors, stakeholders,...

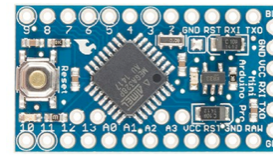


+

=

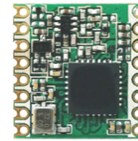


Simple PCBs ease the DIY approach



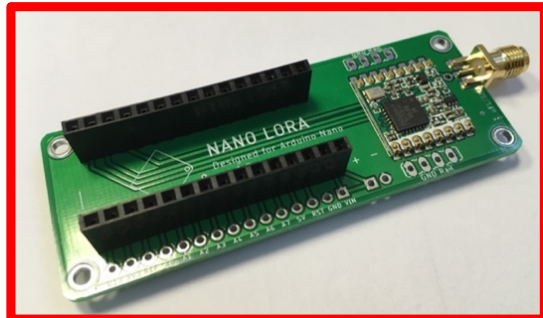
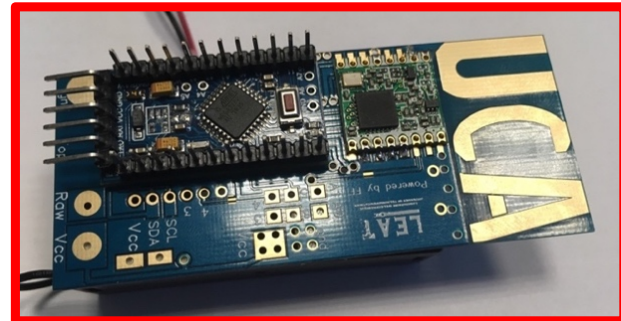
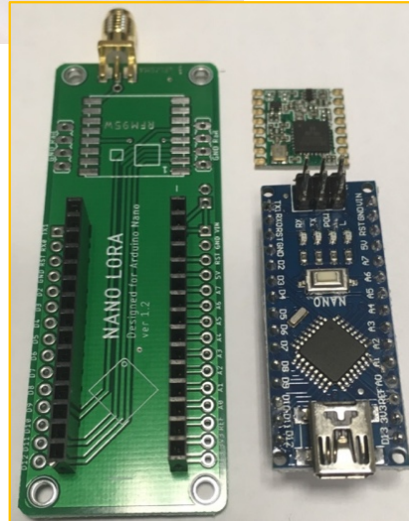
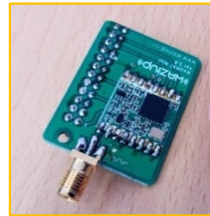
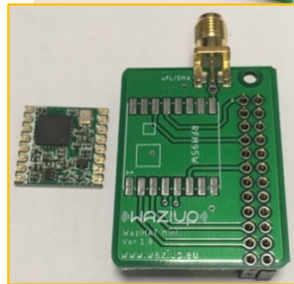
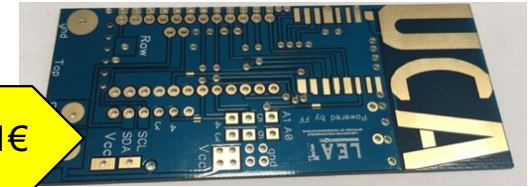
1.5€

https://github.com/FabienFerrero/UCA_Board

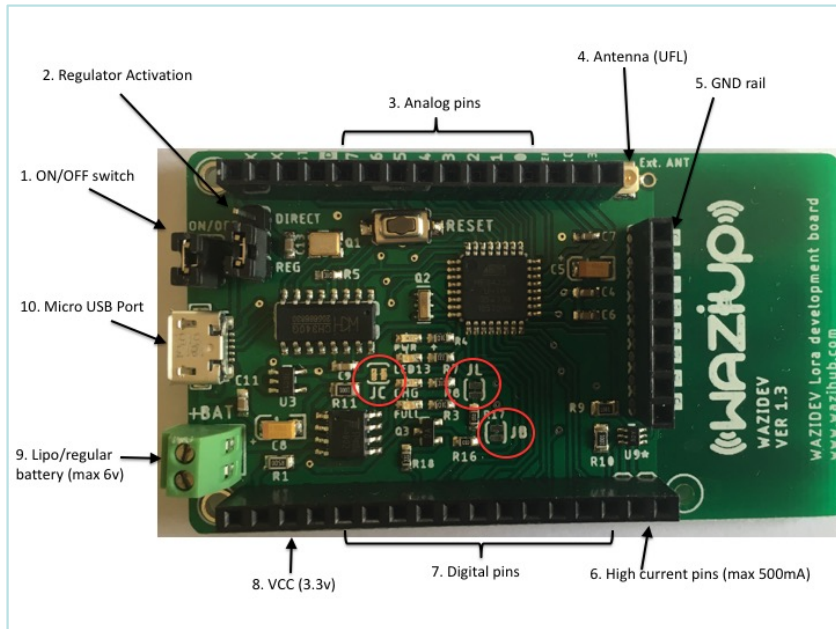


5€

<1€

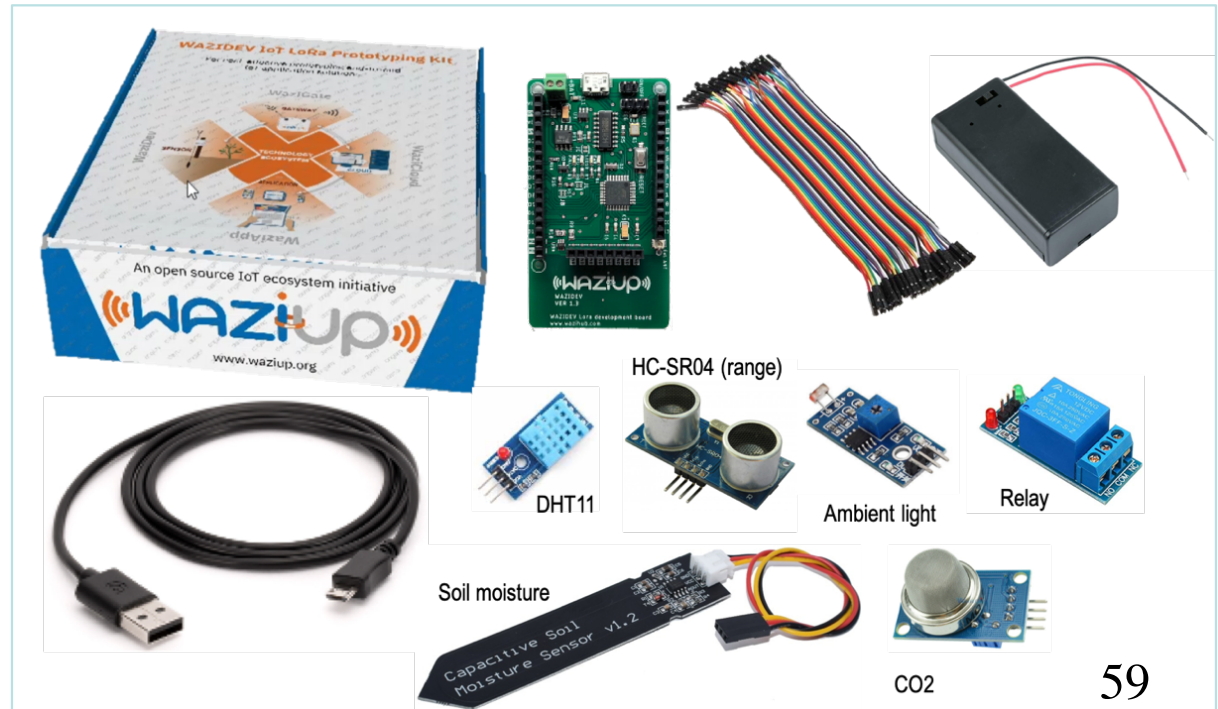


WaziDev kit: IoT in-a-box!



WaziDev

- ATmega328P, 8MHz, 3.3v
- FTDI chip
- RFM95W LoRa module
- Integrated antenna



Included

- LiPo battery regulator accepting solar panel input
- Battery level monitor
- 2 high-current control pin
- GND rail

Generic IoT v.s. highly specialized

The MVP approach in WAZIUP

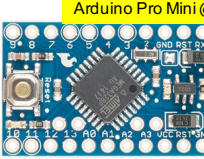
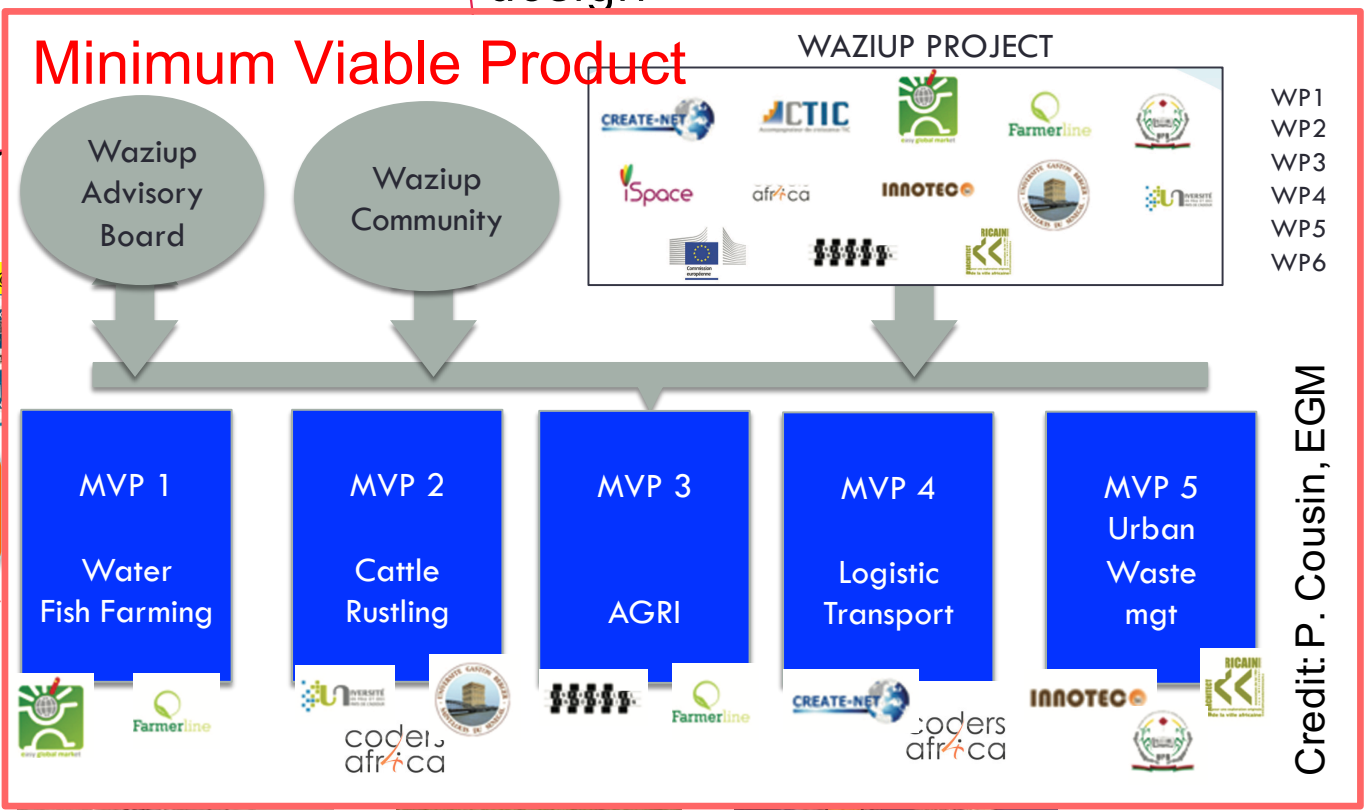
IoT platform design

Physical sensor mgmt

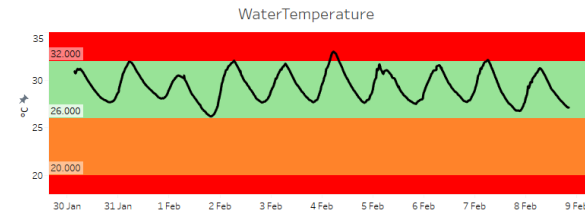
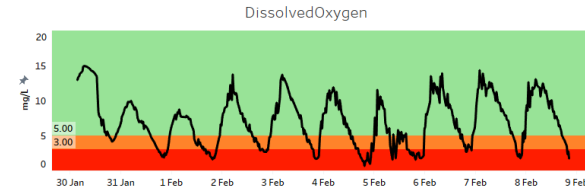
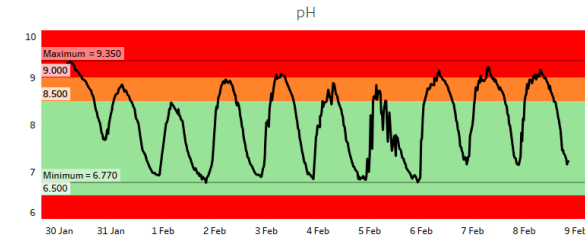
AES encryption

Long-range transmission

VERY IMPORTANT

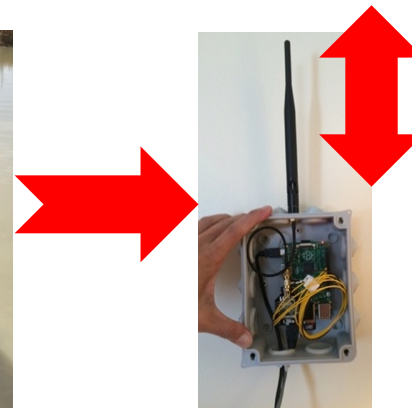
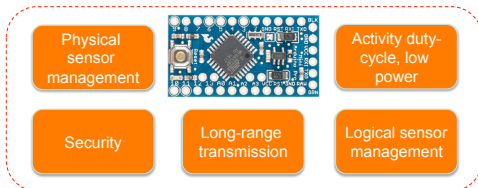



Low-cost buoy for fish farming MVP



Physical sensor reading

Credit: EGM

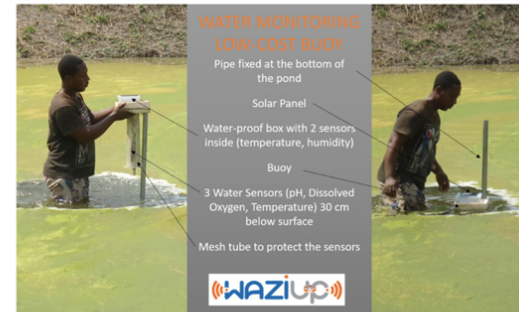


HATCHERY EXPERIMENT, BURKINA FASO

- ❑ Laboratory named Laboratoire d'Études des Ressources Naturelles et des Sciences de l'Environnement (LERNSE)
- ❑ NAZI BONI University in a small village of Bobo-Dioulasso city
- ❑ Sensors are placed in a hatchery and the box is placed outside of the building



LOW-COST BUOY FOR FISH FARMING



In Sub-Saharan Africa, the volume of natural captured fish doesn't meet half of the population demand

Increasing production of aquaculture will help reduce the quantity of imported fishes in Africa

The aim is to monitor in real-time different parameters to control water quality and prevent some diseases that could affect fish in order to improve the quality and quantity of the production



KUMAH FARM, GHANA

- ❑ The Kwame Nkrumah University of Science and Technology (KNUST)
- ❑ Located on the campus of the Kwame Nkrumah University of Science and Technology in Kumasi, Ghana.
- ❑ The farm comprises 30 constructed fish ponds, a farm house, a recirculating aquaculture system (RAS) laboratory and store houses.



SANAR FARM, SENEGAL

- ❑ Farm located at less than 2 km from UGB.
- ❑ One pond is dedicated for the Waziup application : 50x25m, average depth of 0.5 meters, populated by 4000 individuals of saltwater tilapia.
- ❑ The basin is irrigated via a water supply system fed by a river in proximity.
- ❑ The water in the pond is changed every 10 days

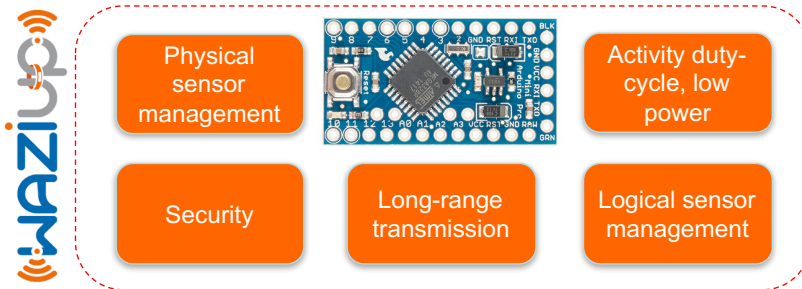
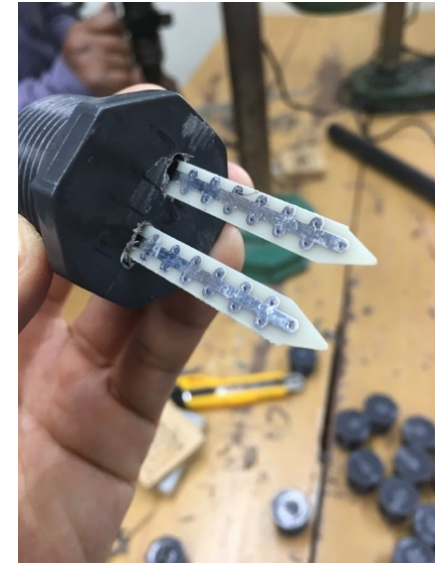
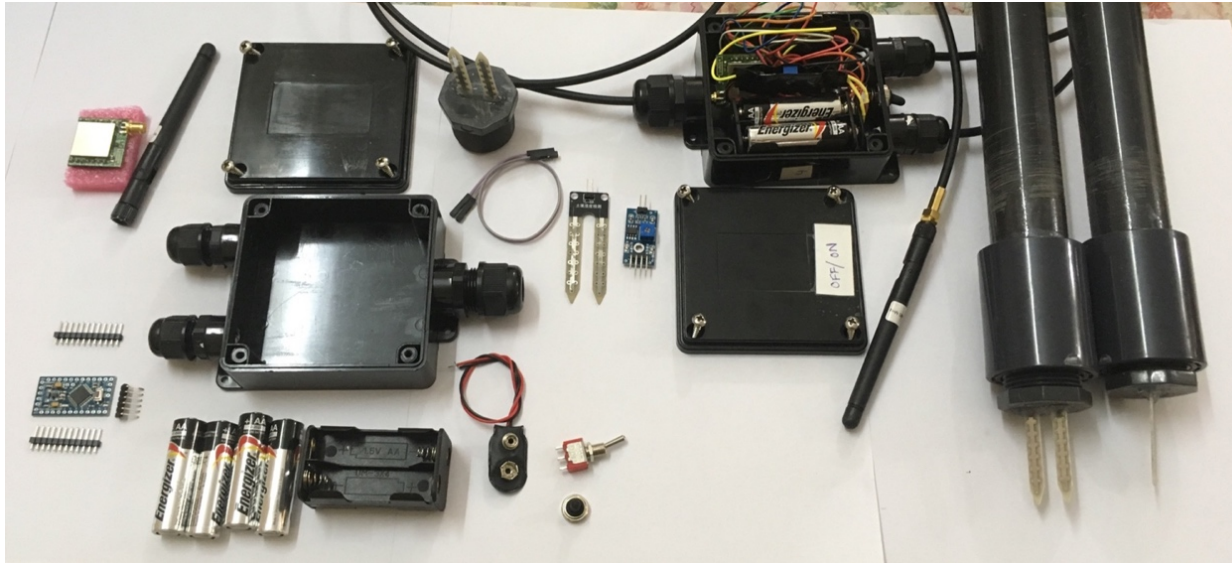


Collar for Cattle Rustling MVP

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

2	6	16	17	18	19	254	124	10
---	---	----	----	----	----	-----	-----	----

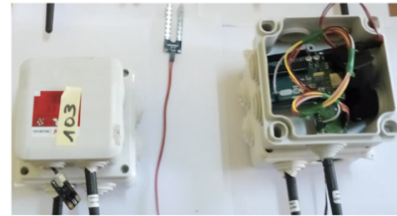
Soil humidity sensors for agri MVP



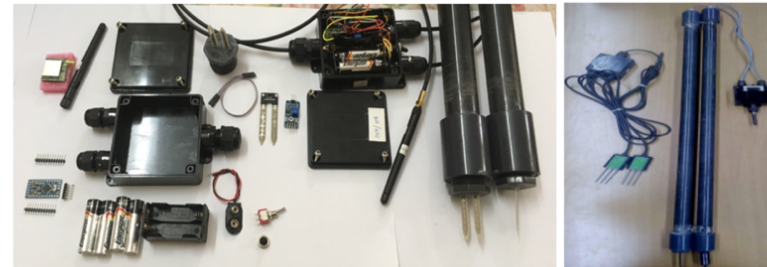
UBG FARM, SENEGAL



SOIL HUMIDITY SENSOR FOR AGRICULTURE



Monitoring soil moisture and other parameters to provide insightful recommendations and notifications to farmers, and advisors



NASSO SITE, BURKINA FASO



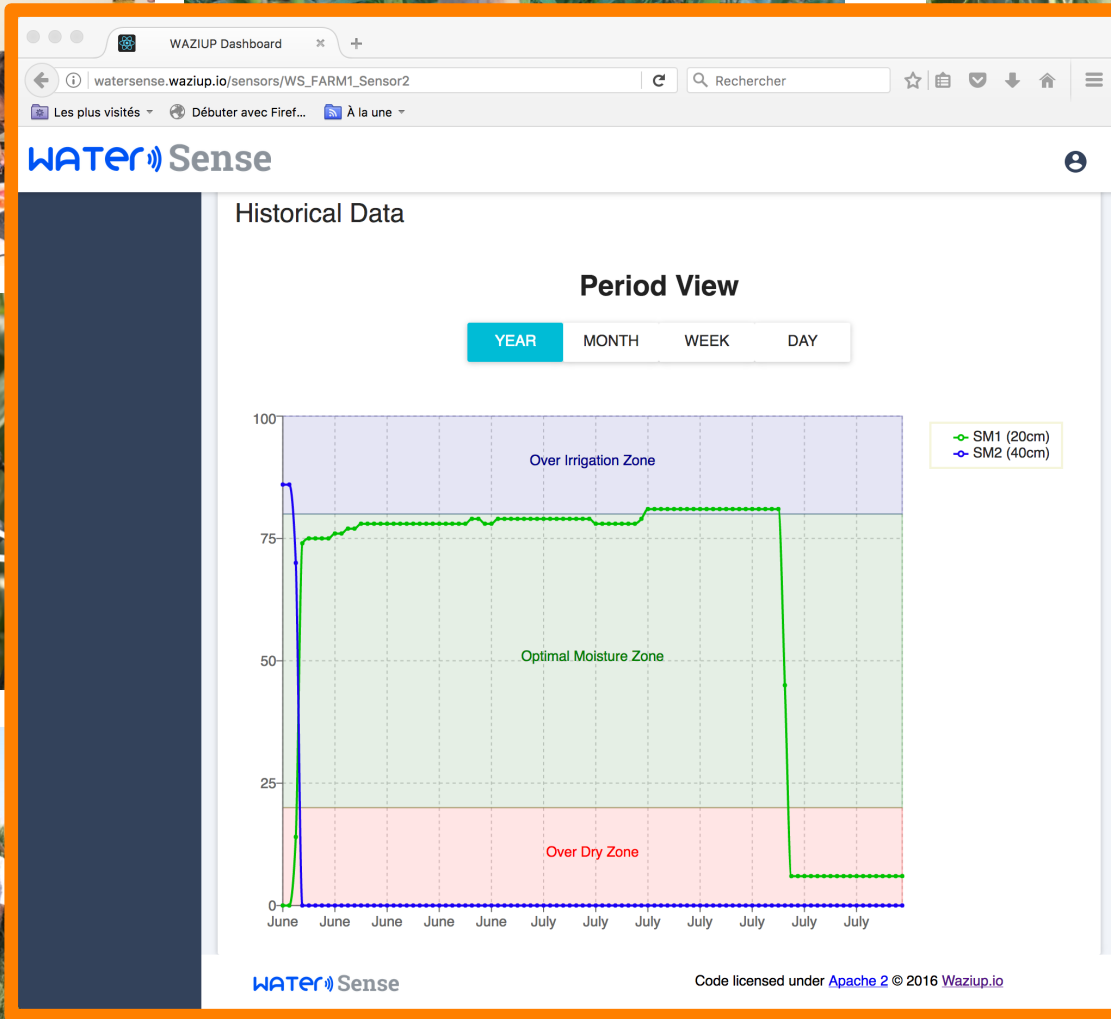
URBANNATIC GARDENS, TOGO



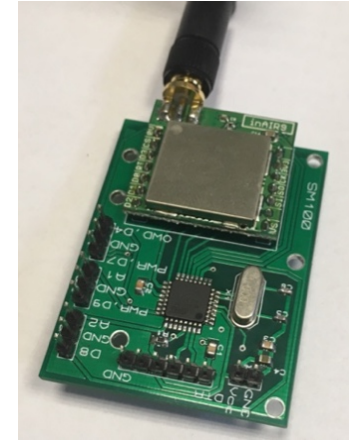
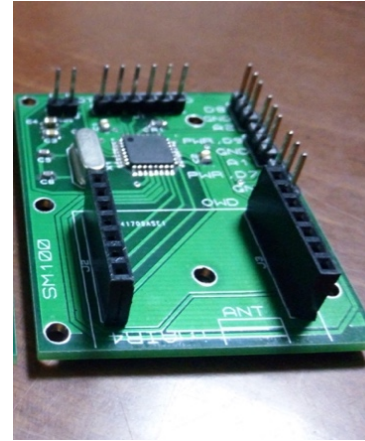
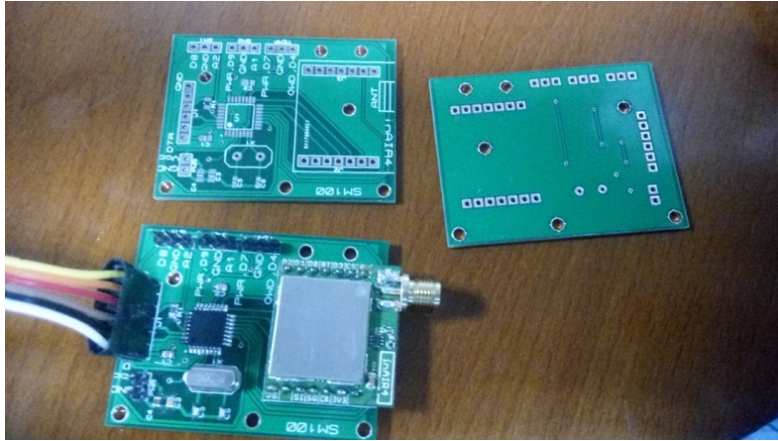
Deployment for Nestlé's WaterSense



Deployment for Nestlé's WaterSense



Local integration, technology transfer



Deployment in rural areas no Internet ☹️

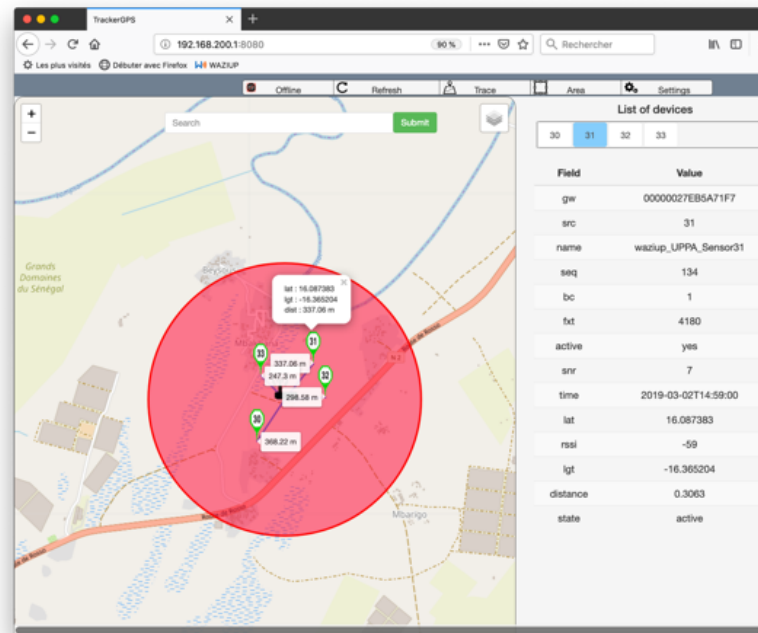
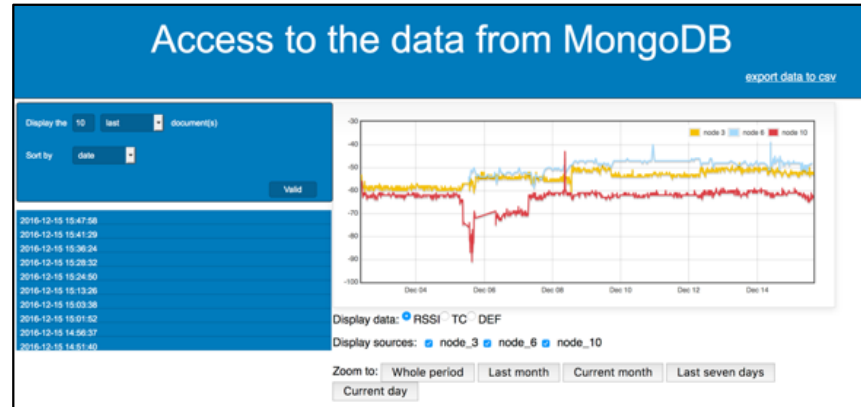
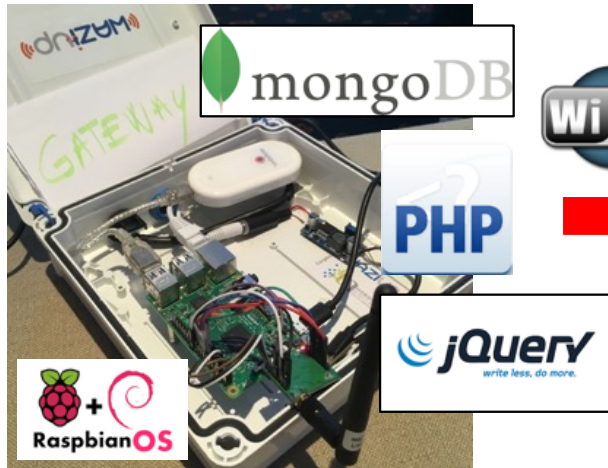
- ⦿ deploying IoT in very isolated areas...
- ⦿ ... where internet and electricity are not stable!

Q: What can we do?



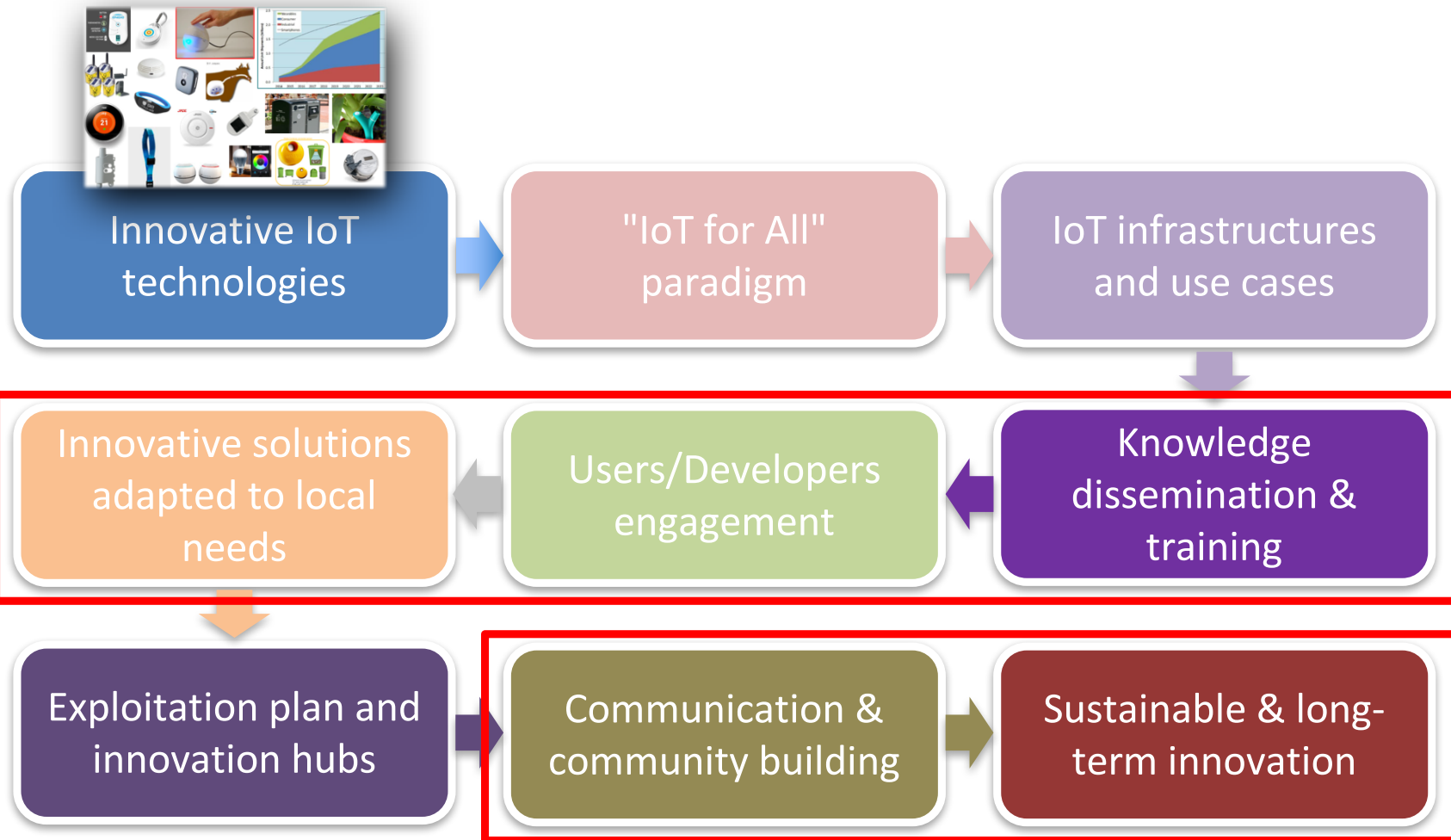
Deploying IoT in Africa

Autonomous gateway - no Internet - Edge IoT



Link to a short demo video of the collar web interface: <https://youtu.be/meFDav1SLPI>

Making IoT happening!



Community building for sustainable innovation

International Events
+ 20 organized & attended

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



Launch event (Ghana, iSpace)



IoTWeek2016 (Belgrade, EGM)



Launch event (Senegal, CTIC Dakar)



IoTBigData2016 (Italy, EGM)



IoT Care Conference (Budapest, CNET)

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



Workshop at the RESSACS 2016 (France, UPPA)

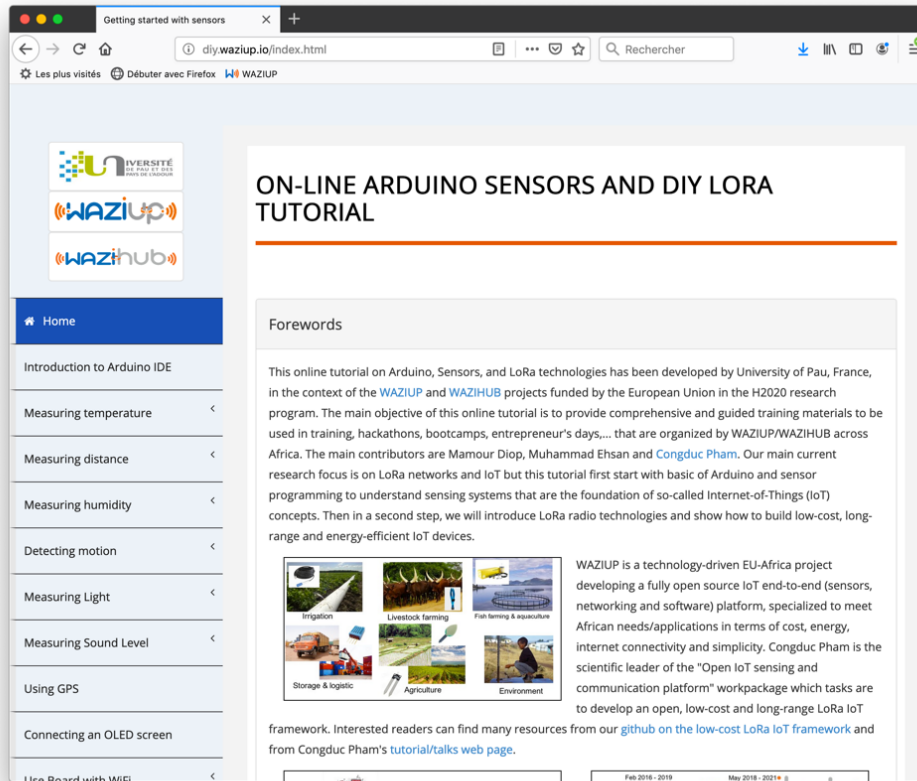
🔗 <http://diy.waziup.io>

The screenshot shows the website interface with a navigation menu on the left and a main content area. The main content area includes a 'Forewords' section with text about the project's development by the University of Pau, France, and a grid of application images for Irrigation, Livestock farming, Fish farming & aquaculture, Storage & logistic, Agriculture, and Environment. Below the grid is a 'START' section with a flowchart and a timeline from Feb 2016 to May 2018-2021.

The screenshot displays the 'WAZIUP IoT Courses' page. It lists various course topics under different categories, including 'Fundamentals of IoT', 'Prototyping and Testing: Getting started', 'Prototyping and Testing: Gateway', 'Prototyping and Testing: WAZIUP IoT and Gateway Deployment Guidelines', 'Prototyping and Testing: Introduction to WAZIUP IoT cloud Platform', and 'Advanced understanding'. Each topic is accompanied by a small icon representing the course.

Training & hackathons

- Technical training sessions
- Hackathons, ...



Online Arduino & IoT step-by-step tutorial
<https://diy.waziup.io>



Tutorials/resources

<https://github.com/CongducPham/tutorials>

WAZIUP
EU Horizon 2020 agreement number 101017407

Low-cost LoRa IoT devices and gateway FAQ

1) **What is Internet-of-Thing (IoT)?**

From ERC (European Research Cluster on the Internet of Things)

The ERC (European Research Cluster on the Internet of Things) 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 focuses on 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 and good practices, enterprise sector. WAZIUP proposes solutions that:

WAZIUP will deliver a connected gateway locally the know how breeders will need to create and to radically new paradigms for breeders by the following objectives:

1. Empower the African R&D to empower the African R&D of local innovation and support the necessary funding on a new scale

Author : Congduc Pham, University of Pau
Last update : 07/09/2018

TUTORIAL ON HARDWARE & SOFTWARE FOR LOW-COST LONG-RANGE IOT

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

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

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

BUILDING AN IOT DEVICE FOR OUTDOOR USAGE: A STEP-BY-STEP TUTORIAL

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

LOW-COST LORA IOT DEVICE: SUPPORTED PHYSICAL SENSORS

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

LOW-COST LORA GATEWAY: A STEP-BY-STEP TUTORIAL

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

LOW-COST LORA IOT: USING THE WAZIUP DEMO KIT

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

The generic hardware platform

The Arduino Pro Mini

The Arduino Pro Mini is a compact form factor Arduino board based on the ATmega328P microcontroller. Use the 3.3v and 5VDC version of the Arduino Pro Mini for lower power consumption.

You can get the original board designed by Sparkfun or get one of the various clones available, mostly from Chinese manufacturers. The last solution is very cost-effective as the Pro Mini board can be purchased for a bit more than 4€ a piece.

Depending to connect pins may pin with a soldered

The LoRa radio module

There are various LoRa radio modules that are all based on the Semtech SX1272/127x.

LoRa

Fully tested LoRa radio modules

Hopf RF R9M2095W Libium LoRa Moduino v44K919B

Most of off-based LoRa radio modules are supported. We recommend the Moduino (v44K919B) if you don't have delicate soldering experience as this module can come with header pins ready to be connected with DuPont wires.

The R9M2095W can be found assembled (Altium) or an adapter can be purchased from Sparkfun for reference.

Connect the LoRa radio module

Connect the connector module to the SPI pins (blue) in pin 21, MISO pin 30 and CS pin (orange) Then connect also the of the radio module to board (right side). The VCC of the Pro Mini board gets 3.3v from the on-board voltage regulator.

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

LOW-COST LORA GATEWAY: WEB ADMIN INTERFACE

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

LOW-COST LORA IOT ANTENNA TUTORIAL FOR GATEWAY

WAZIUP

LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

IOT DEPLOYMENT WITH WAZIUP ***

GUIDELINES, BEST PRACTICES, TROUBLESHOOTING AND FAQ

WAZIUP

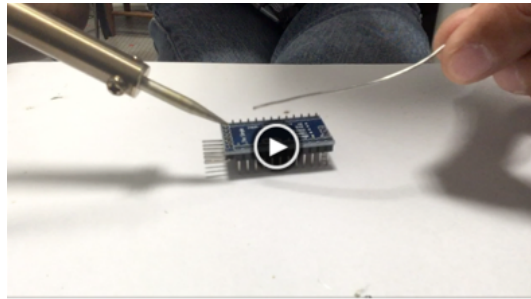
LIUPPA

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

UNIVERSITÉ DE PAU ET DES PAYS DE LAODOUR

YouTube videos

Low-cost LoRa IoT device



+94000 views

May2021

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

Low-cost LoRa IoT gateway



+22000 views

May2021

<https://www.youtube.com/watch?v=mj8ltKA14PY>

Extreme low-power LoRa IoT



+9000 views

May2021

https://www.youtube.com/watch?v=2_VQpcCwdd8

Setting up a gateway in 5mins



+4600 views

May2021

<https://www.youtube.com/watch?v=CJbUFXLpSok>

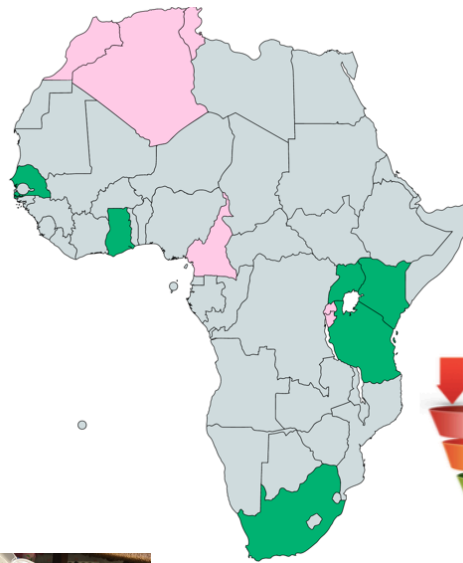
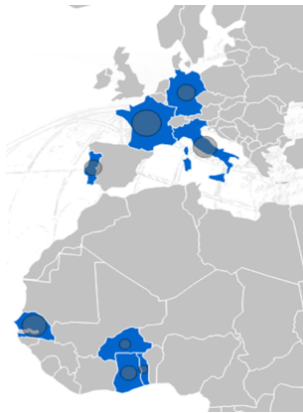


Scaling-up!



May 2018 – July 2021

Feb 2016 - 2019



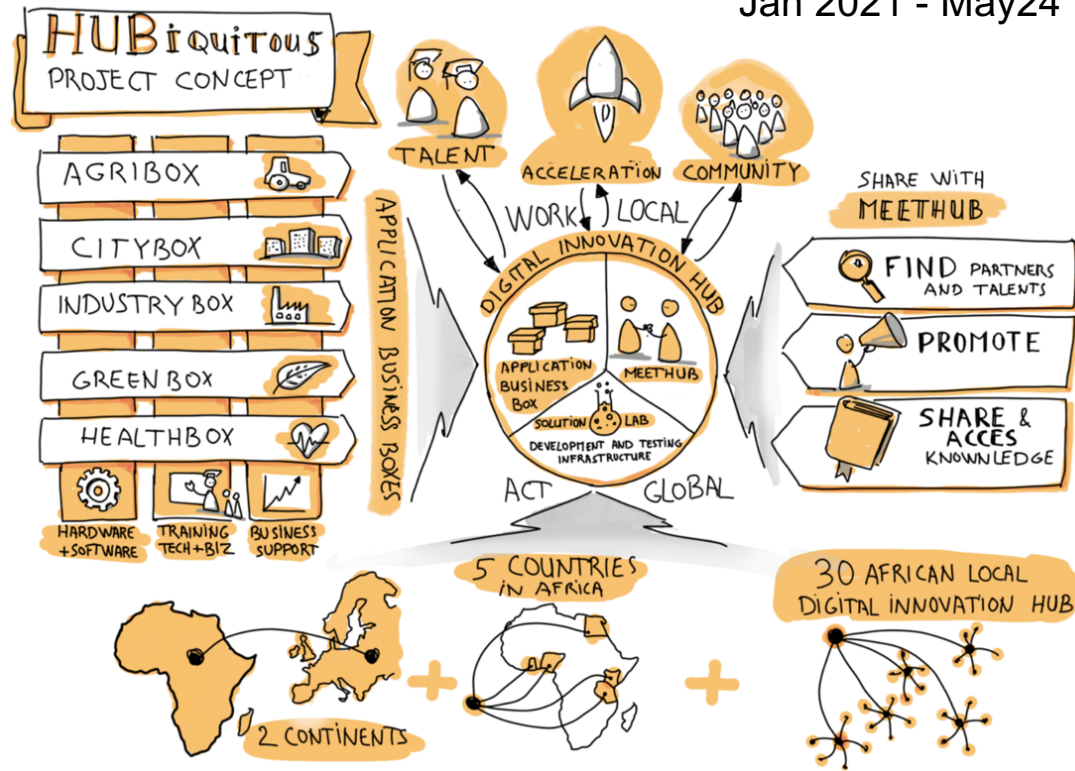
Emergence of an ecosystem!



Beyonds state-of-the-art!

HUBiBiquitous

Jan 2021 - May24



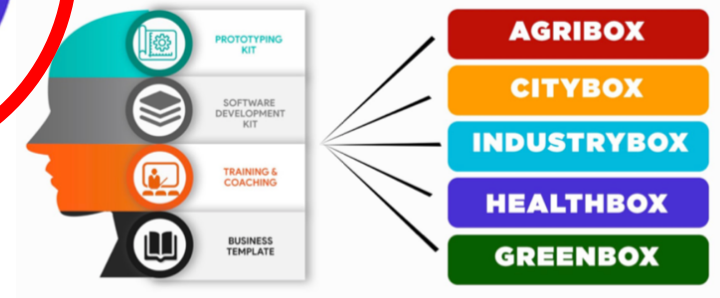
Widen the scope of technologies to prepare for the next 10 years of innovation in IoT, AI & BigData



3 Innovation Enablers



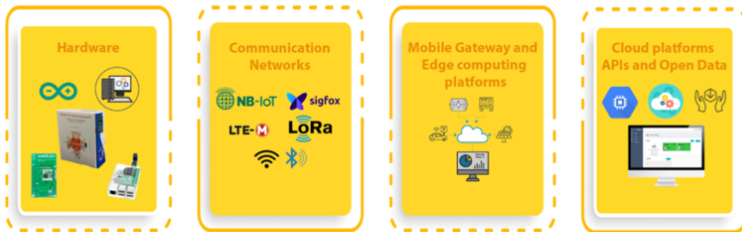
Create vertical solutions with go-to-market objectives



Create synergies amongs innovation actors, DIHs, stakeholders,...

Solution Lab infrastructure

Test bed and experiments



- Rapid prototyping Kit; Mobile Development Kit; Training/Courses/Documentation
- AI development tools and platforms (AI Hardware, Embedded AI, AI accelerators)

Make disruptive technologies accessible to entrepreneurs!

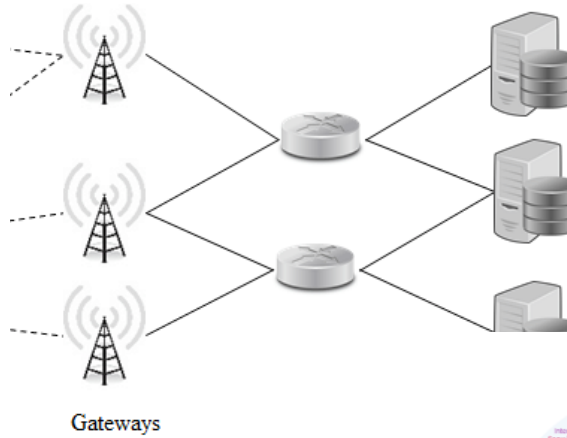


Search Partners
Search DIHs, Start-up, Incubators for partnership

Search Talent
Search African Talents for collaboration

Promote Innovation
For DIH, Startup to promote services to ecosystem

Access HUBbiquitous Digital Resources
Access digital resources related to innovation enablers, programs, course and training materials



Now what?

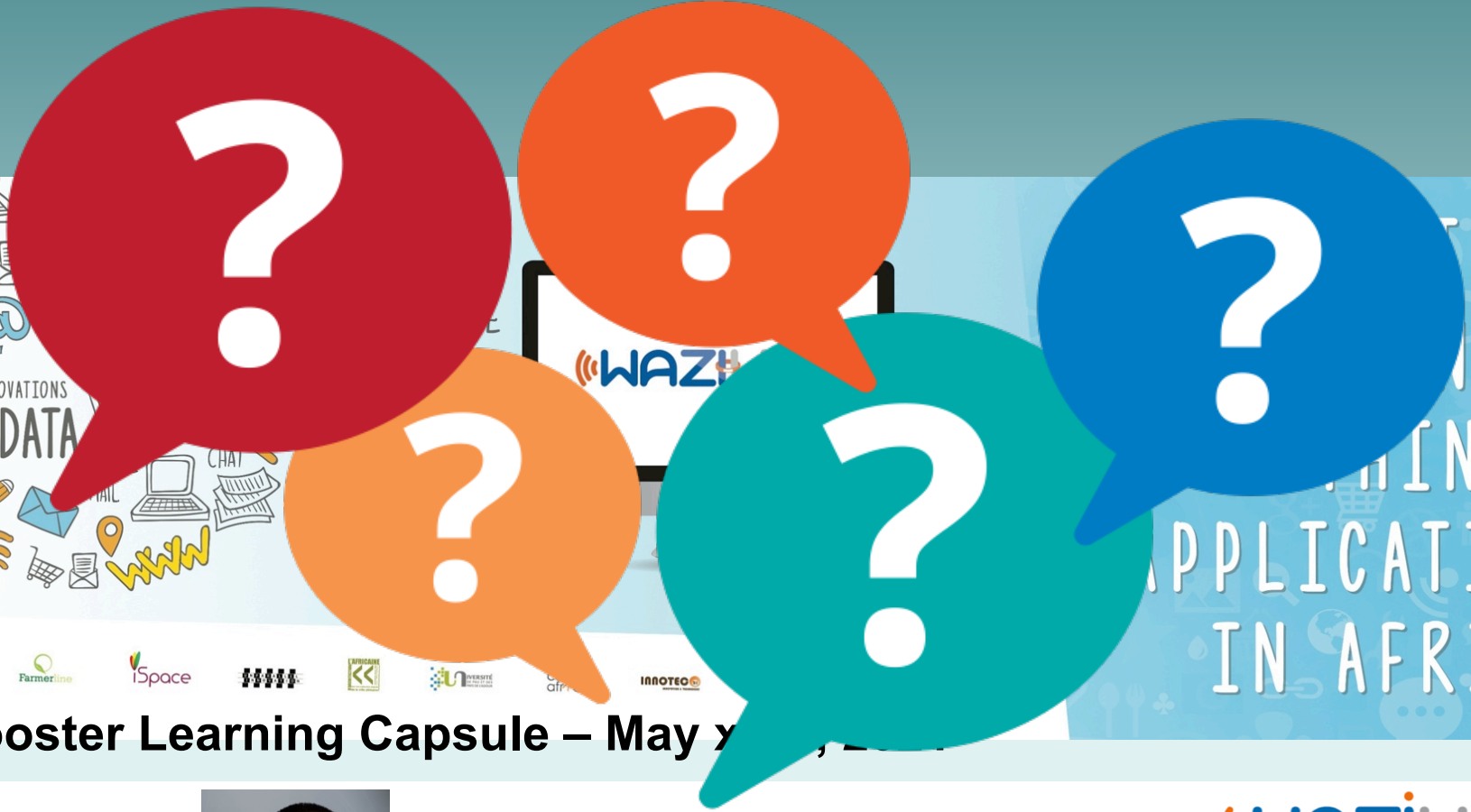


Conclusions

- Internet-of-Things provides the unique feature to make things "talk" to us: localisation, surrounding environmental conditions, particular events, ...
- It has huge potential in industrial applications but has also unique capabilities in helping humanity to reach more sustainable development
- Next gen sensors such as cameras, spectrometers, hyperspectral cameras,... will provide possibilities to further optimize a number of complex processes
- LIUPPA works for more than 8 years to develop & deploy low-cost IoT in Africa with 4 EU H2020/PRIMA projects



UNDESTANDING INTERNET-OF-THING TECHNOLOGIES



INNOVATIVE
NET
THINGS
APPLICATIONS
IN AFRICA



Total Booster Learning Capsule – May x, 2018

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

