AI-Autonomous Robots for Agriculture – Weeding with Laser

WeLASER Summer School

Internet of Things and PA

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CSIC Consejo Superior de Investigaciones Científicas

FUTONICS

LZH Laser Zentrum Hannover e.V.

University of Copenhagen

AGREENCULTURE Smart robots for smart farming

COAG

Alma Mater Studiorum Università di Bologna

IETU Instytut Ekologii Terenów Uprzemysłowionych

Ghent University

van den borne aardappelen

CONTENTS

- What is the Internet of Things
- IoT and (Precision) Agriculture
- IoT device technology
- IoT development
- IoT case study

The Internet of Things

IoT is an infrastructure of interconnected physical entities, systems and information resources together with the intelligent services which can process and react information of both the physical world and the virtual world and can influence activities in the physical world.

The Power of Internet of Things

- decrease cost of devices
- rapid development
- easier sensors interchangeability
- increase space density of sensors
- enhance scalability
- increase device ccessibility (status,updates)
- increase data accessibility
- long term & safe data accessibility (cloud services)
- increase types of devices
- context management (FIWARE)

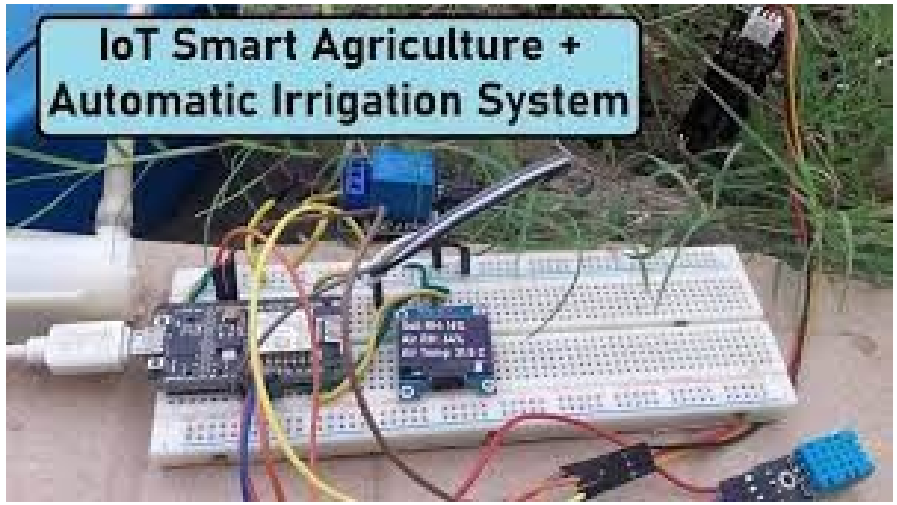
WHAT IS PRECISION AGRICULTURE

- **Enabling Technologies**
  - Geolocalisation → GPS/GNSS/RTK ← Very High frequencies Radio channels (GHz)
  - GIS → Farm Decision & Management Tools
  - ISOBUS → tractor/implement/combos tracking/actuators
  - **INTERNET CONNECTIVITY → Smart Agriculture / Digitalisation**
  - **AUTONOMOUS VEHICLES ← MACHINE LEARNING**
- **Most Recent Applications**
  - **Pesticide Free Agriculture**
    - **Variable Rate Application →P hysical weeding**
  - **Hand Free Agriculture**
    - **Human Robot Collaboration (**for crop management, Pecision viticulture / Horticulture, prescription maps, selective harvest)

A popular topic - Smart Irrigation

Precision in Method choice, Space and Time

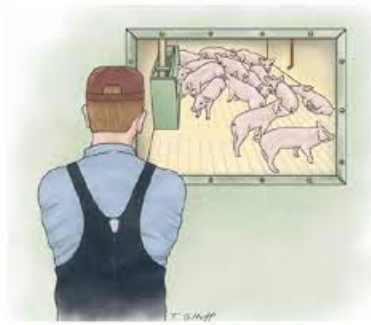
- Choice of the irrigation method
- Characterize the surfaces (zones)
- Identify the timing



Internet of Things in Agriculture

IoT in Agriculture & Livestock management

- **Smart Irrigation**
- **Localized monitoring**
  - Pests monitoring
  - Diseases observation
  - weed appearance
- **Livestock control**
  - Grazing animals
  - Behviour & illness



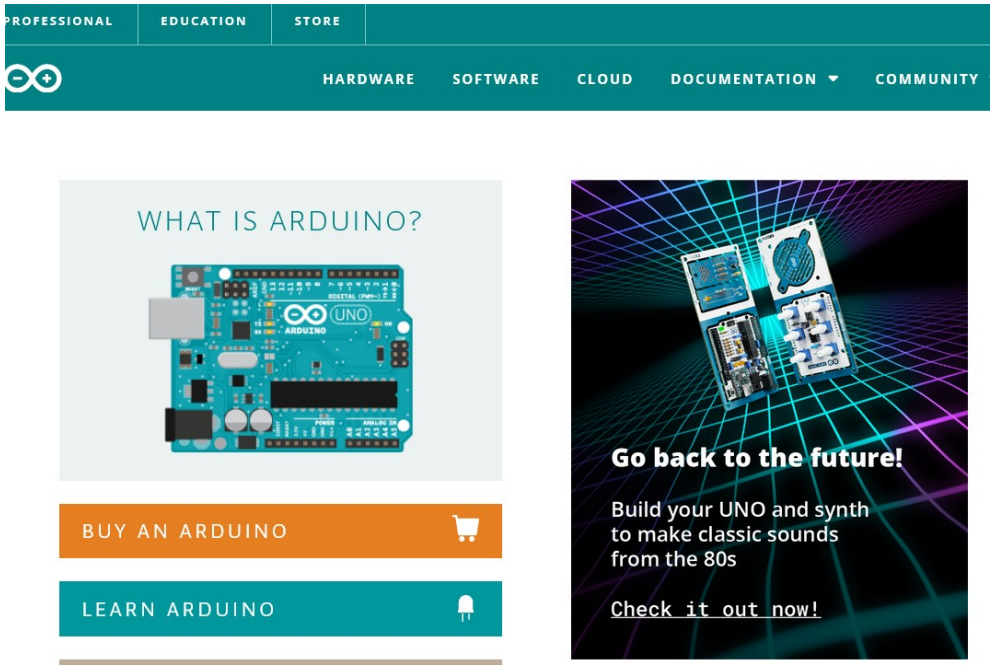
Curiosities:

- Hive weight control

- Presence of animals - hunting cameras

IoT DEVICE Technolgy

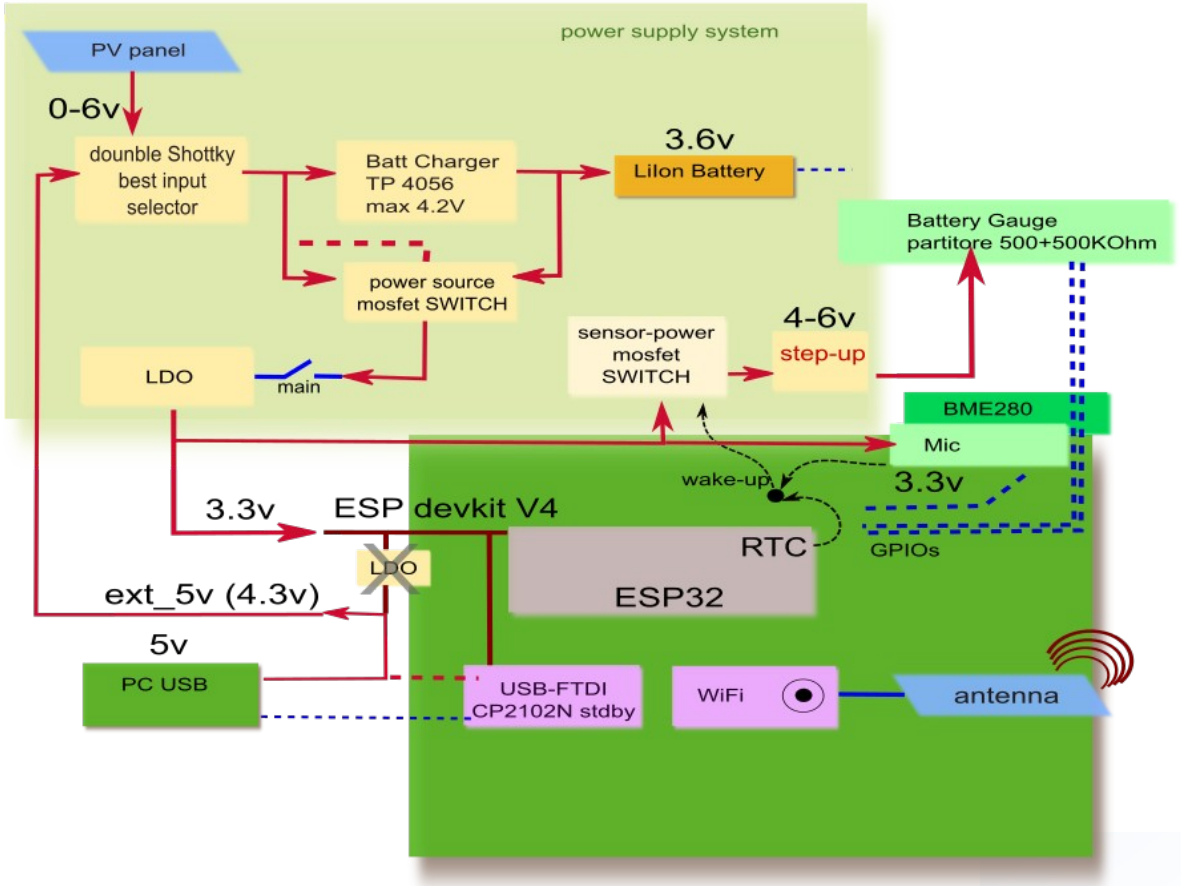
- Development
  - The arduino paradigm - https://blog.arduino.cc/
  - Choice of controller
    - ST series
    - Arduino
    - ESPressif
  - Powering strategy
  - Network Infrastrucutre
  - Choice of sensor
  - Mechanical Design
  - industrialisation process



LoPower IoT Technology

3.7v LiPo

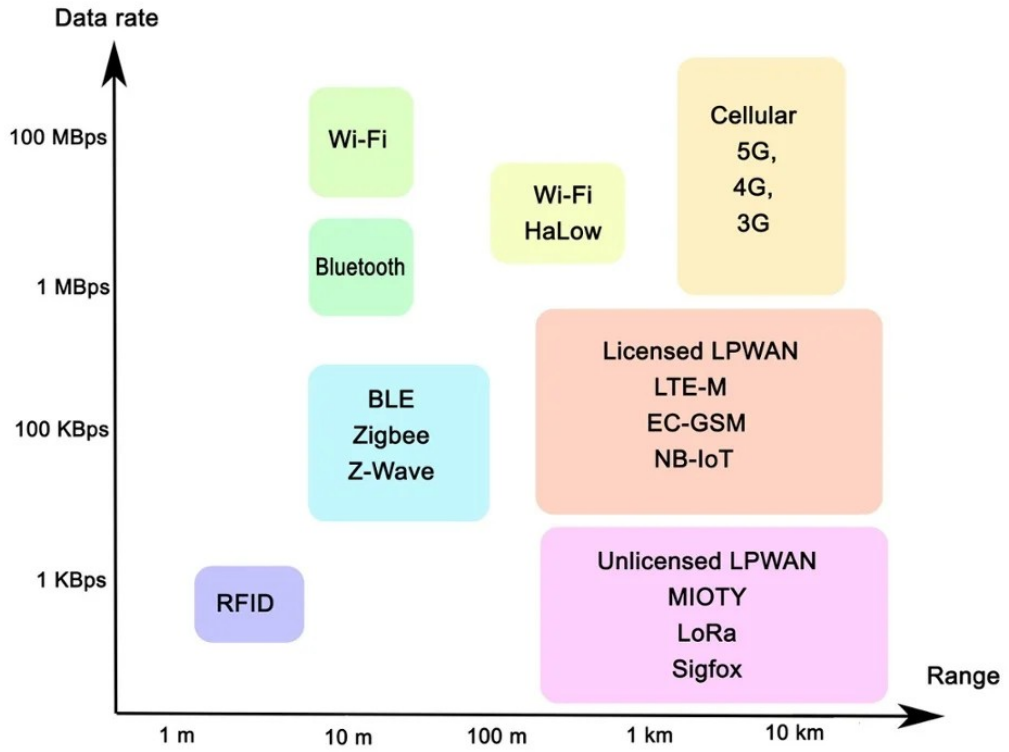
18650
3.6v LiIon



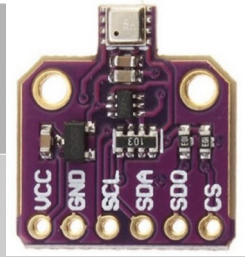
Internet Connection

Messages size / Bandwidth

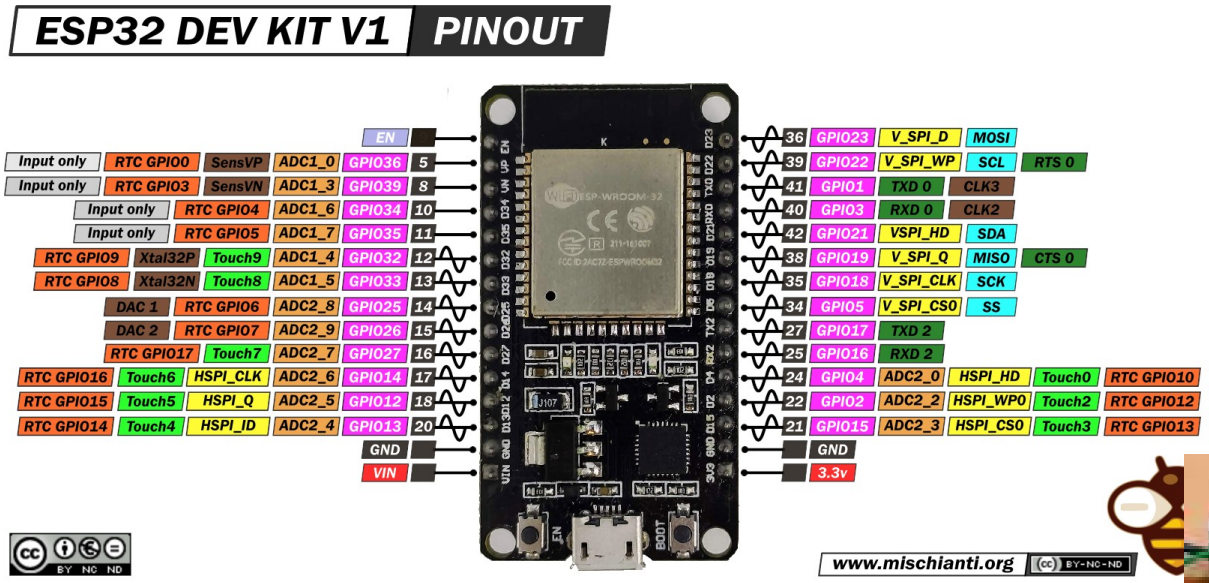
- Network
  - WLAN
  - LoRaWAN
  - NBIoT
  - Sigfox
- Protocols
  - HTTP
  - FTP
  - MQTT

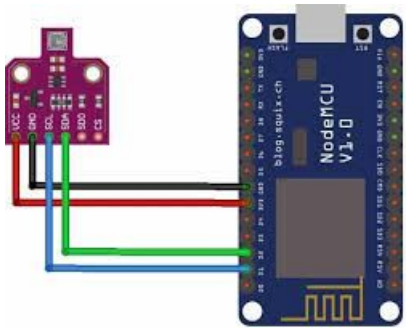


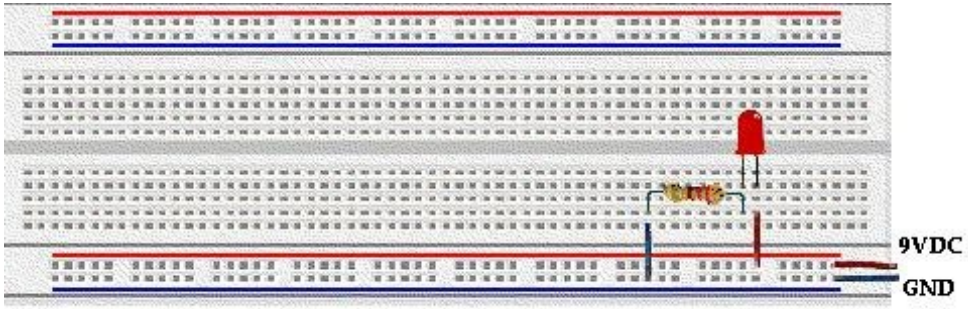
Sensors & Actuators - examples

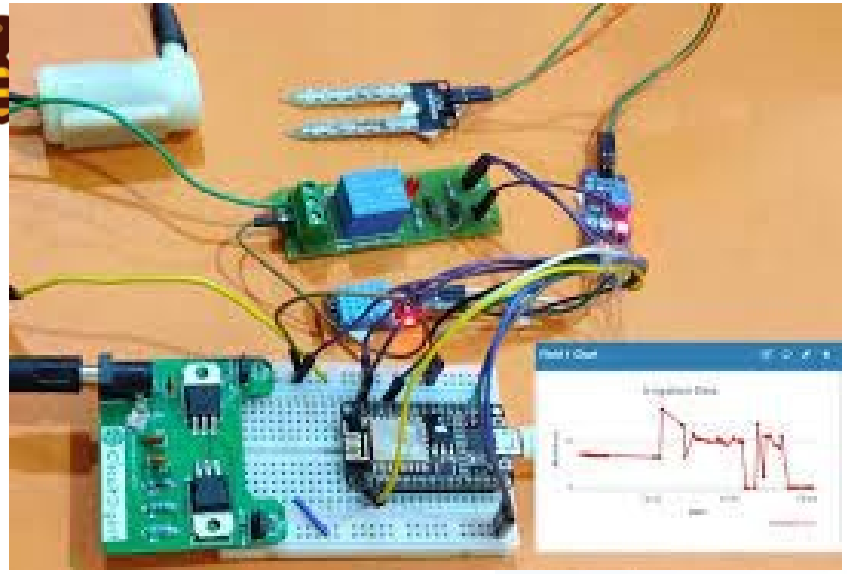
Typology			protocol
Environmental T, RH,Air Pressure, Air Quality – Soil Moisture	BME680 		I2C
Soil Moisture			
Load Cell	HX711	A/D converter	
Acoustic (DMA)			I2S
Relè			Digital

Hands on - Devkits & breadboards

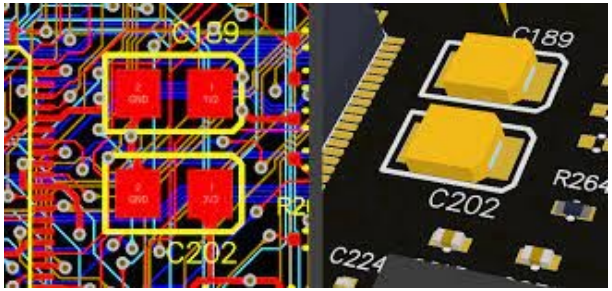


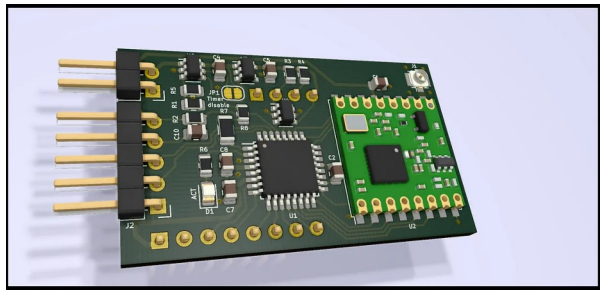


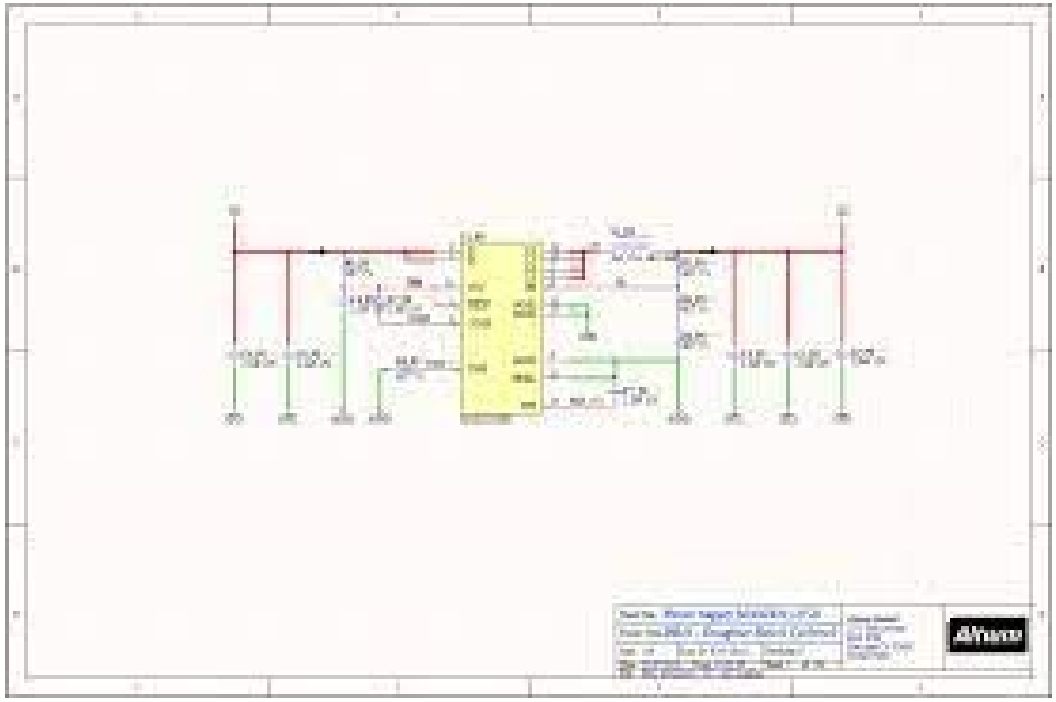


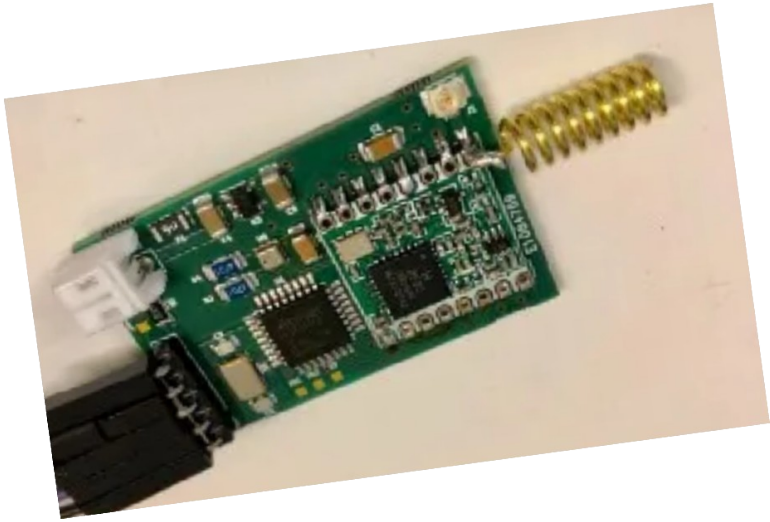


Electronic design for scalability









Developer Technologies & Suppliers

- **Digikey**
  - https://www.digikey.com/
- **Mikroe**
  - https://www.mikroe.com/click/sensors/miscellaneous
- **Espressif**
  - https://www.espressif.com/
- **Pcbway (pcb + printings)**
  - https://www.pcbway.com
- **Altium (pcb design)**
  - https://www.altium.com/

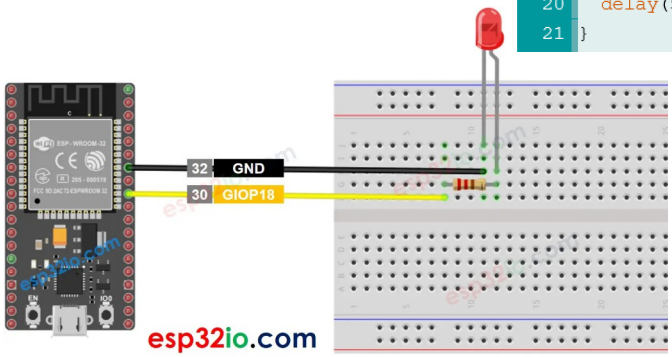
Electronics..what else ?

Firmware development

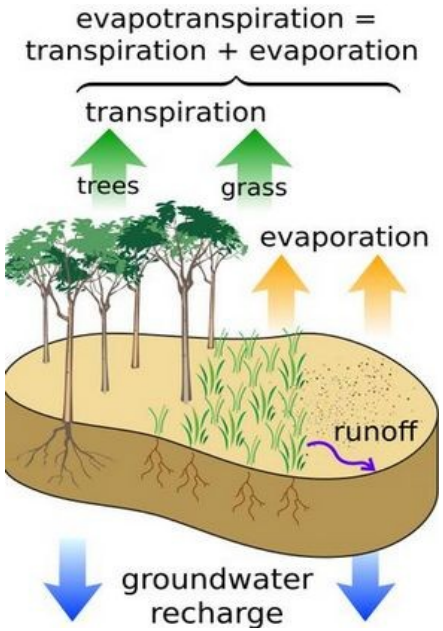
- Choice the platform
  - Arduino
  - VSCode+PlatformIO
- Start from examples
- Familiarize with platform
- Controller drivers
- USB/Serial connection
- Experience the language
- C++ (like)

https://esp32io.com/tutorials/esp32-led-blink

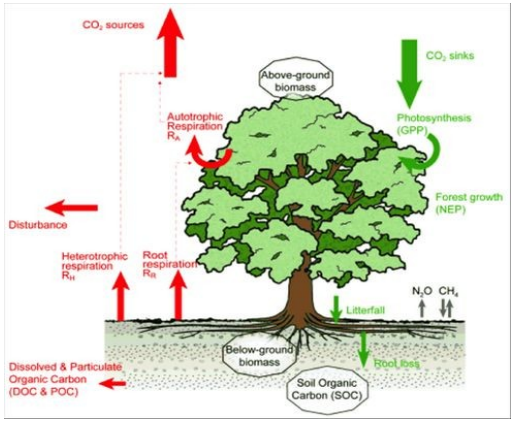
```
/*
 * This ESP32 code is created by esp32io.com
 *
 * This ESP32 code is released in the public domain
 *
 * For more detail (instruction and wiring diagram), visit https://e
 */

// the setup function runs once when you press reset or power the bo
void setup() {
  // initialize digital pin GIOP18 as an output.
  pinMode(18, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(18, HIGH); // turn the LED on
  delay(500);             // wait for 500 milliseconds
  digitalWrite(18, LOW);  // turn the LED off
  delay(500);             // wait for 500 milliseconds
}
```



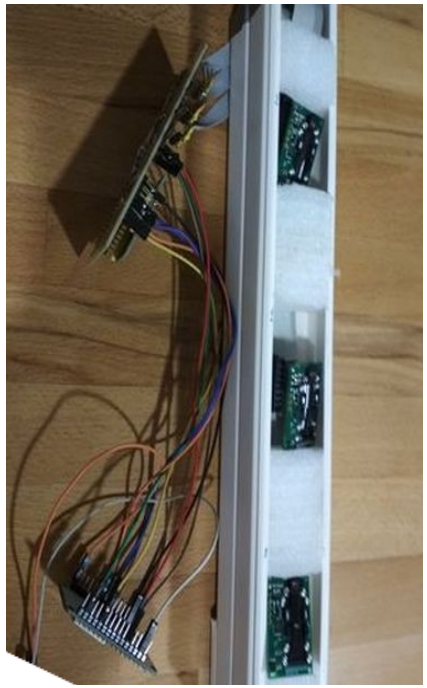
Case study – the ETRometer
What are EvapoTranspiration & Respiration



Planet has lungs ?
Vegetation can be considered the lungs of Earth ?
Soil is part of such a lung ?



ETRometer



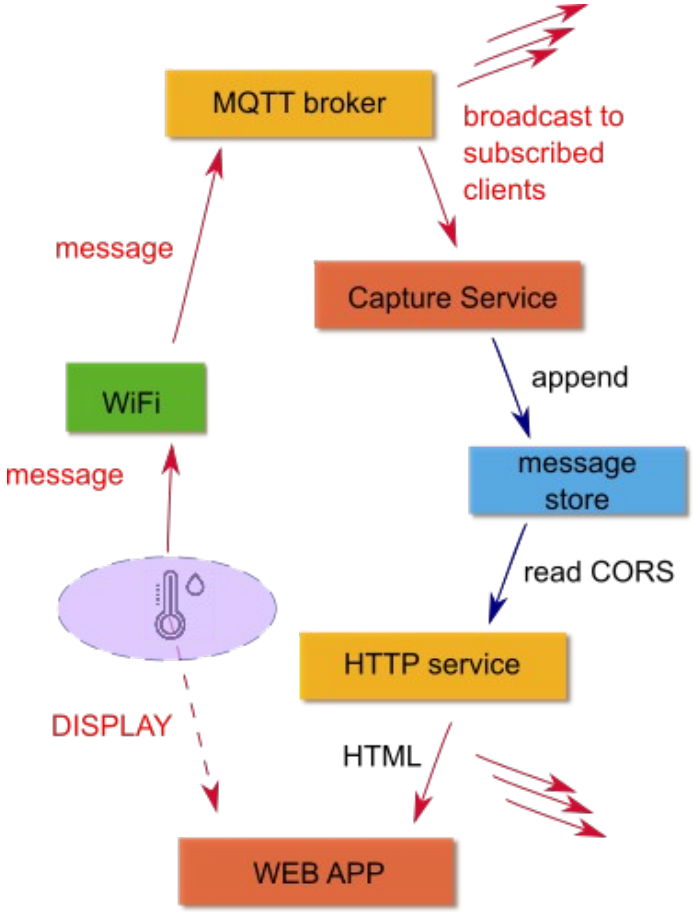
CO_2 Accuracy: ±30 ppm - range: 400 - 10000 ppm
Response time (τ63%): 20s
Temperature stability 2.5 ppm/°C

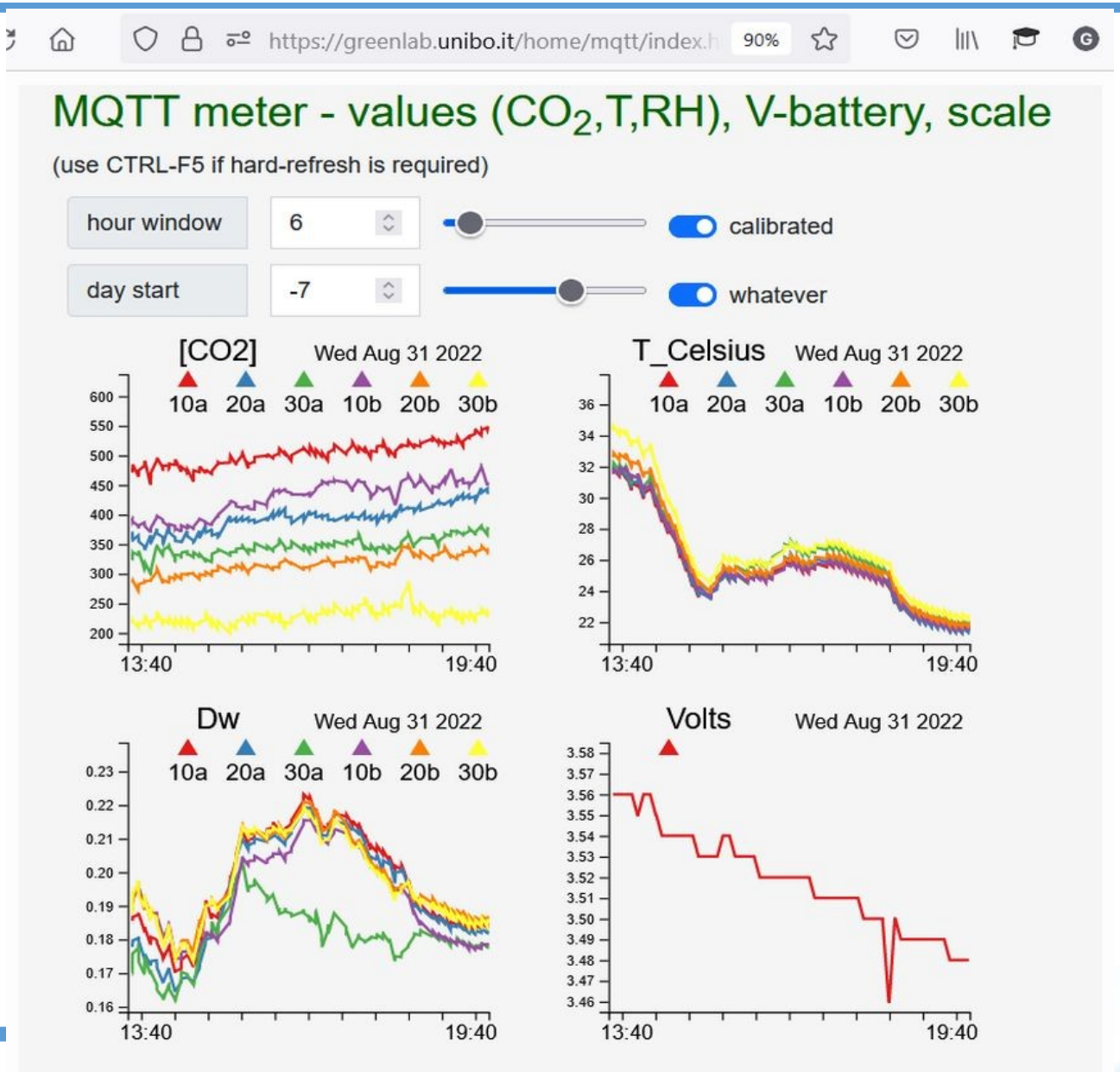
RH accuracy: 3%RH - range:0 - 95%RH
Response time (τ63%): 8s

Temperature accuracy: 0.4 °C - range: -40 - 70°C
Response time (τ63%): 10s

Supply voltage: 3.3 - 5.5V
Average supply current:19mA - Max. 75 mA

W


MQTT broker
broadcast to subscribed clients
message
Capture Service
append
WiFi
message store
message
read CORS
HTTP service
DISPLAY
HTML
WEB APP


https://greenlab.unibo.it/home/mqtt/index.h
90%
MQTT meter - values (CO_2,T,RH), V-battery, scale
(use CTRL-F5 if hard-refresh is required)
hour window
6
calibrated
day start
-7
whatever
[CO2]
Wed Aug 31 2022
10a 20a 30a 10b 20b 30b
600 550 500 450 400 350 300 250 200
13:40
19:40
T_Celsius
Wed Aug 31 2022
10a 20a 30a 10b 20b 30b
36 34 32 30 28 26 24 22
13:40
19:40
Dw
Wed Aug 31 2022
10a 20a 30a 10b 20b 30b
0.23 0.22 0.21 0.20 0.19 0.18 0.17 0.16
13:40
19:40
Volts
Wed Aug 31 2022
3.58 3.57 3.56 3.55 3.54 3.53 3.52 3.51 3.50 3.49 3.48 3.47 3.46
13:40
19:40

Conclusions

IoT is a big opportunity for smart-agriculture to meet the main aim of physics - measurement, and of engineering - machines

IoT is interesting to ***growing audience*** *because of its* ***scalability:***

- ***academic – labs include several skills (programming & electronics & mechanical design , environmental physics)***
- ***spinoff & startup***
- ***research & development***

It can be easily addressed in ***inclusion patterns*** *to involve passionate developers (****DIYers****), and* ***attracting farmers to PA***

Thanks for your attenction

… to be continued

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