

# INTEL-IRRIS

Intelligent Irrigation System for Low-cost Autonomous Water Control  
in Small-scale Agriculture



**Intel-Irris**



# Intelligent Irrigation System for Low-cost Autonomous Water Control in Small-scale Agriculture



## Introduction to IoT



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Université de Pau, France



# Googling for « Internet of Things »

Google search results for "internet of things".

Navigation tabs: architecture, infrastructure, plateforme, agriculture, schéma, capteur, application, transport, objets connectés, chaîne de valeur, big data, gateway, domaine, fonctionnement, etc.

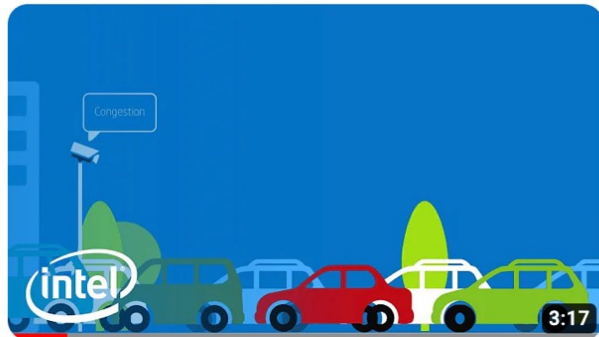
Search results grid (rows of image thumbnails with titles and URLs):

- Row 1:
  - <https://cdn.futura-sciences.com/buildsv6/mag...>
  - Internet of Things (IoT) : qu'est-ce que l'Internet des... portices.fr
  - IoT : Qu'est-ce que l'Internet Of Things ? - Routeur... le.routeur-wifi.com
  - Qu'est ce que l'Internet des objets (IoT) | TIBCO Sof... tibco.com
  - Cybersecurity and the Internet ... fr.coursera.org
  - Les nouvelles opportunités de l'Internet of Things | HUB Inst... hubinstitute.com
  - Tour d'horizon des normes et rapports techniq... portail-qualite.public.lu
  - Internet of Things (IoT) : qu'est-c... portices.fr
- Row 2:
  - Internet Of Things (IoT) Concept big Data Réseau D... fr.freepik.com
  - Les systèmes de l'IoT et interopérabilité - Tri... trialog.com
  - Introduction to the Internet ... fr.coursera.org
  - Chaire Internet des Objets (IoT) | ... escp.eu
  - L'Internet des objets : The next big thi... telegrafik.fr
  - Internet of Things (IoT): les 5 usages es... filrifid.org
  - Qu'est-ce que l'Internet of Things ? votre-it-facile.fr
  - Internet of Things Technology |... mouse.fr
  - What the Internet of Things Means for Your Business ... bignerdranch.com
- Row 3:
  - Libérer le potentiel de l'Int... portail-qualite.public.lu
  - Une introduction à l'IoT pour les débutants geekflare.com
  - Internet des objets, internet of things ou IoT : définition ... vmware.com
  - Internet of Things (IoT) bakom.admin.ch
  - Marché de l'Internet des objets : un bon investisseme... lysbroker.fr
  - Internet Of Things telcoase.com
  - Deep Learning for Internet of T... telecom-sudparis.eu
  - Recherches associées:
    - Internet des objets
    - IoT logo
    - IoT png
- Row 4:
  - Data Science & Internet of Things - Publicis Sapient... blog.engineering.publicissapient.fr
  - Bref état des lieux sur l'IoT (Inter... blog.octo.com
  - Amazon.fr - Internet of Thing... amazon.fr
  - IoT/AI Solutions | Internet of Things and Artificial Intelligence bechtile.com
  - Internet of Things (IoT) Systems and Applications lavoisier.fr
  - IoT : 5 questions à se poser avant de se lan... codeur.com
  - Qu'est ce IoT (Internet of Things) o el interne... luxnia.com
  - l'Internet des objets (IoT - Internet of Things) | Auxilis auxilis.com
  - Amazon.fr - Internet of ... amazon.fr
- Row 5:
  - Internet des objets (IoT : Internet Of Things) ...
  - Définition et cas usage de l'Internet of Things - Actuaill...
  - Internet of Things
  - https://techbullion.com/wp-content/upl...
  - Les enjeux de la supervision IoT (Int...
  - IoT and integration | How they work tog...
  - IoT, Internet-of-Things, Internet des Objets, ... quelle place pour...
  - Why the Internet of Things needs AI

# ...shows communicating objects



# Also on YouTube: IoT teaser & tutorial videos



## Intel IoT -- What Does The Internet of Things Mean?

591 k vues • il y a 8 ans



Fun, animated video answers: What does the Internet of Things mean? The Internet of Things (IoT) is an evolution of mobile, home ...

Intro | What is IoT | Transform our lives | Big picture | Example | Big Possibilities | Intelligent Traffic |... 9 chapitres



## IOT Tutorial | IOT Tutorial For Beginners | IOT - Internet Of Things | IOT Course |

**Simplilearn**

25 k vues • il y a 1 an



This IoT tutorial video introduces you to IoT Technology and how it is revolutionizing the world today. Internet of things or IoT ...



## Internet of Things (IoT) | What is IoT | How it Works | IoT Explained | Edureka

2,1 M de vues • il y a 4 ans



Subscribe to our channel to get video updates. Hit the subscribe button above. #Edureka #EdurekaloT #InternetOfThings ...

Sous-titres

# All communicating objects?

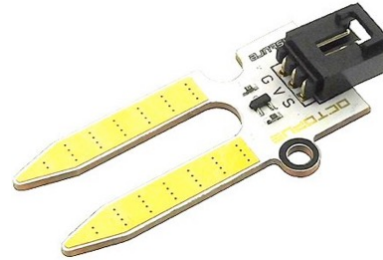


# IoT=interactions with physical world



**Q: Interactions? How?**

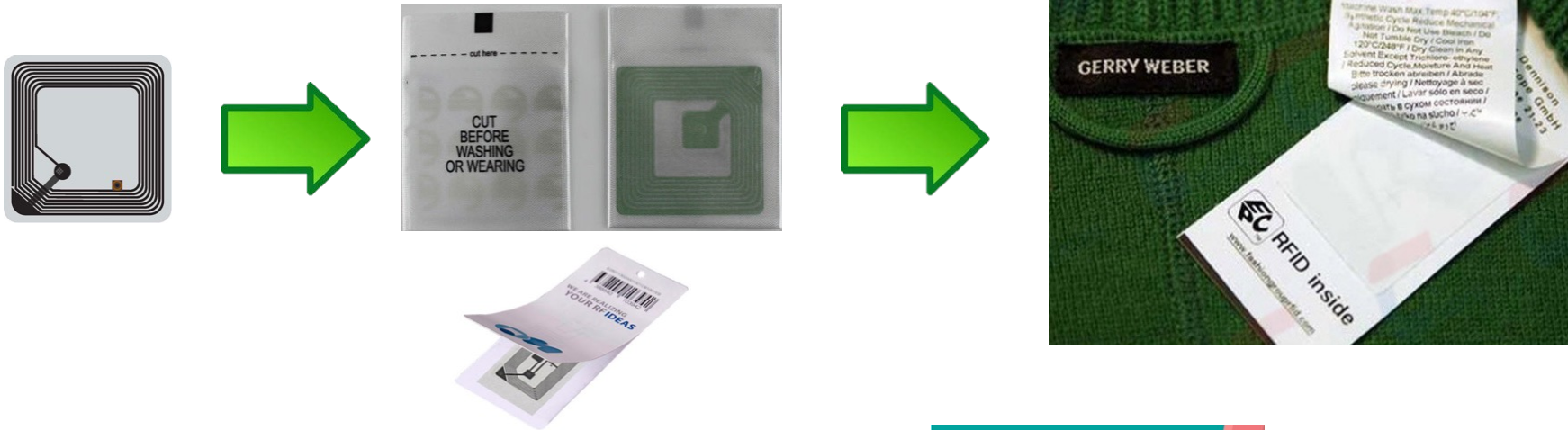
# Interaction: Sensors



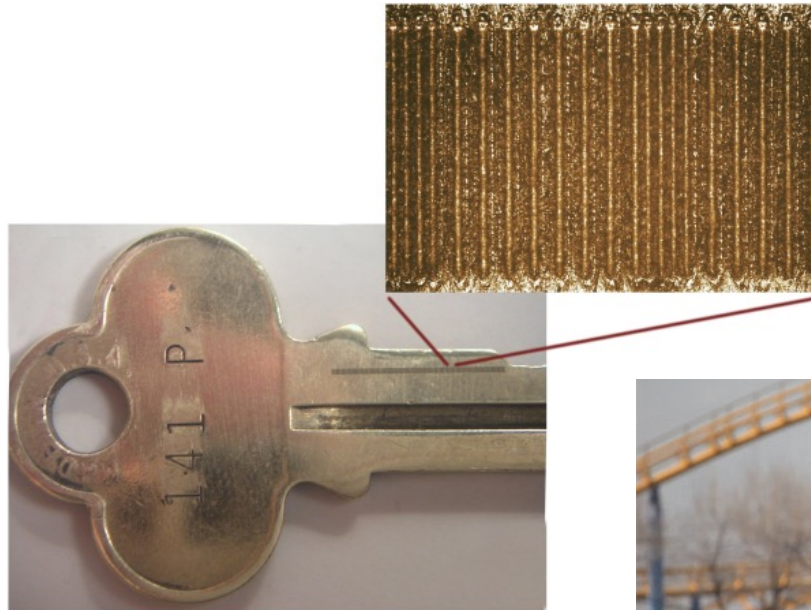


# Interaction: RFID, NFC

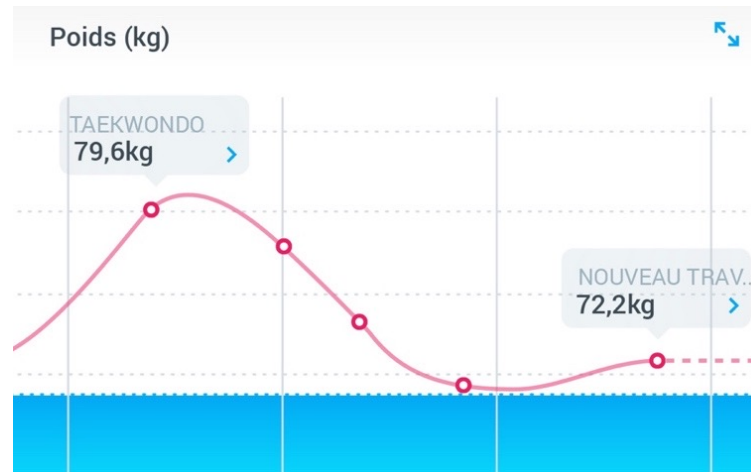
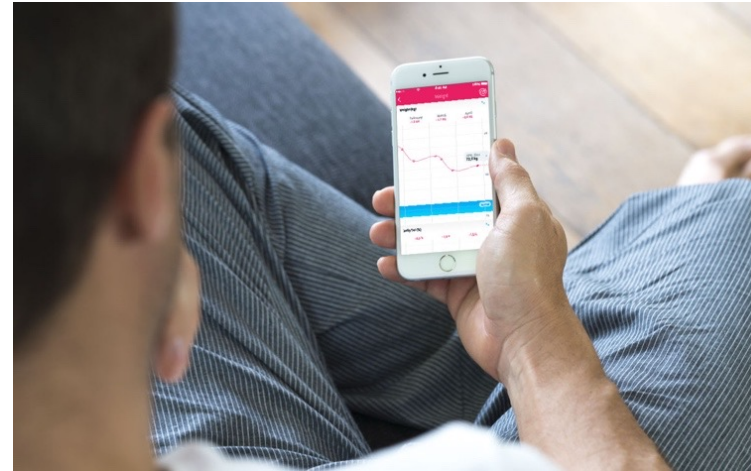
- Radio-Frequency Identification (RFID)
- Near Field Contact (NFC)



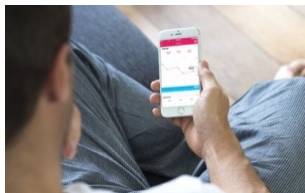
# Interaction: always complex?



# Home/consumer IoT products



# Local interaction is possible...



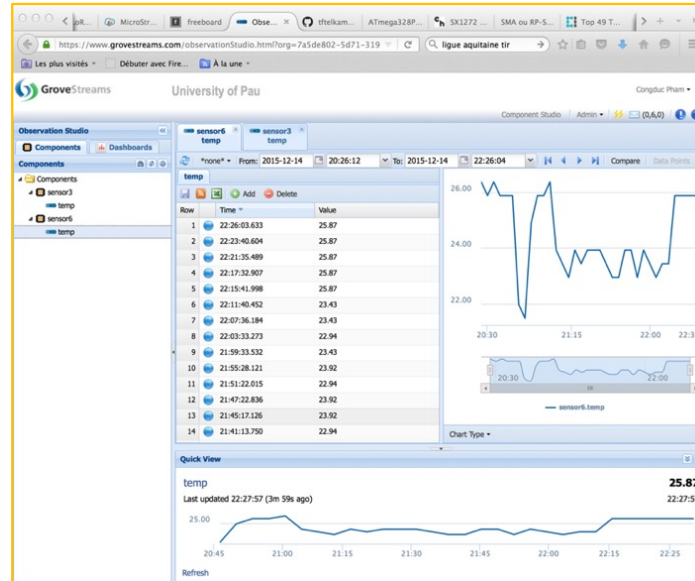
# ...but IoT added-values come from interactions & linked data!



# Clouds for IoT



**VS**



# Sense, Monitor, Optimize & Control

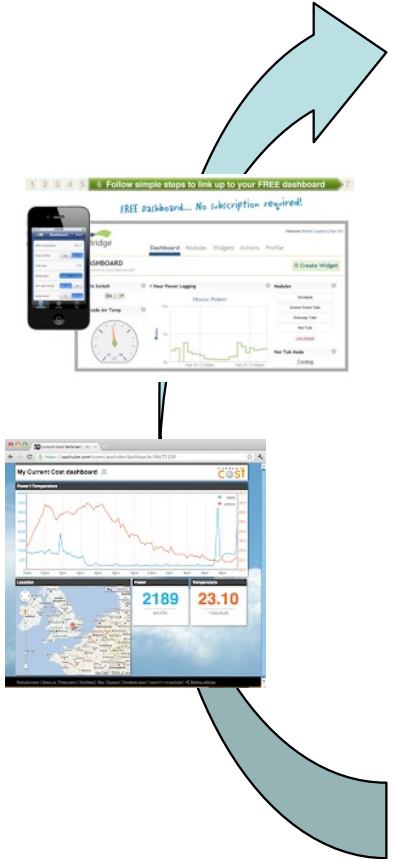


**DATA ANALYSIS, OPTIMIZATION & CONTROL**

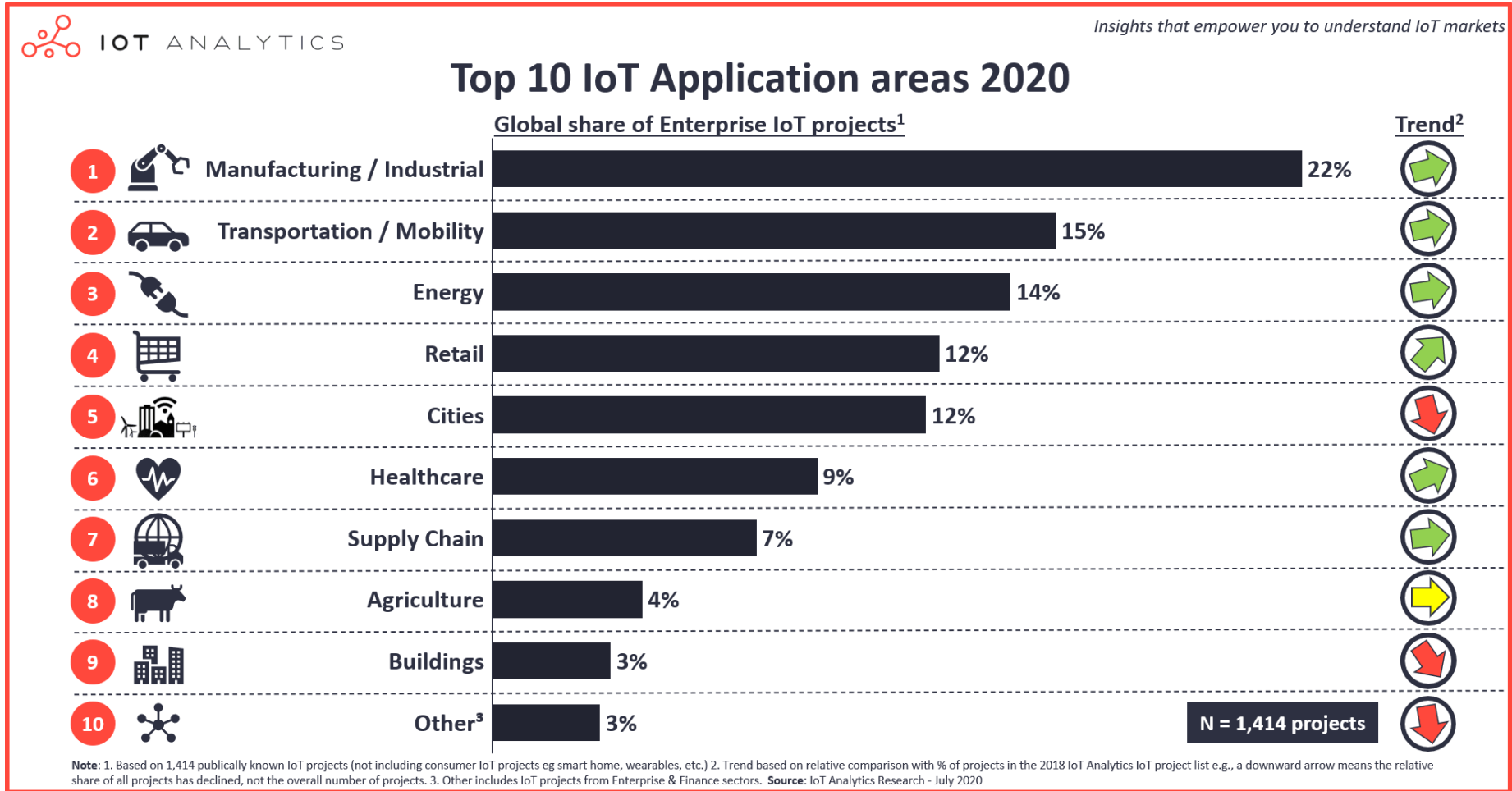
**Monitoring**

**Sensing  
Physical world interaction**

**APPLICATION DOMAINS**



# Top IoT applications, 2020



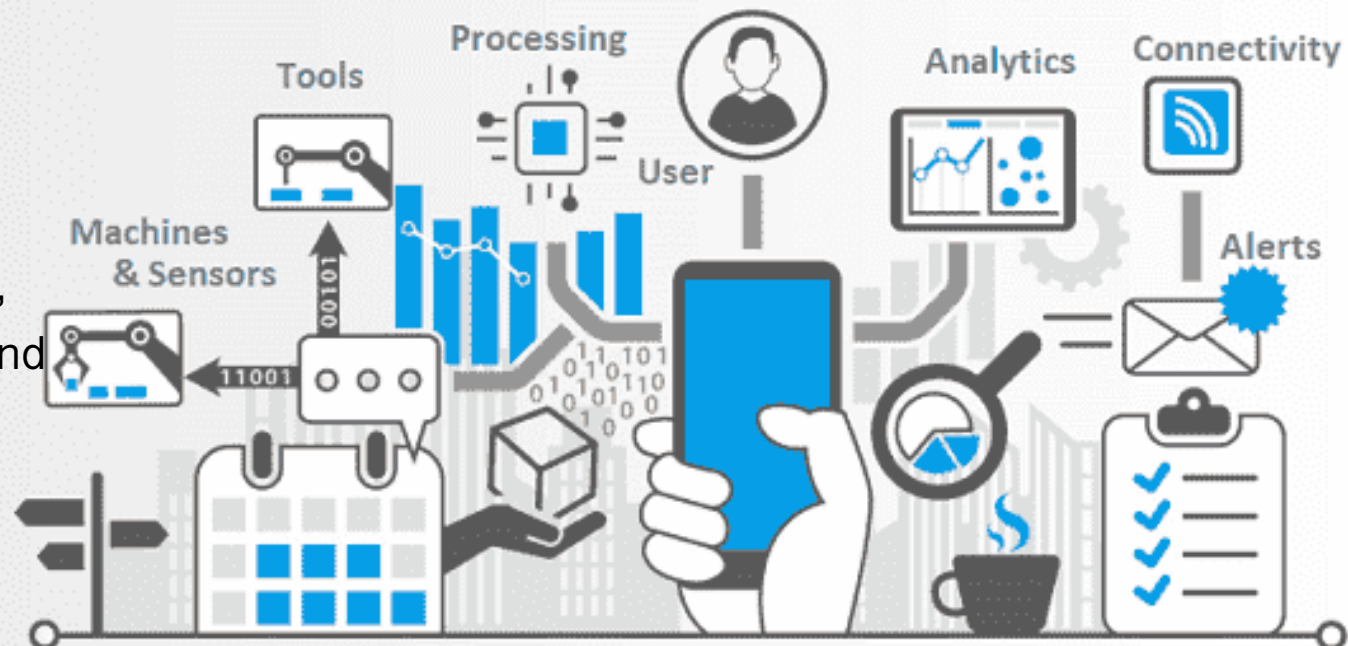


# IoT in industry



- 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

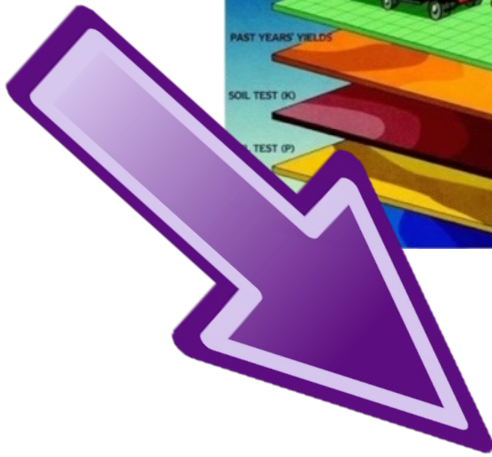
## Industrial Internet of Things



# IoT for Smart Agriculture



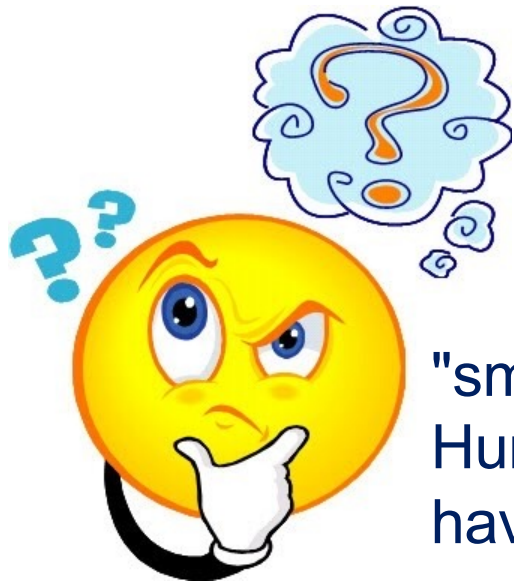
**Soil Monitoring**



**Connected Agriculture**

# Is IoT the solution for your problem?

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



"smartphone"  
Hum, they only  
have 2 hands...



ITU Telecom World 2018  
Phathwa Senene at MTN booth



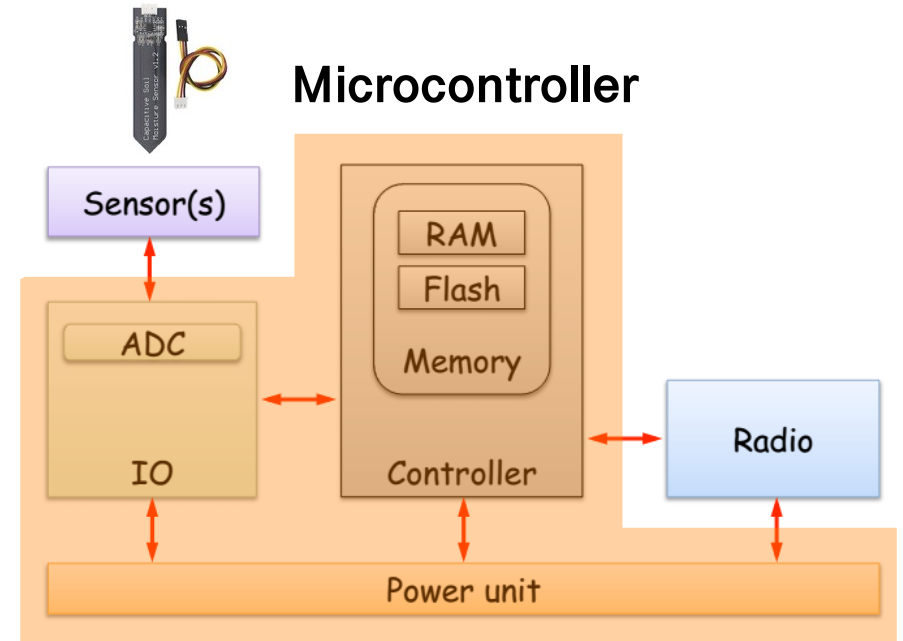
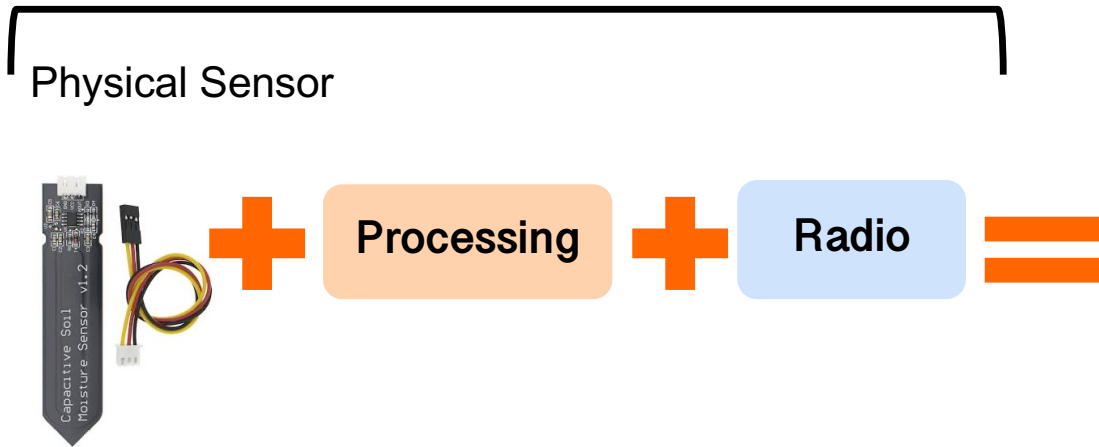
# IOT

TECHNOLOGY ?

CONCEPT ?

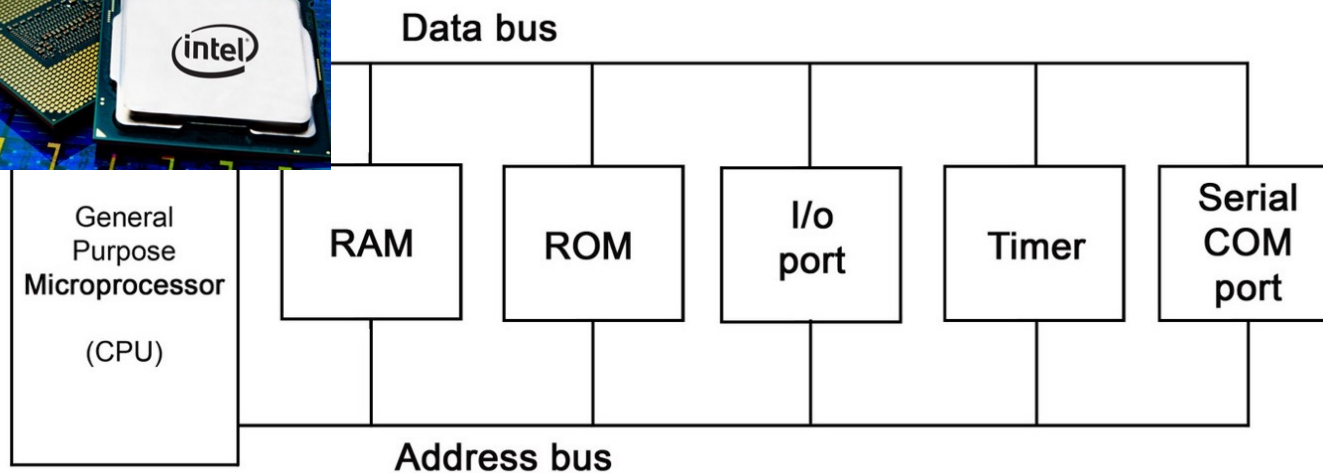
# Typical IoT device

- IoT device can be viewed as a simple Embedded System

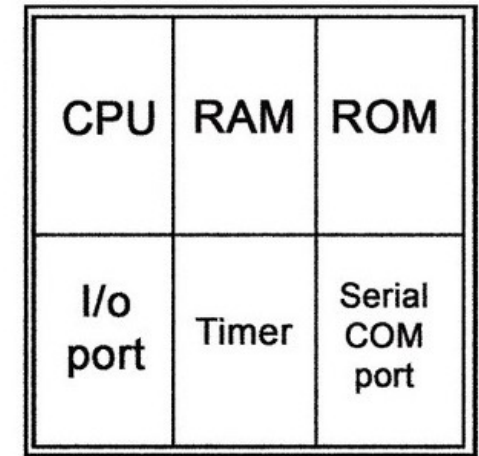


**Q: uprocessor vs ucontroller?**

- ⦿ 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)

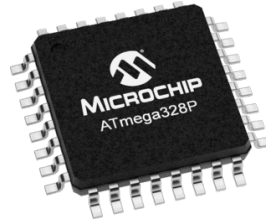
From "An Embedded System Overview" by Dr. Eng. Amr T. Abdel-Hamid

# From $\mu$ controller to $\mu$ controller board

- ⦿ A  $\mu$ controller can be standalone...

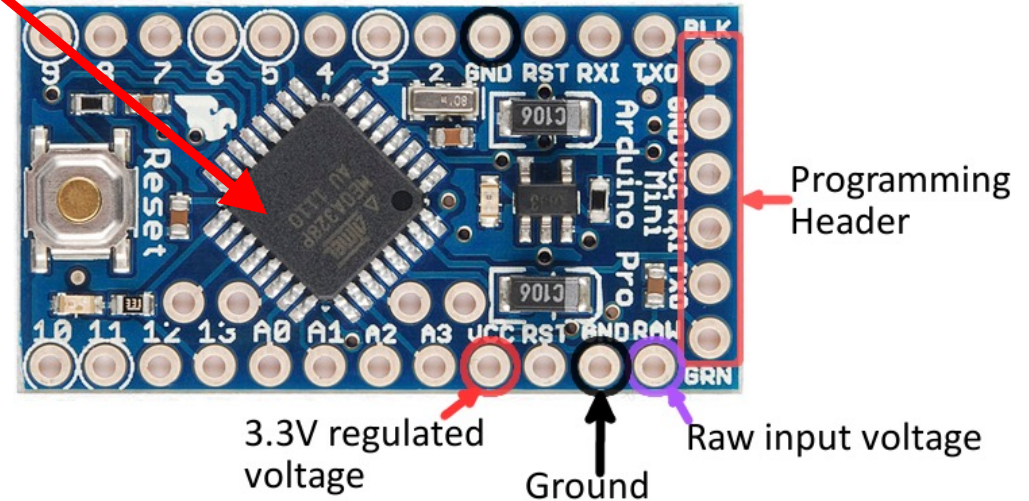
CPU	RAM	ROM
I/o port	Timer	Serial COM port

(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



# Arduino's success story starting in 2005



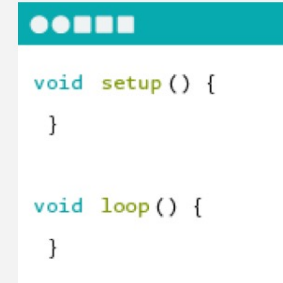
## WHAT IS ARDUINO?

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



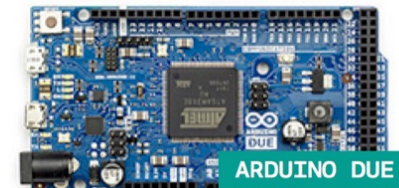
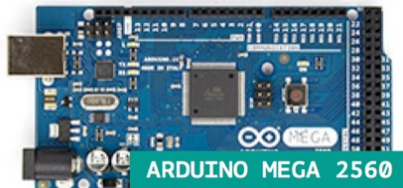
## ARDUINO BOARD

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



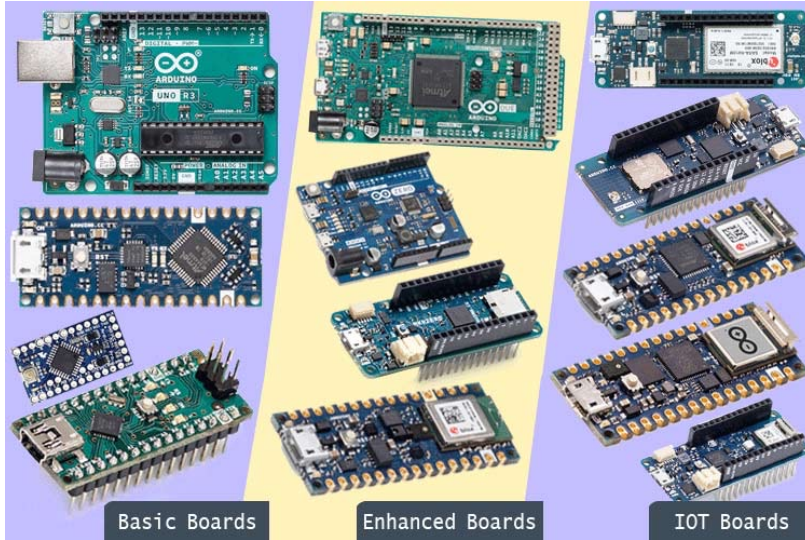
## ARDUINO SOFTWARE

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





# 17 years later: the incredibly large microcontroller board ecosystem!



Basic Boards

Enhanced Boards

IOT Boards



LoPy

STM32 Nucleo-32



Teensy 3.2



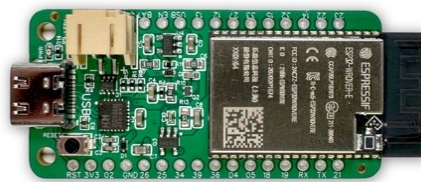
LinkIt Smart7688 duo



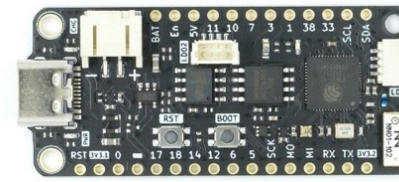
Adafruit Feather



uPesy ESP32



ePulse Feather Low Power ESP32



FeatherS3 - ESP32-S3



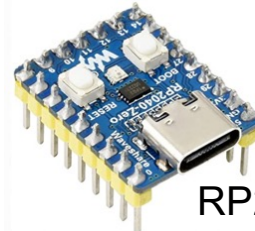
Heltec ESP32



XIAO SAMD21



Arduino Nicla Sense ME



RP2040 zero



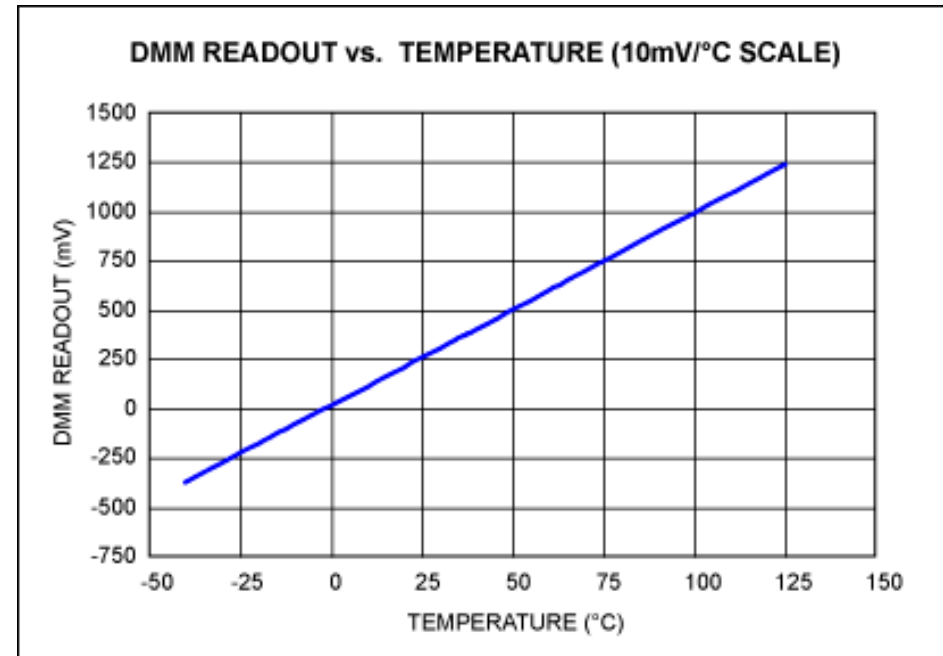
DFRobot Beetle



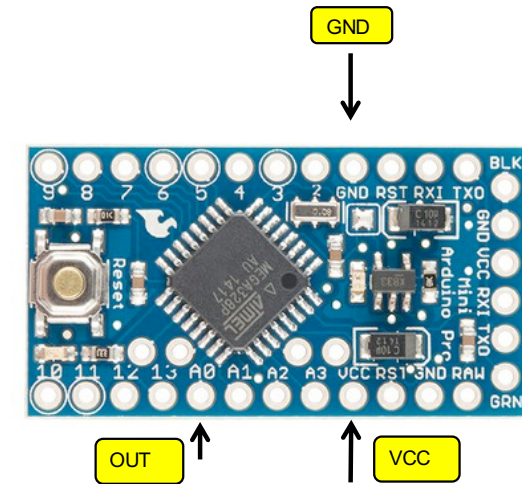
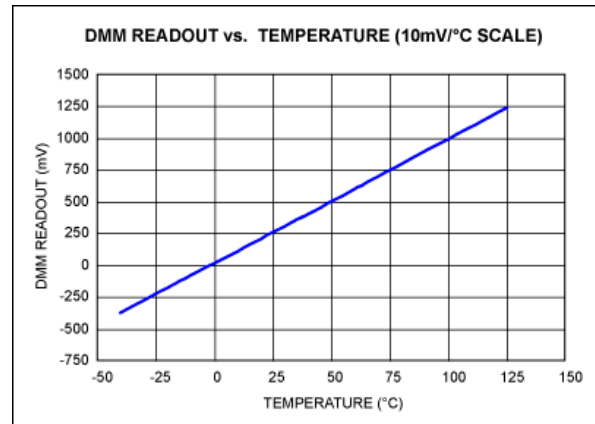
QT Py ESP32-C3

# Interacting with the real world?

- ⦿ Taking the simple analog sensors example
- ⦿ Analog sensors provides a voltage output that varies according to a physical parameter, e.g. temperature, humidity, luminosity,...



# Digitalizing the physical world!



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

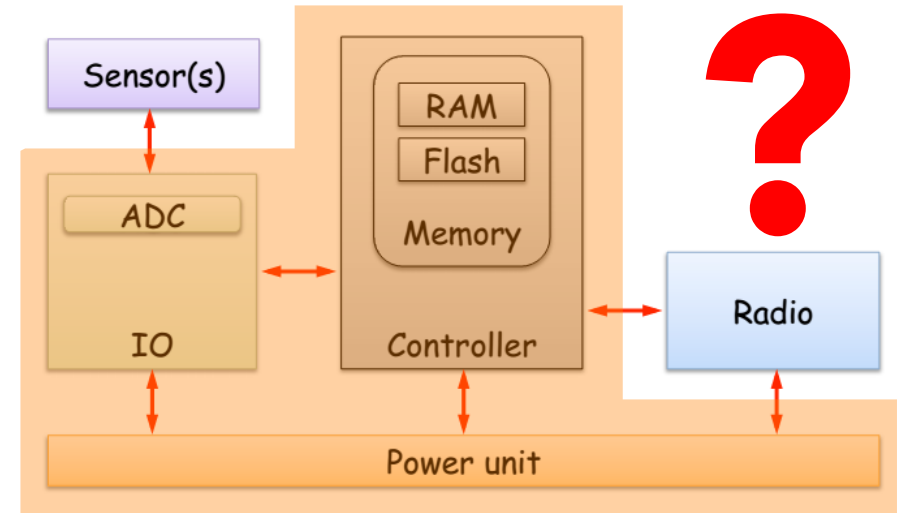
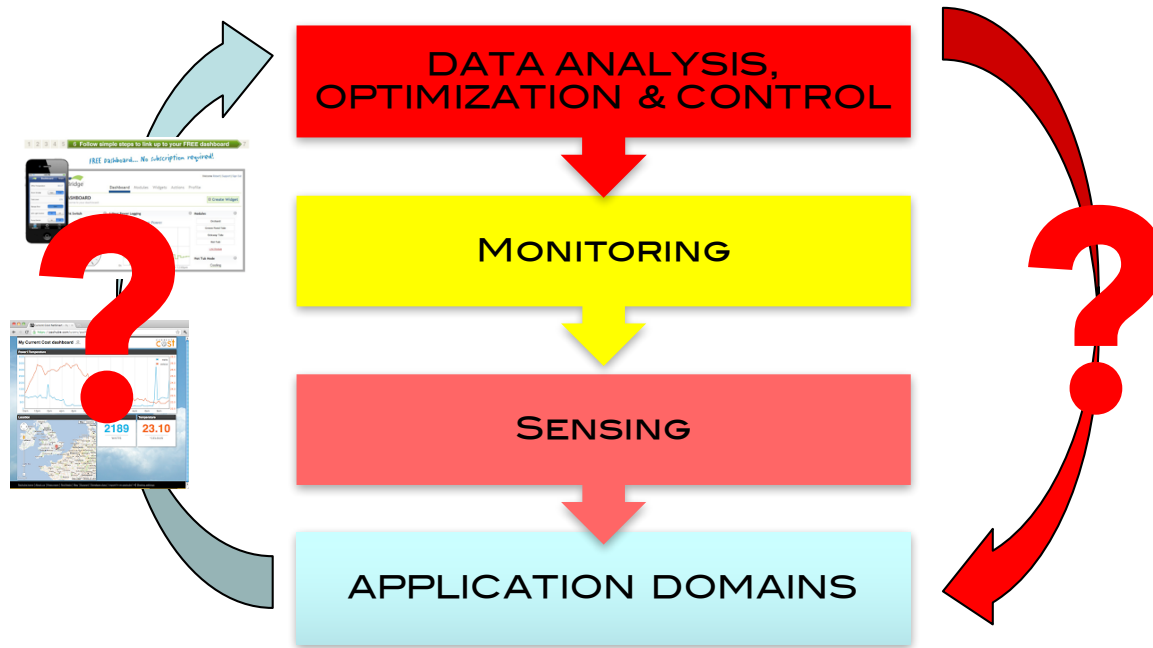
Vcc usually refers to the operating voltage of a given microcontroller. Vcc is typically 3.3V.

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

Reading a digital value of 100 means  $100*3.22mV=322mV$

**If the sensor output is  $10mV/1°C$  then the physical temperature is  $322mV/10mV=32.2°C$**

# How to collect data?

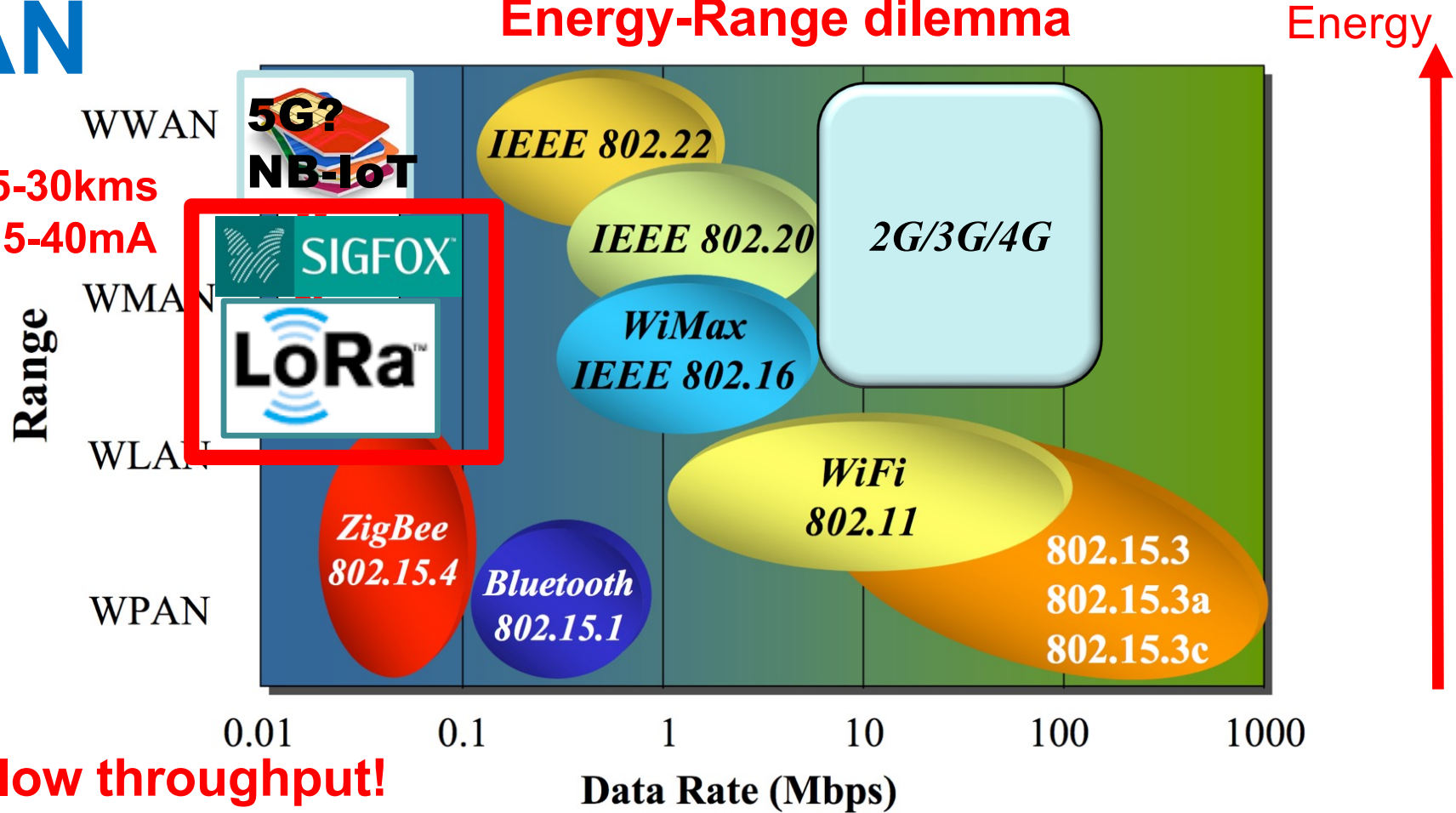


**Microcontroller**

## LPWAN

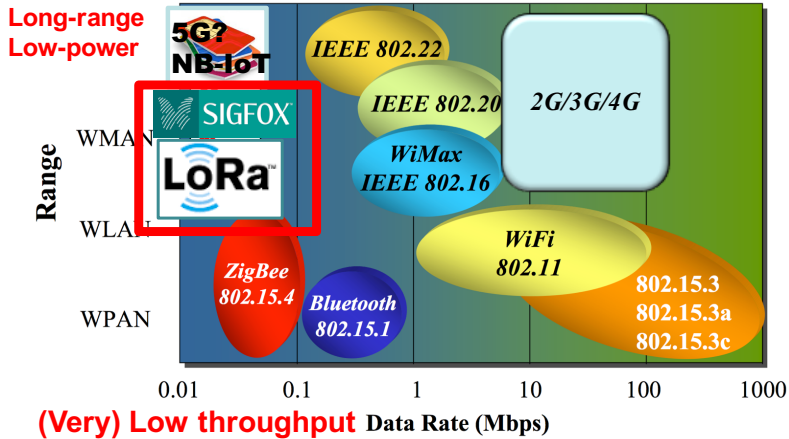
### Energy-Range dilemma

Long-range: 5-30kms  
 Low-power: 15-40mA



# Energy consumption comparison

## Energy-Range dilemma



Energy ↑

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



2500mAh

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

$2500 / 1.11 = 2252h = 93 \text{ days} = 3 \text{ months} \text{ ☹️}$

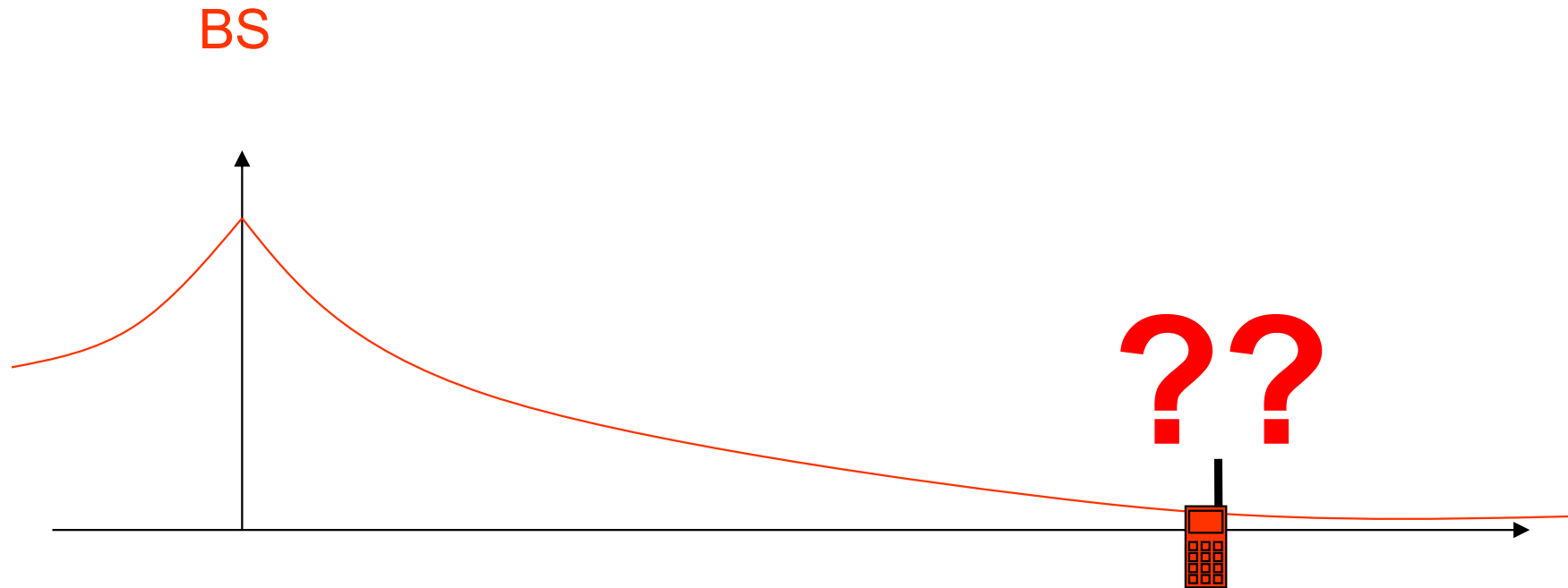
In most cellular networks, the device is still maintaining communication with BS even if it is inactive

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

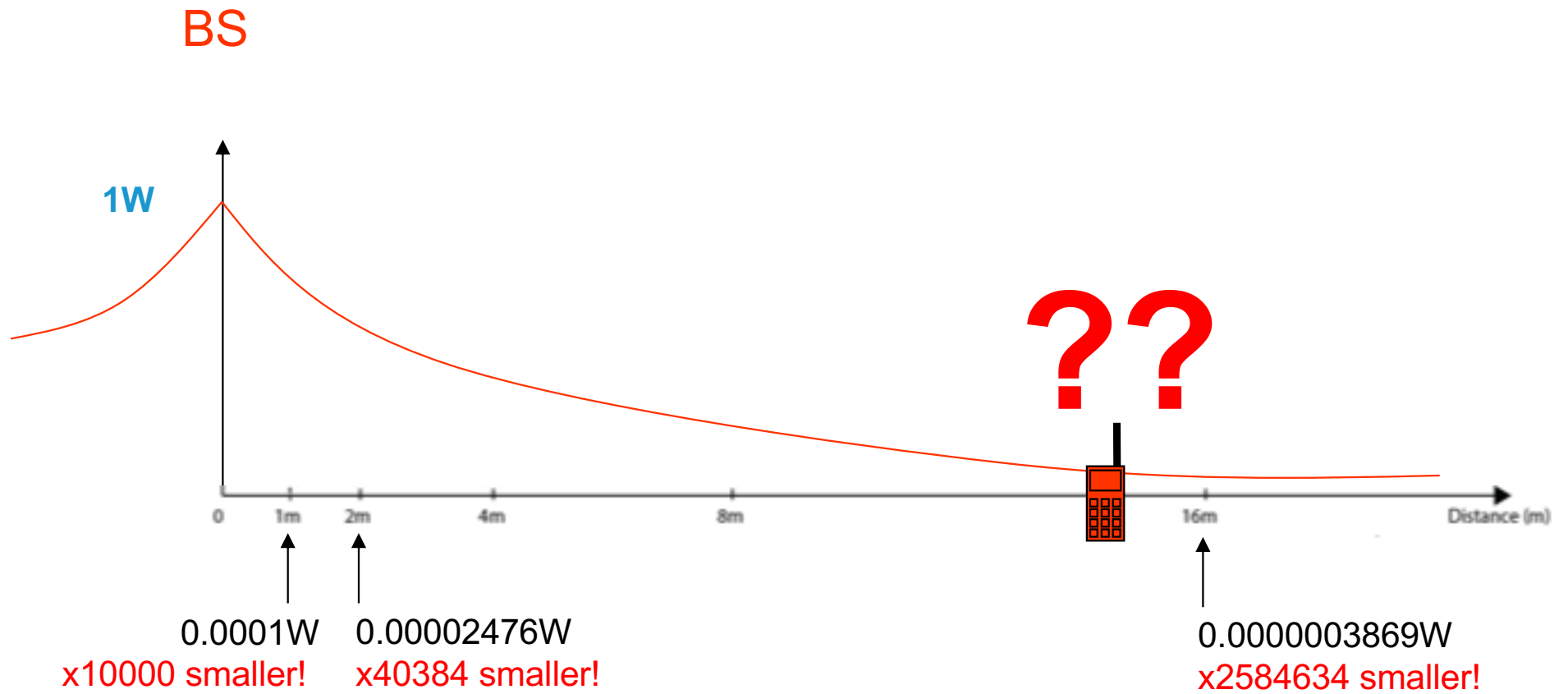
$2500 / 0.027 = 92592h = 3858 \text{ days} = 10 \text{ y.} \text{ 😊}$

LPWAN does not need to maintain connection if not in used

# 1st challenge: signal attenuation



# Attenuation is the main problem!





# IoT for everybody?



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



# Convergence of technologies

**17 years later: the incredibly large microcontroller board ecosystem!**

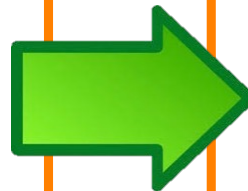
Pr. Congduc Pham  
<http://www.univ-pau.fr/~cpham>

**LoRa modules with Semtech's SX12xx**

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



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



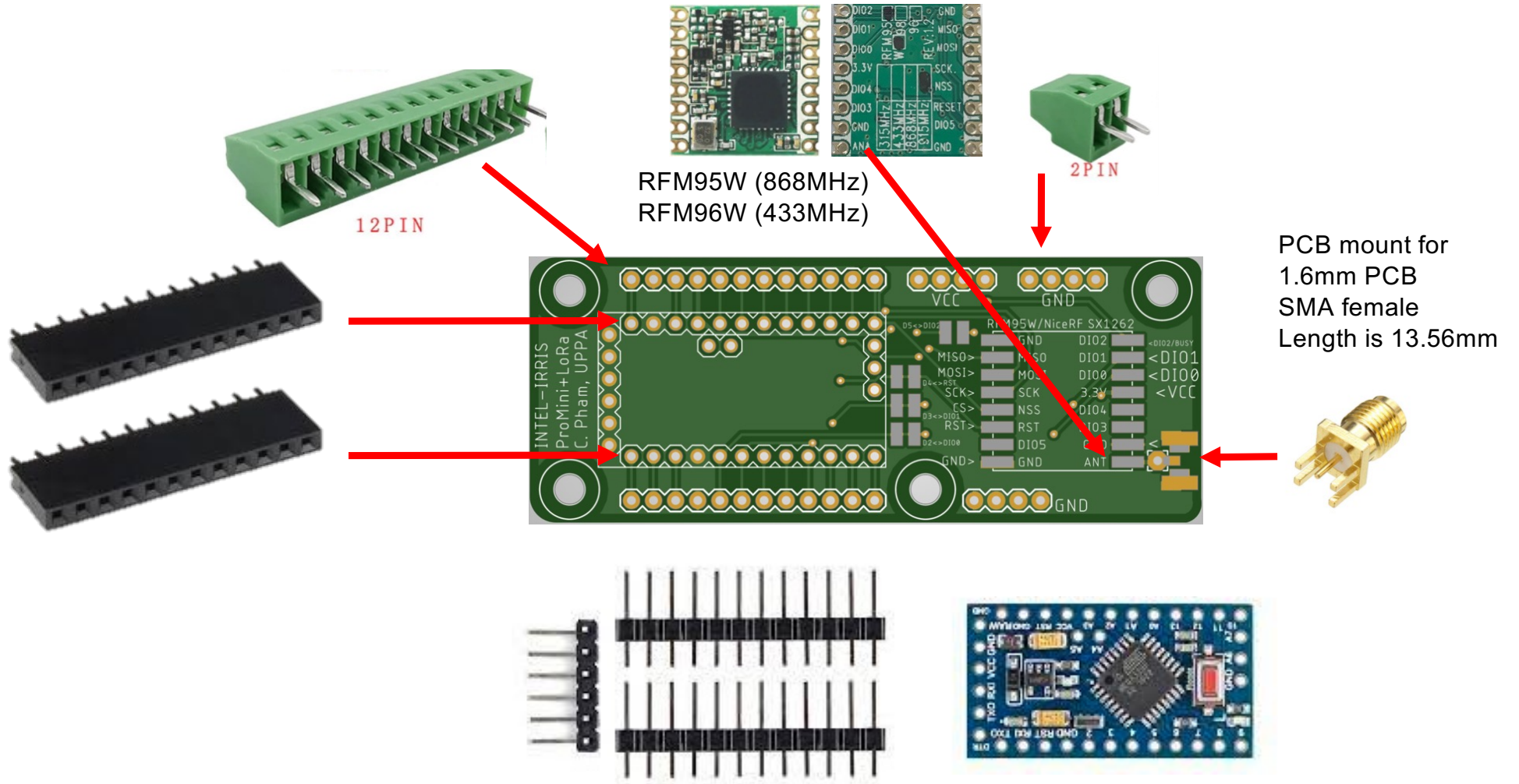
Do-It-Yourself (DIY) IoT  
 Off-the-shelves parts  
 Generic platform  
 Open-source  
 Modular design

# INTEL-IRRIS starter-kit

- ⦿ "Intelligent Irrigation in-the-box", "plug-&-sense", fully autonomous
- ⦿ **From idea to reality!**

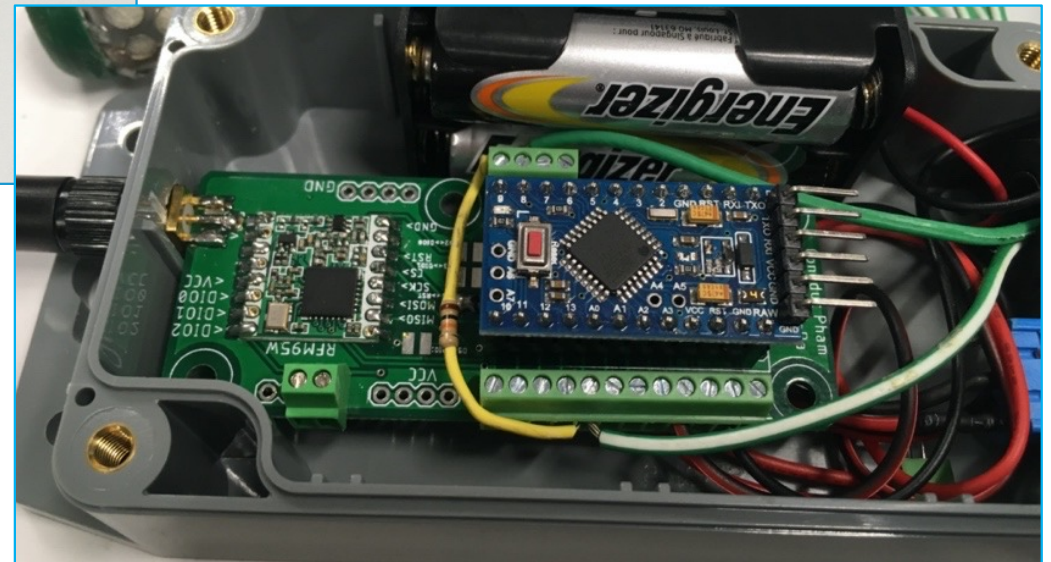
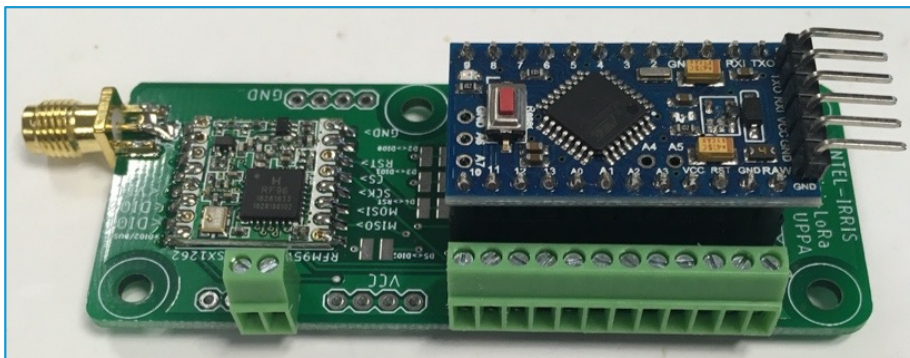
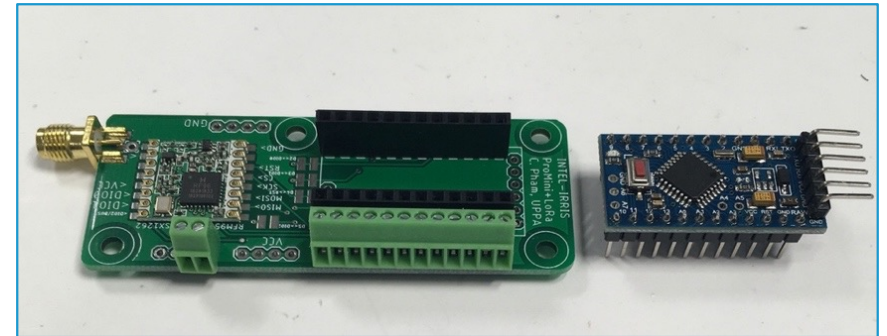
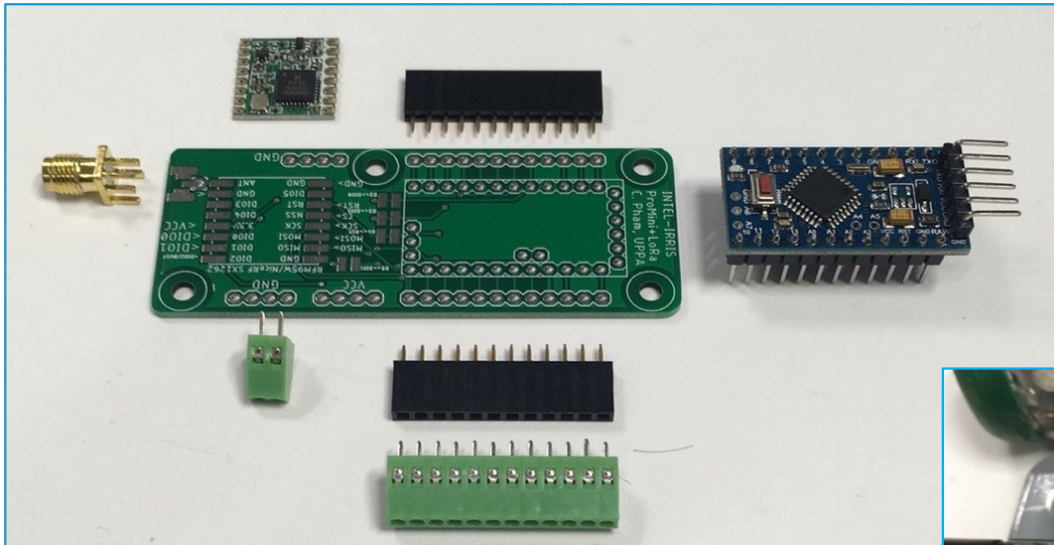


# Soil sensor: electronic parts starter-kit version



# Simple & Modular design

- Simple integration on PCB of off-the-shelves components

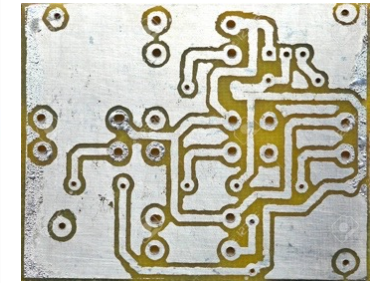


# What is a PCB?

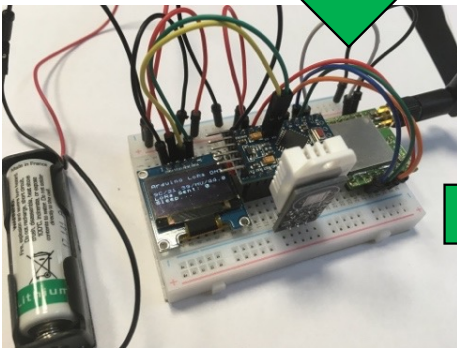
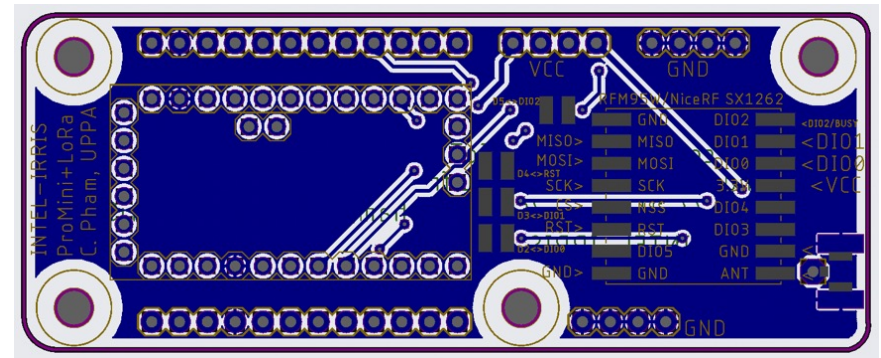
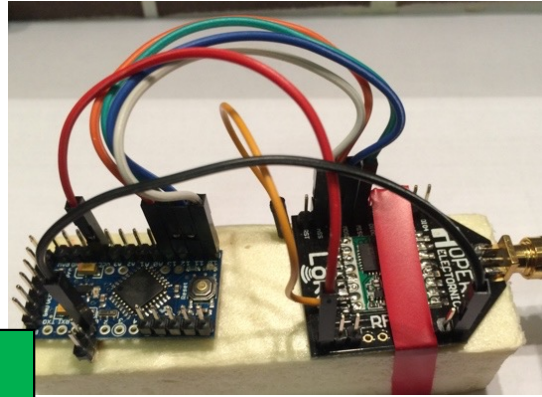
- PCB=Printed Circuit Board
- Copper paths replace Dupont wires



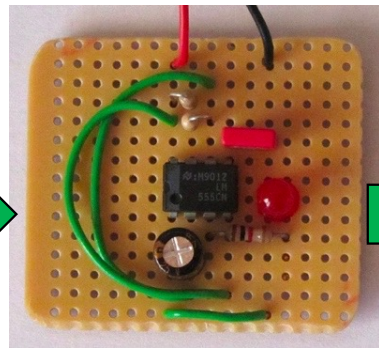
Raw PCB copper board



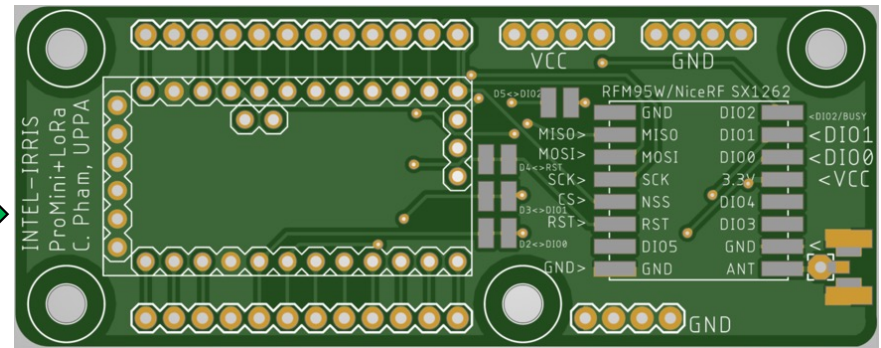
Removing copper to create wire path



Breadboard



Stripboard

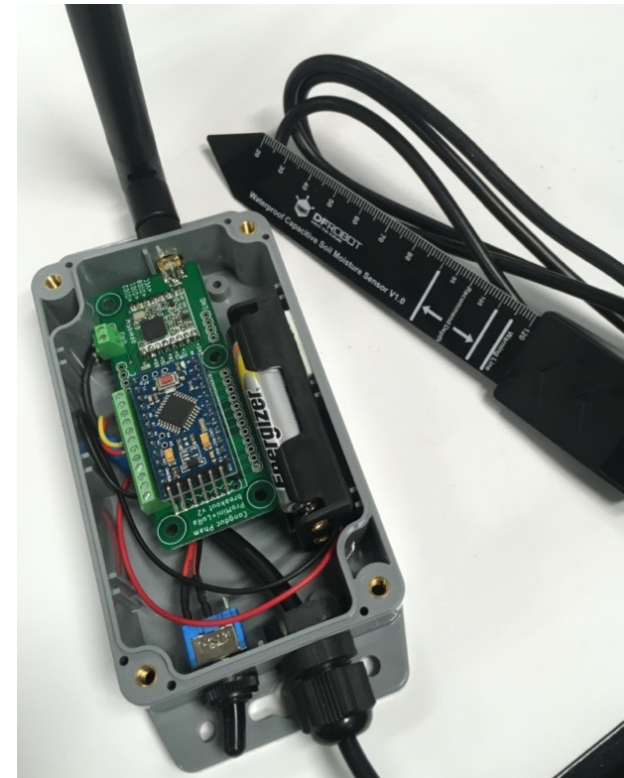
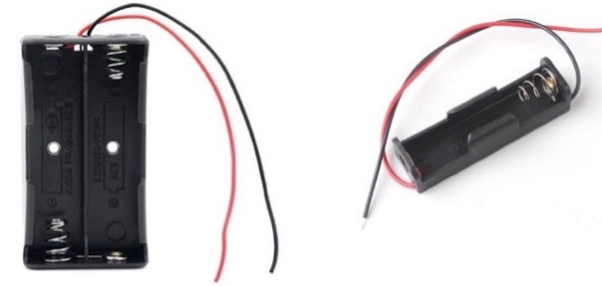


# A generic sensor platform

- Low-cost: < 20€
- Off-the-shelves components
- Easily duplicated
- Assembling by local partners
- Can connect several sensors
- Can be adapted by local partners
- Can be improved by local entrepreneurs
- Can increase capacity-building for local innovation



# Final integration - DIY





# Low-cost soil moisture device



**SEN0308  
capacitive sensor**

**Watermark WM200  
Water tension sensor**



**A soil temperature  
sensor can be added**