

INTRODUCING THE CONCEPTS & TECHNOLOGIES OF INTERNET-OF-THINGS

WAZIHUB ENTREPRENEUR TRAINING EVENT
HIVE COLAB, KAMPALA, UGANDA
MAY 5TH, 2018

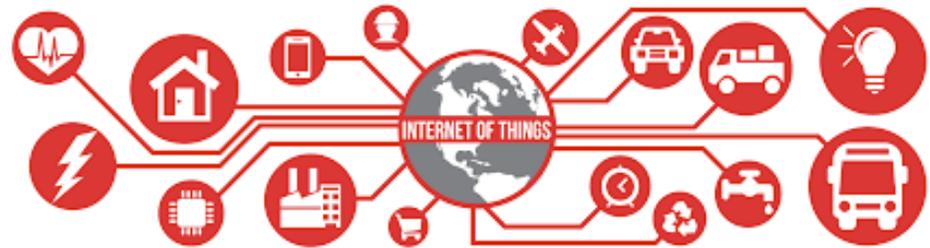
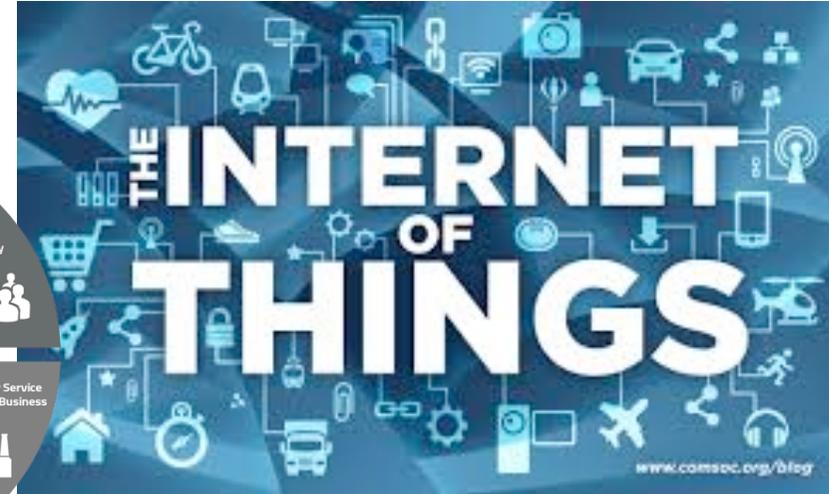
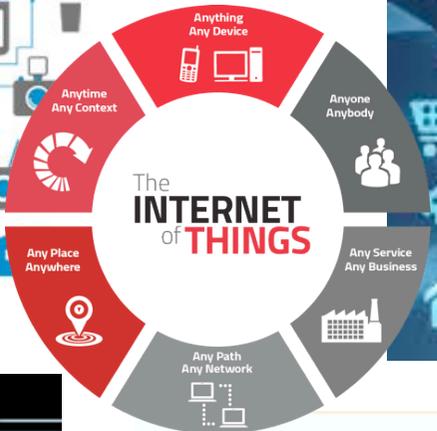


Accelerating Open IoT and Big Data
Innovation in Africa

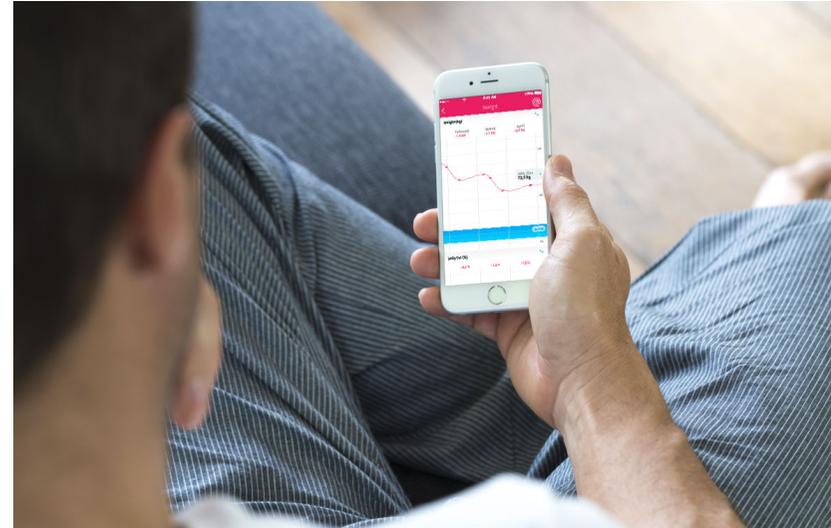


PROF. CONGDUC PHAM
[HTTP://CPHAM.PERSO.UNIV-PAU.FR/](http://cpham.perso.univ-pau.fr/)
UNIVERSITÉ DE PAU, FRANCE
CONGDUC.PHAM@UNIV-PAU.FR

typically shows communicating objects



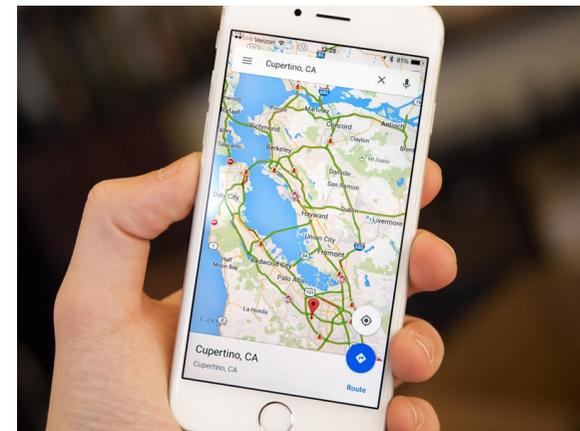
Home/consumer IoT products



IoT & physical world



Waste Container connected sensor



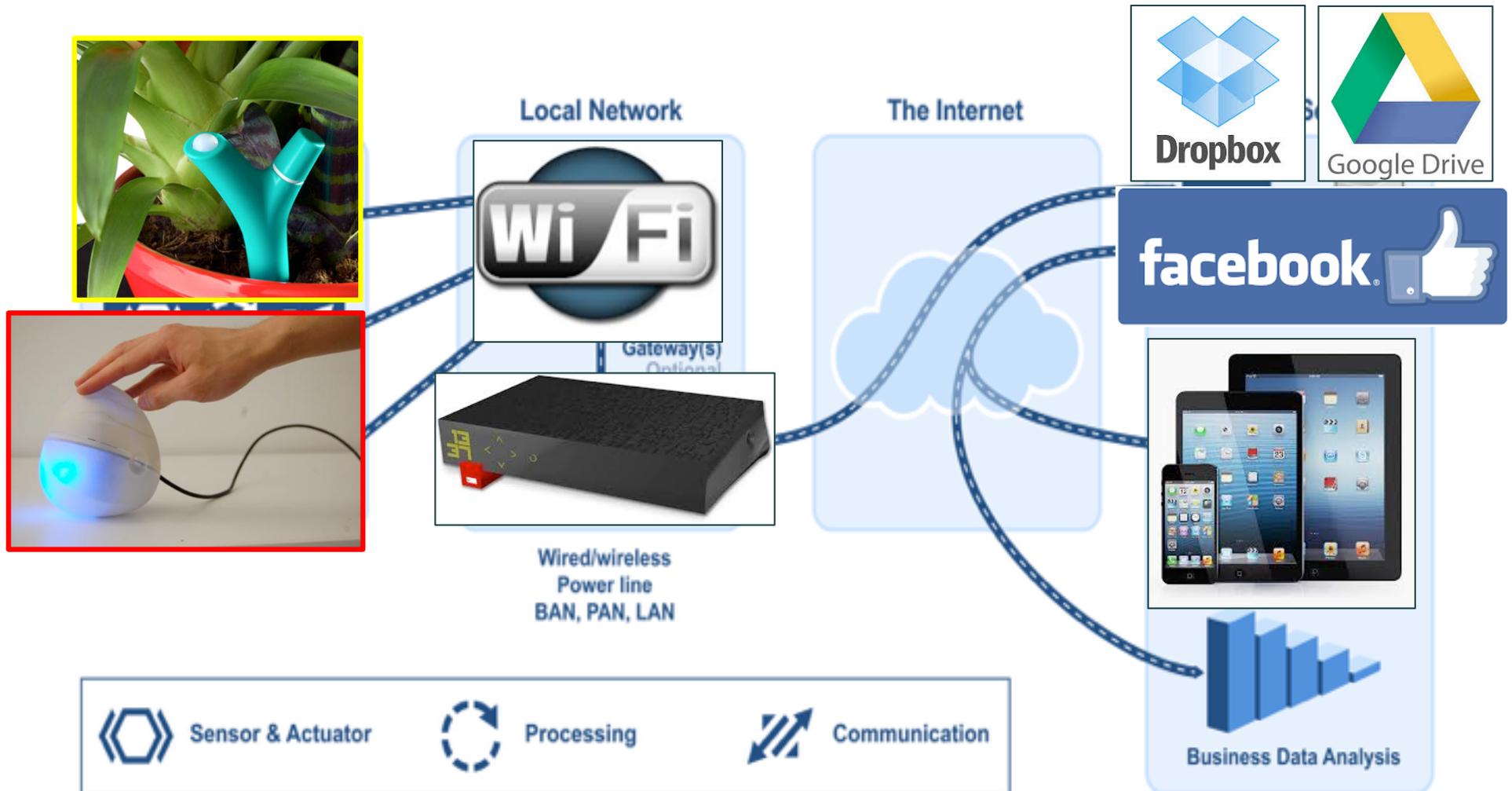
Local interaction is possible



But IoT usually means cloud data



General public IoT architecture



Pictures from ArchitectCorner

Dedicated IoT cloud



Using ThingSpeak



ThingSpeak Channels Apps Blog Support

User: cpham

 **Test LoRa UPPA**

Channel ID: **66583**
 Author: **cpham**
 Test of LoRa gateway at University of Pau, France

 Test, lora, uppa

19.6



Node 10

ThingSpeak Channels Apps Community Support Commercial Use How to Buy Sign In Sign Up

WAZIUP LORA Demo channel

Channel ID: 123986 | WAZIUP LORA Demo channel
 Author: cpham64
 Access: Public

Data Export

Field 1 Chart

Temperature from demo devices (HCMUTCS)

Field 2 Chart

Temperature from demo devices (SUTSCDF)

Field 3 Chart

Temperature from demo device at ENSA, Safi (DHT22)

Field 4 Chart

Humidity from demo device at ENSA, Safi (DHT22)

Field 5 Chart

Temperature from demo device at UMMISCO, Yaoundé (DHT22)

Field 6 Chart

Humidity from demo device at UMMISCO, Yaoundé (DHT22)

Using



Browser address bar: <https://www.grovestreams.com/observationStudio.html?org=7a5de802-5d71-319>

Page Title: University of Pau

Component Studio | Admin | (0,6,0)

Observation Studio

Components: sensor3, temp, sensor6

temp

| Row | Time | Value |
|-----|--------------|-------|
| 1 | 22:26:03.633 | 25.87 |
| 2 | 22:23:40.604 | 25.87 |
| 3 | 22:21:35.489 | 25.87 |
| 4 | 22:17:32.907 | 25.87 |
| 5 | 22:15:41.998 | 25.87 |
| 6 | 22:11:40.452 | 23.43 |
| 7 | 22:07:36.184 | 23.43 |
| 8 | 22:03:33.273 | 22.94 |
| 9 | 21:59:33.532 | 23.43 |
| 10 | 21:55:28.121 | 23.92 |
| 11 | 21:51:22.015 | 22.94 |
| 12 | 21:47:22.836 | 23.92 |
| 13 | 21:45:17.126 | 23.92 |
| 14 | 21:41:13.750 | 22.94 |

Chart Type

Quick View

temp **25.87**
Last updated 22:27:57 (3m 59s ago) 22:27:57

Refresh

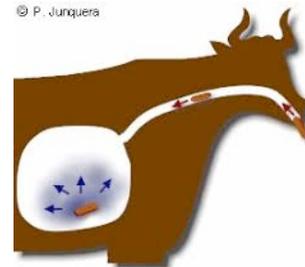
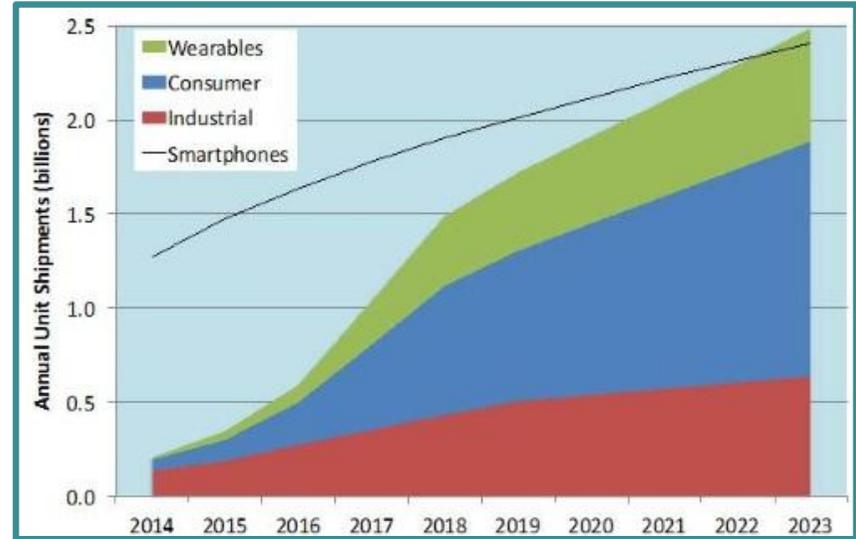
The WAZIUP/WAZIHUB cloud



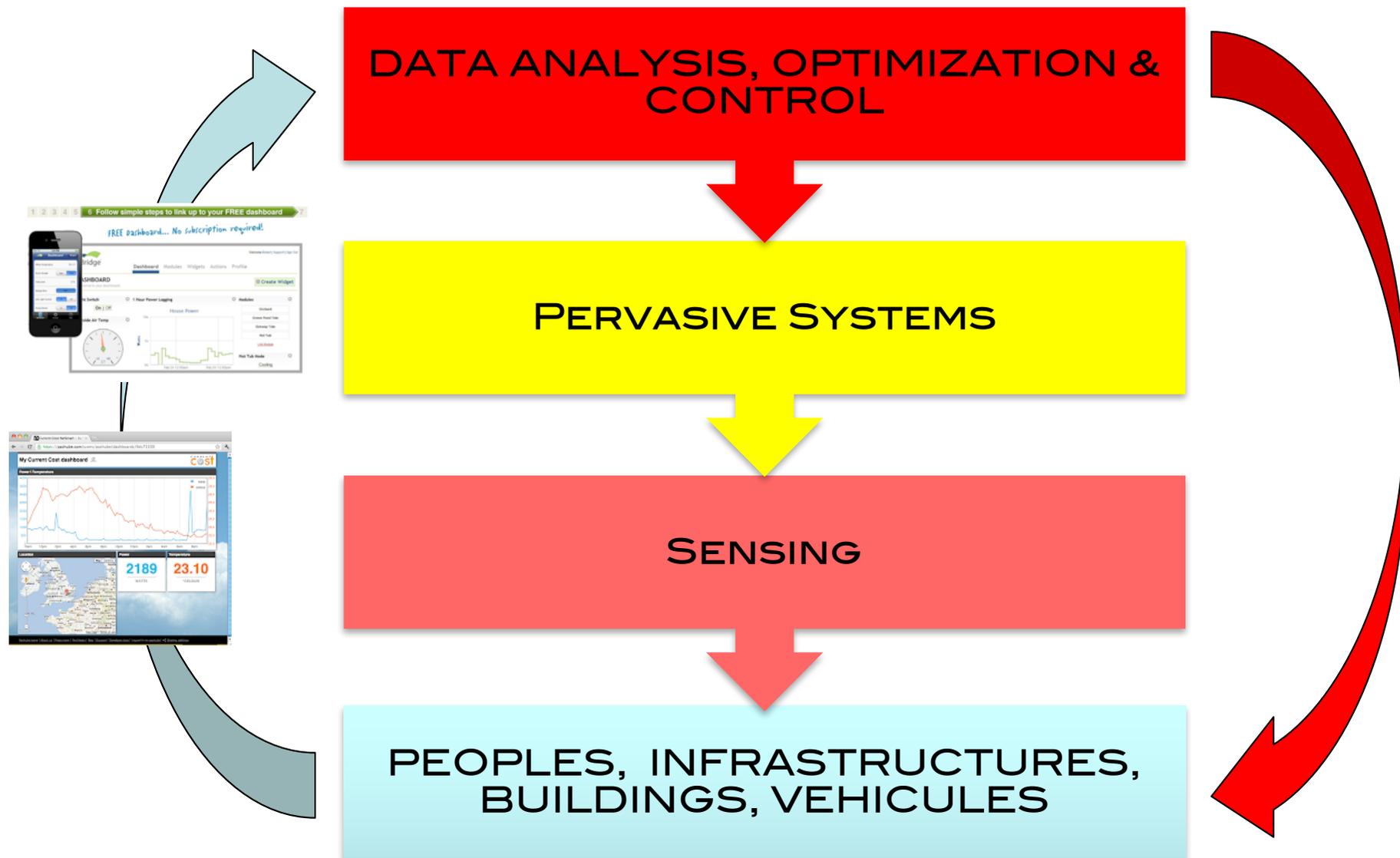
□ dashboard.waziup.io

The screenshot displays the WAZIUP dashboard interface. At the top, the browser address bar shows 'dev.waziup.io:3000/sensors'. The main content area is titled 'Domain waziup-UPPA-TESTS2' and lists three sensor nodes. The first node, 'Node UPPA Sensor 6', shows a temperature of 17.21 °C. The second node, 'Node (UPPA_Sensor3)', shows a temperature of 21.43. The third node, 'Node (UPPA_Sensor10)', shows a temperature of 23.97. A detailed view of 'UPPA Sensor 6' is shown on the right, featuring a 'Temperature' gauge with a needle pointing to 17.21 °C and a small line graph. Below the gauge is a 'Location' map of France and surrounding regions, with a blue pin indicating the sensor's location near Bordeaux. The map includes labels for various cities and regions like Paris, Nantes, Bordeaux, and Marseille. The dashboard also includes navigation buttons like 'EDIT', 'ADD MEASUREMENT', and 'DELETE' for the sensor details.

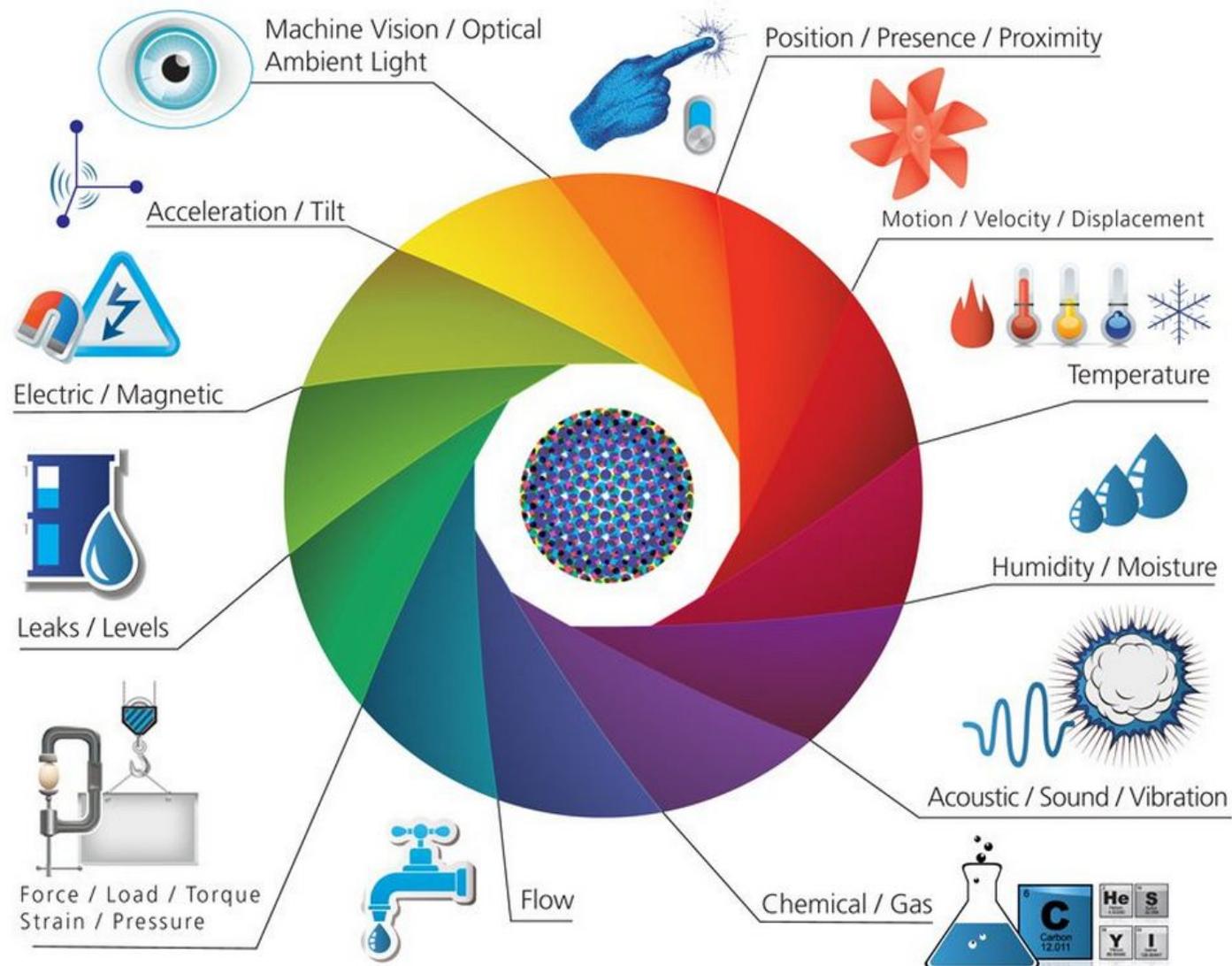
One of the most promising market is IoT!



Control, Optimize & Instrument !



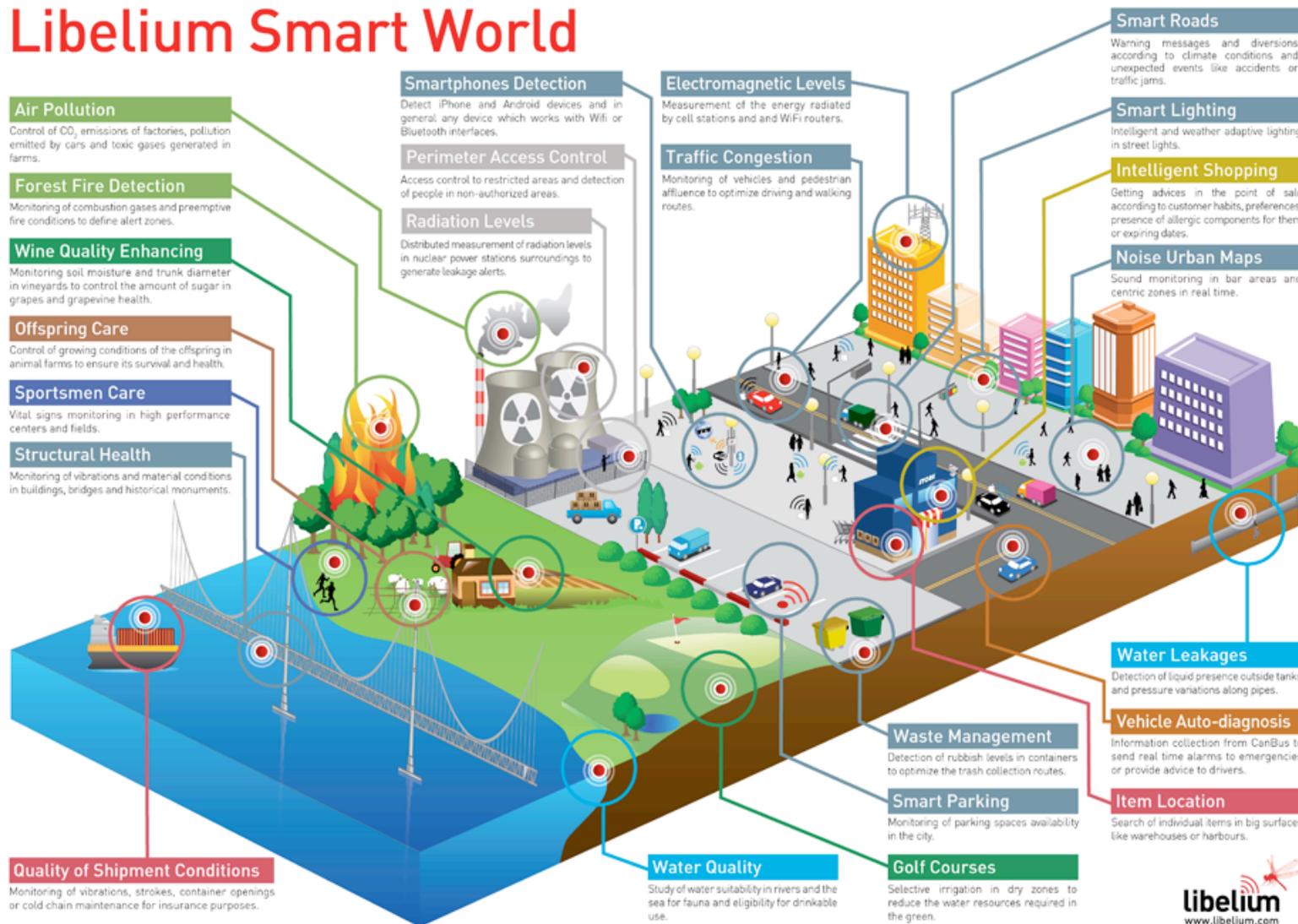
Large variety of sensing needs



Example 1: Smart Cities



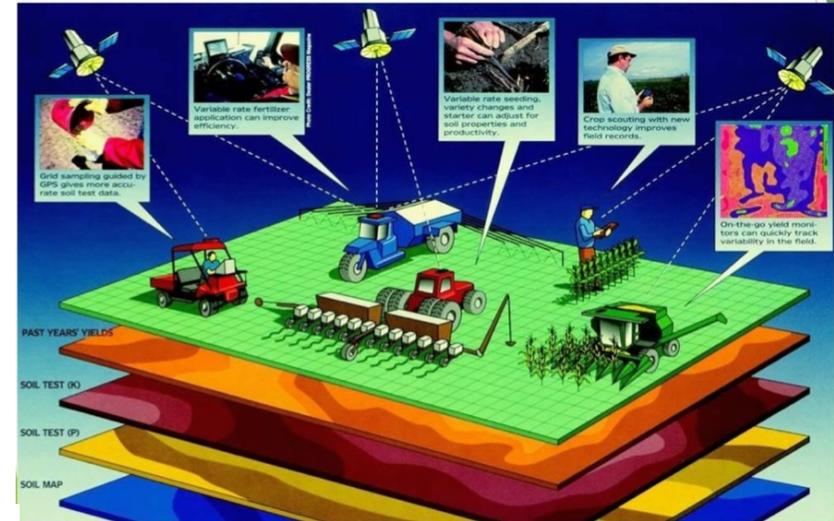
Libelium Smart World



Example 2: Farming & Agriculture



GPS in Agriculture



IoT4D: development for rural areas



Irrigation



Aquaculture



Storage & logistic



Agriculture



Environment



The IoT ecosystem



1st issue: IoT are small devices

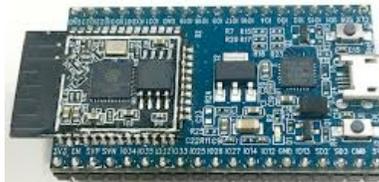
□ ANSWER: Smaller and more powerful boards are now available!



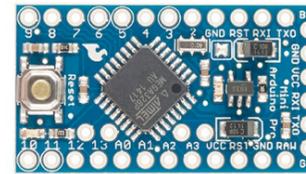
Theairboard



LoPy



Expressif ESP32



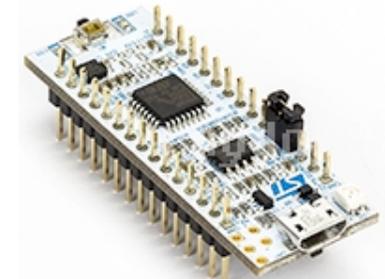
Arduino Pro Mini



LinkIt
Smart7688 duo



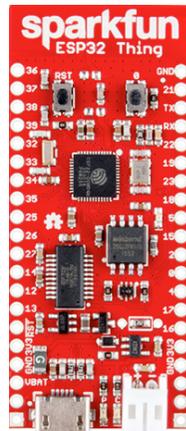
Teensy 3.2



STM32 Nucleo-32



Adafruit Feather



Sparkfun ESP32 Thing



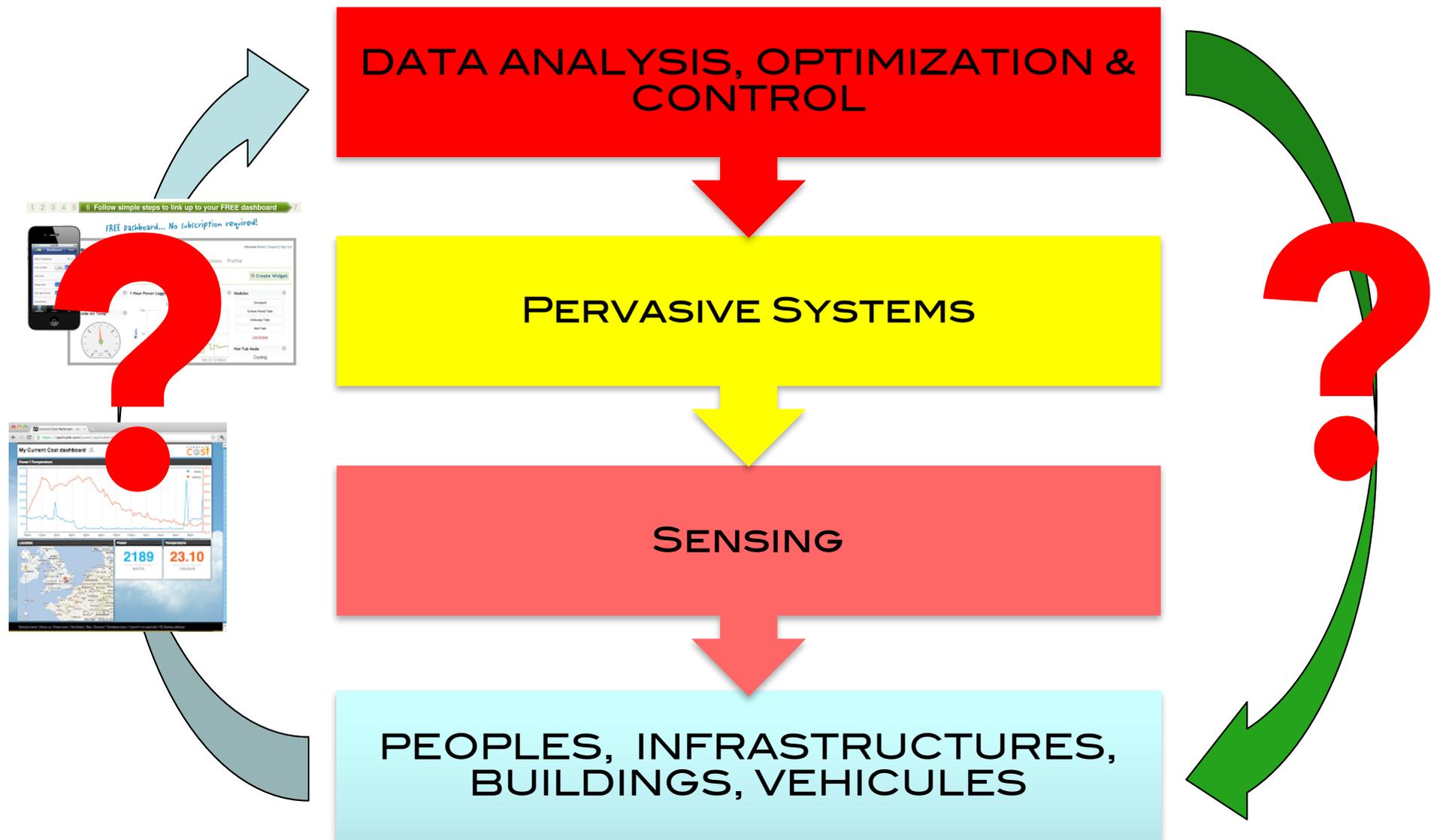
Tessel

SodaqOnev2

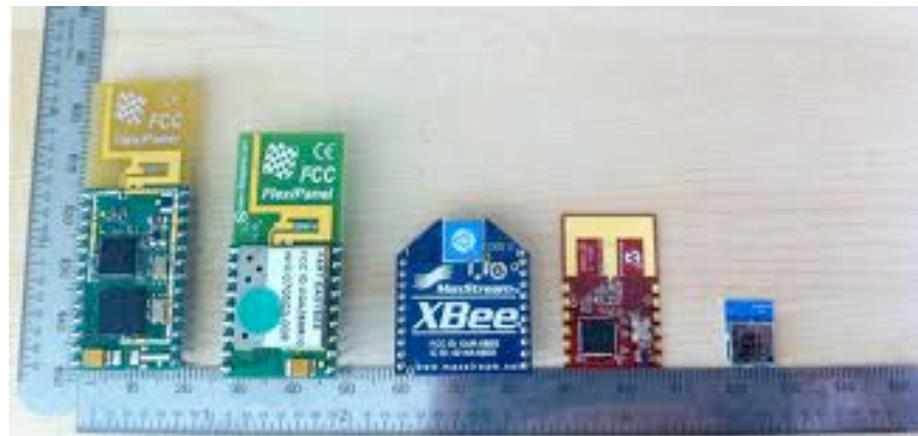


Tinyduino

2nd issue: collect data



Wireless Communication made easy

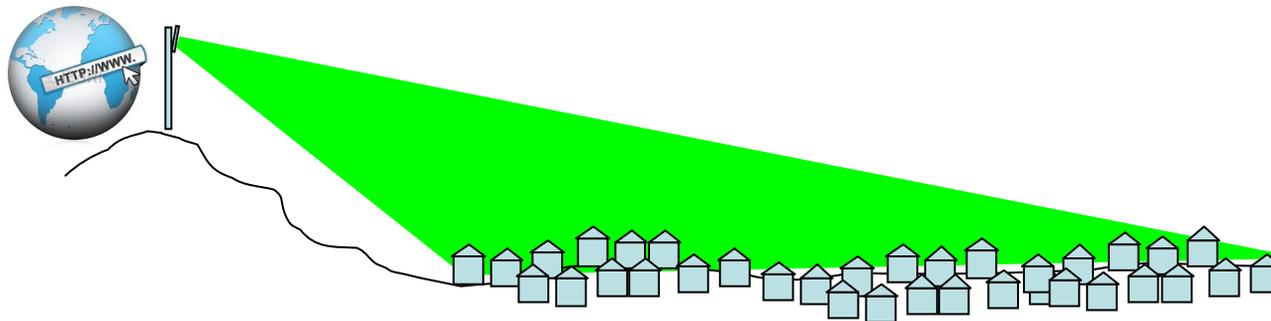


IoT=wireless+battery



Telemetry and Transmission cost

Moisture/
Temperature of
storage areas

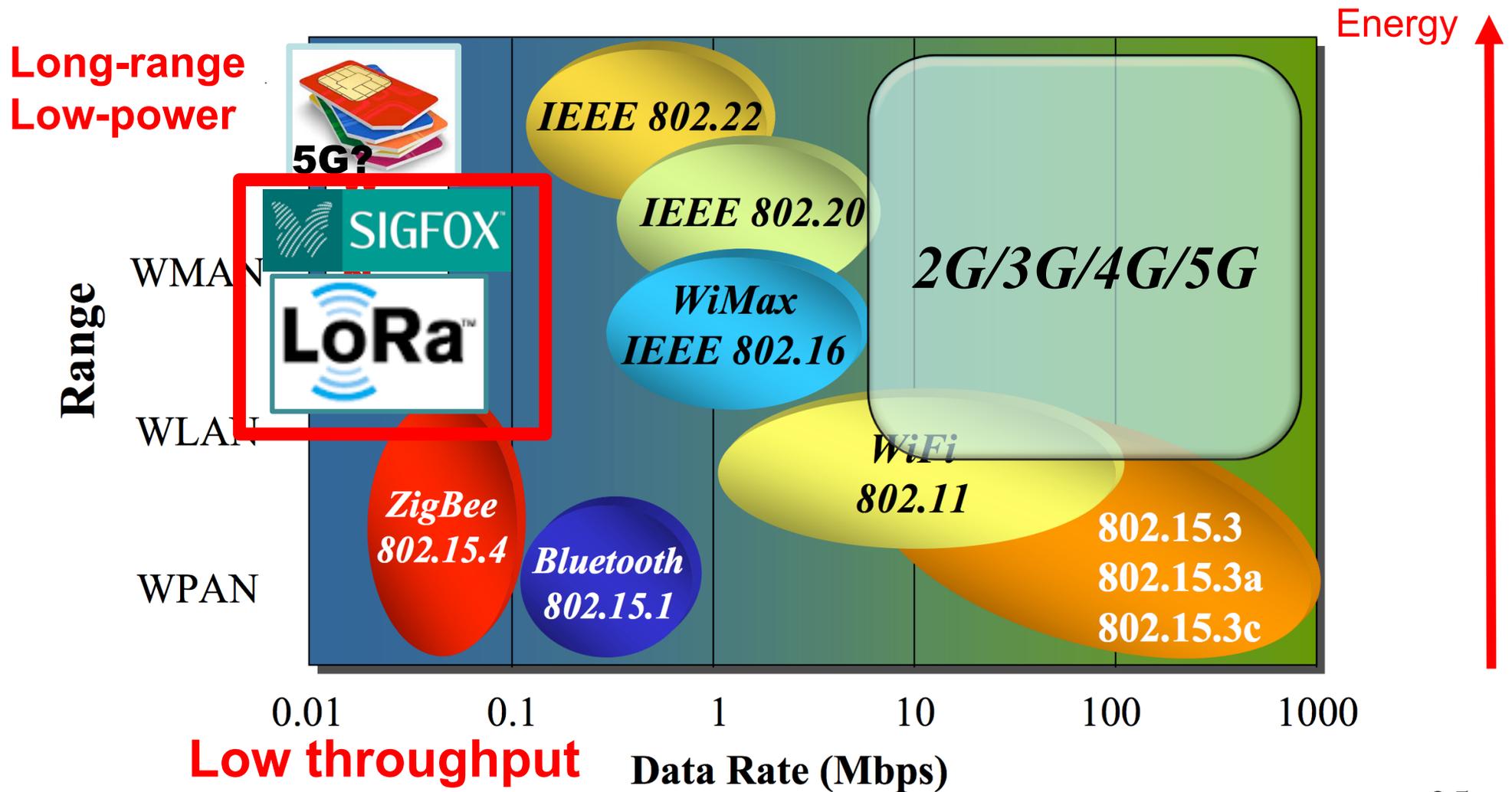


| Technology | 2G | 3G | LAN |
|--------------------------------|-----------|------------|-------------------|
| Range (I=Indoor, O=Outdoor) | N/A | N/A | O: 300m I: 30m |
| Tx current consumption | 200-500mA | 500-1000mA | 100-300mA |
| Standby current | 2.3mA | 3.5mA | NC |

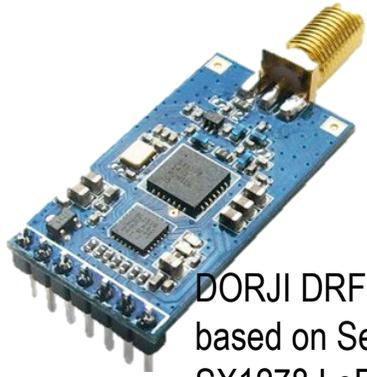
Low-power & long-range radio technologies



Energy-Range dilemma



Some LoRa radio modules



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



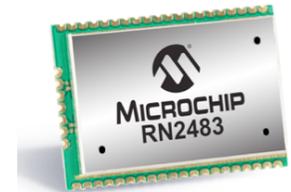
LinkLabs Symphony module



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



habSupplies



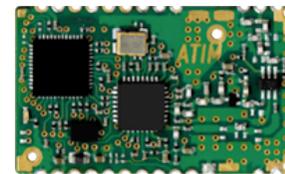
Adeunis ARF8030AA- Lo868



Multi-Tech MultiConnect mDot



AMIHO AM093



ARM-Nano N8 LoRa module from ATIM



SODAQ LoRaBee Embit

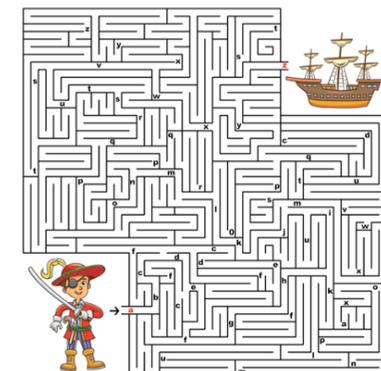


SODAQ LoRaBee RN2483

3rd issue: finding the information you need

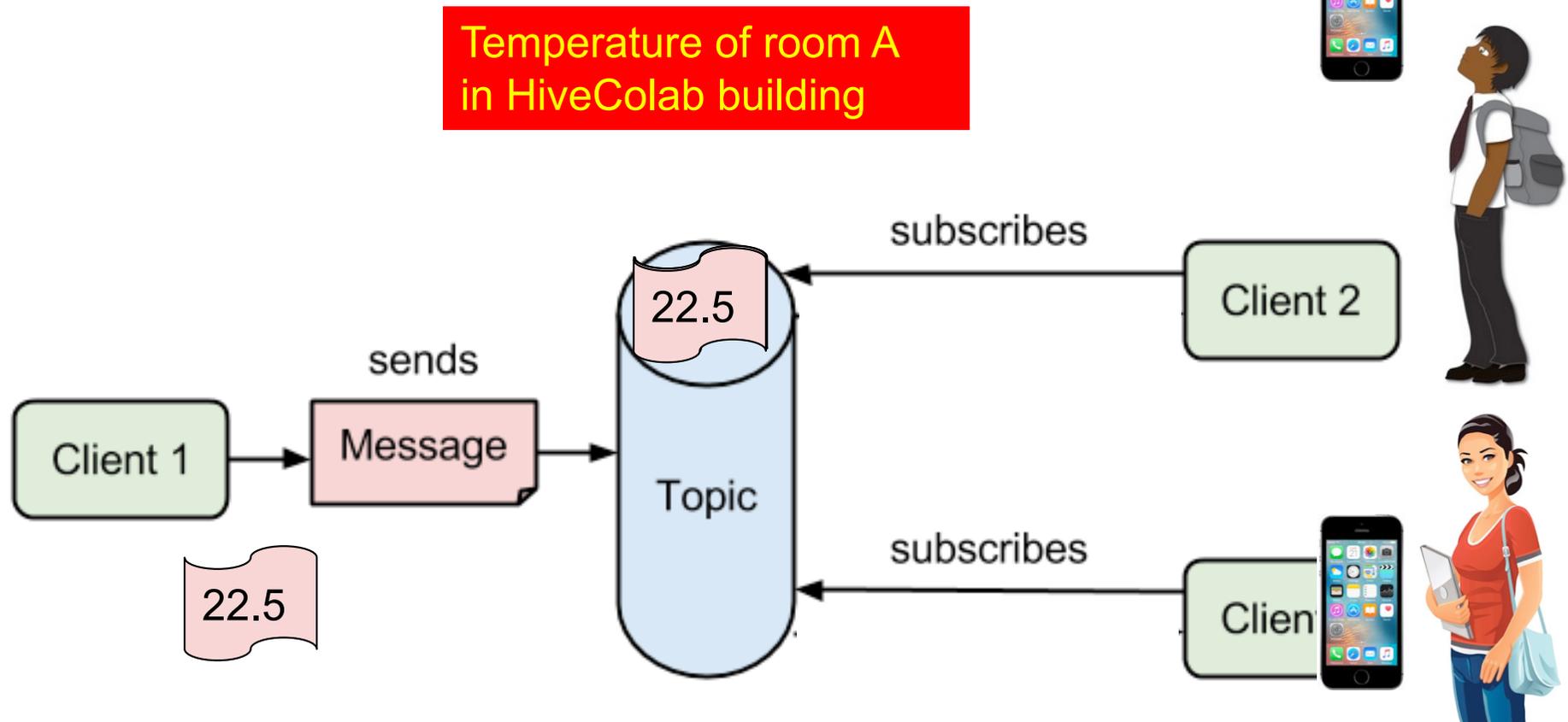


- ❑ Searching for information is a tough issue
 - ❑ Web search engine: Google,...
- ❑ Most IoT clouds uses HTTP request (GET, POST, PUT, ...) to push/store data to web platforms/servers
- ❑ If you need an information, for instance **the temperature in room A of HiveColab in Kampala**, then you have to 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

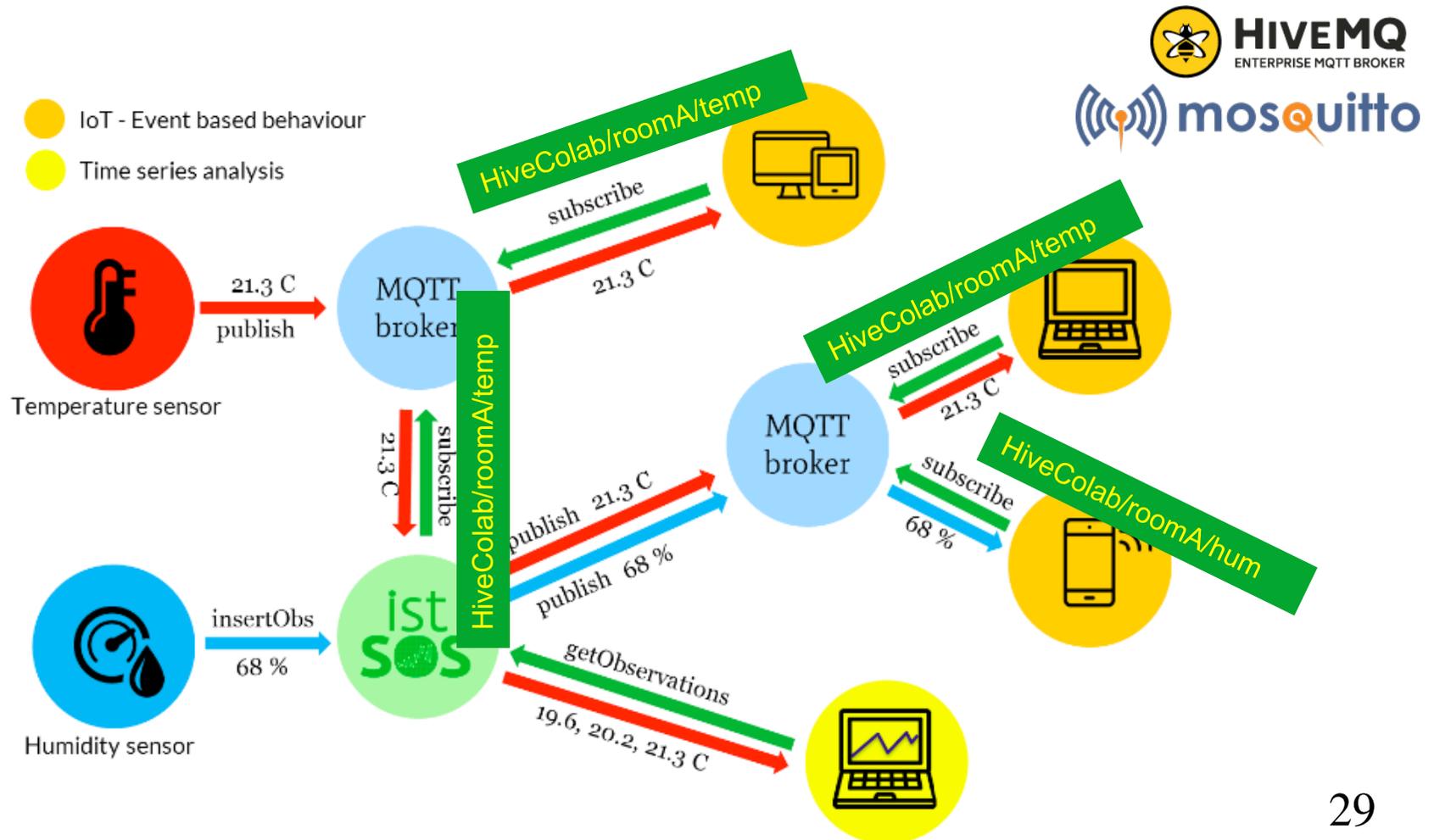


MQTT

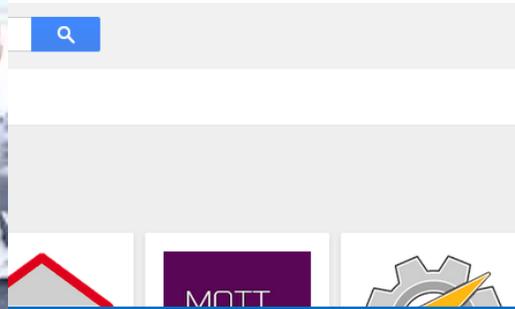
Message Queue Telemetry Transport



- Use broker nodes to manage topics
 - HiveColab/roomA/temp, HiveColab/roomA/hum



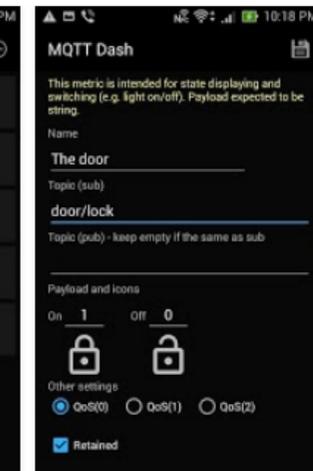
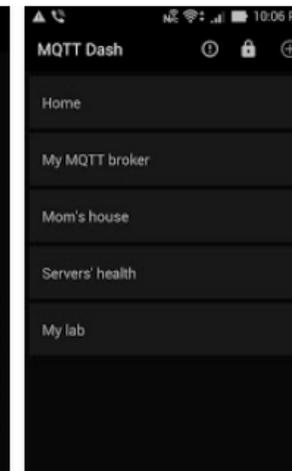
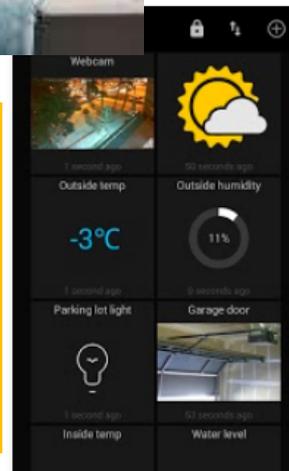
MQTT+smartphone=



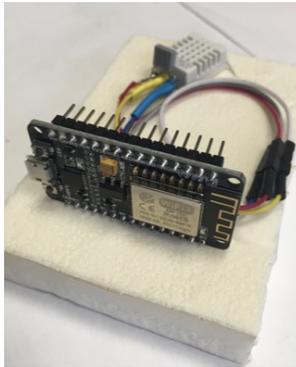
MQTT Dash (IoT, Smart Home)
Routix software Communication ★★★★★ 1,584
PEGI 3
This app is compatible with all of your devices.

Installed

- ☐ Towards open data
 - ☐ HiveColab/roomA/#
 - ☐ KPL/CITY/WEATHER/#
 - ☐ KPL/CONGRESS/#

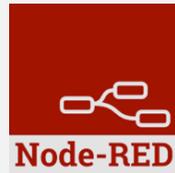


4th issue: make it simpler?

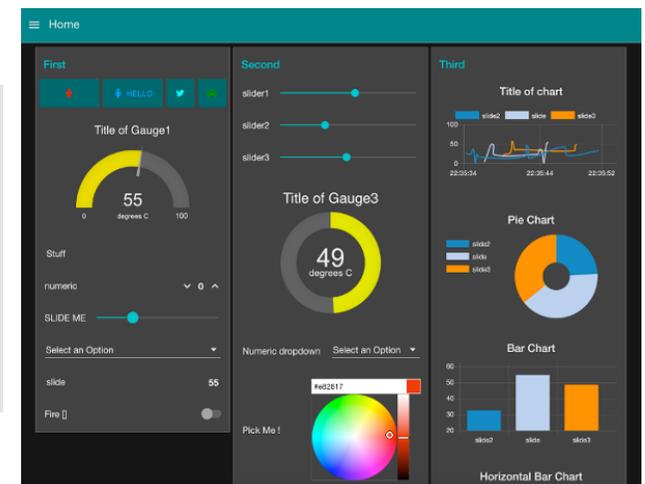
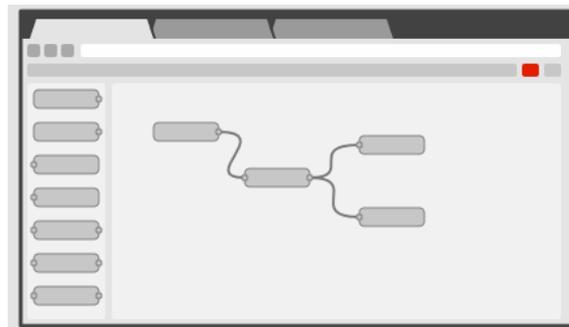


- ❑ End-users are not necessarily computer science experts nor high-skilled programmers
- ❑ Use graphical tools to build data processing flows, allowing intuitive connection from data producers to data consumers

Node-Red



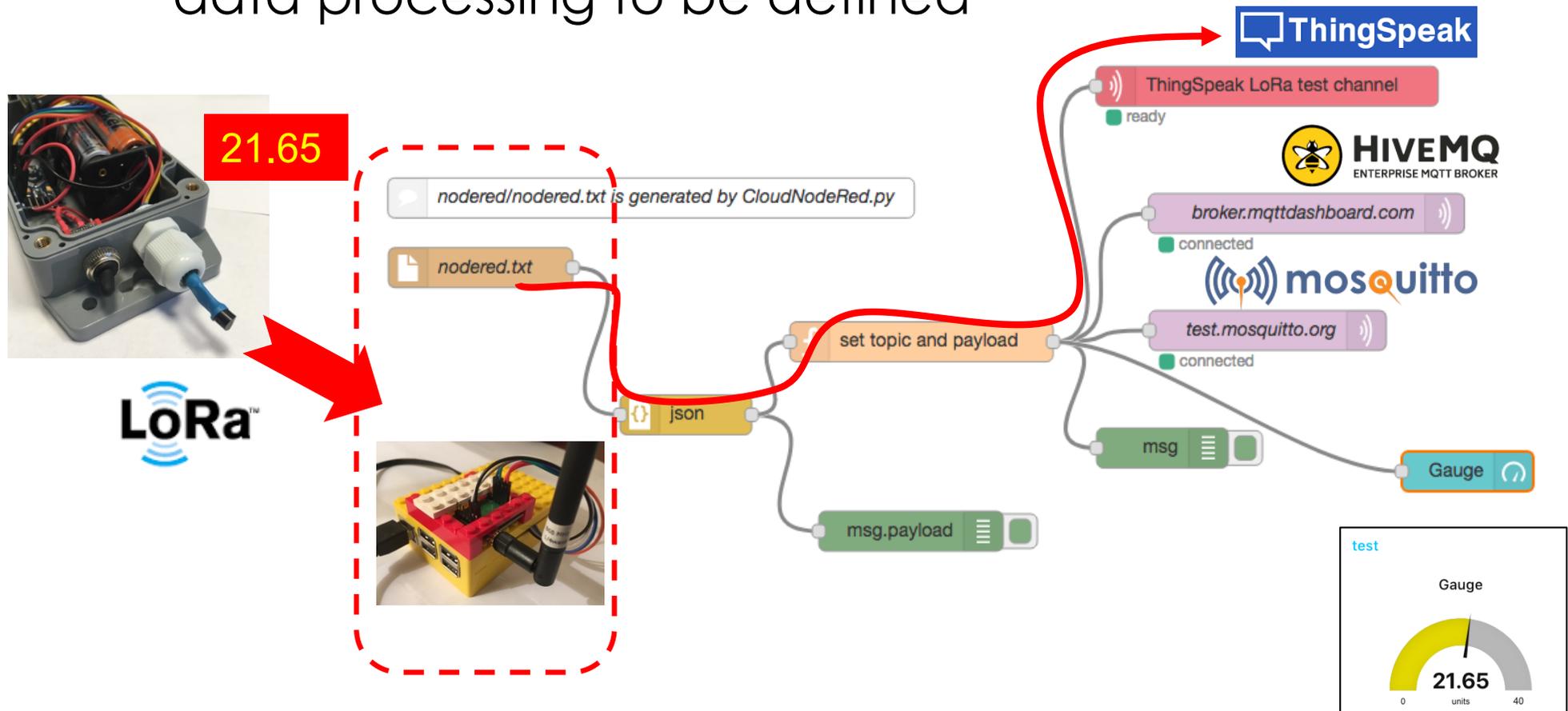
- Node-RED is a programming tool for wiring together hardware devices, APIs and online services, e.g. clouds of various types
- provides a browser-based flow editor to wire together flows with a wide range of nodes



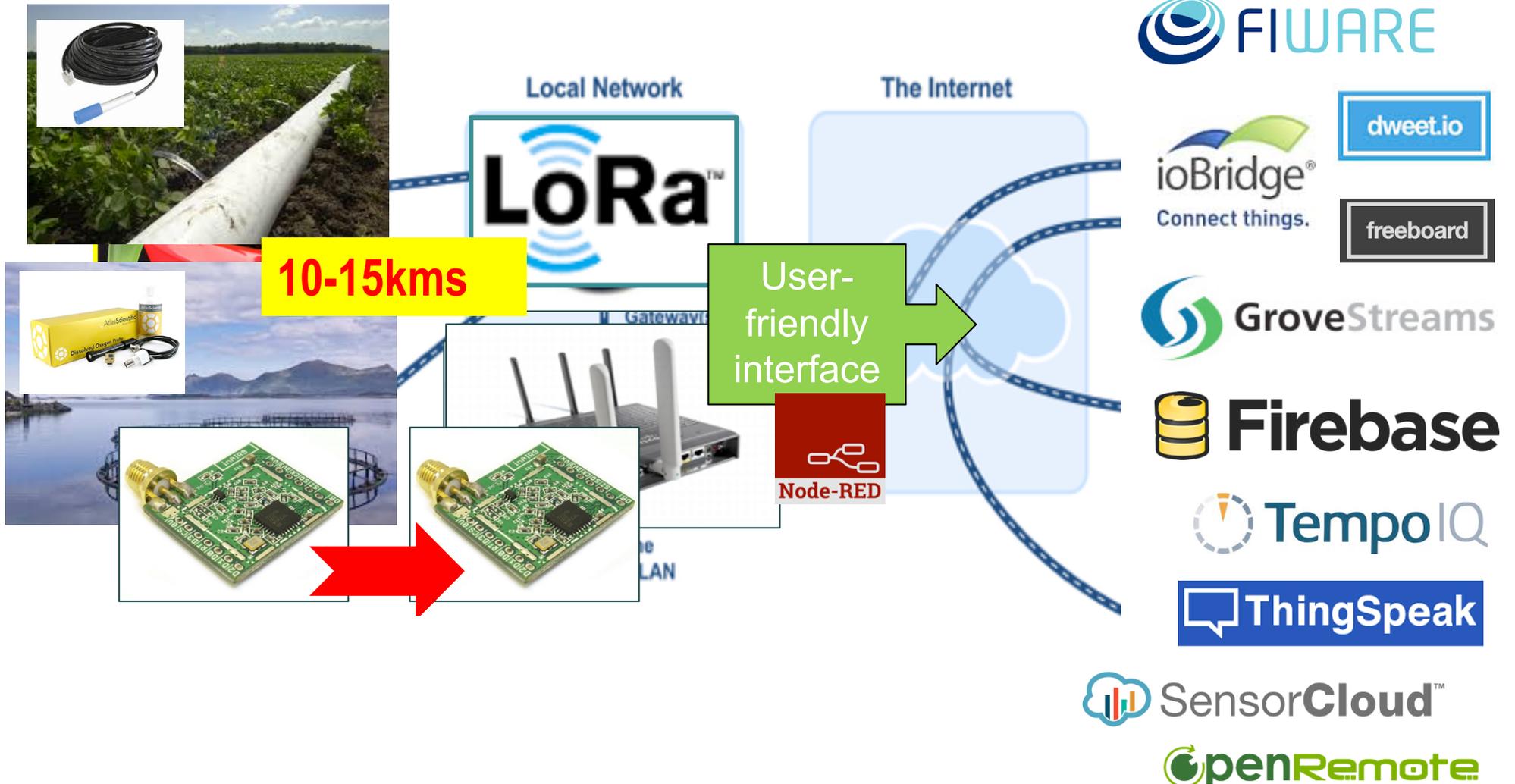
Node-red enabled IoT gateway



- 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



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!

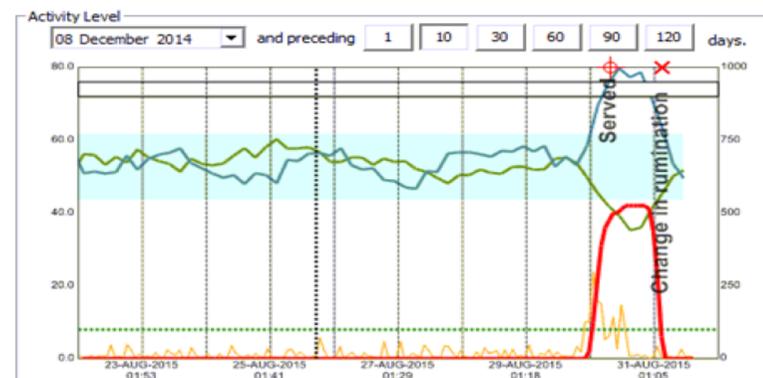
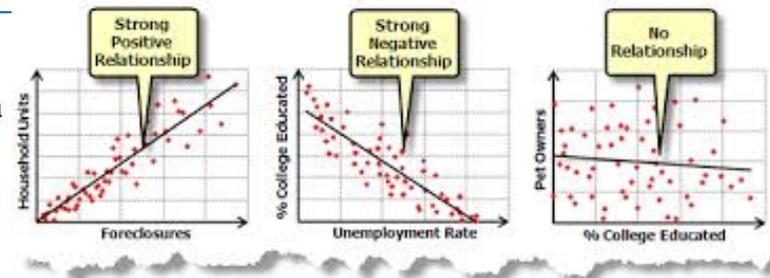
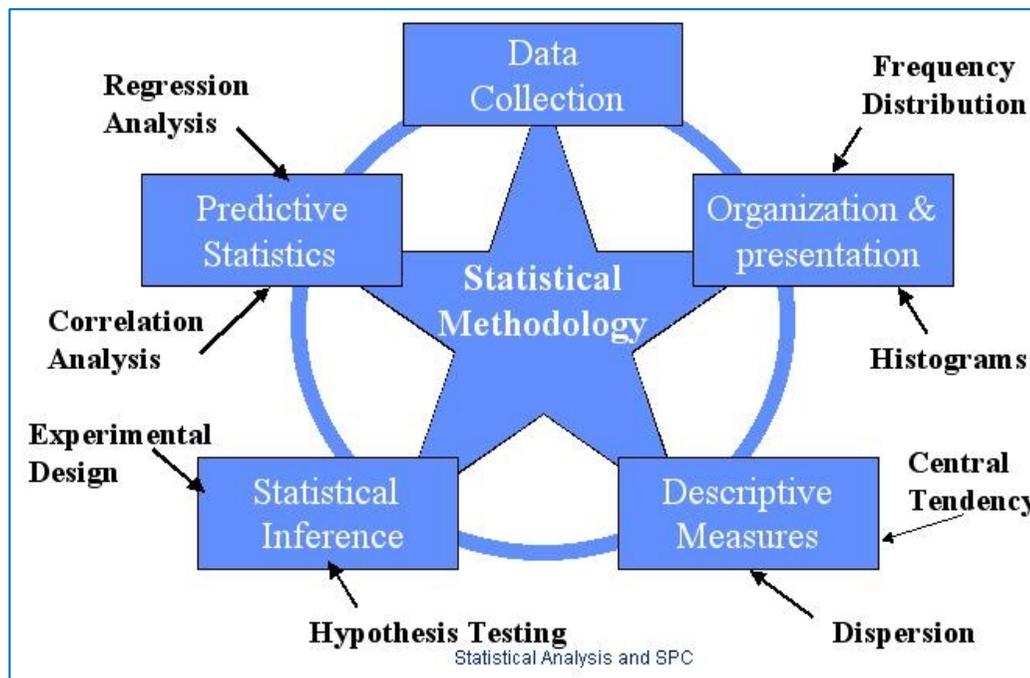


Fig. 3. Illustration of a rise in activity accompanied by a fall in rumination at the point of oestrus

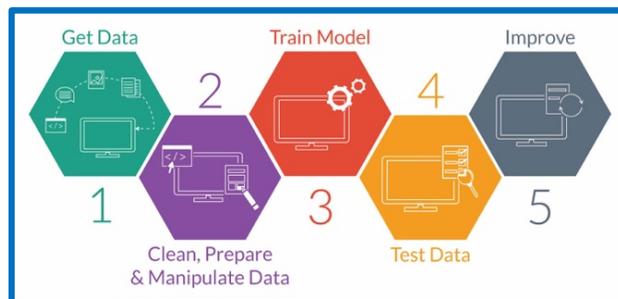
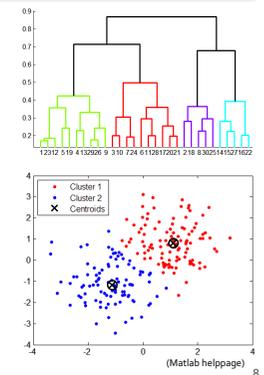
Analysis techniques

□ Traditional statistic methods still valid, and useful!



Clustering Analysis

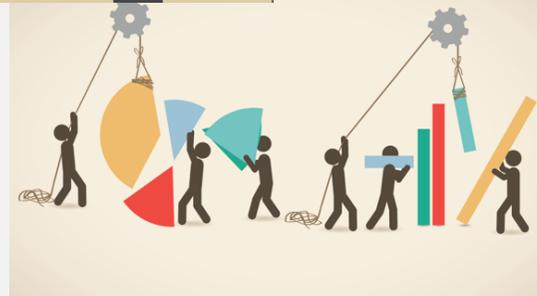
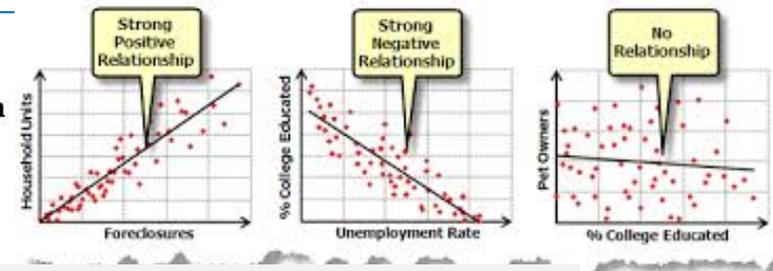
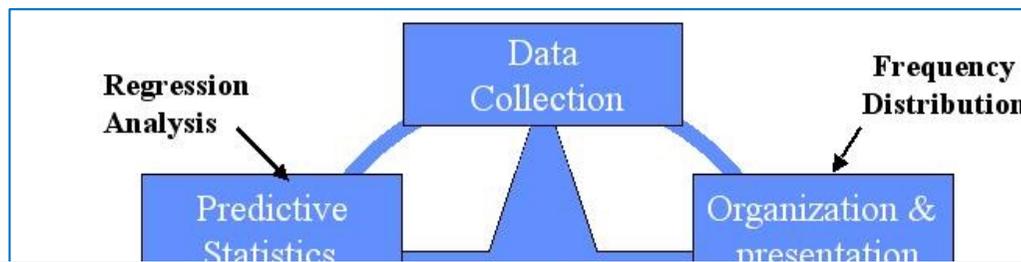
- Definition
 - Grouping unlabeled data into clusters, for the purpose of inference of hidden structures or information
- Dissimilarity measurement
 - Distance : Euclidean(L_2), Manhattan(L_1), ...
 - Angle : Inner product, ...
 - Non-metric : Rank, Intensity, ...
- Types of Clustering
 - Hierarchical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



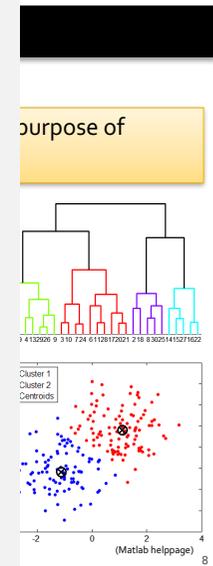
From Jong Youl Choi

Analysis techniques

□ Traditional statistic methods still valid, and useful!



Going old school ?

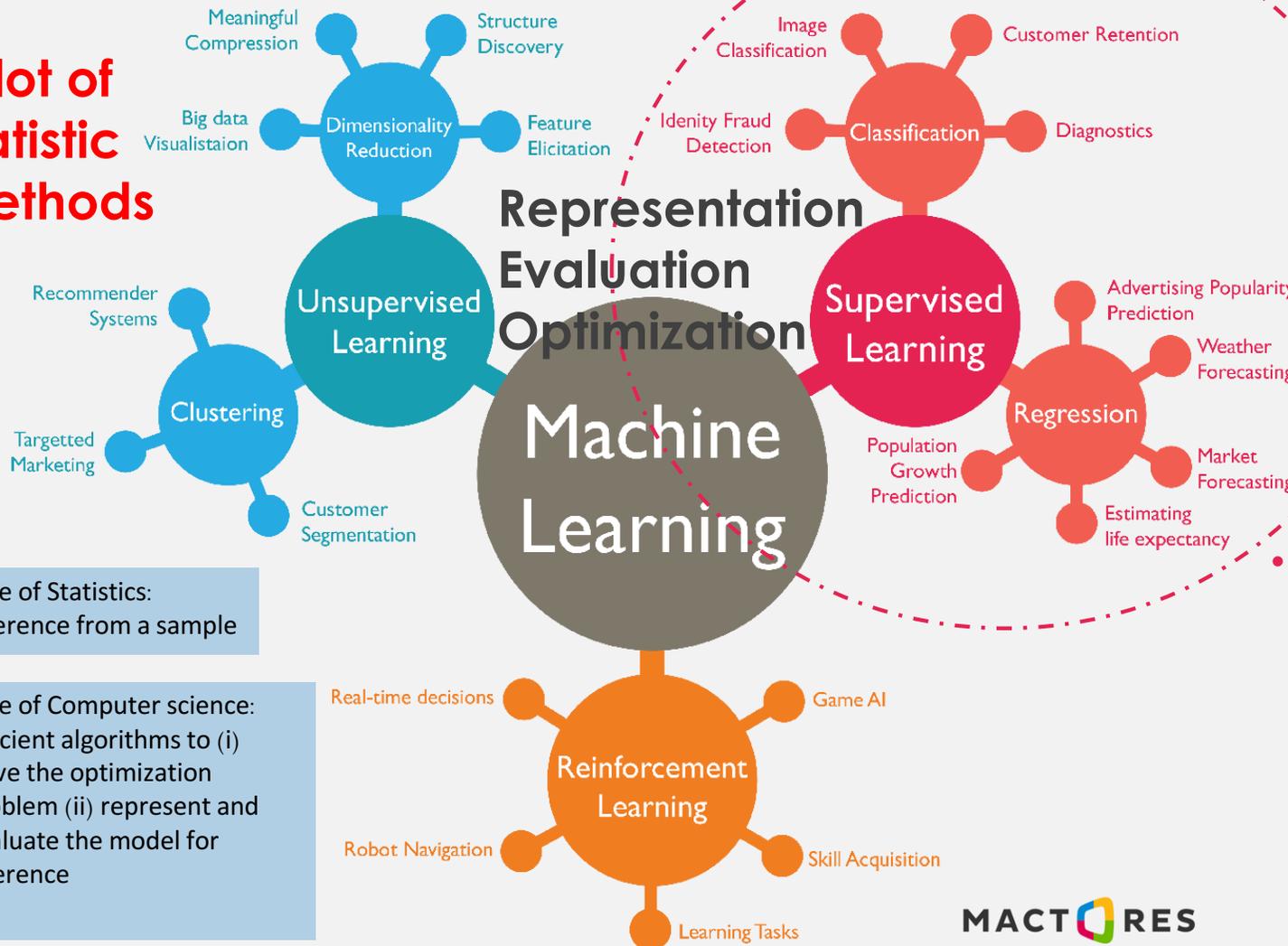


Machine Learning Techniques

Optimize a performance criterion using example data or past experience

Machine Learning Bubble Chart

A lot of statistic methods



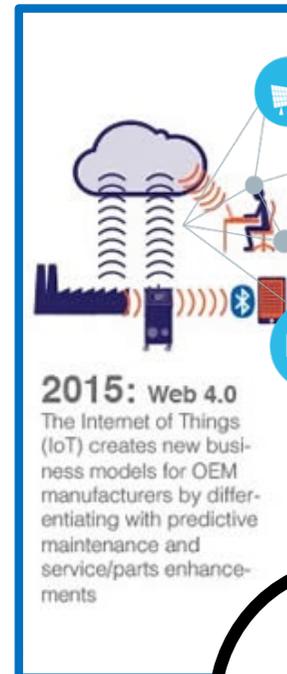
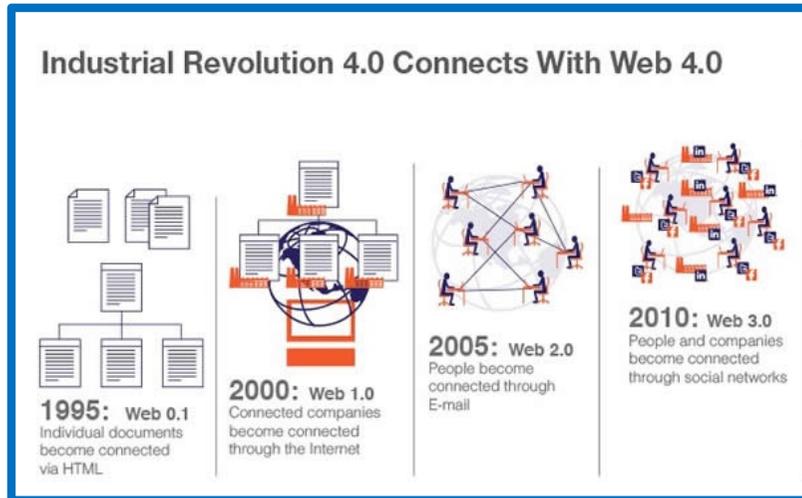
- Classification
 - Logic
 - SVM
 - Random Forest
 - Hidden Markov
 - ...

- 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



The Datafloq Open Source Landscape 2.0

The Datafloq Open Source Landscape 2.0 is a comprehensive grid of open-source big data technologies, categorized into various functional areas:

- Data Analysis & Platforms:** HPCC Systems, Storm, Dremel, Hadoop, MapReduce, Spark, SAMOA, APACHE DRILL, IKANOW, BRILLIANT DECISIONS, Hortonworks.
- Databases / Data warehousing:** bigdata, INFOBRIGHT, Cassandra, 4store, H2, GlobalDB, InfiniDB, riak, Infinispan, HYPERTABLE, MariaDB, Drizzle, SQLite, RethinkDB, Firebird, ORACLE, BERKELEY DB, HyperSQL, monetdb.
- In-Memory Computing:** GridGain, hazelcast, TERRACOTTA, NMemory, GORA.
- ERP BI Solutions:** talend, spagobi, pentaho, Jaspersoft, Palo, jedox, BIRT, openi.org, Open Intelligence.
- Business Intelligence:** openi.org, Open Intelligence.
- Data Mining:** orange, rapidminer, KNIME, mahout, WEKA, KEEL, togaware, SPMF.
- Big Data search:** Lucene, Apache Solr, elasticsearch.
- Multivalued database:** Rocket, U2, REVELATION, northgate, jBASE INTERNATIONAL, ScarletDME, QM, Ladybridge Systems.
- Programming:** julia.
- Data aggregation:** oqoop, Caume, zhukuz.
- KeyValue:** AEROSPIKE, leveldb, redis, Chordless, Tokyo Cabinet, MEMCACHED.
- Document Store:** mongoDB, Couchbase, Raven DB, CLUSTERPOINT, Tokutek, RaptorDB, EJDB, djon, JasDB, SchemafreeDB, sisodb, CouchDB, relax.
- Graph databases:** Gephi, Gremlin, GraphBuilder, FRANZ INC, Sparksee, IntiniteGraph, INFO GRID, HYPERGROPHDB, Neo4j, FlockDB, GraphBase, BrightstarDB.
- Operational:** VOLTDB.
- Social:** Apache Kafka, ThinkUp, Corona.
- Multidimensional:** FIS, SciDB, rasdaman, raster data manager.
- Object databases:** db4objects, ZOPE, mobject, Magma, Picoisp, siaqodb, NEOPPOD, EyeDB, PERSEVERE, RAMER D, Sterling, NDatabase, C# Lightweight Object Database.
- Multimodel:** ArangoDB, alchemydatabase.
- XML Databases:** istdb, BASE, Qizx, sedna, LIQUIBASE.
- Grid Solutions:** GIGASPACE, Galaxy.

Created by: www.Datafloq.com

IoT for Development



Irrigation



Livestock farming



Fish farming & aquaculture



Storage & logistic



Agriculture



Environment



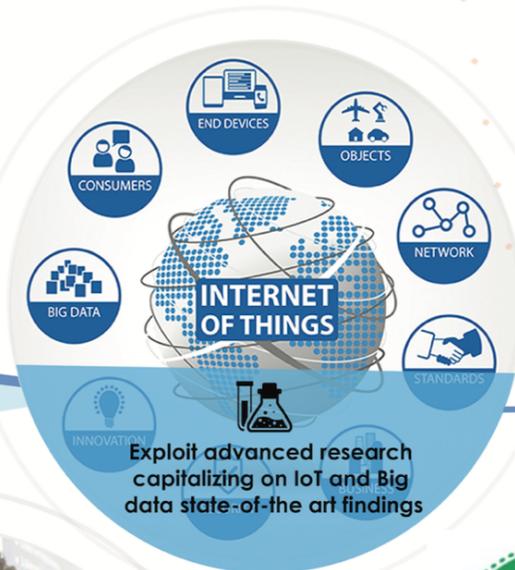
Needs, constraints, cost, design approach, control mechanism

Challenge: Bridging the digital divide





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



waziup.community@create-net.org

Ready-to-use templates

Moisture/
Temperature of
storage areas



10-15kms



Physical
sensor



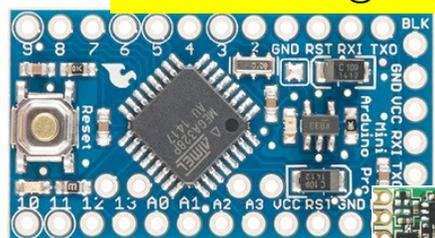
Physical
sensor



Physical
sensor



Physical
sensor
mgmt



Arduino Pro Mini @3.3V

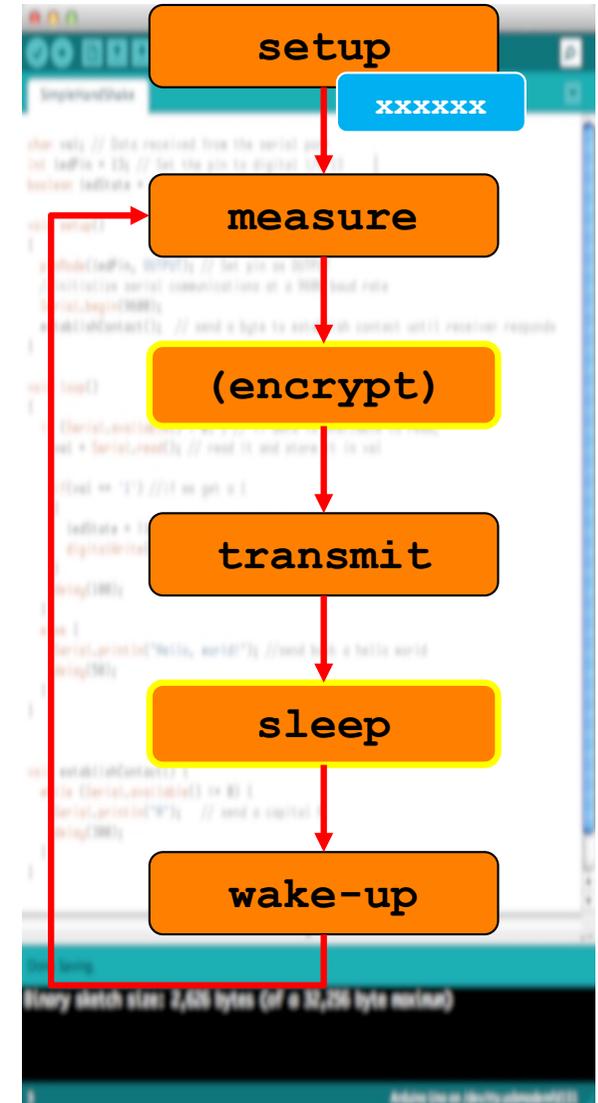
VERY IMPORTANT

Activity
duty-cycle,
low power

VERY IMPORTANT
AES
encryption

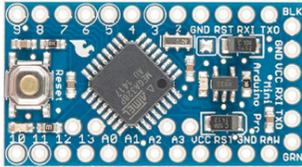
Long-range
transmission

Logical
sensor
mgmt



A simple temperature sensor example

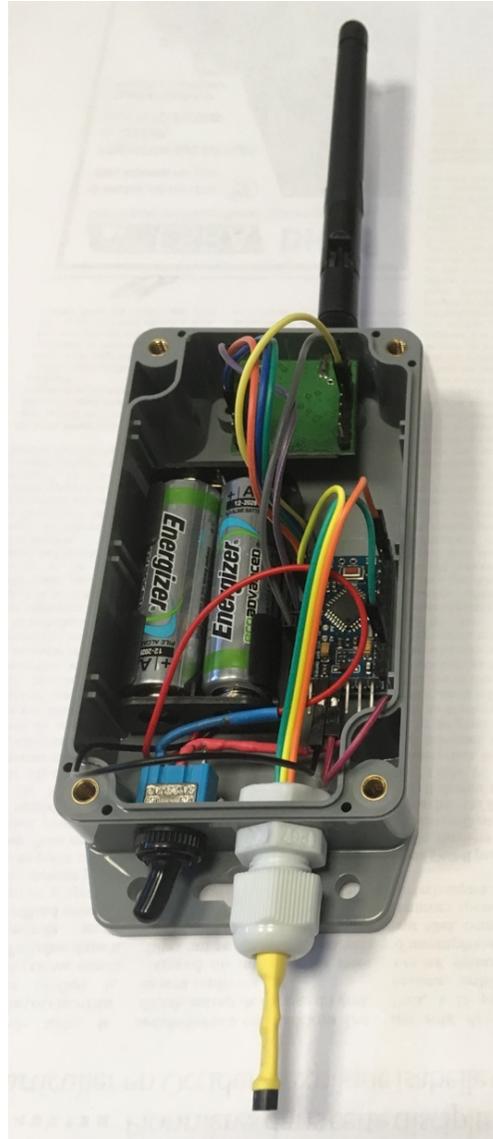
Arduino Pro Mini @3.3V



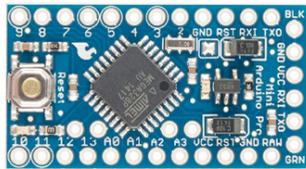
Modtronix inAir9



TMP36



Low-cost integration

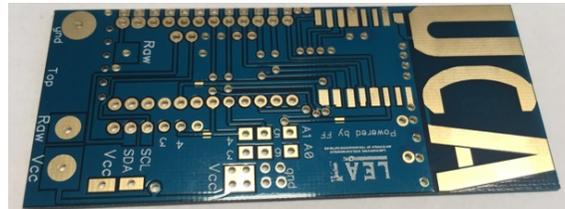


1.5€

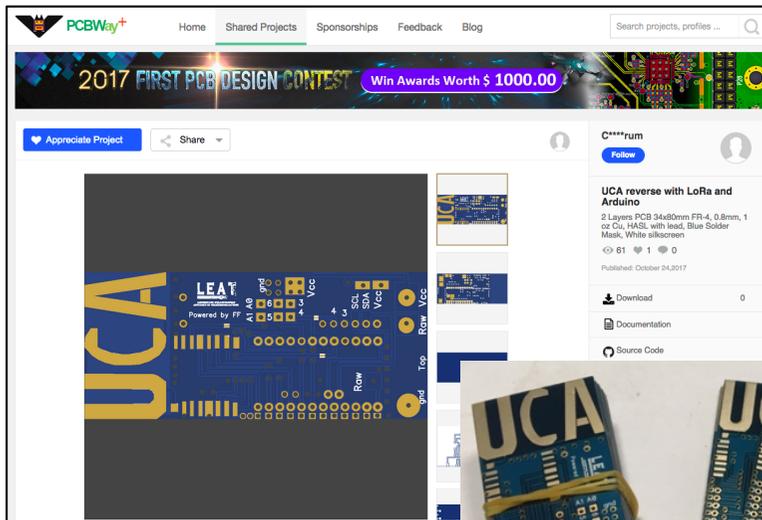
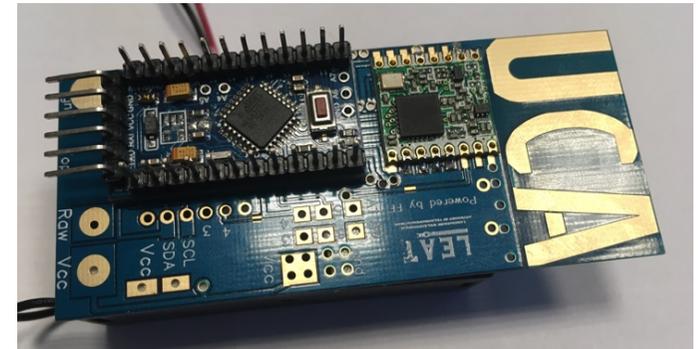
https://github.com/FabienFerrero/UCA_Board



4€

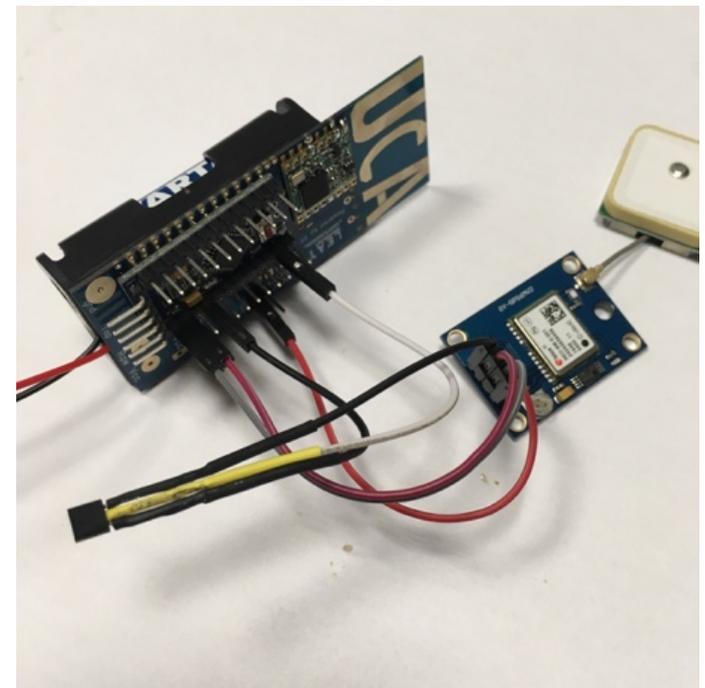
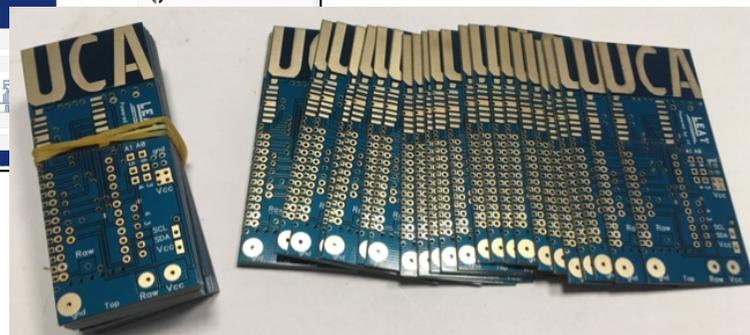


1€



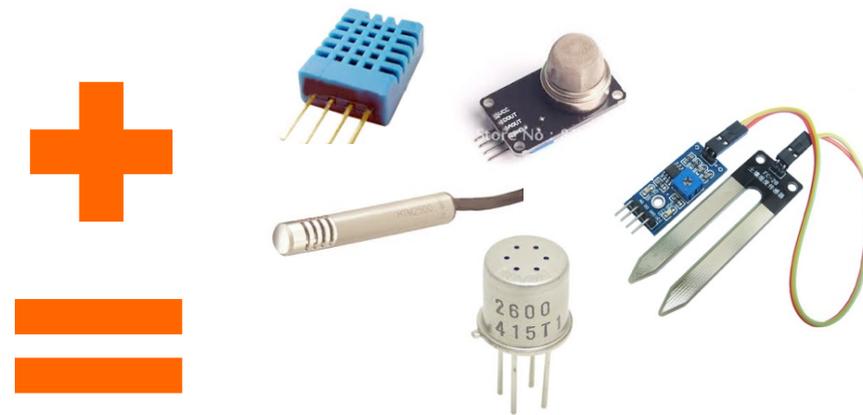
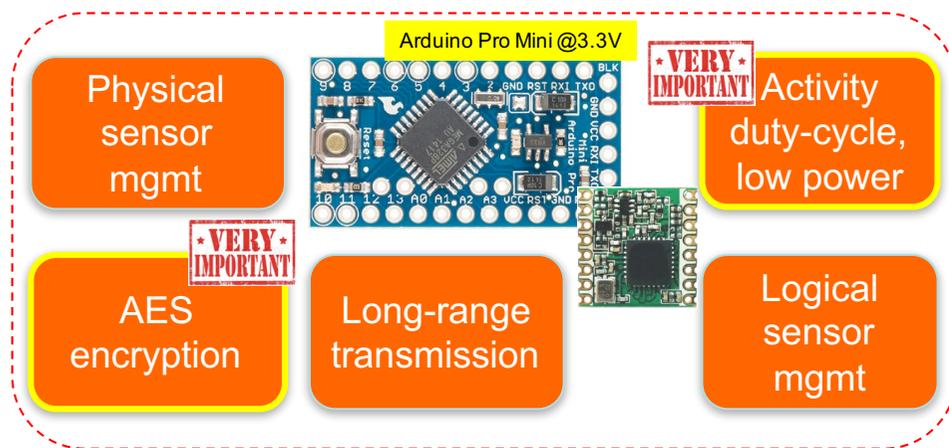
Less than 10€/device

1-click order

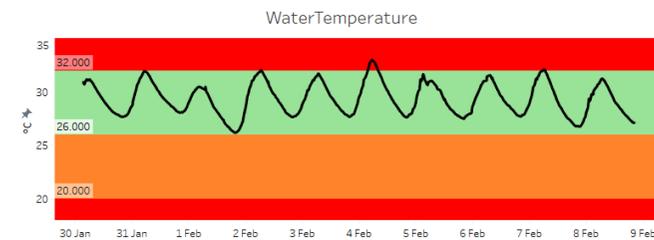
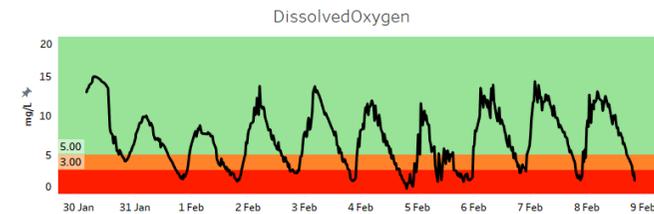
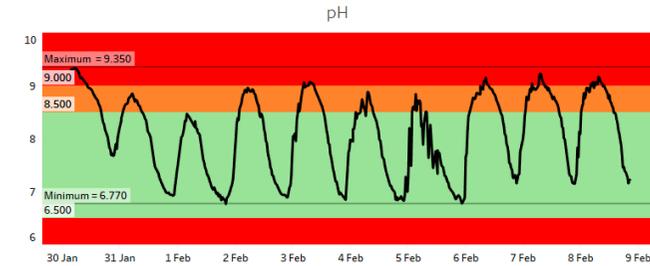


Generic sensing IoT device v.s. Highly specialized

- ❑ 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



Physical sensor management

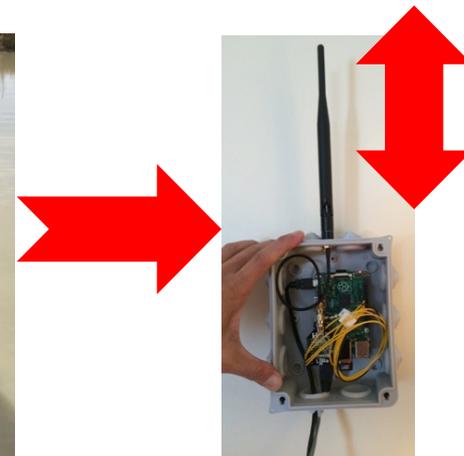


Activity duty-cycle, low power

Security

Long-range transmission

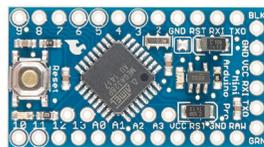
Logical sensor management



Soil humidity sensors for agri MVP



Physical sensor management



Activity duty-cycle, low power

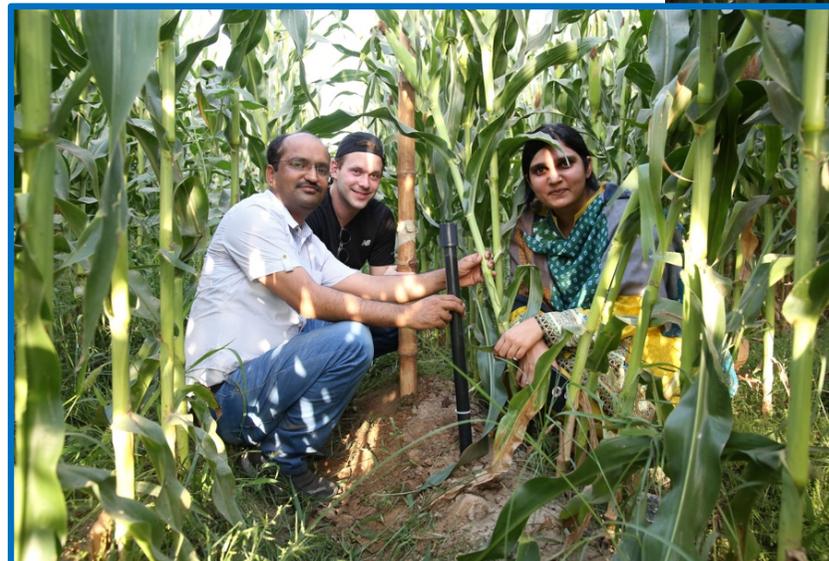
Security

Long-range transmission

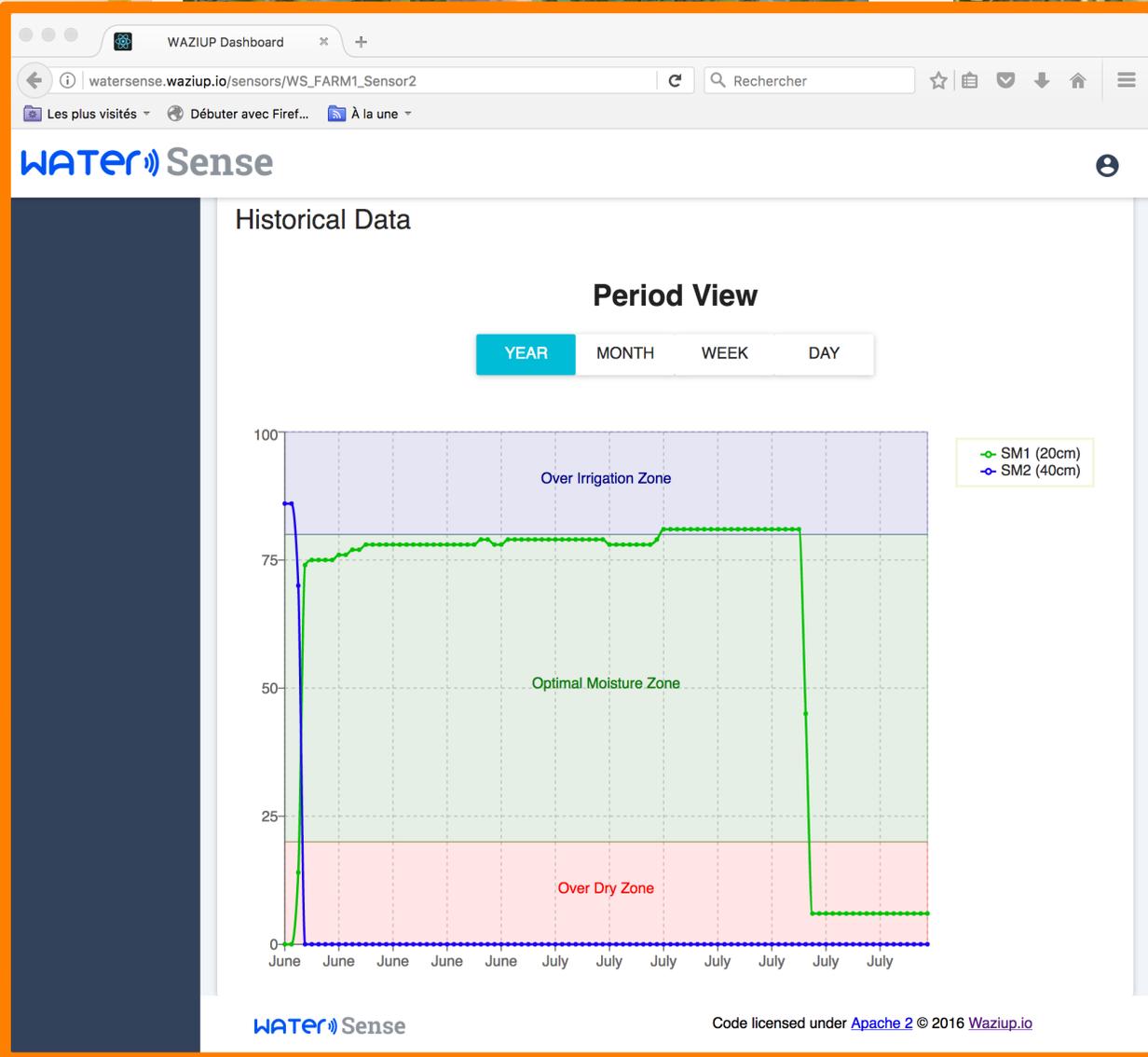
Logical sensor management



Deployment for Nestlé's WaterSense project



Deployment for Nestlé's WaterSense project



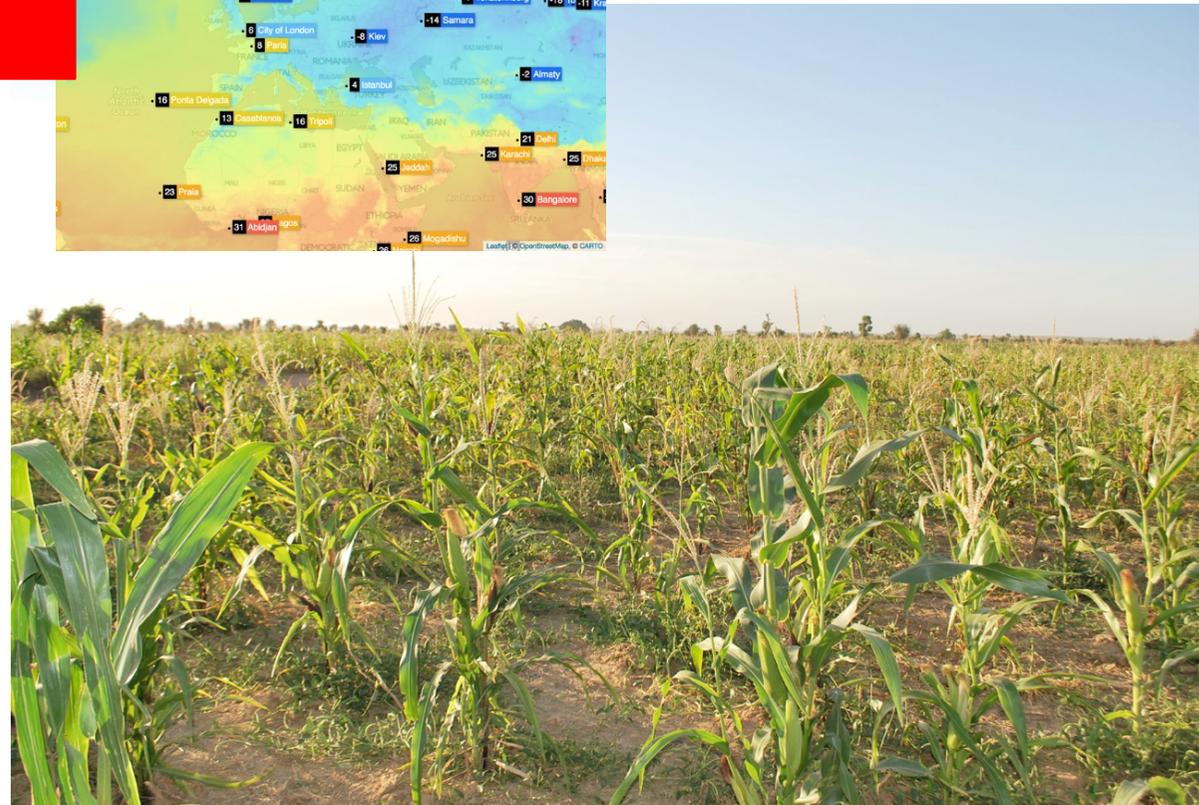
Local weather station for AGRI MVP



<https://openweathermap.org/>



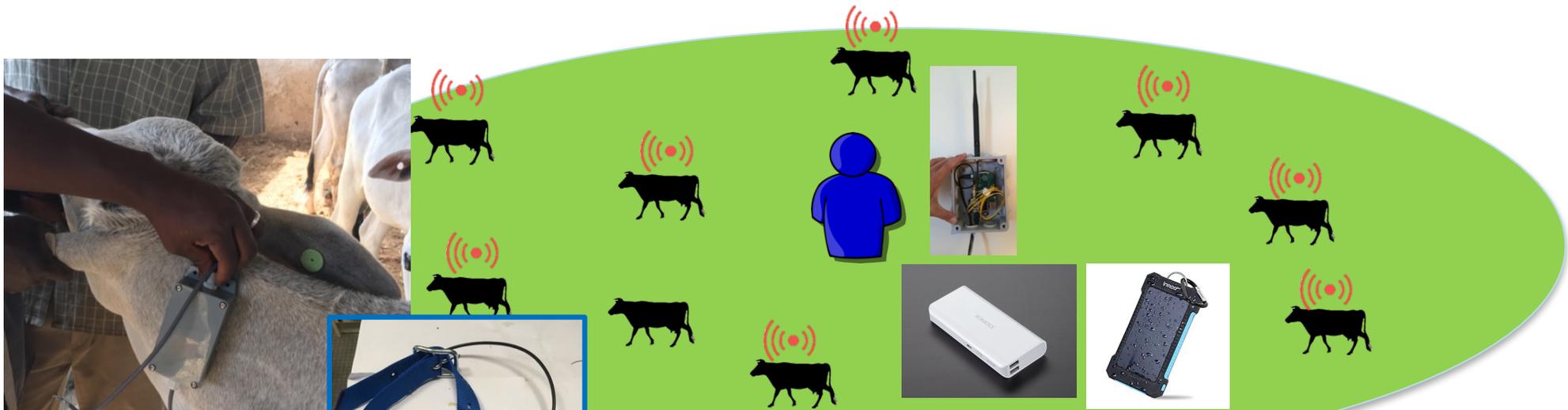
Photo from Unparallel



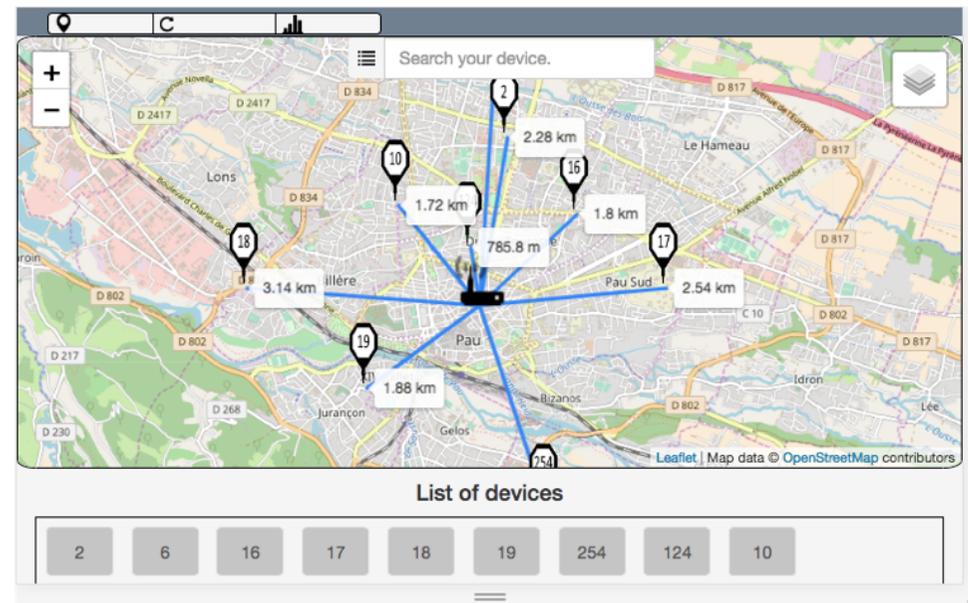
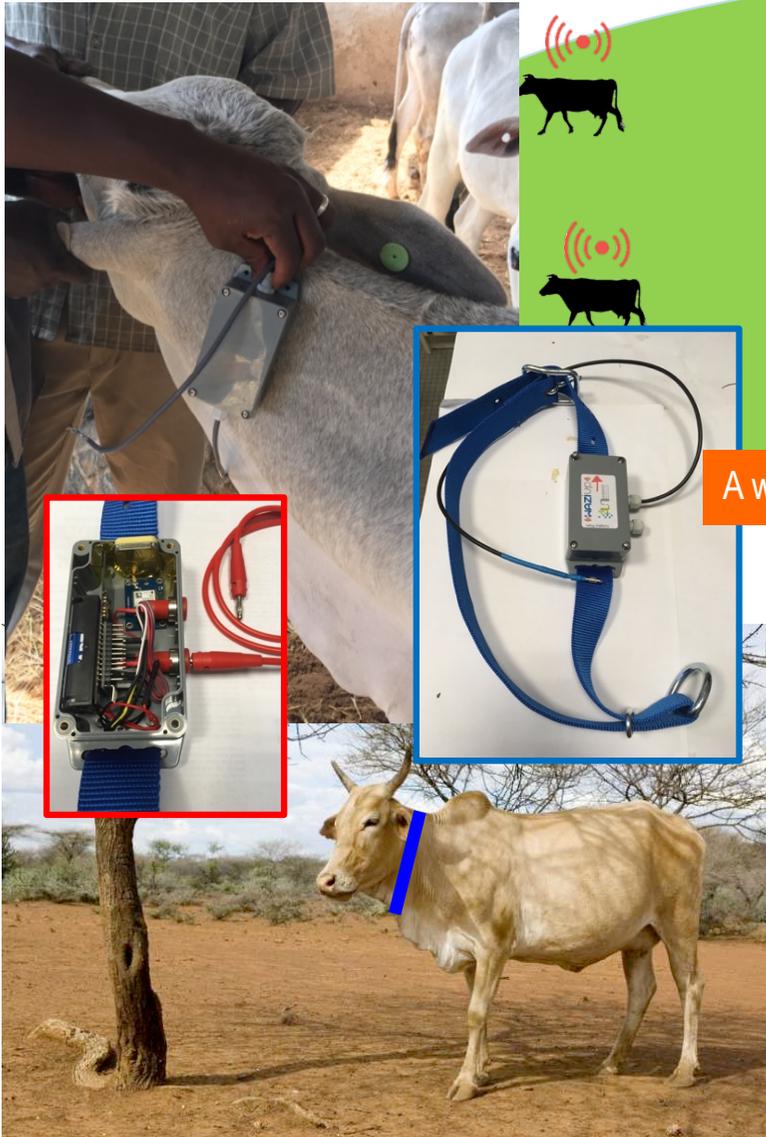
Get local weather measurements

Combine with open weather data to get more accurate predictions

Collar for Cattle Rustling MVP



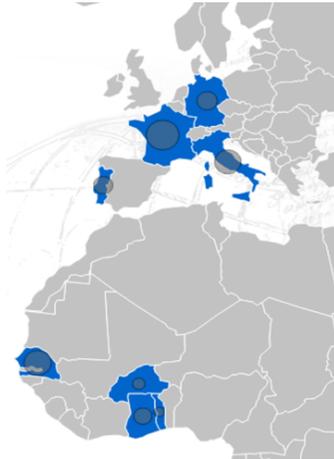
A web interface displays the position of the gateway those of the remote GPS devices



Scaling up!



Feb 2016 - 2019



May 2018 - 2021

