The Internet-of-Things ecosystem: from monitoring to advanced data analysis

ENSA EL JADIDA
March 12th, 2019

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

L'Internet-des-Objets pour la collecte et l'analyse de données

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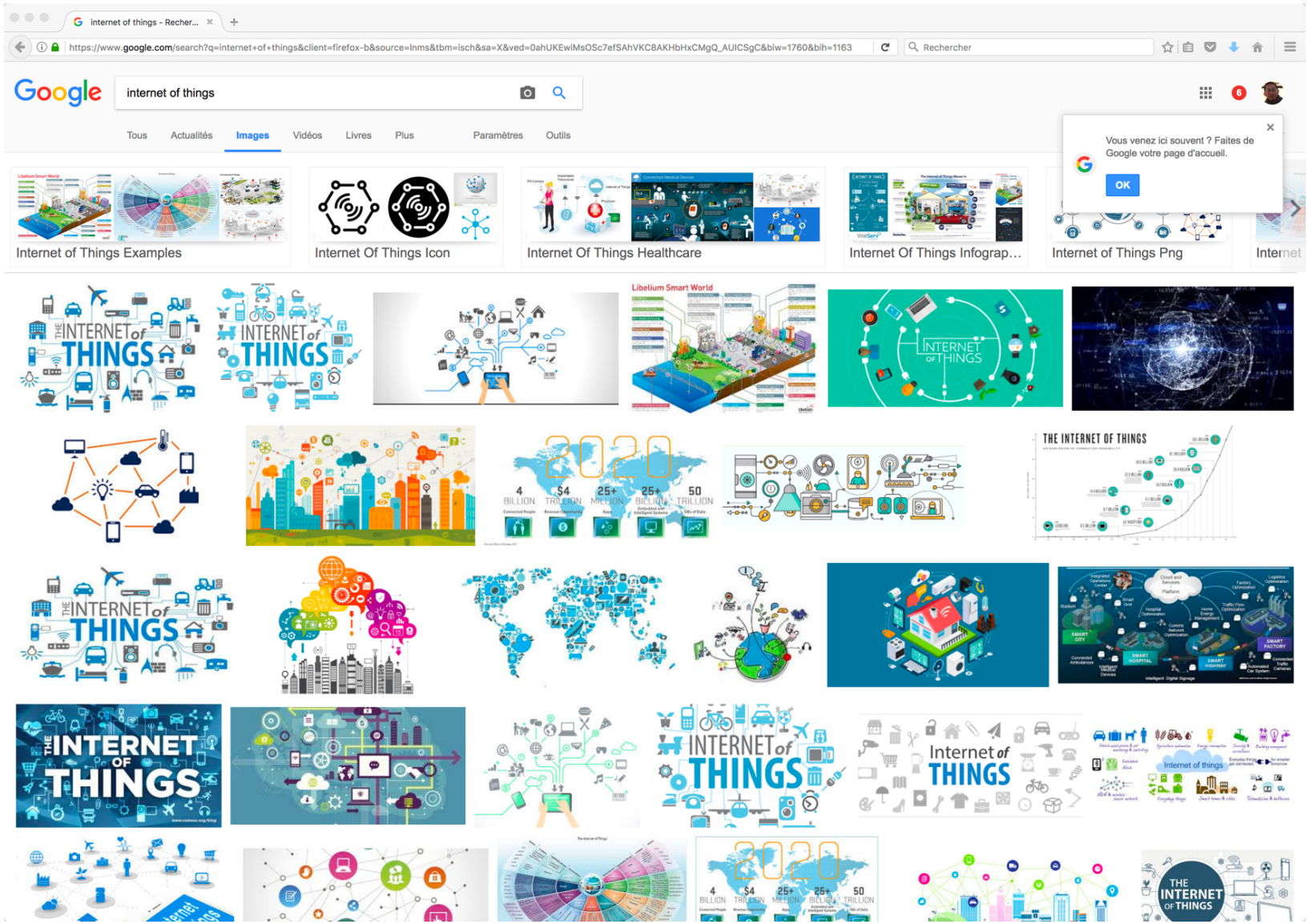
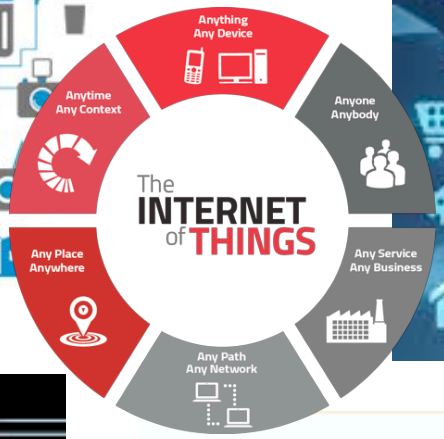
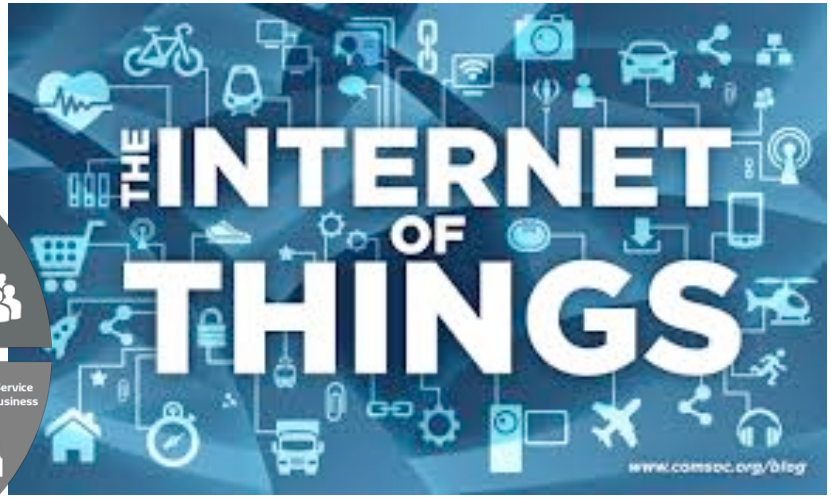
Googling for « Internet of Things »…

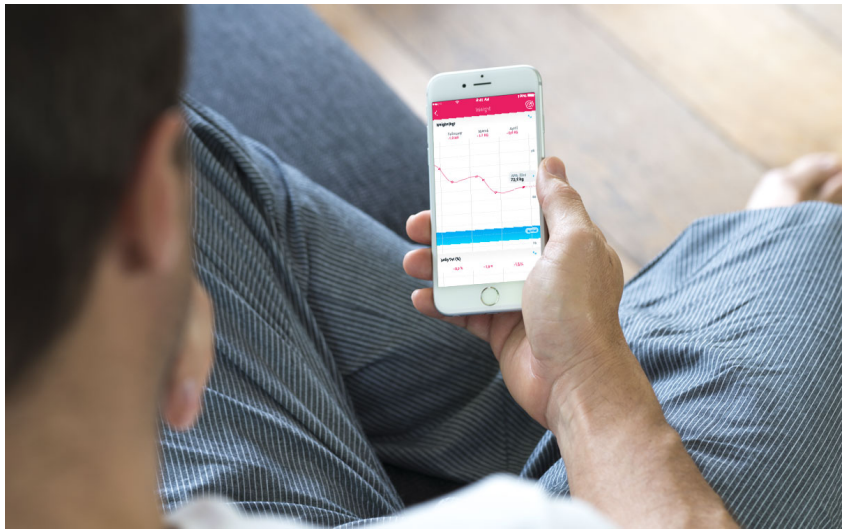


typically shows communicating objects



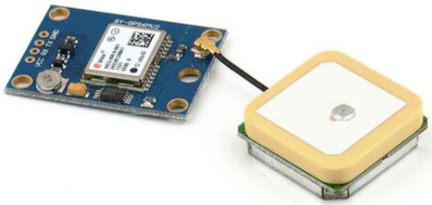


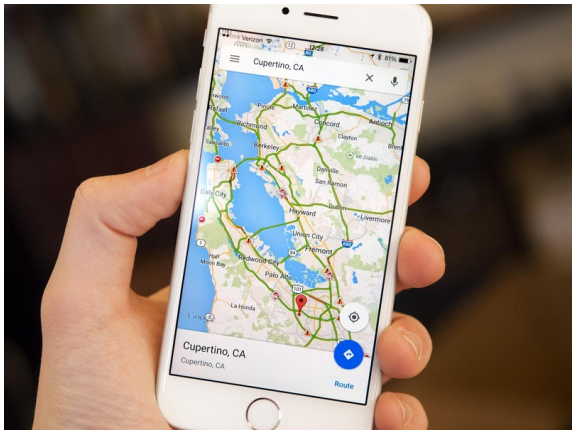
Home/consumer IoT products



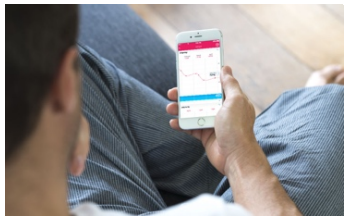
Pictures from WiThing, https://www.withings.com/eu/fr/products/body

IoT & physical world



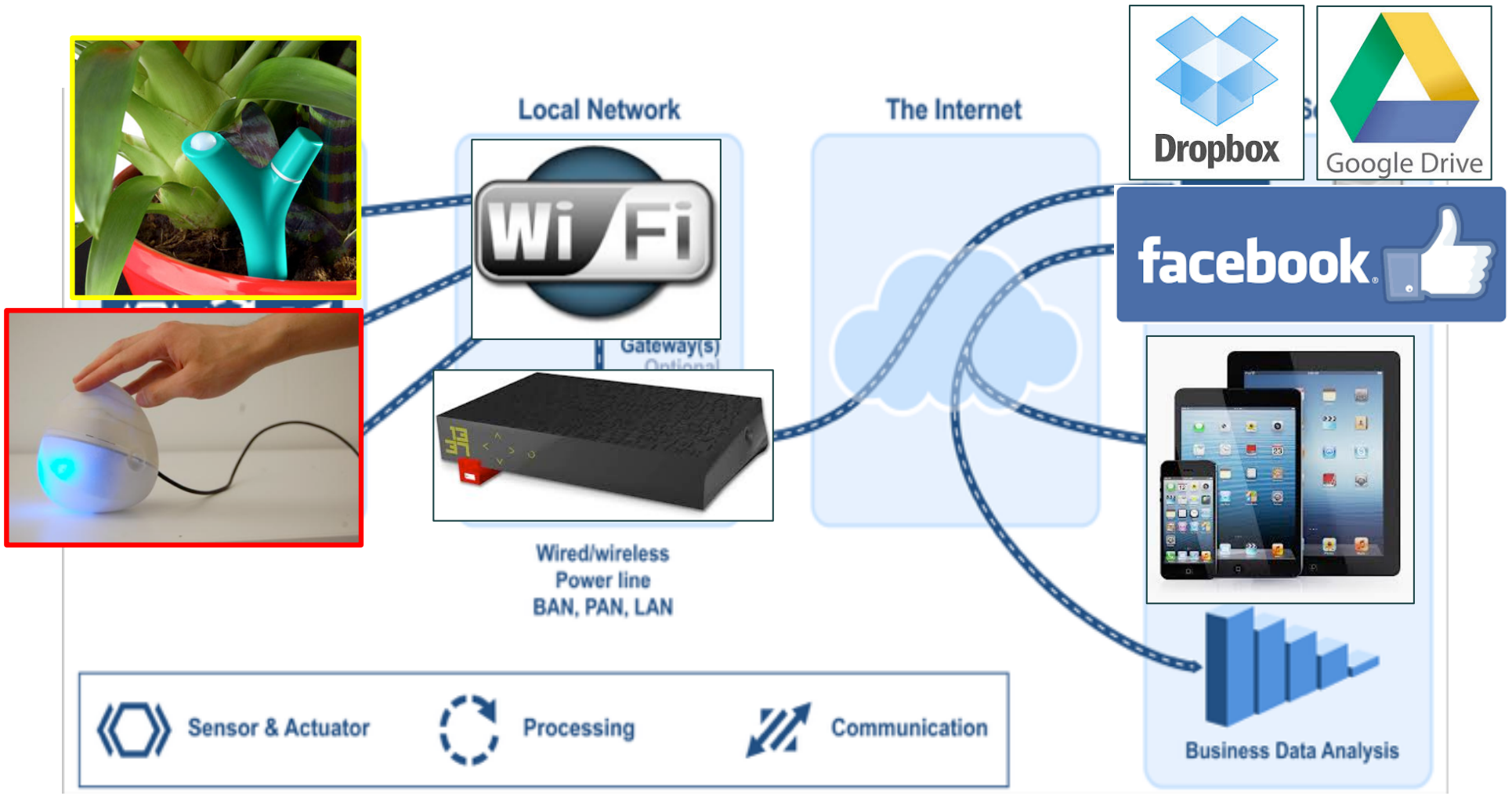


Local interaction is possible



But IoT usually means cloud data

General public IoT architecture

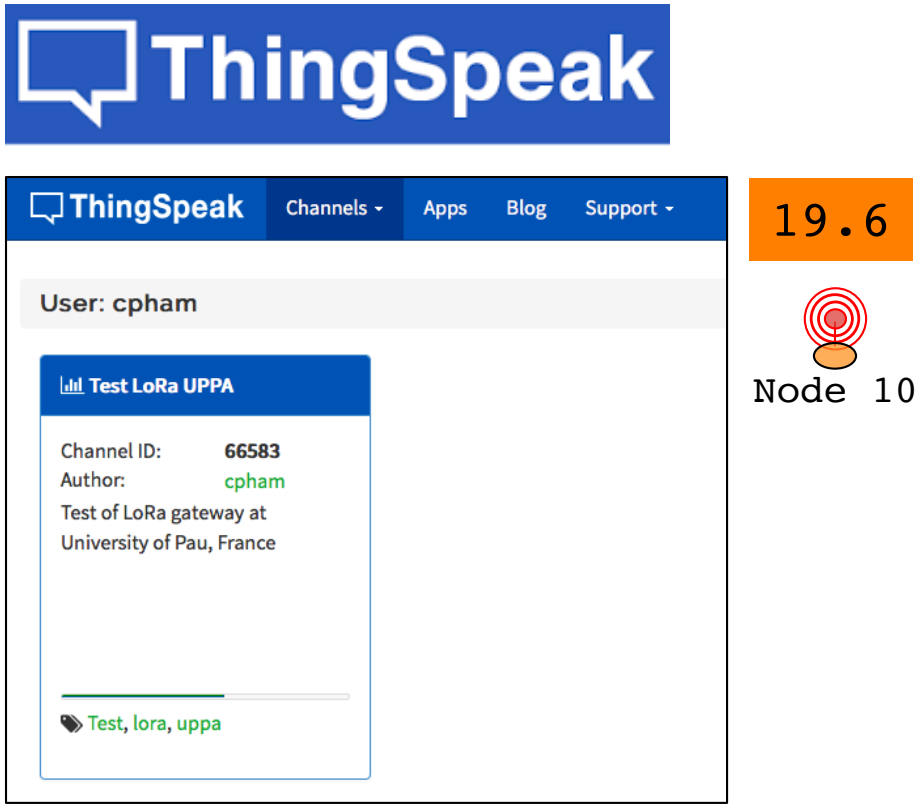


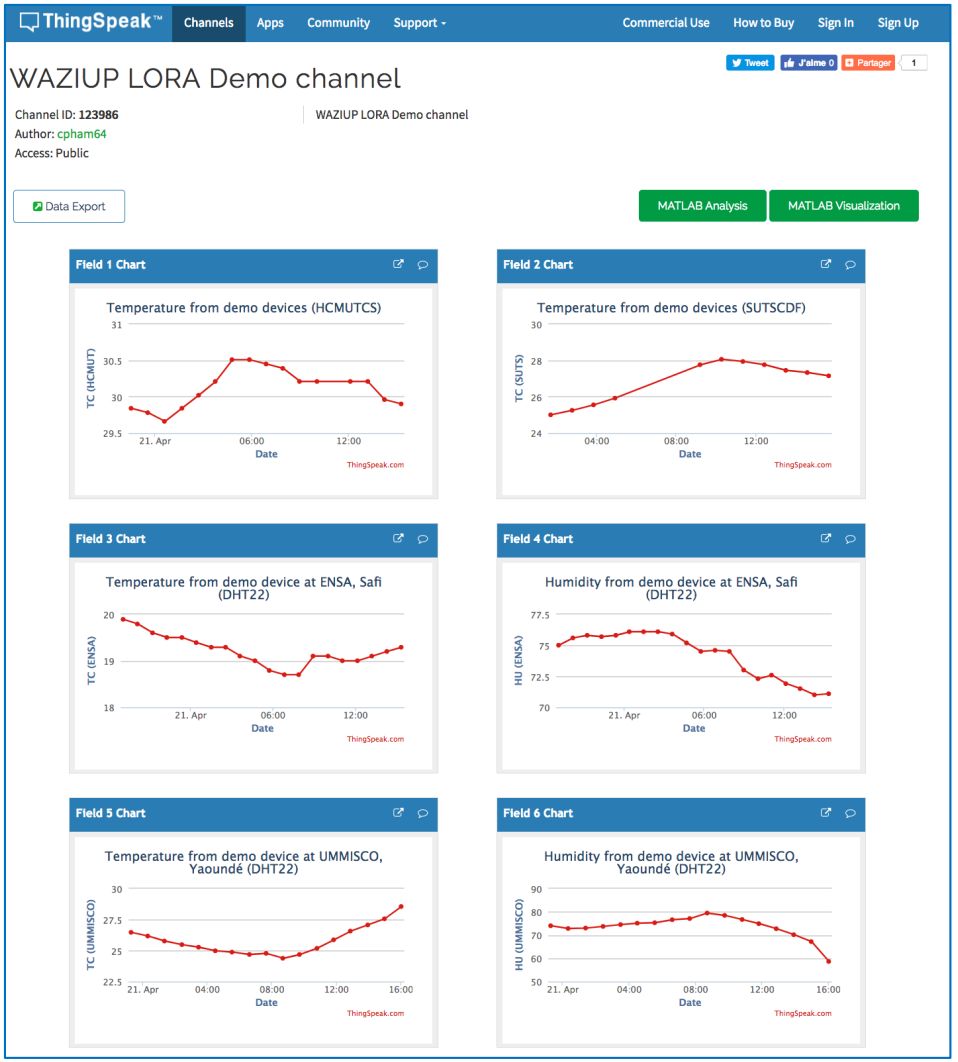
Pictures from ArchitectCorner

Dedicated IoT cloud

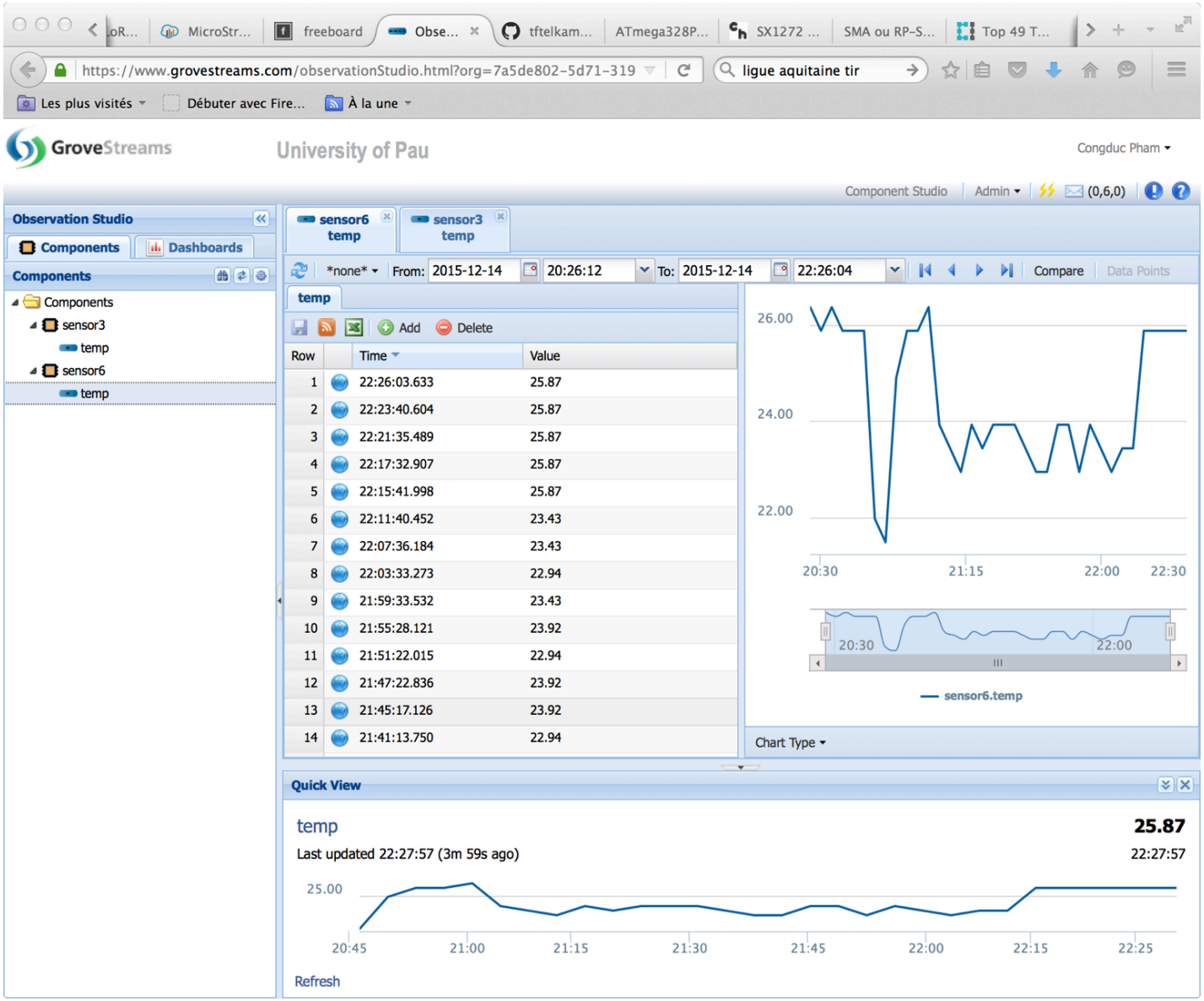
- **Most of them use HTTP POST/GET**

Using ThingSpeak

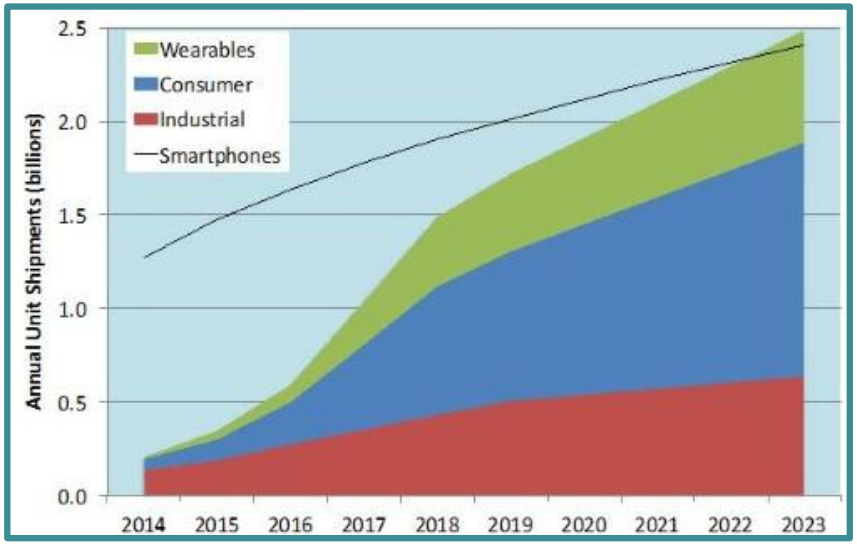


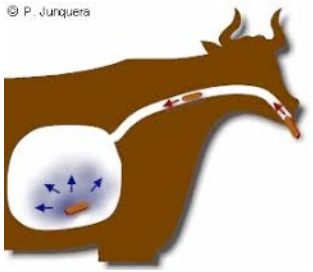


Using GroveStreams

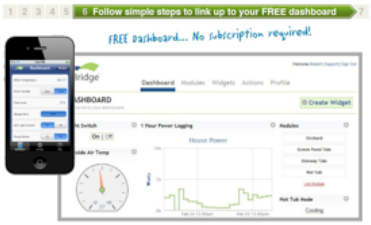


One of the most promising market is IoT!





Monitor, Optimize & Control !



DATA ANALYSIS, OPTIMIZATION & CONTROL

MONITORING

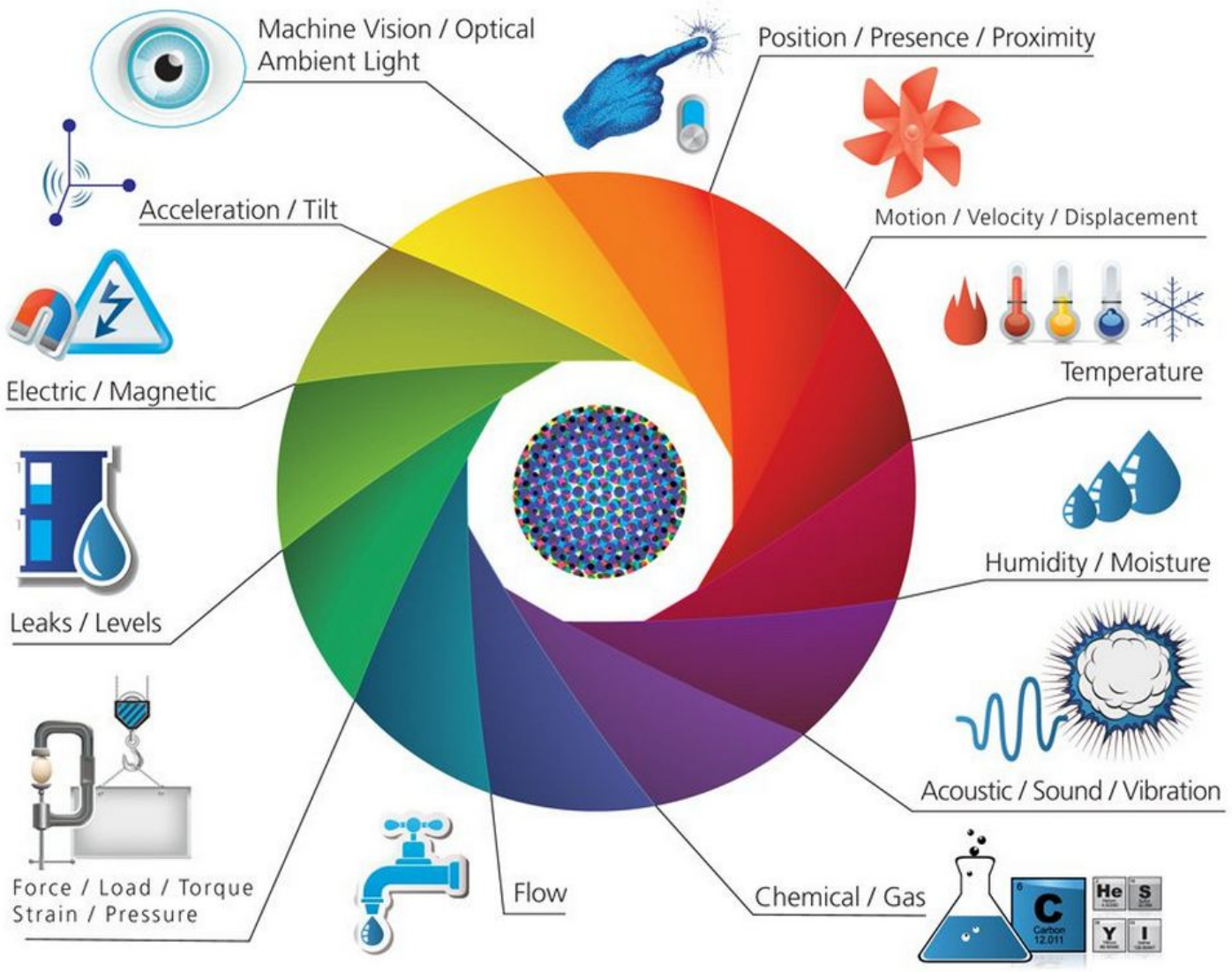
SENSING

APPLICATION DOMAINS



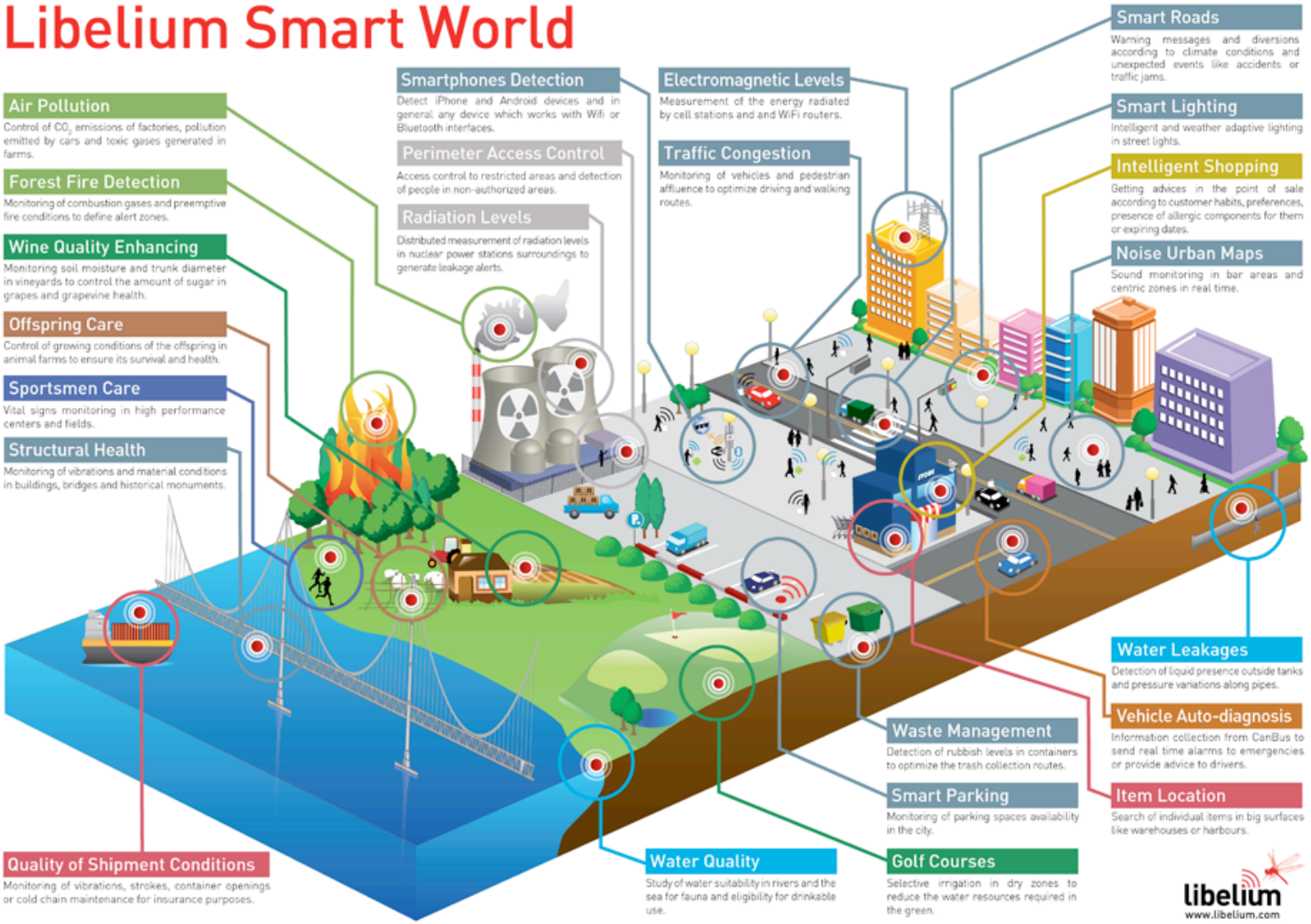



Large variety of sensoring needs



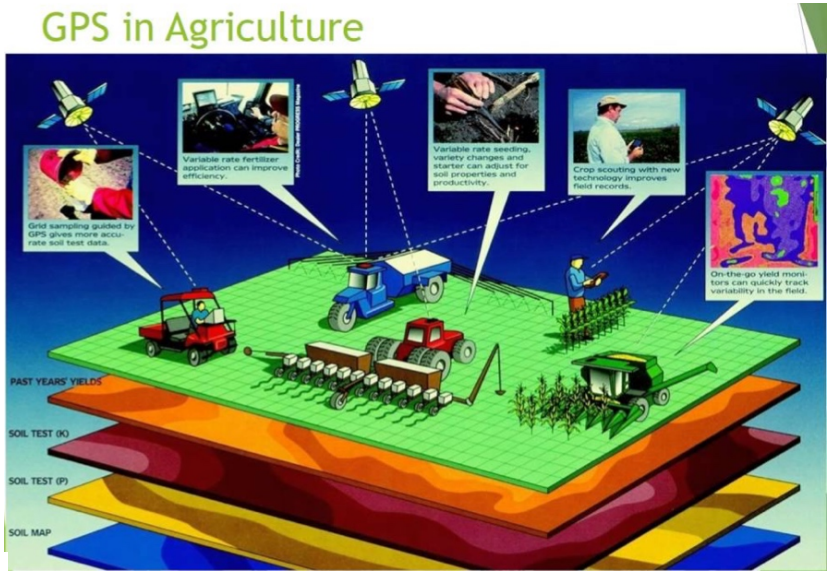
infographic made by Postscapes in collaboration with Harbor Research

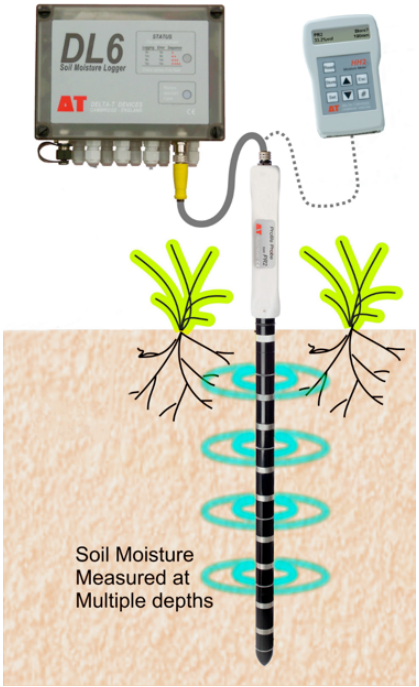
Example 1: Smart Cities



HTTP://WWW.LIBELIUM.COM/TOP_50_IOT_SENSOR_APPLICATIONS_RANKING/#SHOW_INFOGRAPHIC

Example 2: Farming & Agriculture





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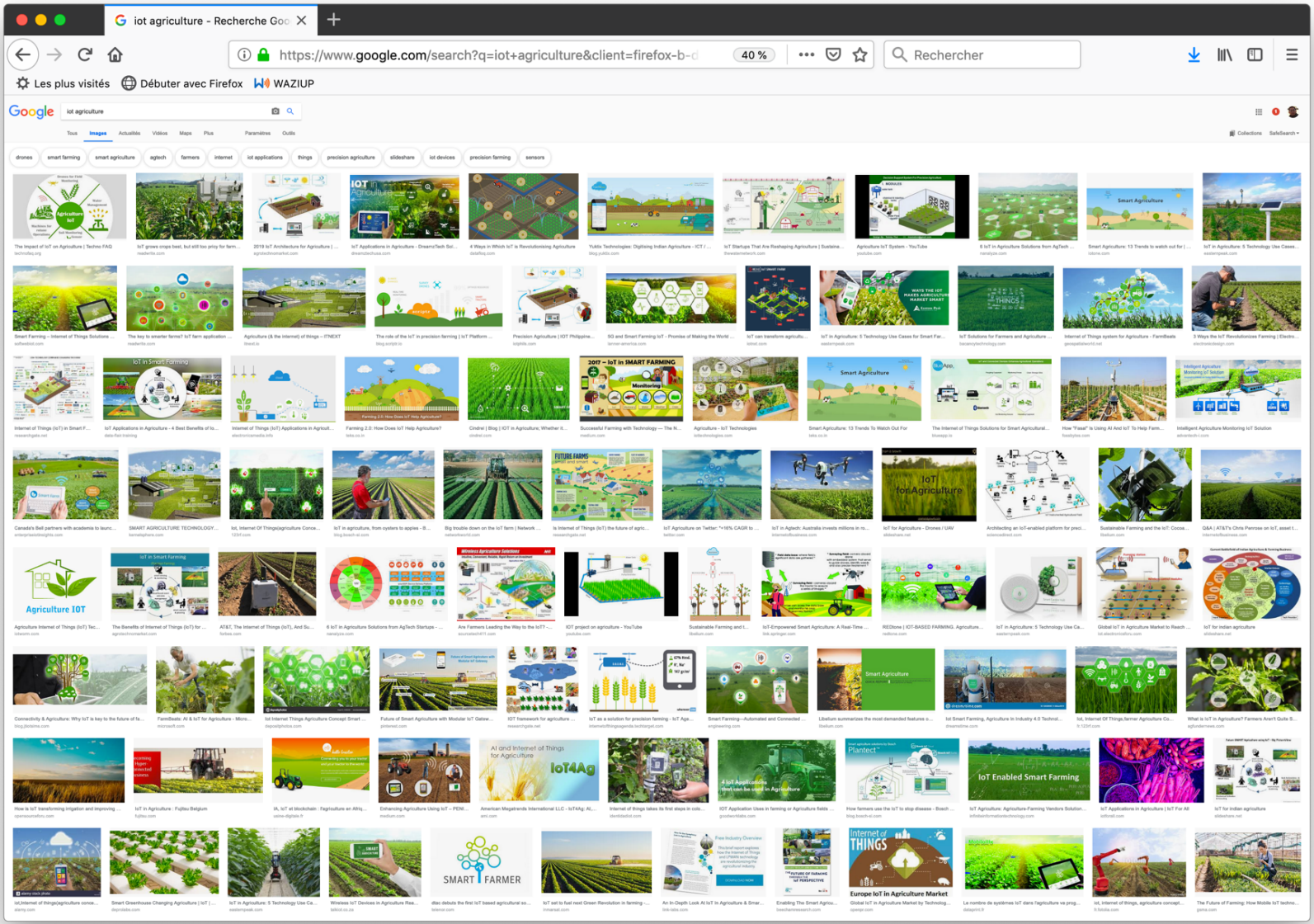
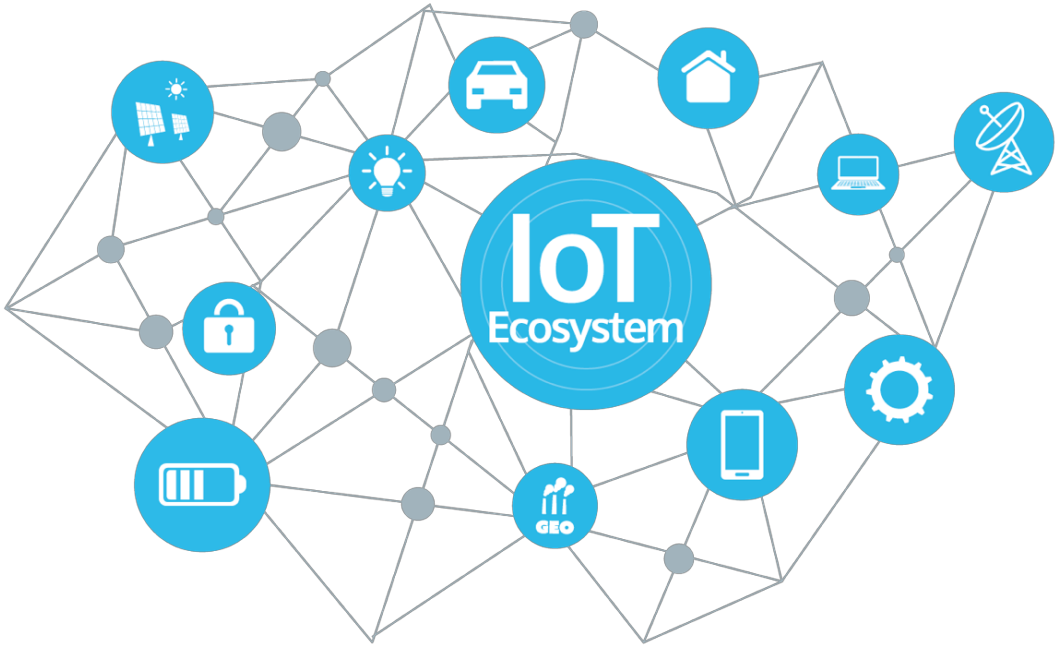
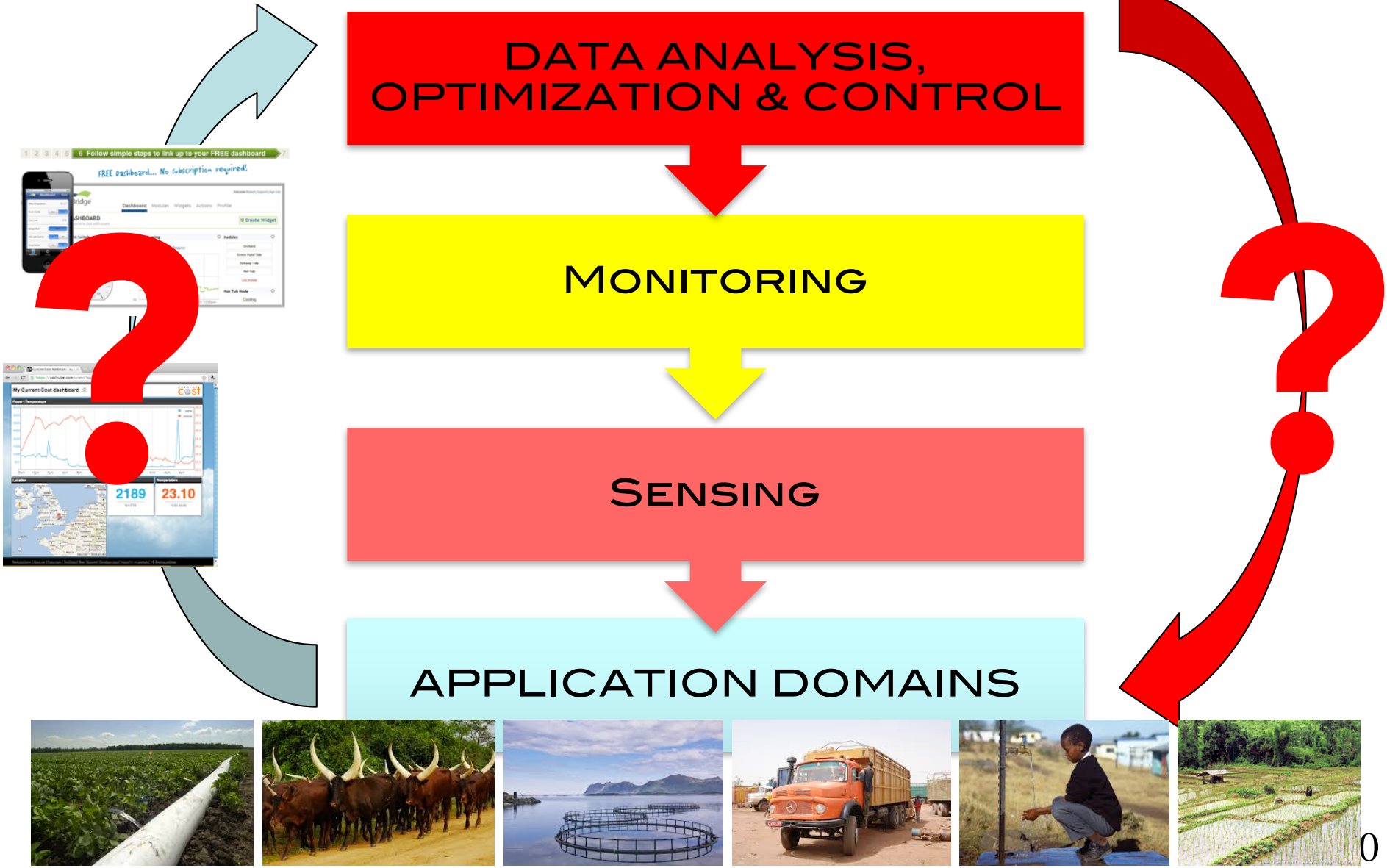


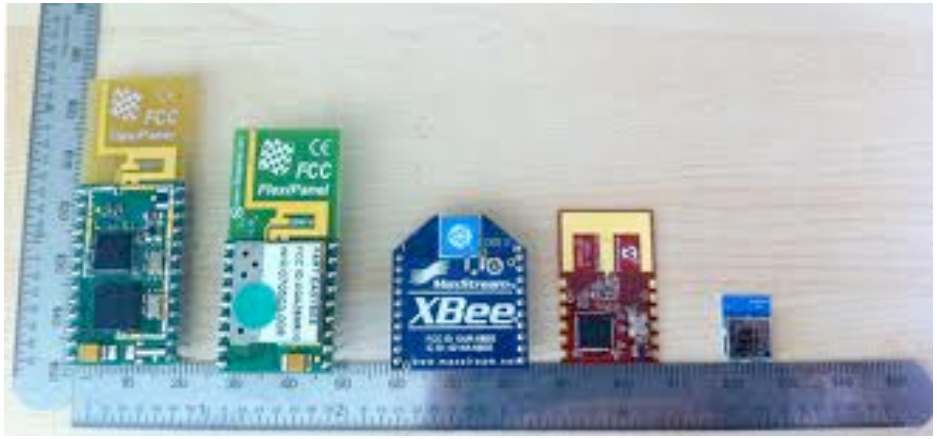
The IoT ecosystem



1st issue: collect data?



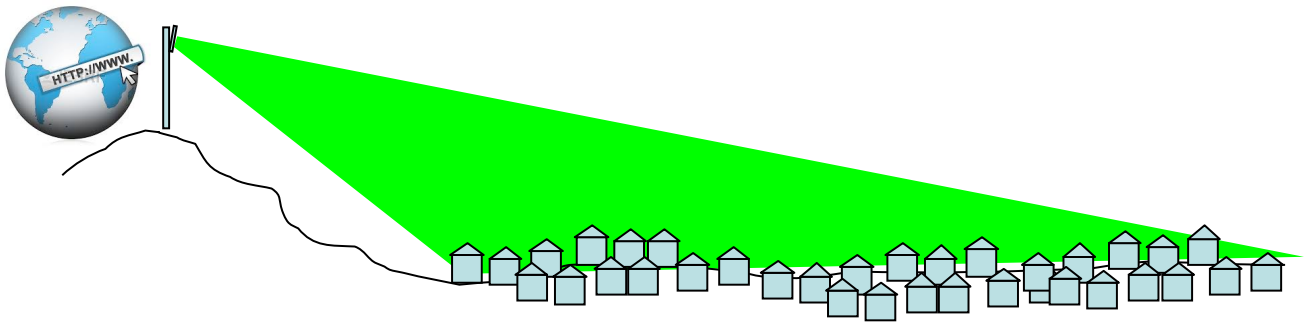
Wireless Communication made easy

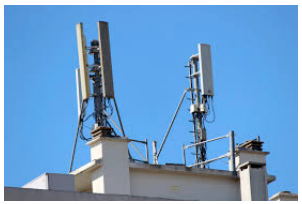


Telemetry and Transmission cost

Soil moisture monitoring

10-15kms

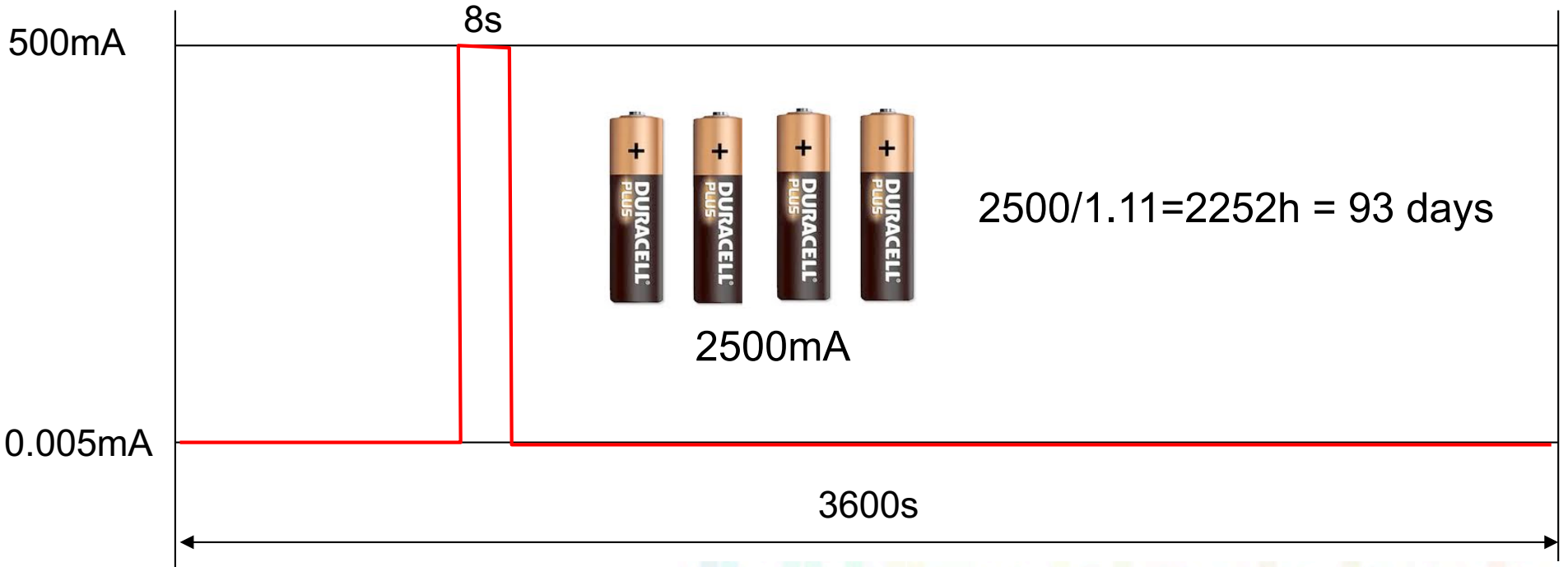


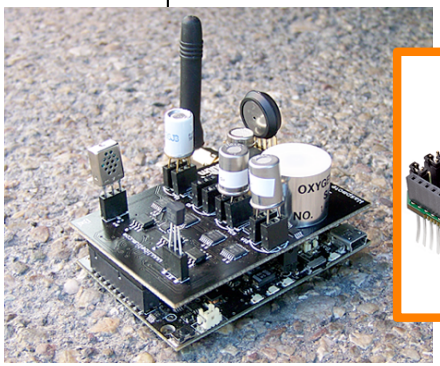


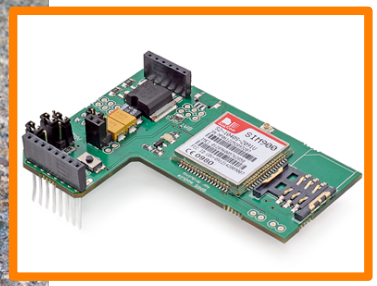
Technology	2G	3G	LAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m
Tx current consumption	200-500mA	500-1000mA	100-300mA
Standby current	2.3mA	3.5mA	NC

Energy consideration

TX power: 500mA. Mean consumption: (8sx500+3592sx0.005)/3600=1.11mA







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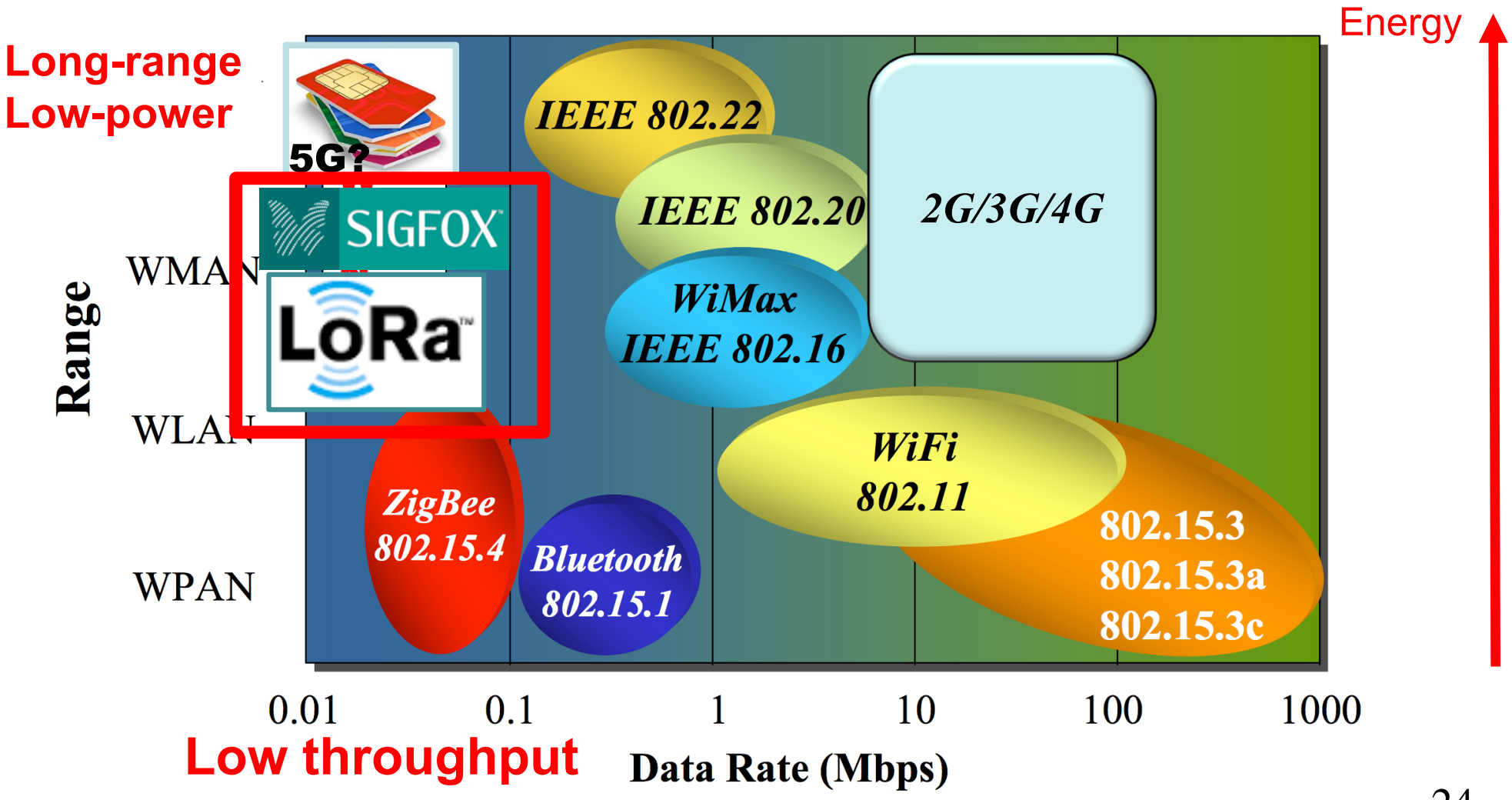
Low-power & long-range radio technologies

Energy-Range dilemma



Energy consumption comparaison

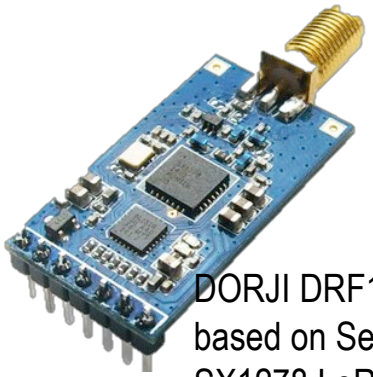
Tables from Semtech

Technology	2G	3G	LAN	ZigBee	Lo Power WAN
Range (I=Indoor, O=Outdoor)	N/A	N/A	O: 300m I: 30m	O: 90m I: 30m	Same as 2G/3G
Tx current consumption	200-500mA	500-1000mA	100-300mA	18mA	18mA-40mA
Standby current	2.3mA	3.5mA	NC	0.003mA	0.001mA
Energy harvesting (solar, other)	No	No	No	Possible	Possible
Battery 2000mAh (LR6 battery)	4-8 hours(com) 36 days(idle)	2-4 hours(com) X hours(idle)	50 hours(com) X hours(idle)	60hours (com)	120 hours(com) 10 year(idle)

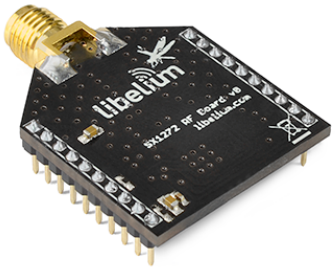
TX power: 40mA. Mean consumption: (2sx40+3598sx0.005)/3600=0.027mA

2500/0.027=92592h = 3858 days = 10 years

LoRa modules from Semtech's SX127x chips



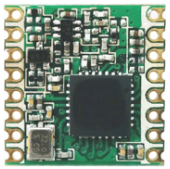
DORJI DRF1278DM is based on Semtech SX1278 LoRa 433MHz



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

inAir9 based on SX1276

Froggy Factory LoRa module (Arduino)



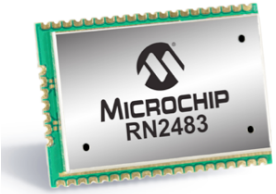
HopeRF RFM series

HopeRF HM-TRLR-D

LinkLabs Symphony module

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

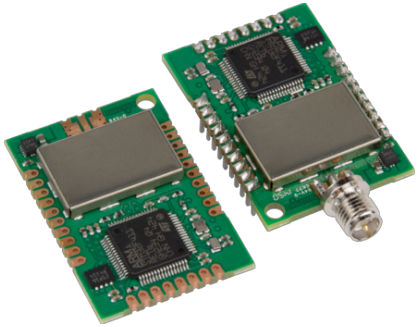
Embit LoRa



Microship RN2483

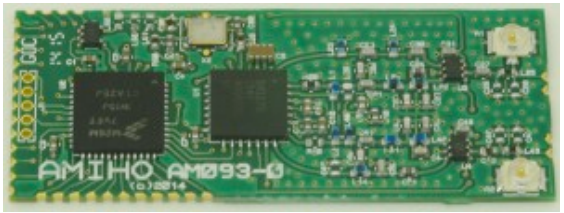
habSupplies

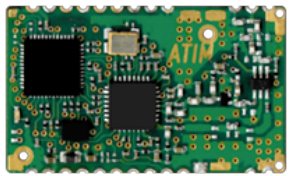
Adeunis ARF8030AA- Lo868



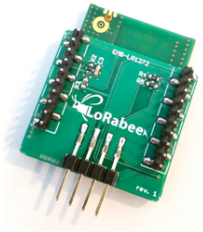
Multi-Tech MultiConnect mDot

AMIHO AM093

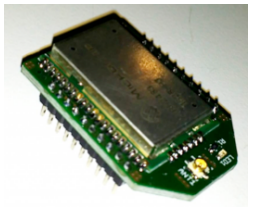




ARM-Nano N8 LoRa module from ATIM



SODAQ LoRaBee Embit



SODAQ LoRaBee RN2483

LPWAN networks roll-ou

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

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

Tata Communication world's largest IoT n India

Semtech and STMicroelectronics aborate to Scale LoRa nology to Meet High-Volume Demands of rnet of Things Applications

OTIO to Connect 1 Million Devices to SIGFOX

From www.businesswire.com - February 22, 4:59 PM

OTIO, a subsidiary of Groupe HBF specializ electrical equipment, lighting and home automation, has chosen the SIGFOX netwo deploy its new international offer of connec devices.

Swisscom sets up a Swiss-wide network for the Internet of Things

From www.swisscom.ch - March 14, 7:49 PM

The Internet of Things has long connected millions of objects and devices to one another and to people. In the future, this number will reach into the billions worldwide. Swisscom is the first provider in Switzerland to set up an additional network dedicated to the Internet of Things: the Low Power Network, designed for the transmission of small amounts of data independently of the electrical network.

From www.sudo 16, 2015 2:24 PM

" Gestionnaire les Landes, e Dordogne, So ondes radio de Sigfox pour relever les compteurs et surveiller l'état des canalisations Le compteur..."

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

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

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

From www.theinternetofthin September 10, 4:41 PM

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

Rise from the Ashes?

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

News taken from scoop.it (N. Ayuso)

2nd issue: low-cost hardware

WHAT IS ARDUINO?

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

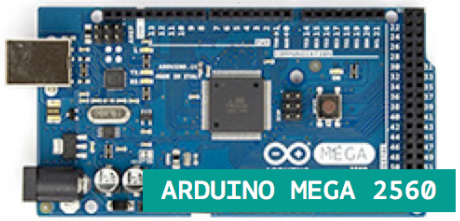
ARDUINO BOARD

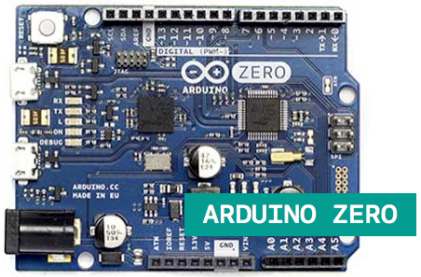
Arduino senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators.

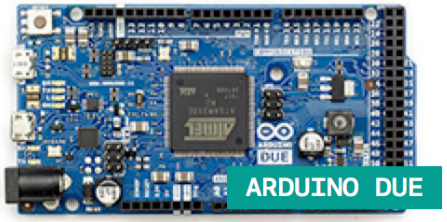
ARDUINO SOFTWARE

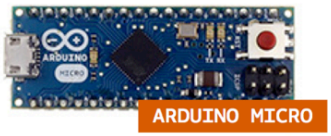
```
void setup() {
 }

void loop() {
 }
```

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



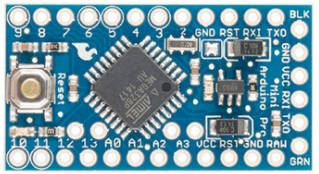






Large ecosystem, still growing…

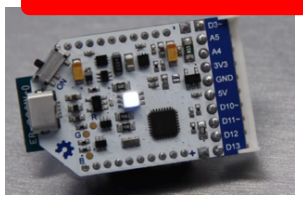
Arduino Pro Mini



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/

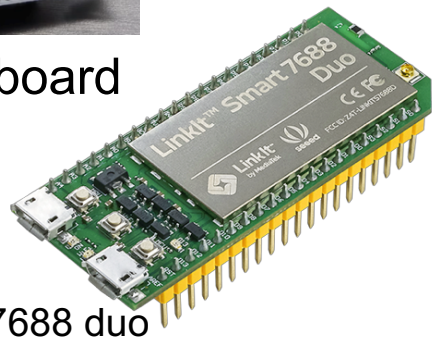


Theairboard

ARDUINO

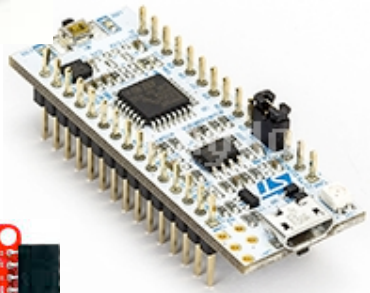
Expressif ESP32

Teensy 3.2



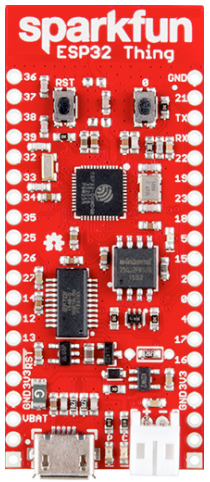
LinkIt Smart7688 duo

STM32 Nucleo-32



Heltec ESP32 + OLED

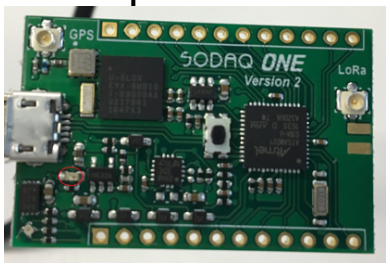
Adafruit Feather



Sparkfun ESP32 Thing

Tessel

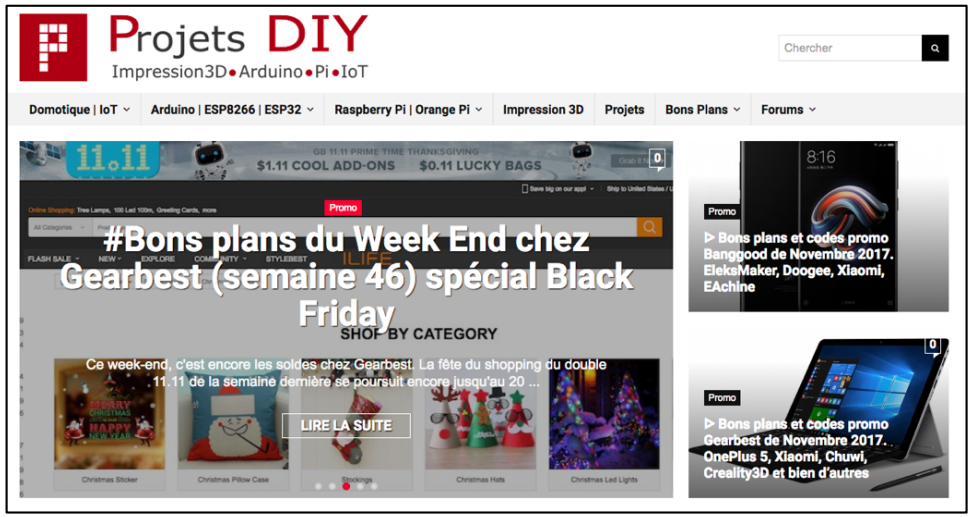
SodaqOnev2

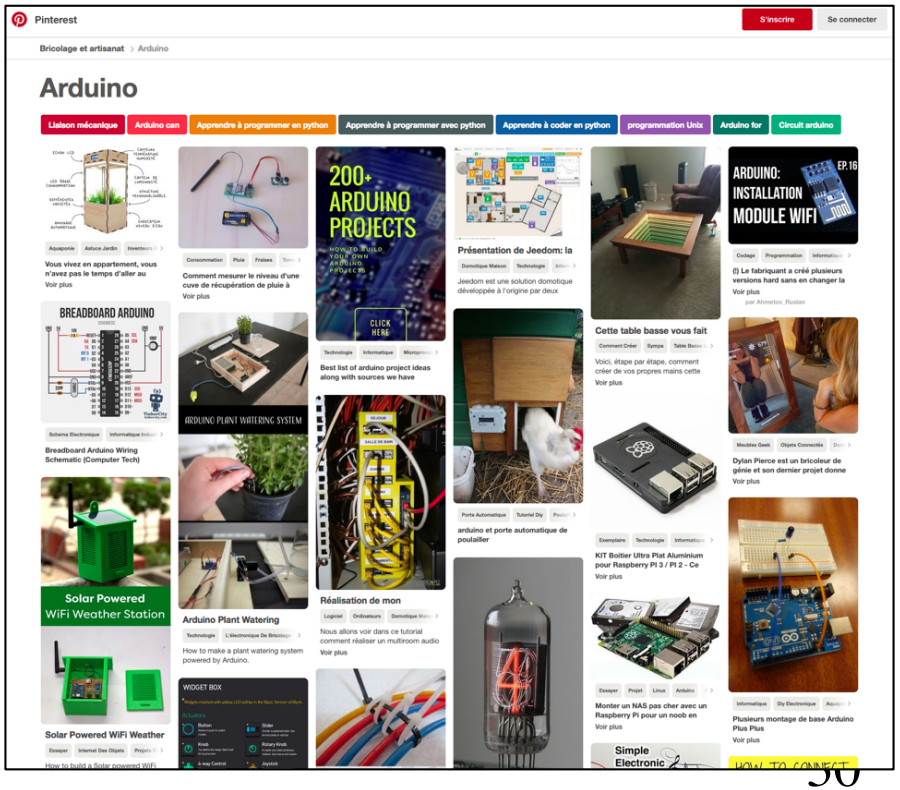


Tinyduino

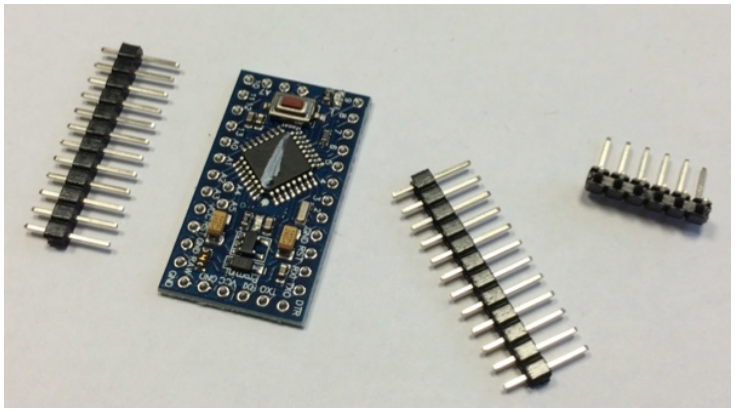
… stimulating worldwide "Do-it-Yourself" projects

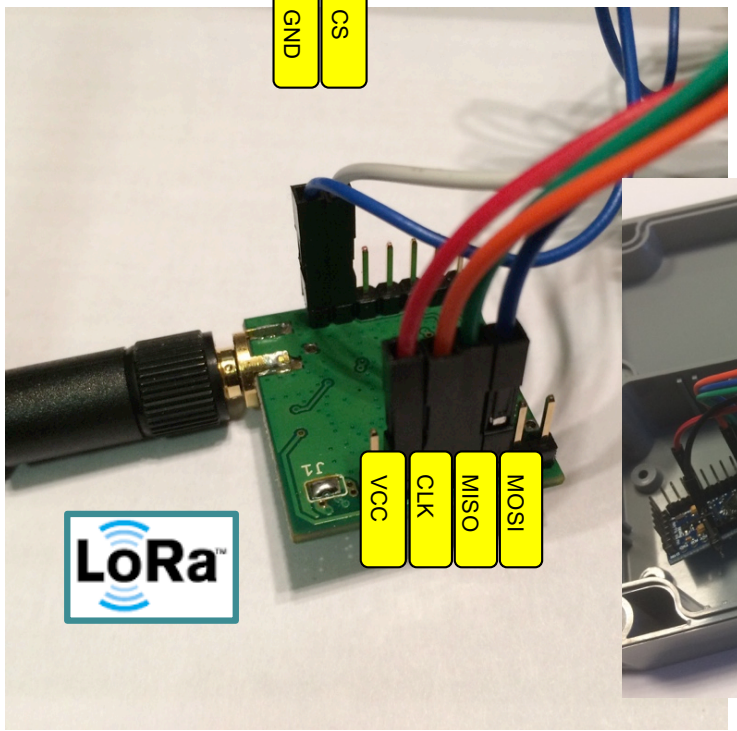
- DIY usually means
  - More open-source software from larger community
  - More flexibility

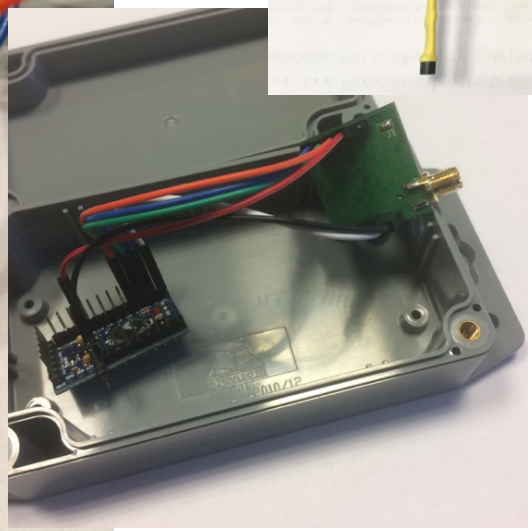




Full Do-It-Yourself approach





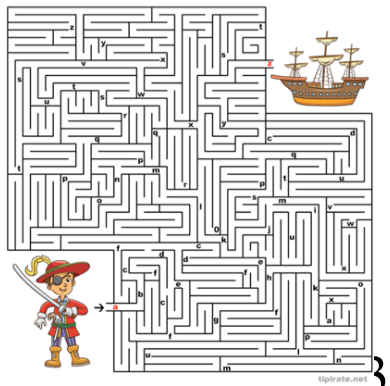


3rd issue: get the information

- Searching for information is a tough issue
  - Web search engine: Google,…
- Most IoT clouds uses HTTP request (GET, POST, PUT, …) to push/store data to web platforms/servers

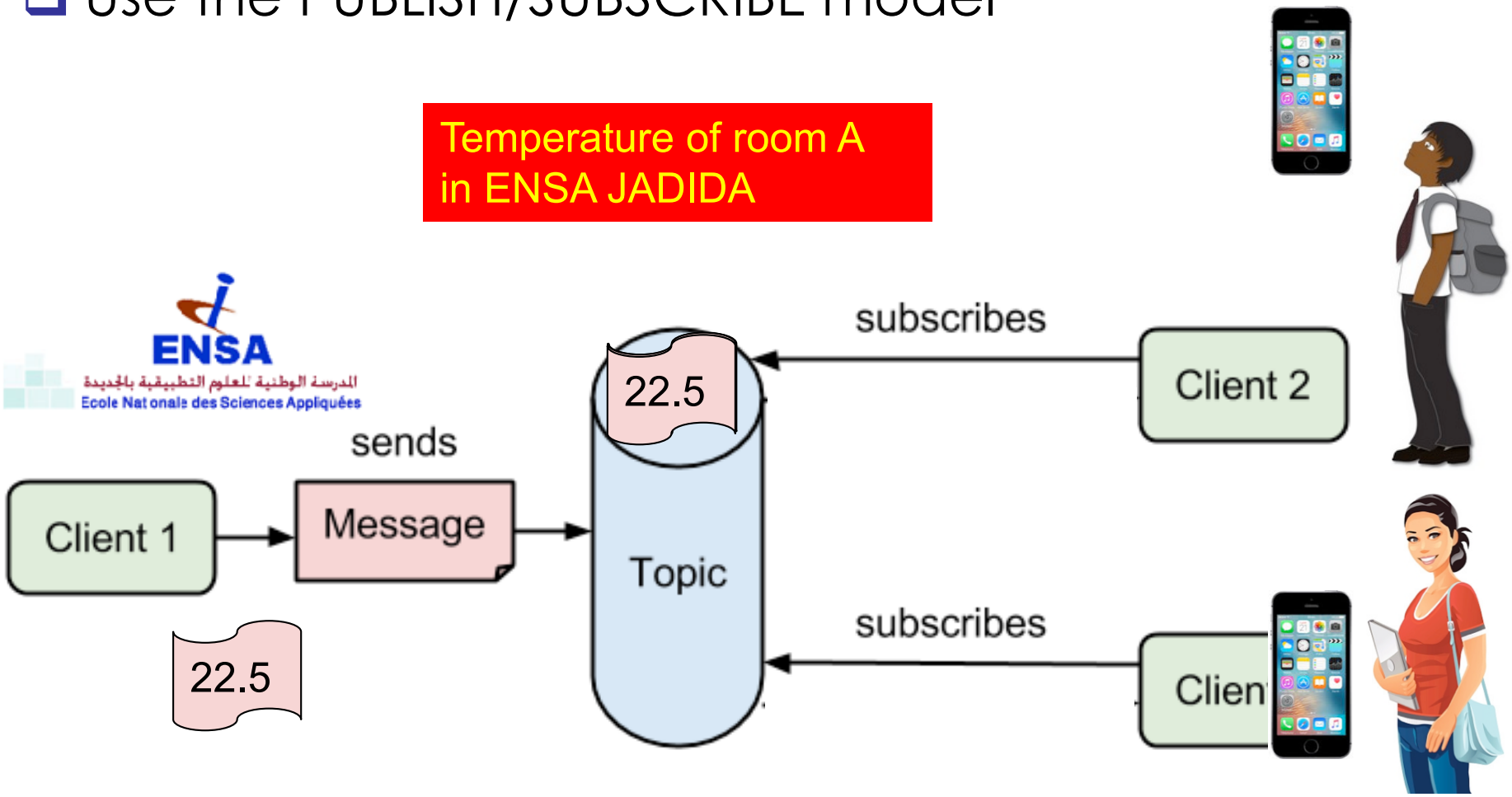
ThingSpeak

- If you need an information, for instance the temperature in room A of ENSA JADIDA, then you have to go to the right web page
- When there can be millions of IoT nodes providing large variety of data, it is difficult to find your way!



From *search for info* to *get the info*

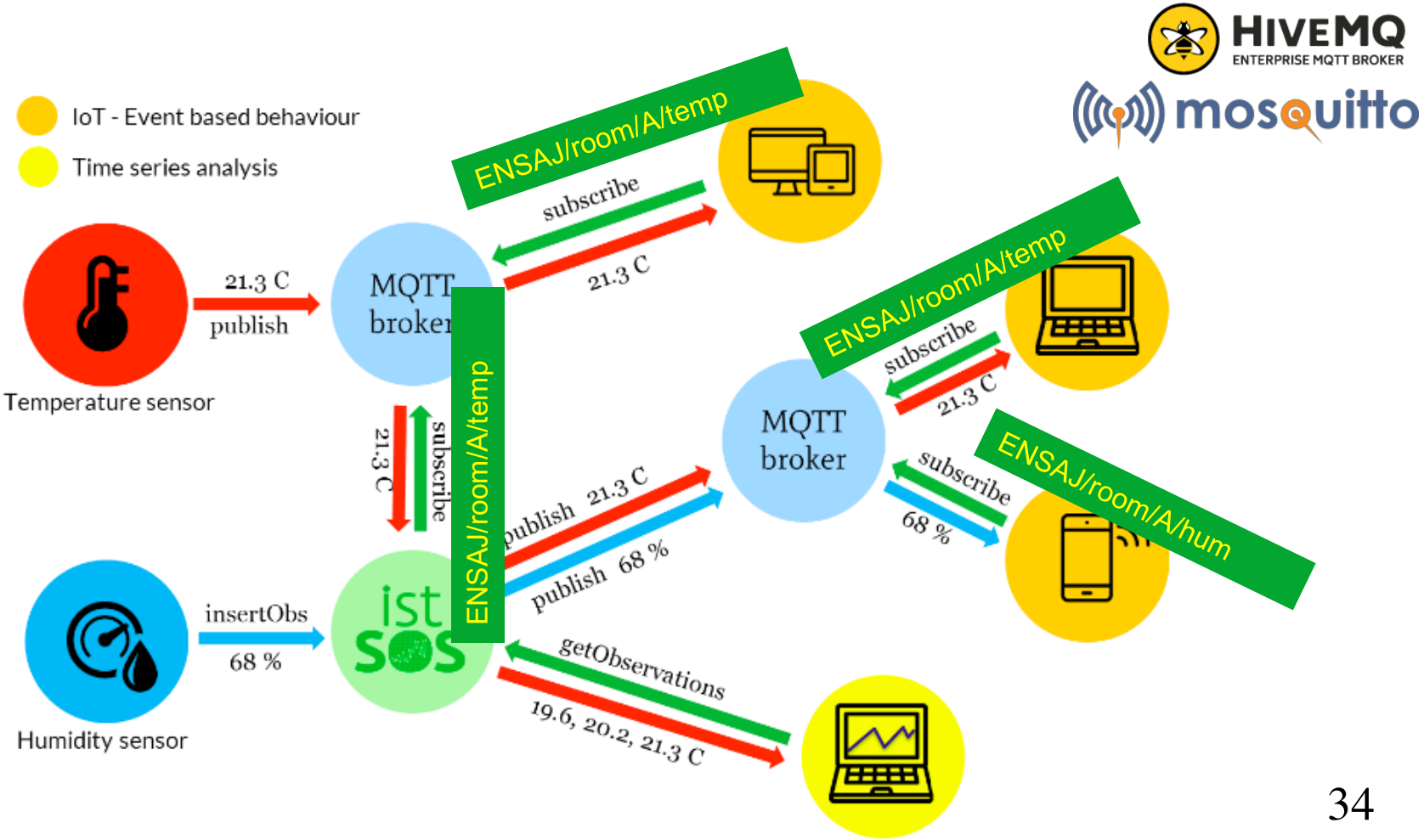
- Use the PUBLISH/SUBSCRIBE model



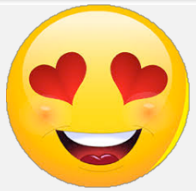
MQTT

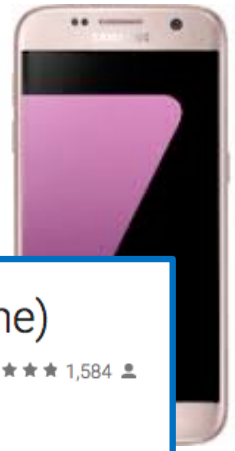
Message Queue Telemetry Transport

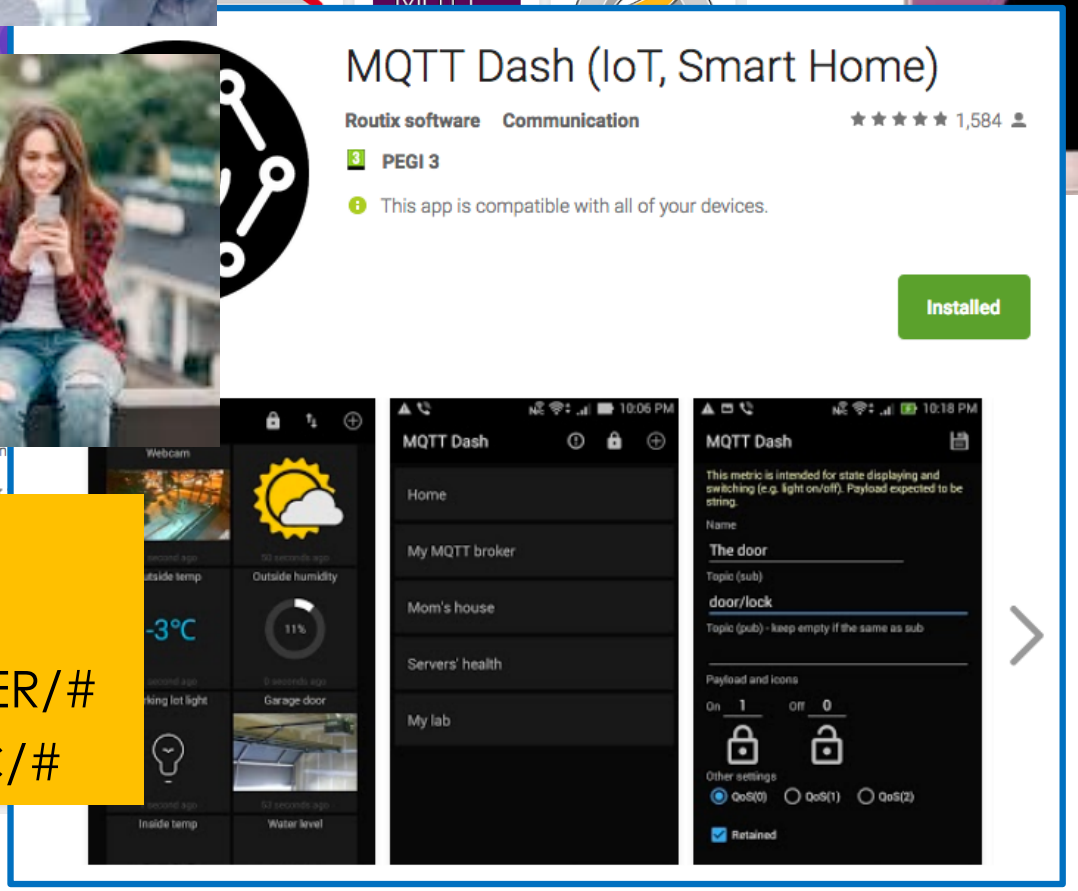
- Use broker nodes to manage topics
  - ENSAJ/room/A/temp, ENSAJ/room/A/hum



MQTT+smartphone=

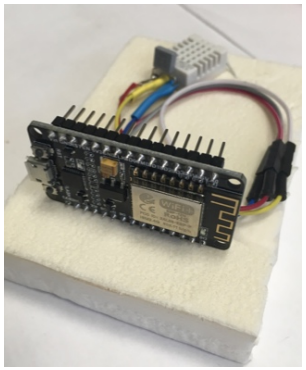






- Towards open data
  - ENSAJ/room/#
  - ELJADIDA/CITY/WEATHER/#
  - ELJADIDA/CITY/TRAFFIC/#

4th issue: make it simpler?



FIWARE

ioBridge® Connect things.

dweet.io

freeboard

GroveStreams

Firebase

TempoIQ

ThingSpeak

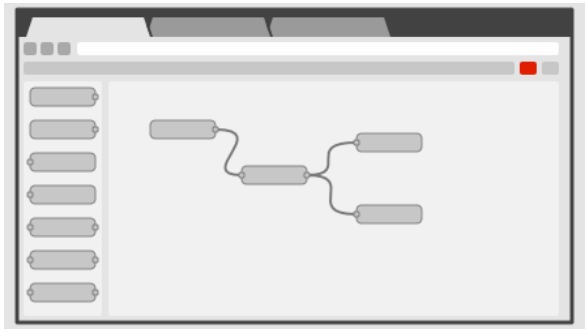
SensorCloud™

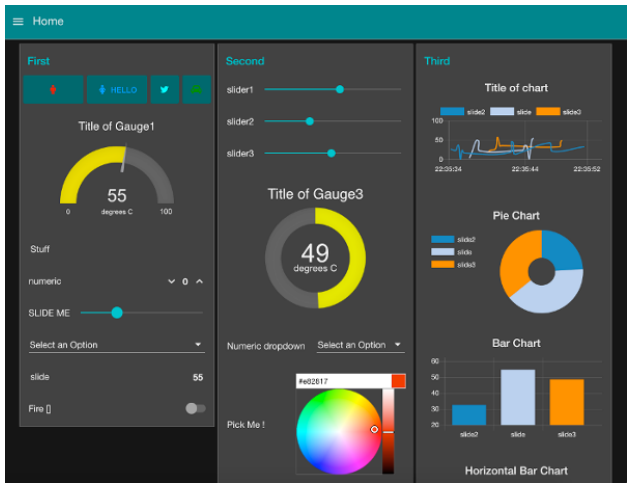
OpenRemote

- End-users are not necessarily computer science experts nor high-skilled programmers
- Use graphical tools to build data processing flows, allowing intuivive connection from data producers to data consumers

Node-Red

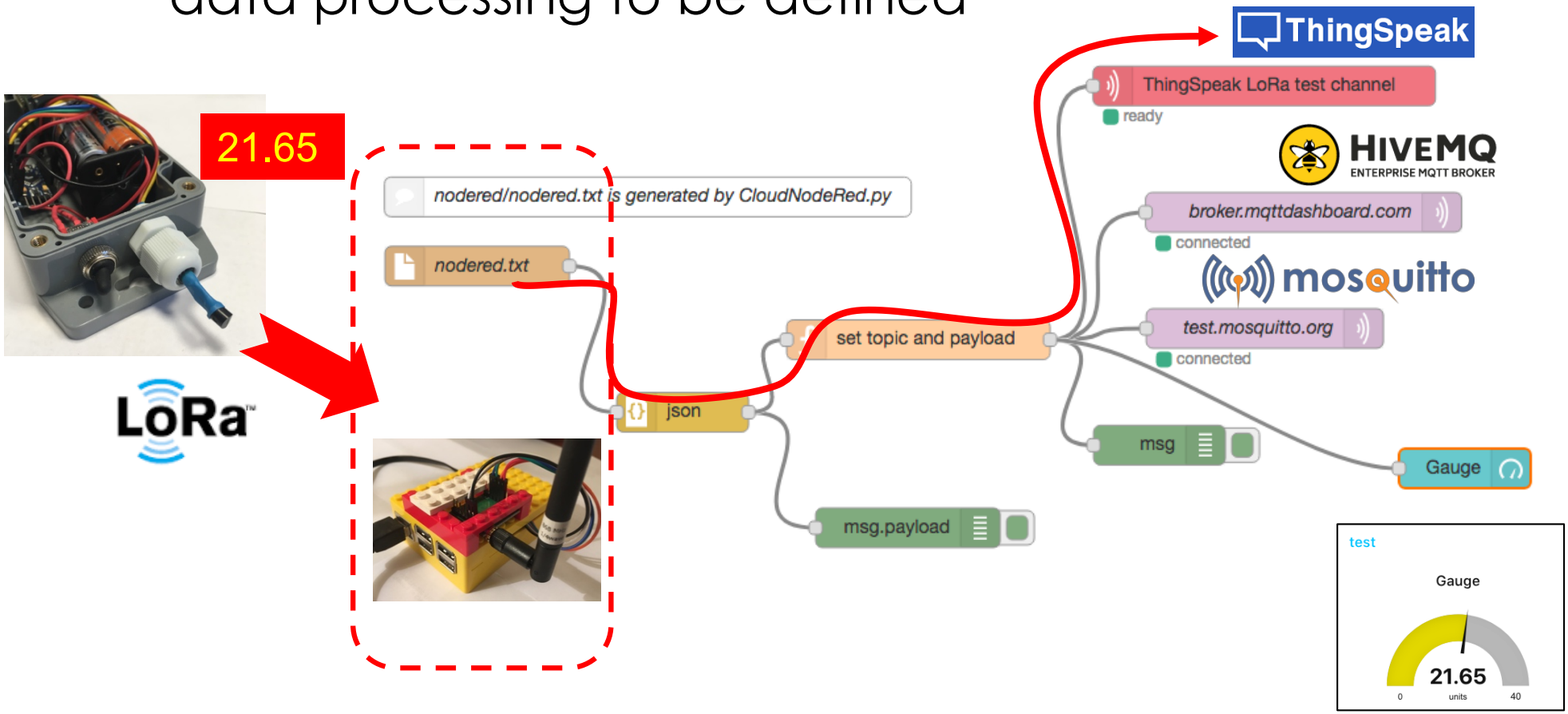
- Node-RED is a programming tool for wiring together hardware devices, APIs and online services, e.g. clouds of various types
- provides a browser-based flow editor to wire together flows with a wide range of nodes



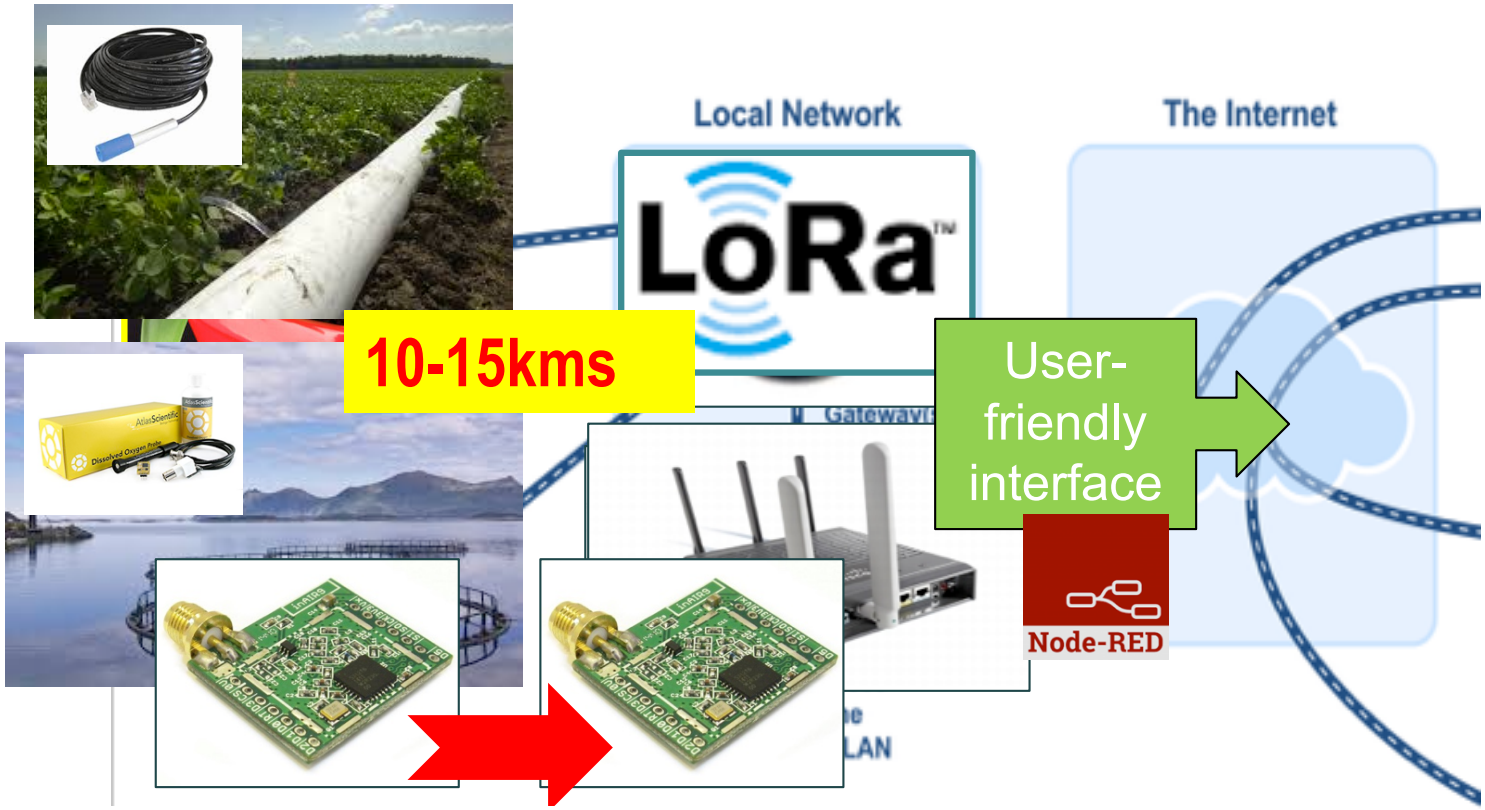


Node-red enabled IoT gateway

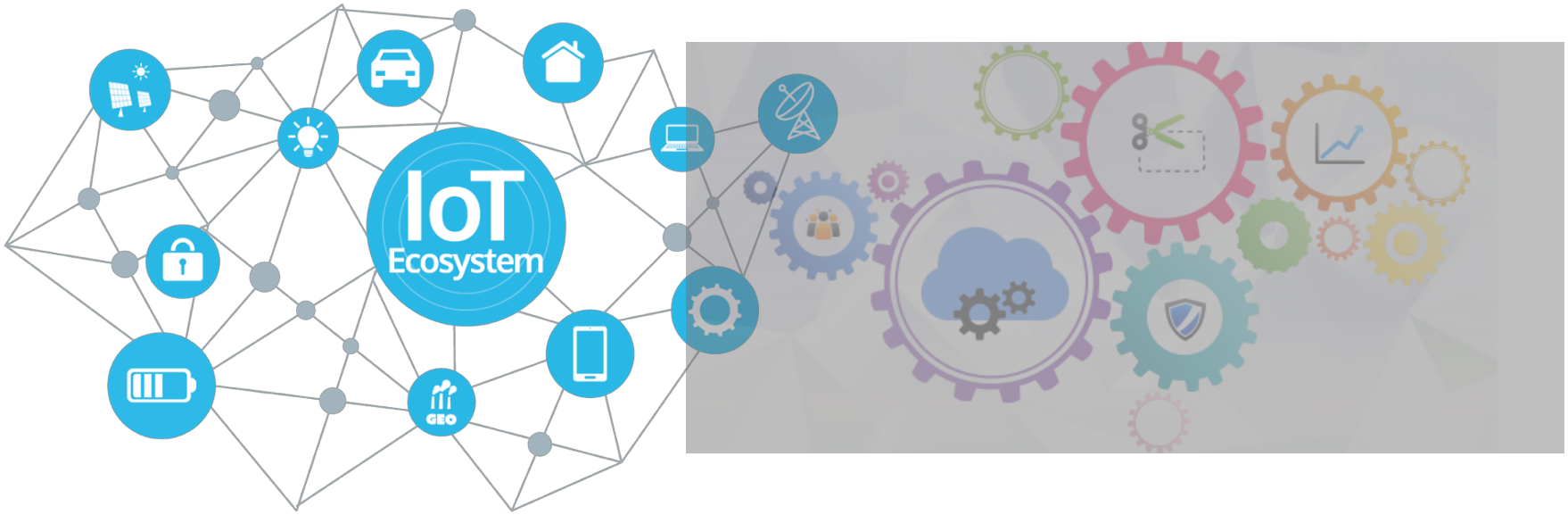
- Messages received on the IoT gateway can be injected into a Node-Red flow, allowing complex data processing to be defined



Global picture of long-range IoT ecosystem



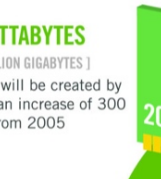
The IoT BackOffice



IoT usually means

Volume
SCALE OF DATA

40 ZETTABYTES
[43 TRILLION GIGABYTES]
of data will be created by 2020, an increase of 300 times from 2005



It's estimated that
2.5 QUINTILLION BYTES
[2.3 TRILLION GIGABYTES]
of data are created each day

6 BILLION PEOPLE
have cell phones

WORLD POPULATION: 7 BILLION

Most companies in the U.S. have at least
100 TERABYTES
[100,000 GIGABYTES]
of data stored

The FOUR V's of Big Data

From traffic patterns and music downloads to web history and medical records, data is recorded, stored, and analyzed to enable the technology and services that the world relies on every day. But what exactly is big data, and how can these massive amounts of data be used?

As a leader in the sector, IBM data scientists break big data into four dimensions: **Volume, Velocity, Variety and Veracity**

Depending on the industry and organization, big data encompasses information from multiple internal and external sources such as transactions, social media, enterprise content, sensors and mobile devices. Companies can leverage data to adapt their products and services to better meet customer needs, optimize operations and infrastructure, and find new sources of revenue.

By 2015
4.4 MILLION IT JOBS
will be created globally to support big data, with 1.9 million in the United States

Variety
DIFFERENT FORMS OF DATA

As of 2011, the global size of data in healthcare was estimated to be
150 EXABYTES
[161 BILLION GIGABYTES]

By 2014, it's anticipated there will be
420 MILLION WEARABLE, WIRELESS HEALTH MONITORS

4 BILLION+ HOURS OF VIDEO
are watched on YouTube each month

30 BILLION PIECES OF CONTENT
are shared on Facebook every month

400 MILLION TWEETS
are sent per day by about 200 million monthly active users

Velocity
ANALYSIS OF STREAMING DATA

The New York Stock Exchange captures
1 TB OF TRADE INFORMATION
during each trading session

Modern cars have close to
100 SENSORS
that monitor items such as fuel level and tire pressure

By 2016, it is projected there will be
18.9 BILLION NETWORK CONNECTIONS
– almost 2.5 connections per person on earth

Veracity
UNCERTAINTY OF DATA

1 IN 3 BUSINESS LEADERS
don't trust the information they use to make decisions

Poor data quality costs the US economy around
$3.1 TRILLION A YEAR

in one survey were unsure of how much of their data was inaccurate

Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS

But also how to analyse the data

- What is the meaning of the collected data?
- Example with farming
  - What is interesting for farmers?
    - Fertility detection
    - Eating/Ruminating time for welfare
  - What data can be easily obtained?
    - accelerometer data with neck-mounted collar
  - How to detect relevant event from these data?

Advanced data analysis

Need of experts from the domain!

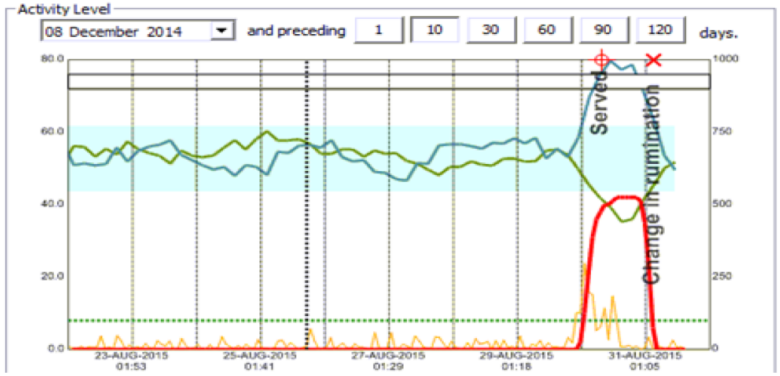
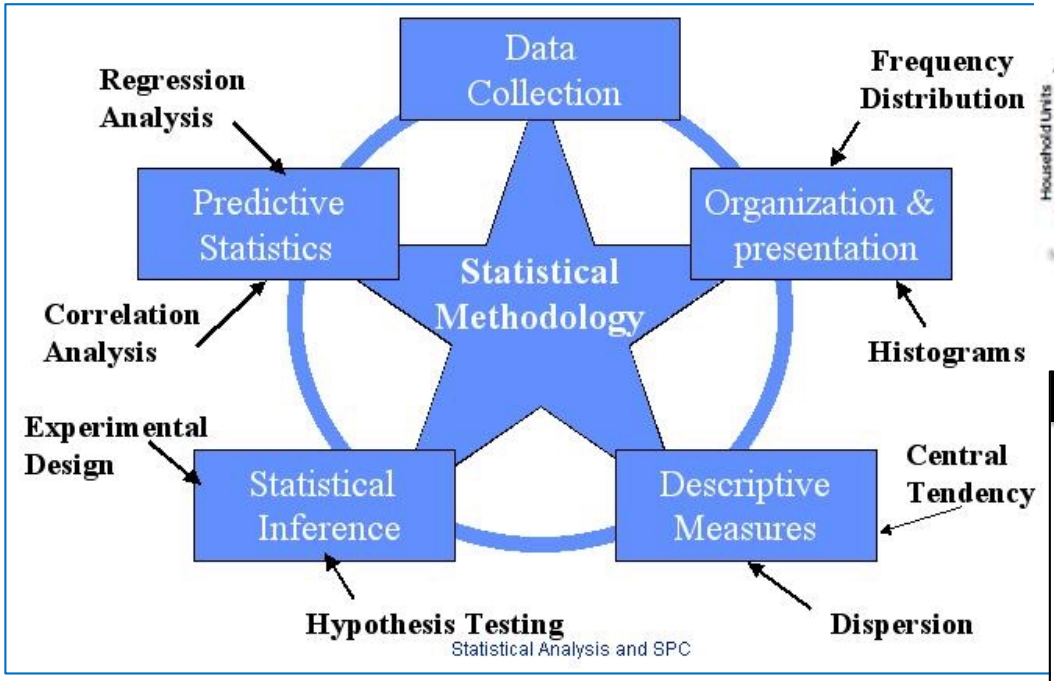
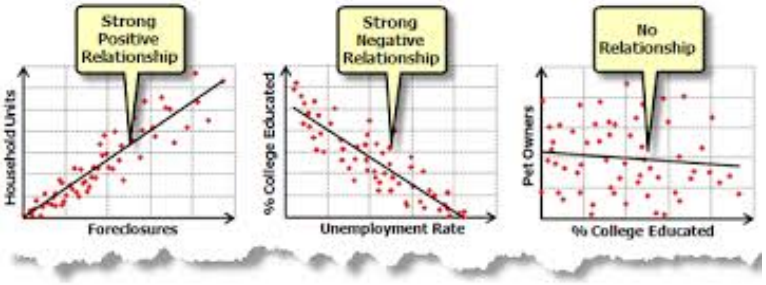


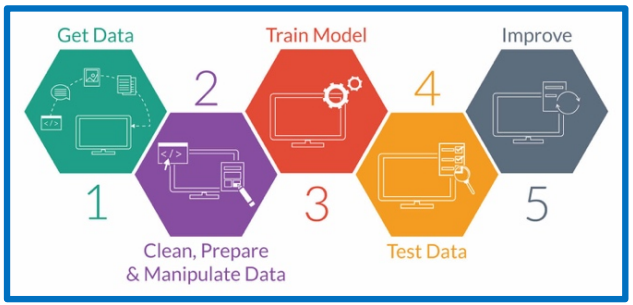
Fig. 3. Illustration of a rise in activity accompanied by a fall in rumination at the point of oestrus

Analysis techniques

- Traditional statistic methods still valid, and useful!

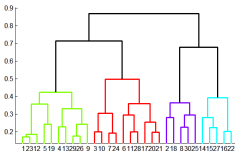


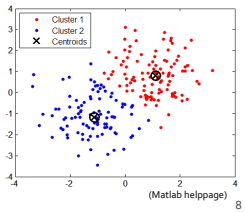




Clustering Analysis

- Definition
  - Grouping unlabeled data into clusters, for the purpose of inference of hidden structures or information
- Dissimilarity measurement
  - Distance : Euclidean(L_2), Manhattan(L_1), …
  - Angle : Inner product, …
  - Non-metric : Rank, Intensity, …
- Types of Clustering
  - Hierarchical
    - Agglomerative or divisive
  - Partitioning
    - K-means, VQ, MDS, …

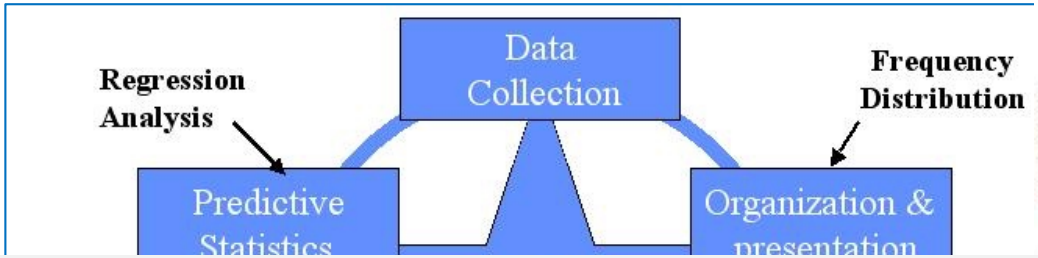


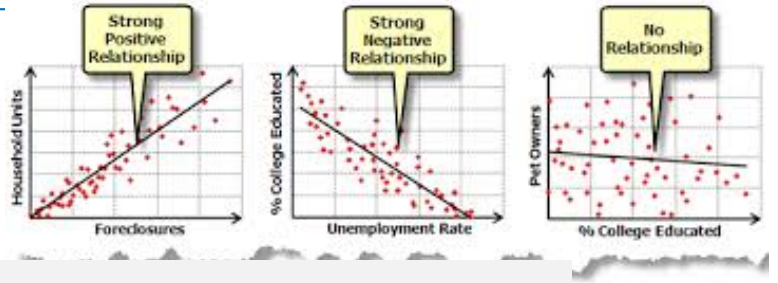


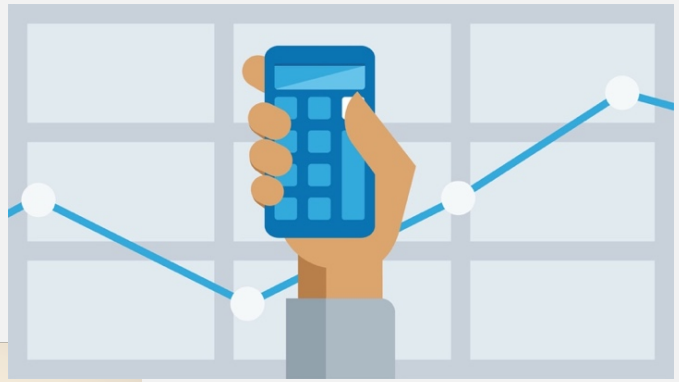
From Jong Youl Choi

Analysis techniques

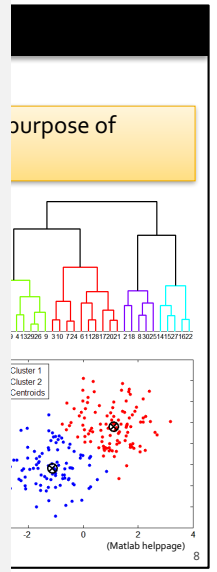
- Traditional statistic methods still valid, and useful!







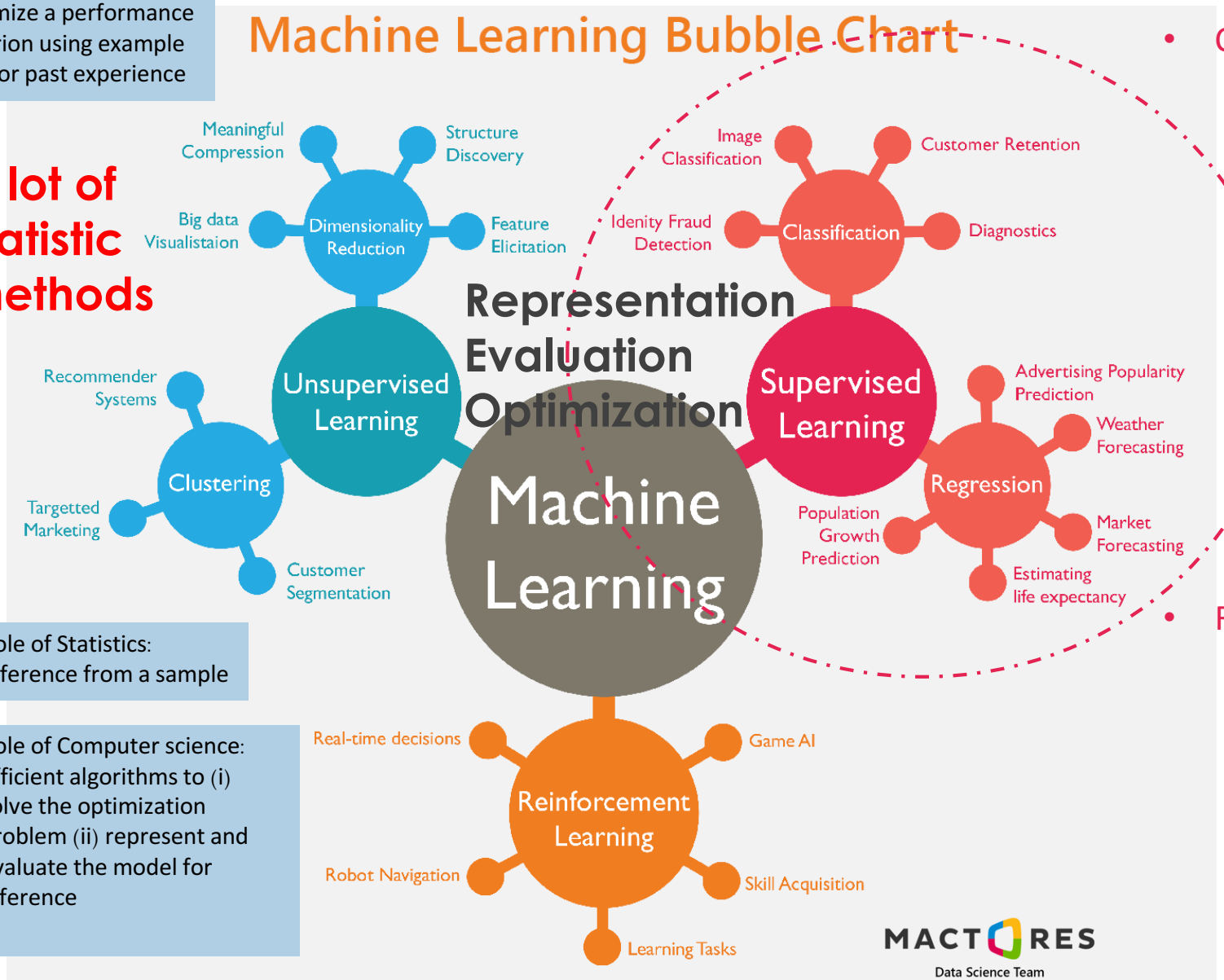
Going old school ?



Machine Learning Techniques

Optimize a performance criterion using example data or past experience

A lot of statistic methods

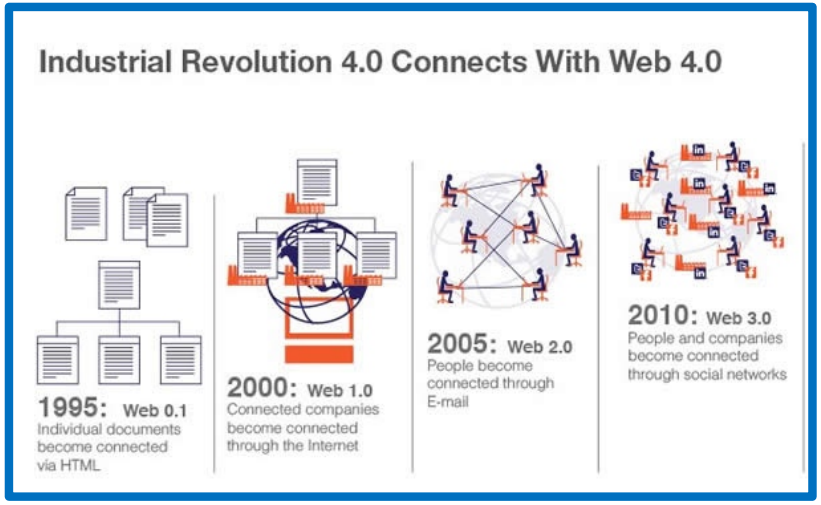


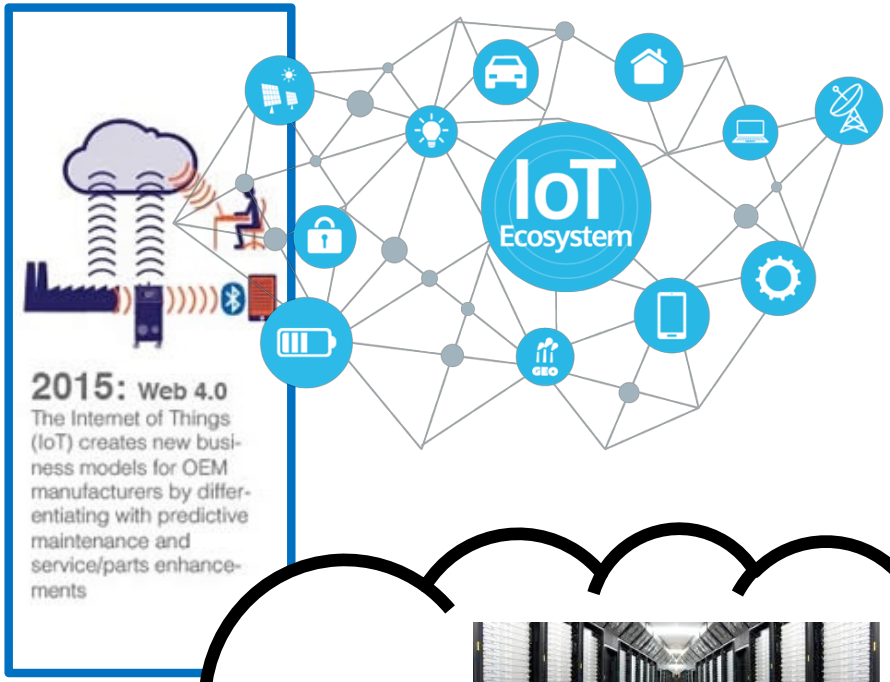
- Classification
  - Logic
  - SVM
  - Random Forest
  - Hidden Markov
  - …
- Regression
  - Lasso
  - Ridge
  - Loes
  - KNN
  - Spline
  - XGBoost
  - …

Role of Statistics: Inference from a sample

Role of Computer science: Efficient algorithms to (i) solve the optimization problem (ii) represent and evaluate the model for inference

Use the full power of the Internet!

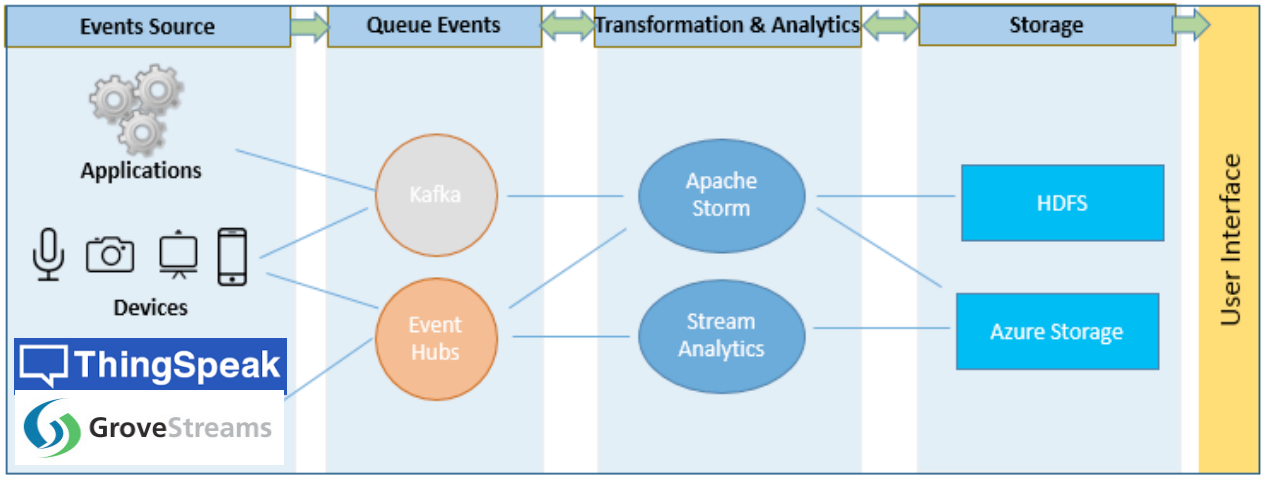




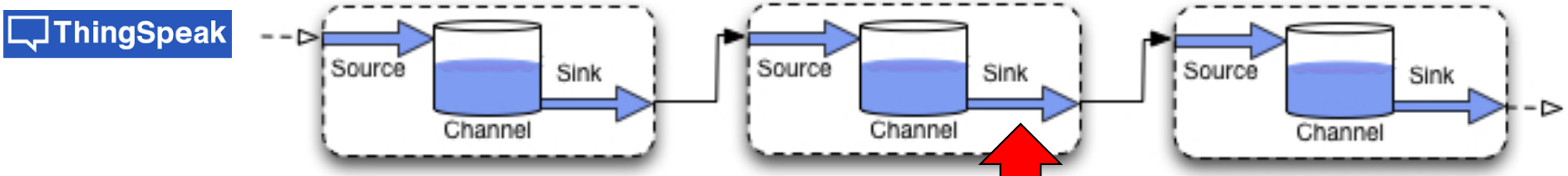
- IoT data are pushed on Internet data clouds
- Computing resources using Virtual Machines are obtained from Internet Computing clouds
- Parallel processing
- Optimized libraries
- Web tools to orchestrate

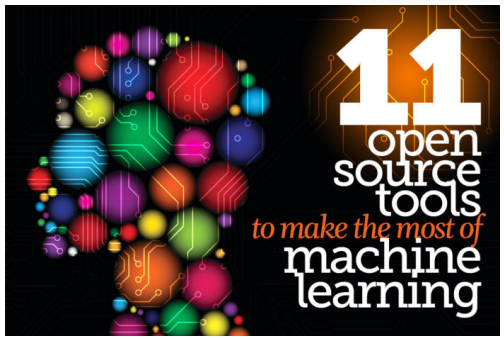
The Big Data landscape

Example: the APACHE ecosystem



SensorCloud™ kafka

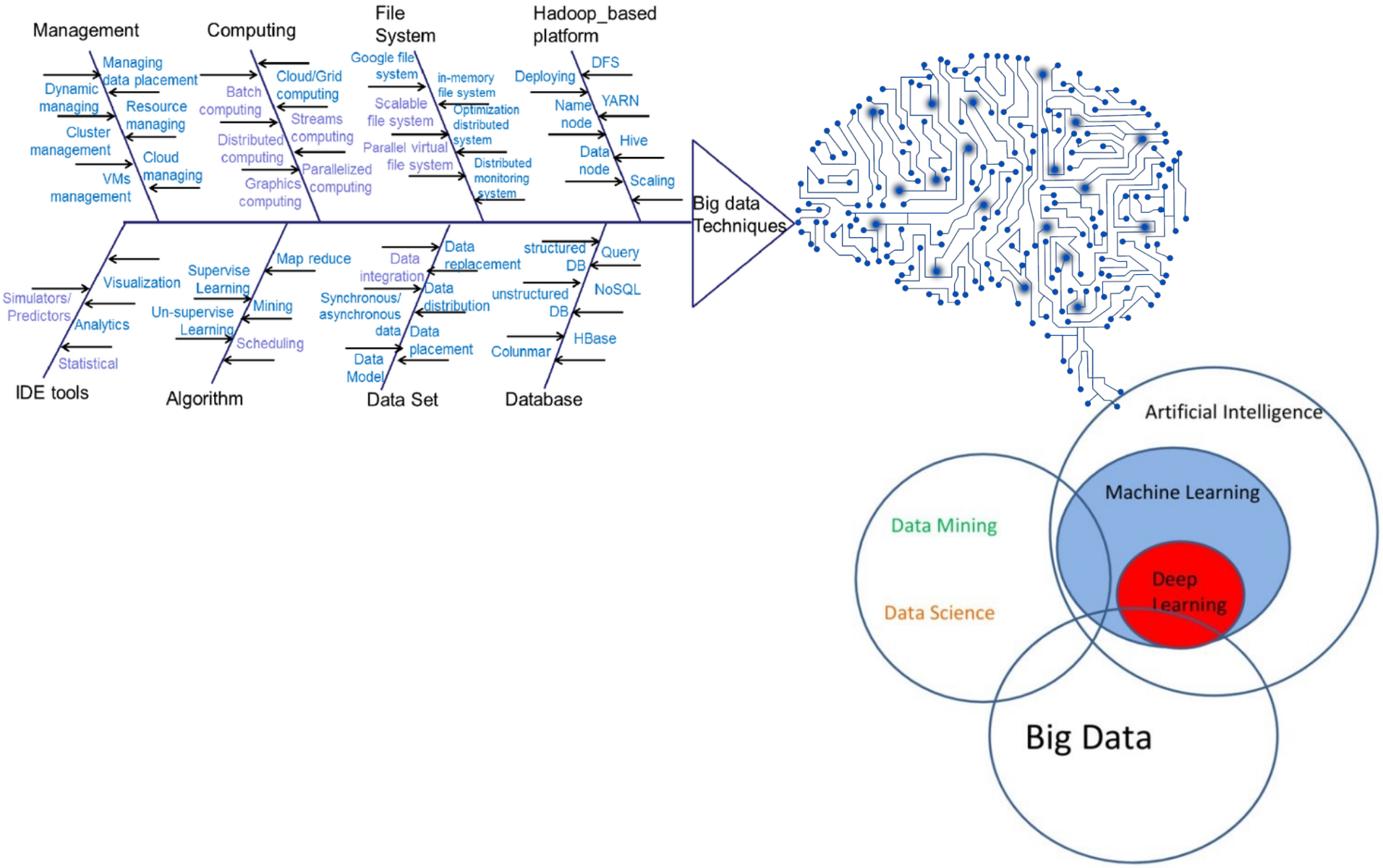




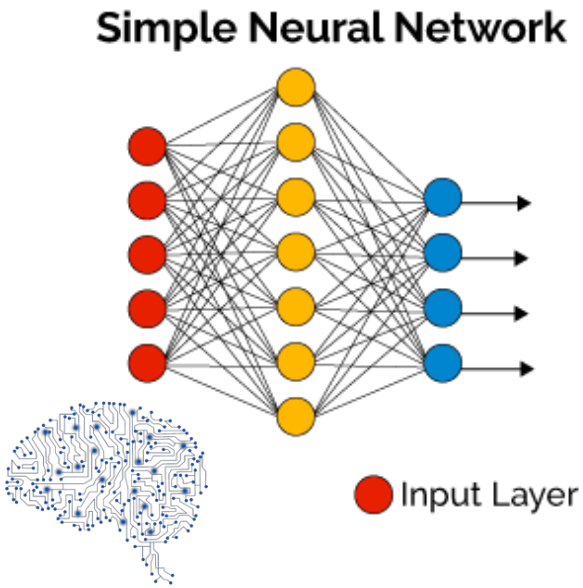
Google
Amazon
Microsoft
IBM
…

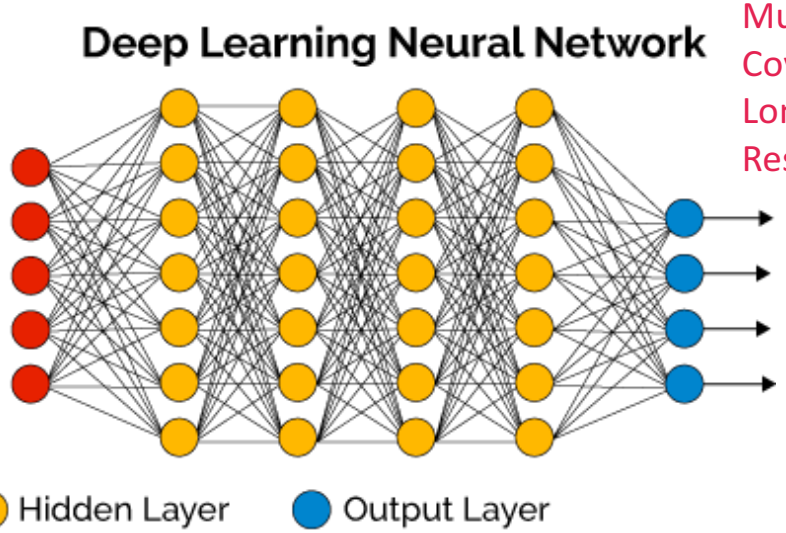
Advanced & customized data management

Beyonds Machine Learning?

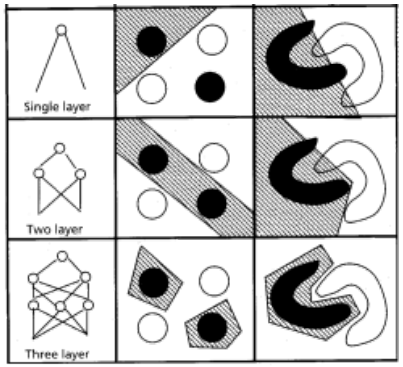


Deep Learning is essentially NN





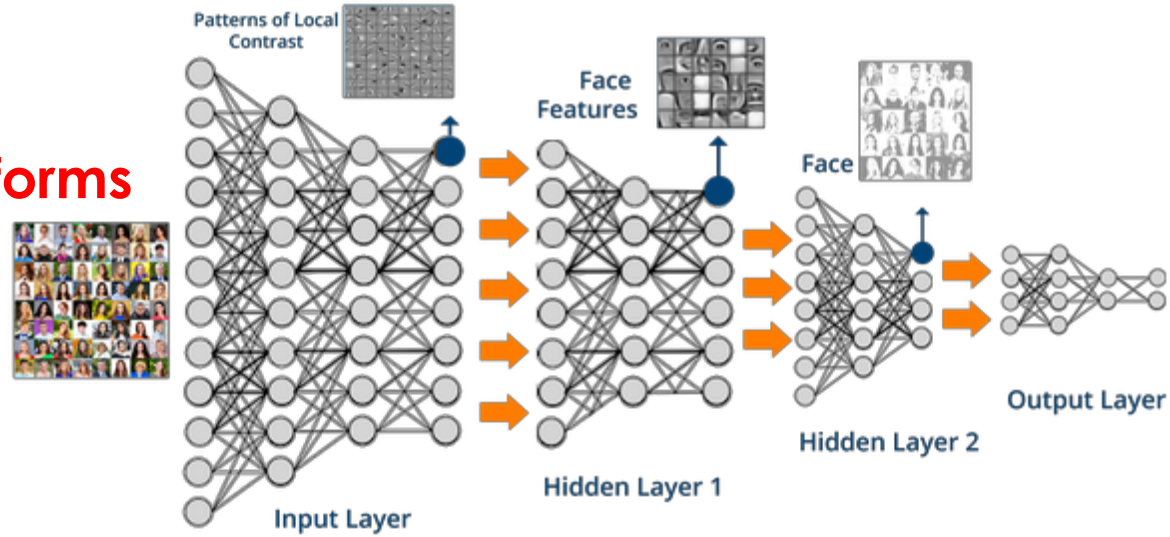
Multilayer Perceptron
Covolutional Neural Nets
Long Short–Term Memory
Restricted Boltzmann Machine



(Jain, 1996)

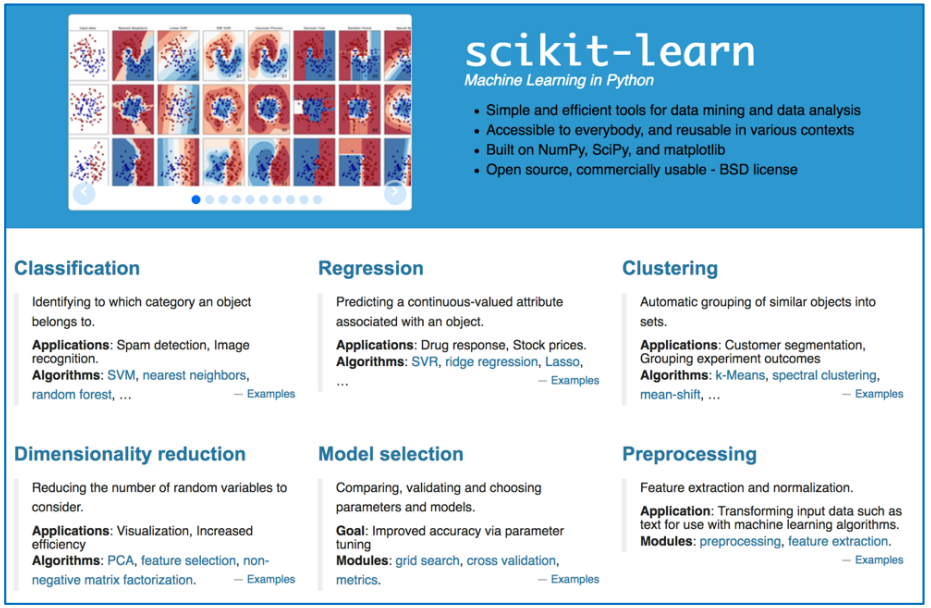
Voice/Face/Patterns recognition on many platforms

- **Facebook**
- **Google Photos**
- **Twitter**
- **Siri**
- **…**



Machine/Deep Learning for scientists

- Large variety of supported languages
  - Python, R, C++, Java, Scala, Javascript, Go, …
- Many statistical methods/algorithms are implemented in libraries
- Examples
  - Scikit-learn
  - Google TensorFlow
  - Microsoft Distributed Machine Learning Toolkit
  - Apache Mahout
  - …
- But, beware
  - There are hundredth of tools…
  - …and new tools every months!



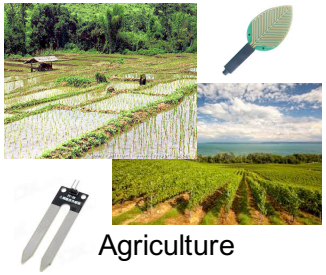
IoT for Development

Irrigation

Livestock farming

Fish farming & aquaculture

Storage & logistic



Agriculture

Environment

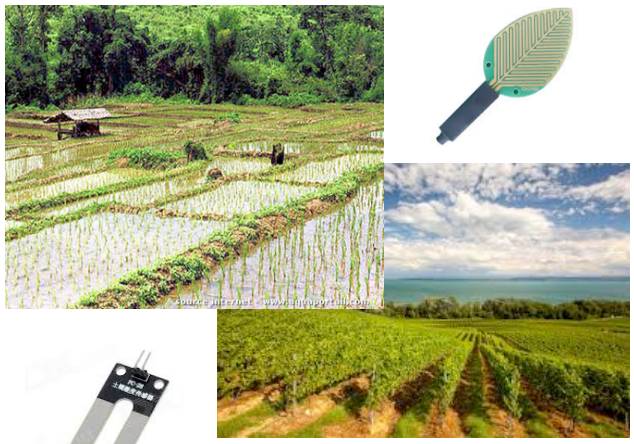
IoT4D: development for rural areas

Irrigation

Livestock farming

Fish farming & aquaculture

Storage & logistic



Agriculture

Environment

Example: IoT in agriculture

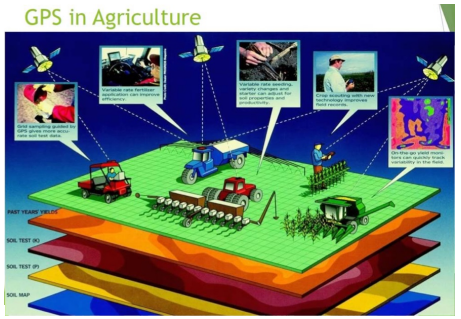
IoT in Agriculture: 5 Technology Use Cases for Smart Farming (and 4 Challenges to Consider)

- **Data, tons of data, collected by smart agriculture sensors,** e.g. weather conditions, soil quality, crop's growth progress or cattle's health. This data can be used to track the state of your business in general as well as staff performance, equipment efficiency, etc.
- **Better control over the internal processes and, as a result, lower production risks**. The ability to foresee the output of your production allows you to plan for better product distribution. If you know exactly how much crops you are going to harvest, you can make sure your product won't lie around unsold.
- **Cost management and waste reduction thanks to the increased control over the production**. Being able to see any anomalies in the crop growth or livestock health, you will be able to mitigate the risks of losing your yield.
- **Increased business efficiency through process automation**. By using smart devices, you can automate multiple processes across your production cycle, e.g. irrigation, fertilizing, or pest control.
- **Enhanced product quality and volumes**. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.

The adoption of IoT solutions for agriculture is constantly growing. Namely, BI Intelligence predicts that the number of agriculture IoT device installations will hit 75 million by 2020, growing 20% annually.
At the same time, the global smart agriculture market size is expected to triple by 2025, reaching $15.3 billion (compared to being slightly over $5 billion back in 2016).

- Climate conditions
- Greenhouse automation
- Plant & soil monitoring
- Fertilizer optimization
- Crop management
- Livestock monitoring
- End-to-end farm mngt
- …

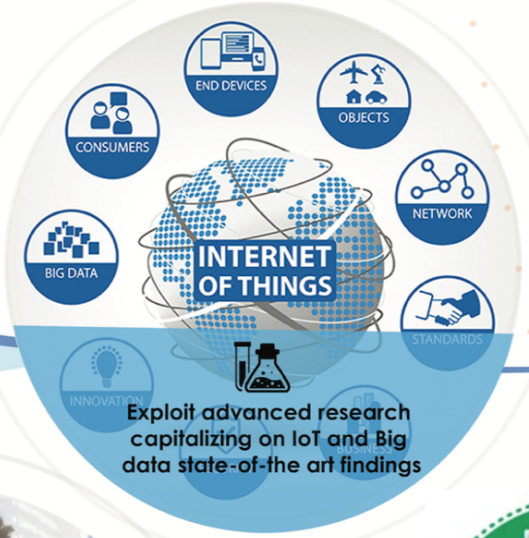
Most of existing system are not adapted for small holders



WAZIUP Open IoT and Big data platform for Africans, by Africans

HORIZON 2020

Affordable technologies to empower rural economics



Exploit advanced research capitalizing on IoT and Big data state-of-the art findings

Develop IoT solutions and applications meeting African needs

DO MORE with LESS

www.waziup.eu

Waziup IoT

Waziup IoT

Waziup

Waziup

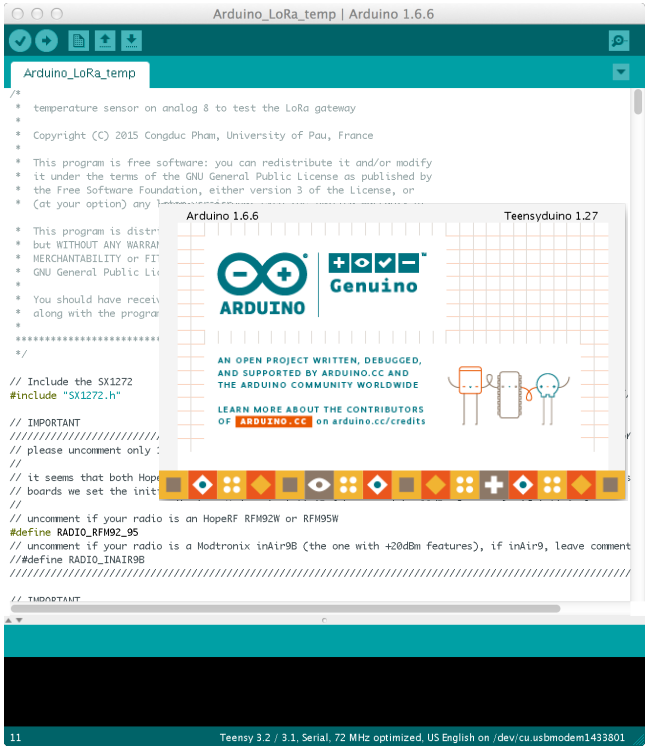
CREATE-NET · CTIC · Farmerline · iSpace · coders africa · INNOTEC

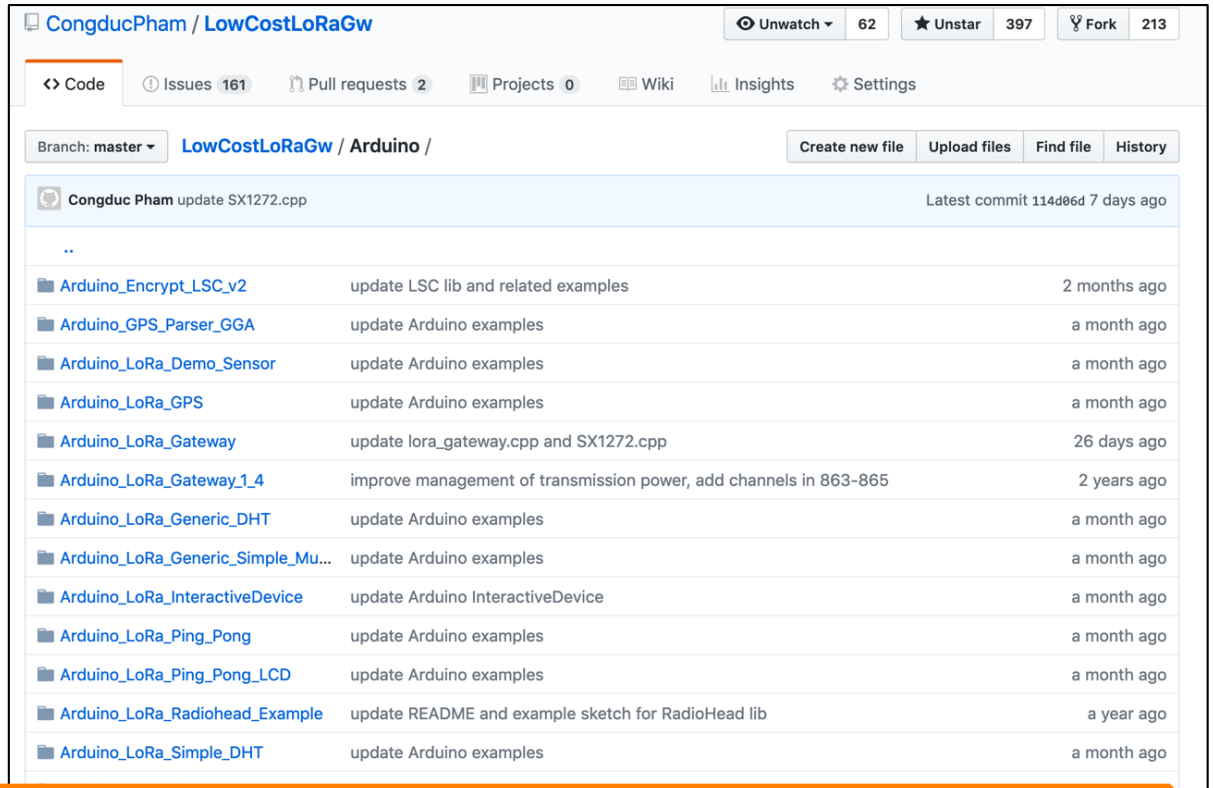
waziup.community@create-net.org

IoT in developing countries and rural areas

- Developing countries/rural areas are still far from being ready to enjoy the smallest benefit of IoT
  - lack of infrastructure
  - high cost of hardware
  - complexity in deployment
  - lack of technological eco-system and background
- **to deploy IoT in developing countries, it is necessary to target three major issues**
  - **reduce cost of infrastructures, hardware and services**
  - **limit dependancy to proprietary infrastructures and provide local interaction models**
  - **target technology appropriation, push for local business models**

100% open-source code templates

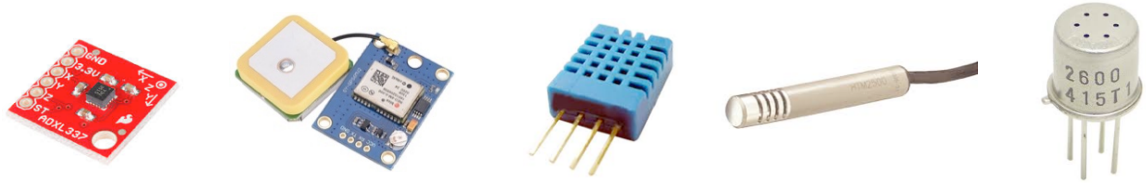




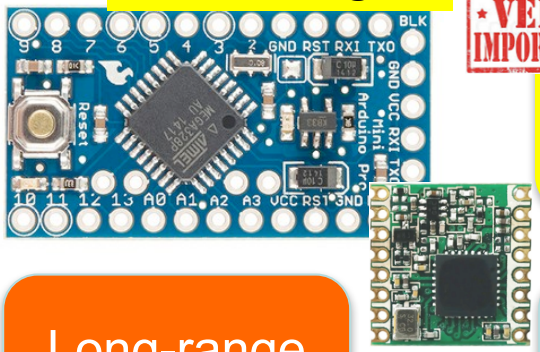
LowCostLoRaGw github has latest general distribution:
https://github.com/CongducPham/LowCostLoRaGw
Many examples using various temp/hum sensors
https://github.com/CongducPham/LowCostLoRaGw/tree/master/Arduino

Reduce development cost & time

Physical sensor | Physical sensor | Physical sensor



Arduino Pro Mini @3.3V



Physical sensor mgmt

VERY IMPORTANT

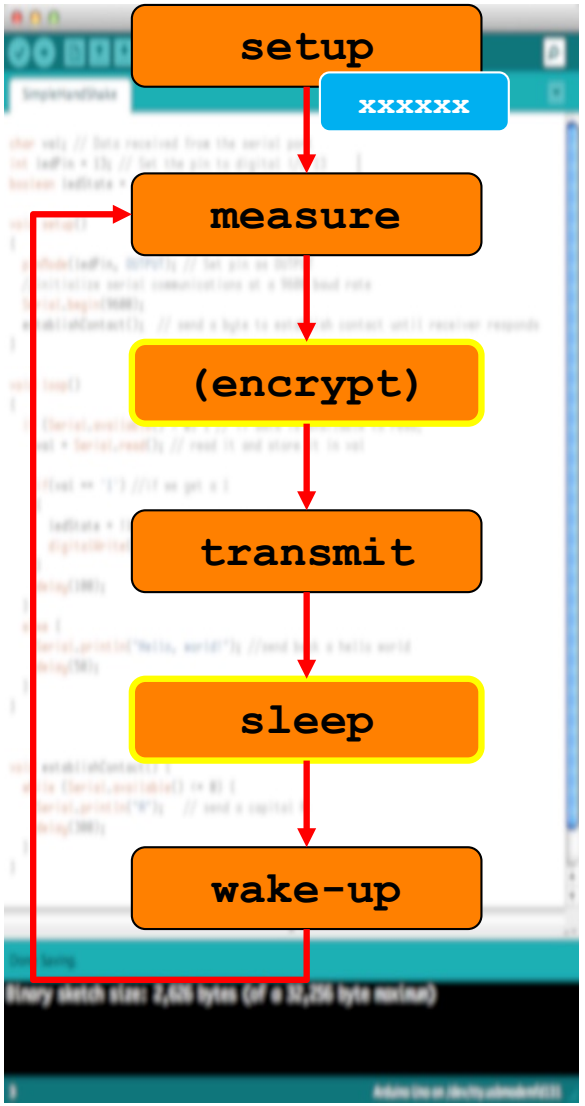
Activity duty-cycle, low power

VERY IMPORTANT

AES encryption

Long-range transmission

Logical sensor mgmt



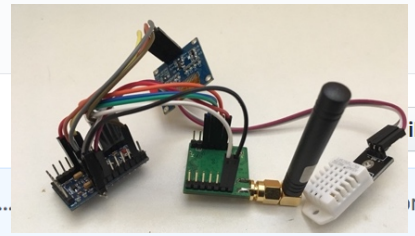
Large variety of examples to learn and adapt

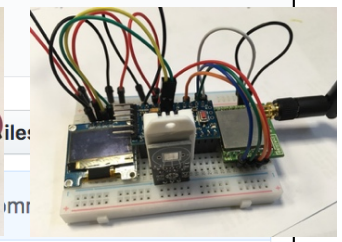
CongducPham / LowCostLoRaGw

Unwatch 49 | Unstar 216 | Fork 120

Code | Issues 96 | Pull requests 2 | Projects 0 | Wiki

Branch: master ▾ LowCostLoRaGw / Arduino /





Congduc Pham update README files, fix MD5 digest computation of gw id, always use ...

..	
Arduino_LoRa_GPS	update README
Arduino_LoRa_Gateway	update gateway r
Arduino_LoRa_Gateway_1_4	improve managen
Arduino_LoRa_Generic_Sensor	update Arduino ex
Arduino_LoRa_InteractiveDevice	update Arduino ex
Arduino_LoRa_Ping_Pong	update Arduino ex
Arduino_LoRa_Simple_BeaconCol...	update Arduino ex
Arduino_LoRa_Simple_SoilHum	update Arduino ex
Arduino_LoRa_Simple_temp	update Arduino ex
Arduino_LoRa_SoilHum	update Arduino ex
Arduino_LoRa_temp	update Arduino ex
Arduino_LoRa_ucamII	update image sup
libraries	update README f
README.md	update README 19 days ago

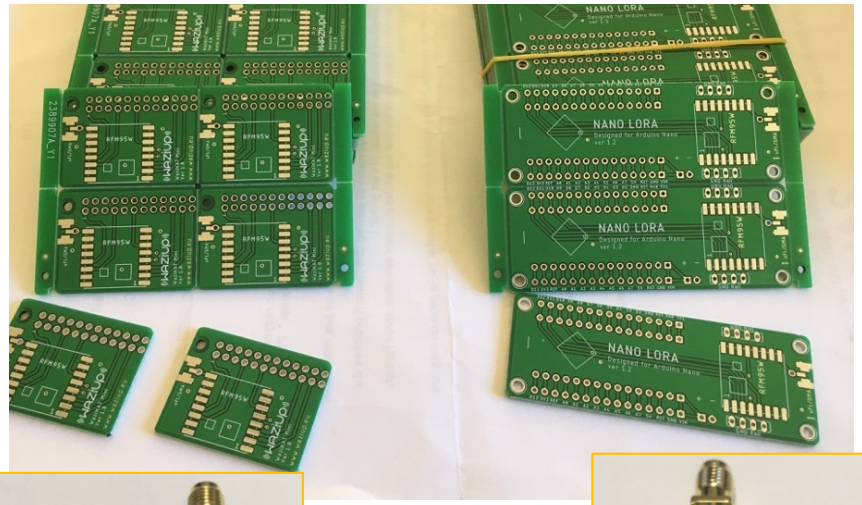
`Arduino_LoRa_Demo_Sensor` is a very simple demo sketch for training purpose. The main program, i.e. `Arduino_LoRa_Demo_Sensor` can be left unchanged by the students. They just have to add/modify code in `my_demo_sensor_code.h` and `my_demo_sensor_code.cpp` to adapt the code for a given physical sensor. The provided example reads from either an LM35DZ or a TMP36 analog temperature sensor. The sensor is connected on pin A0 and is powered with digital pin 9.

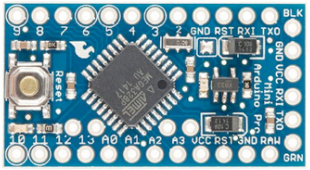
`Arduino_LoRa_Simple_temp` uses the same simple structure than `Arduino_LoRa_Demo_Sensor` where `my_temp_sensor_code.cpp` contains the code to read values from the physical sensor (which is still either an LM35DZ or a TMP36 analog temperature sensor). Additionally, this example illustrates how to implement periodic sensing with low-power mode to run on battery for years. The sensor is connected on pin A0 and is powered with digital pin 9.

`Arduino_LoRa_Simple_DHT` shows how a more elaborated digital sensor such as the DHT22 (also known as AM2302) can be used. Code for DHT sensor is provided by the DHT library by Adafruit. This example therefore shows how you can use libraries provided by third-parties which is most likely the approach that you will use if you need to support a new physical sensor. Note that the DHT code can also be used for the AM2305 sensor. One advantage of the AM2305 is that it usually comes in an outdoor casing which make it suitable for outdoor and real-world deployment scenarios. Note that as it is a very simple example, only one physical measure is provided. In the example, it is the temperature even if the DHT22 sensor can provide both temperature and humidity. The sensor is connected on pin A0 and is powered with digital pin 9.

`Arduino_LoRa_temp` ends the simple temperature example serie. It illustrates a more complex example with AES encryption and the possibility to send LoRaWAN packet. It can also open a receive window after every transmission to wait for downlink message coming from the gateway (to do so, uncomment `#define WTH_RCVW`). The template shows for instance how an '/@Ax#' command from the gateway can be parsed to set the node's address to 'x'. It can serve as a template for a more complex LoRa IoT device with actuation capability on downlink packets from the gateway. The sensor is connected on pin A0 and is powered with digital pin 9.

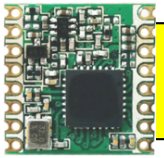
Simple PCBs make it much easier for developers



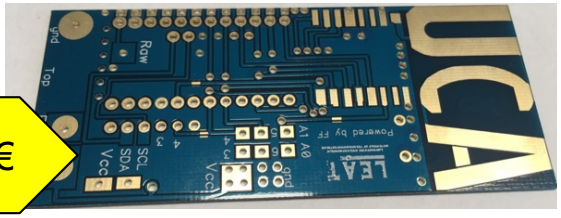


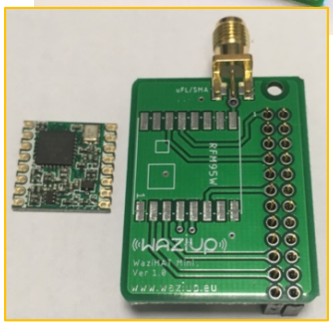
1.5€

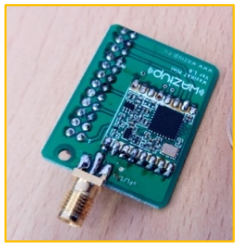
https://github.com/FabienFerrero/UCA_Board

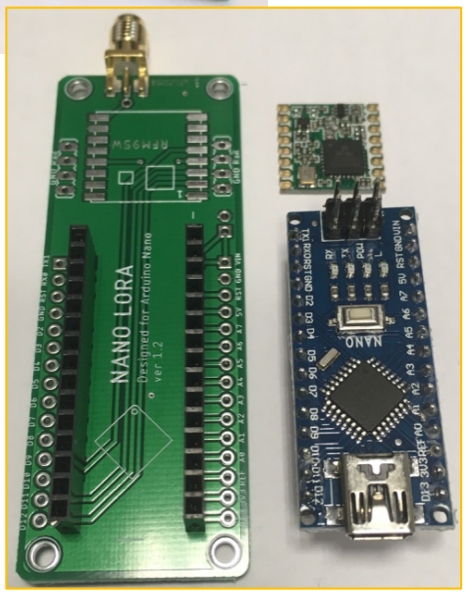


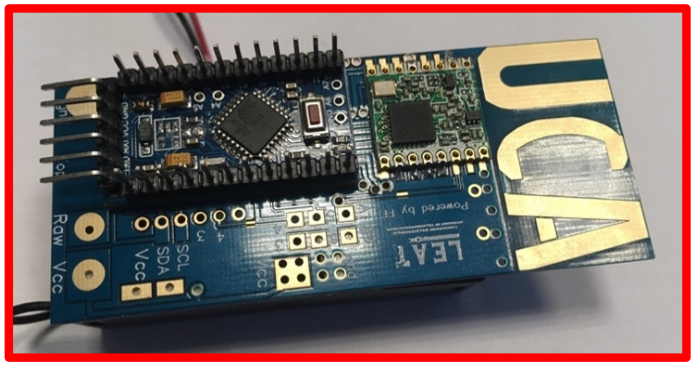
5€

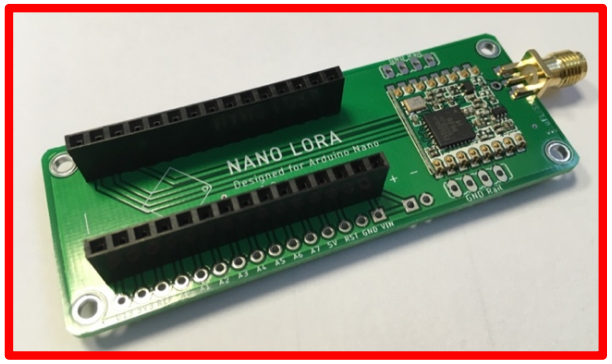


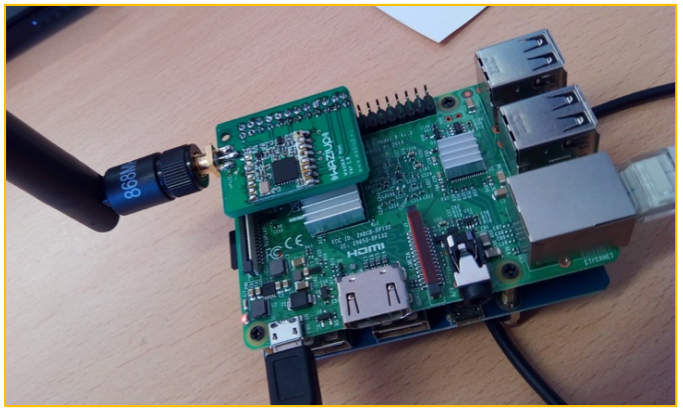












Tutorials/docs and videos

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

PROF. CONGDUC PHAM
HTTP://WWW.UNIV-PAU.FR/~CPHAM
UNIVERSITÉ DE PAU, FRANCE

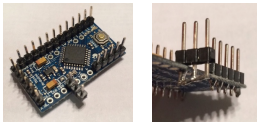
Congduc Pham, http://cpham.perso.univ-pau.fr

http://www.waziup.eu

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 8MHz version** of the Arduino Pro Mini for lower power consumption

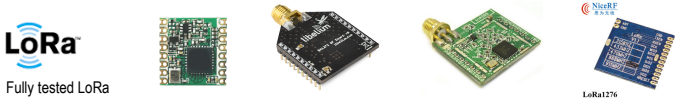


You can get the original board designed by Sparkfun or get one of the various clones available mainly from Chinese manufacturer. The last solution is very cost-effective as the Pro Mini board can be purchased for a bit more than 1€ a piece.

Depending on how many sensors you want to connect, the number of ground (GND) pins may be limited. You can extend a GND pin with a header pin where all pins are soldered together.

The LoRa radio module

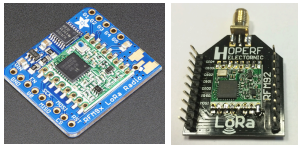
There are various LoRa radio modules that are all based on the Semtech SX1272/1276 chips family



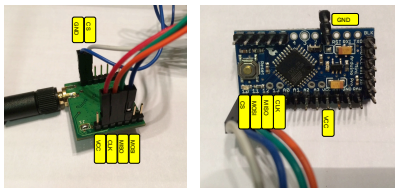
Fully tested LoRa radio modules | HopeRF RFM92W/95W | Libelium LoRa | Modtronix inAir4/9/9B | NiceRF LoRa1276

Most of SPI-based LoRa radio modules are supported. We recommend the Modtronix inAir model if you don't have delicate soldering experience as this module can come with header pins ready to be connected with Dupont wires.

The RFM95W can be found assembled (Adafruit) or an adapter can be purchased (from Ideetron for instance)



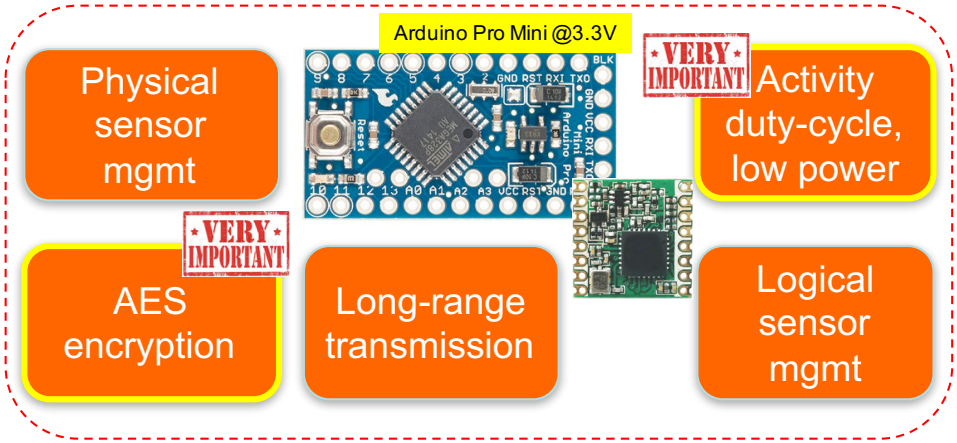
Connect the LoRa radio module

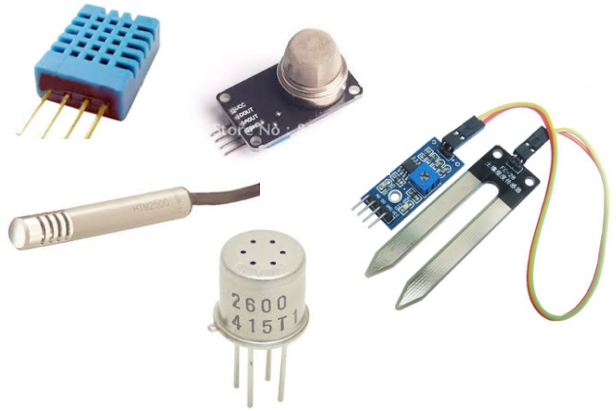


Connect the corresponding SPI pins of the radio module to the SPI pins on the Pro Mini board. MOSI (blue) is pin 11, MISO (green) is pin 12, CS (white) is pin 10 and CLK (orange) is pin 13 (right picture). Then connect also the VCC (red) and the GND (black) of the radio module to the VCC and the GND of the board (right picture). The VCC of the Pro Mini board gets 3.3v from the on-board voltage regulator.

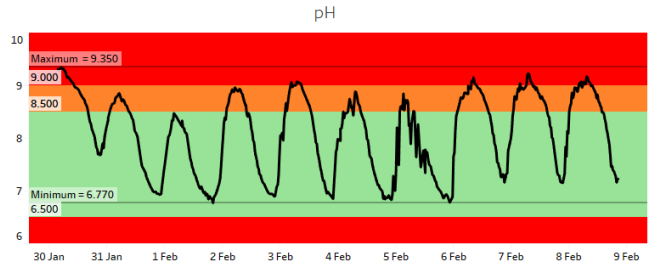
Generic sensing IoT device v.s. Highly specialized

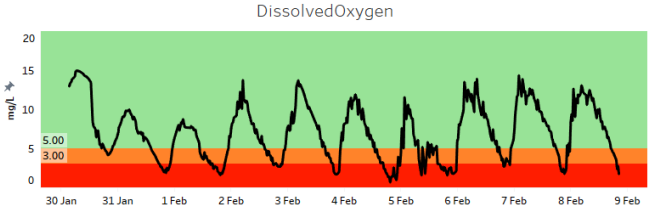
- Build low-cost, low-power, **long-range** enabled generic platform
- Methodology for low-cost platform design
- Technology transfers to user communities, economic actors, stakeholders,…

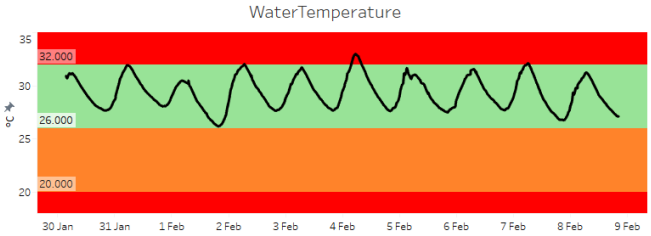




Low-cost buoy for fish farming MVP

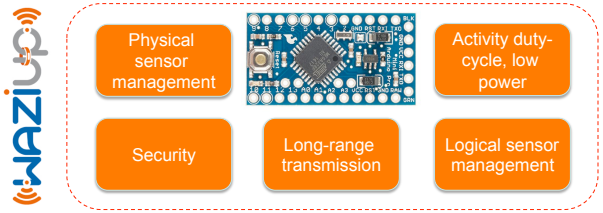




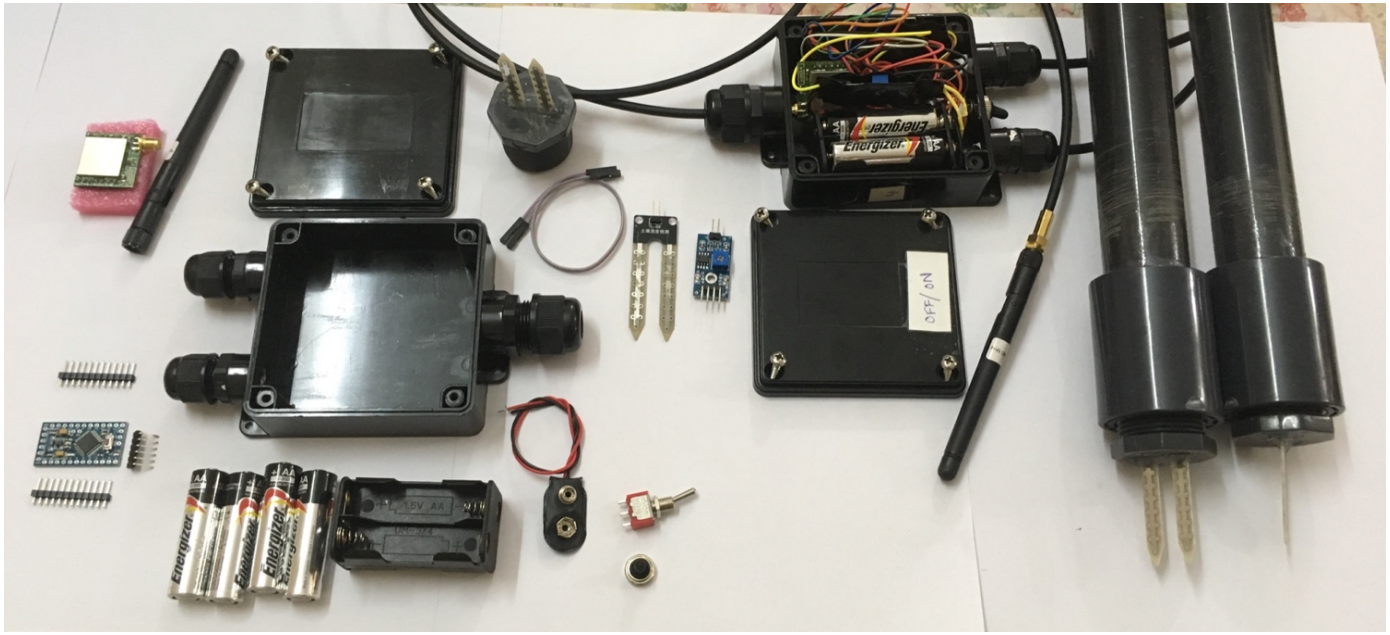


Physical sensor reading

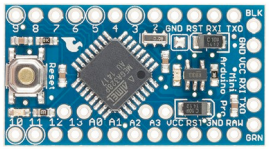
Credit: EGM



Soil humidity sensors for agri MVP



Physical sensor management



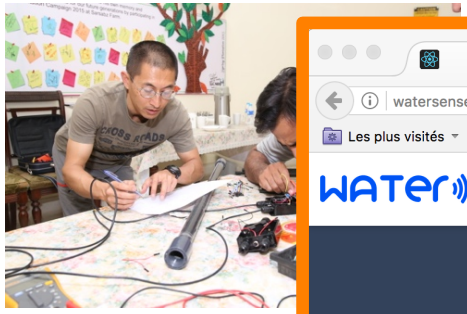
Activity duty-cycle, low power

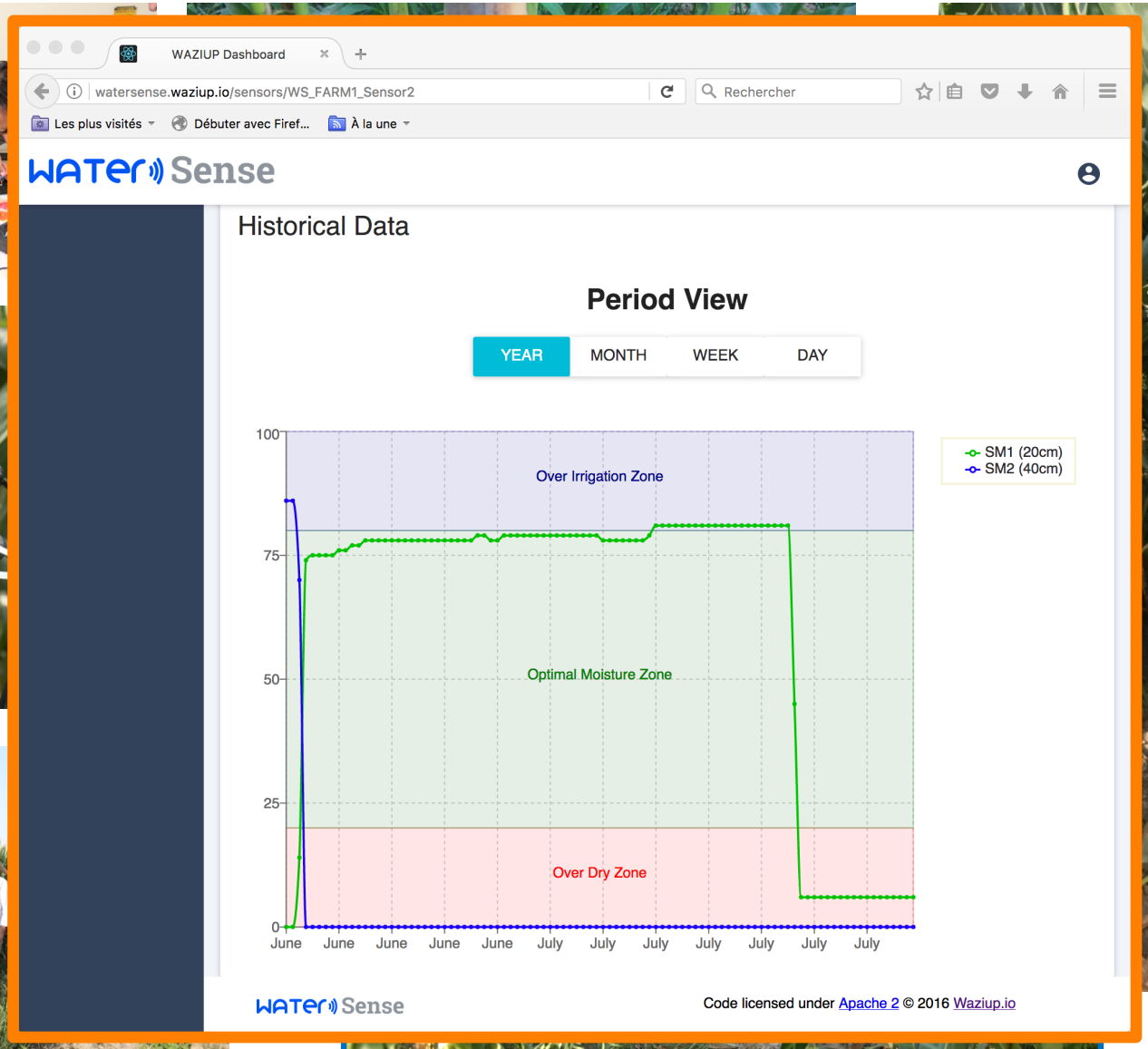
Security

Long-range transmission

Logical sensor management

Deployment for Nestlé's WaterSense project





Local weather station for AGRI MVP

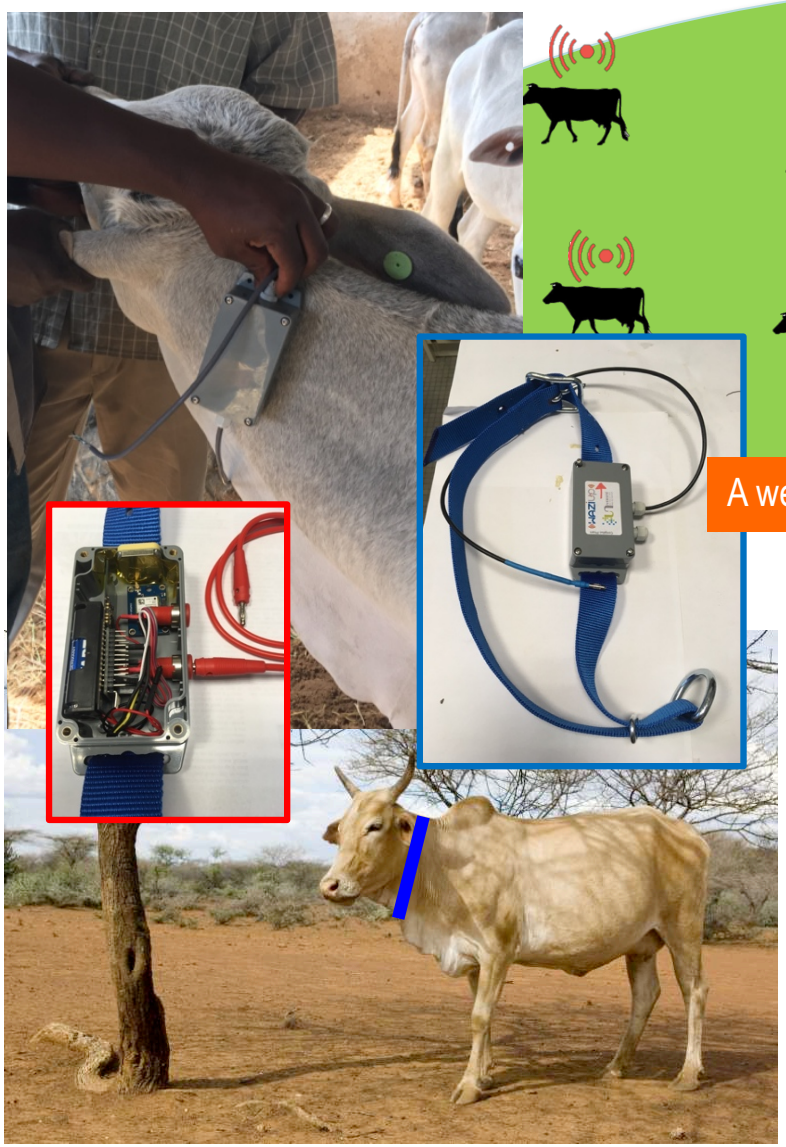
https://openweathermap.org/

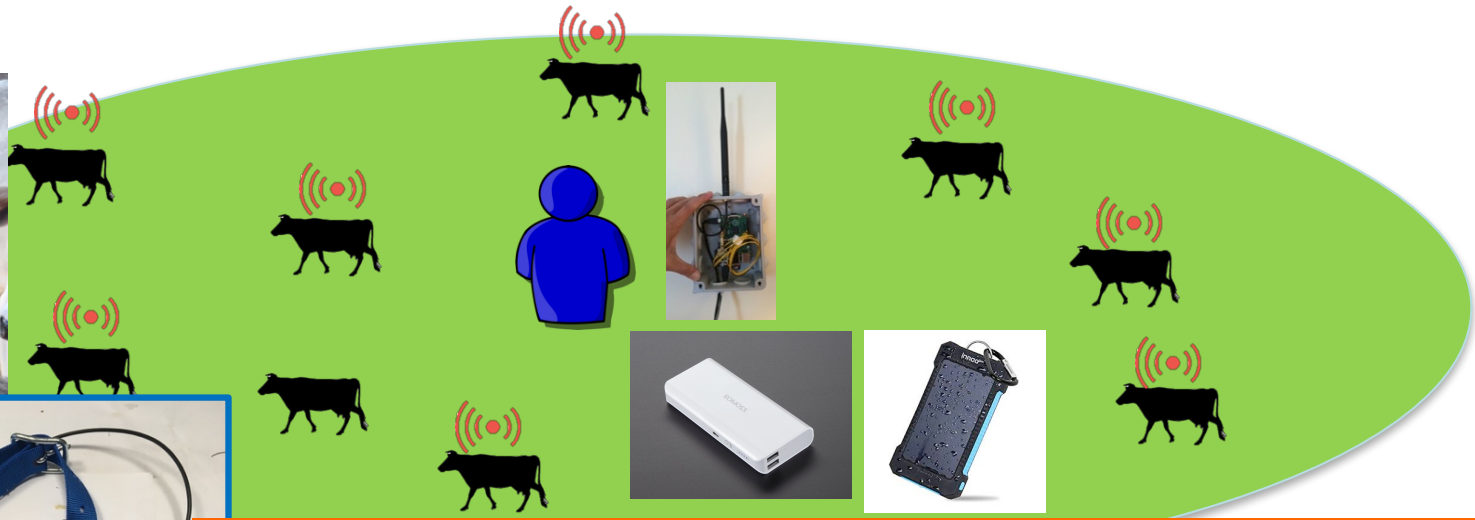
Photo from Unparallel

Get local weather measuments

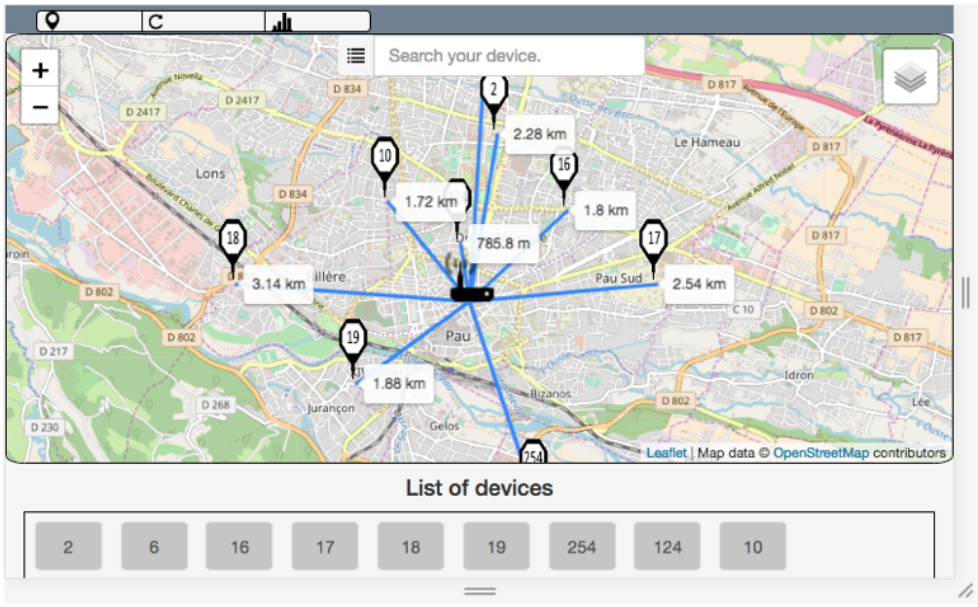
Combine with open weather data to get more accurate predictions

Collar for Cattle Rustling MVP



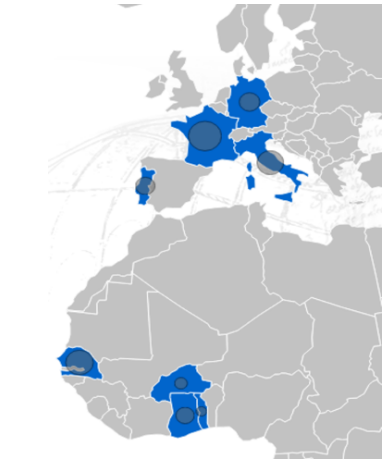


A web interface displays the position of the gateway those of the remote GPS devices



Scaling up!

Feb 2016 - 2019



May 2018 - 2021

Thanks.

Let's keep in touch

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