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A Feasible IoT-Based System for Precision Agriculture

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CPS&IoT

Outline

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- **Problem definition**
- **State of the arts**
- **Methods/Approach**
- **Results**
- **Conclusions**

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Problem definition

- Global world growing population faces many challenges, among others, in food production. There are obvious efforts to employ Industry 4.0 technologies in agriculture, in order to achieve increased production in term of quantity and quality, efficient ecological management, financial savings, water supply management and other benefits.

Problem definition

- Specific data for precision agriculture (PA) are provided by range of specific sensors connected to hardware devices with adequate software applications. Such systems are capable to measure, visualize, monitor and analyze soil and environmental parameters and provide adequate feedbacks from the user

State of the art

- It offers several functional advantages as:
  1. powering autonomy,
  2. long-range communication,
  3. integration with existing commercial or free IoT platforms,
  4. easy embedding in individual or company web sites/servers and
  5. accessibility with any person or farmer equipped by internet access.

State of the art

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- IoT devices are becoming more popular in personal, home and industry use
- Growing number of application areas: agriculture, health, weather, smart homes/cities, farming…
- Easy to use
- Controlled by smartphones
- Agricultural potential
  - water saving
  - desease and pest detection and prediction
  - improving soil health

Methods/Approach

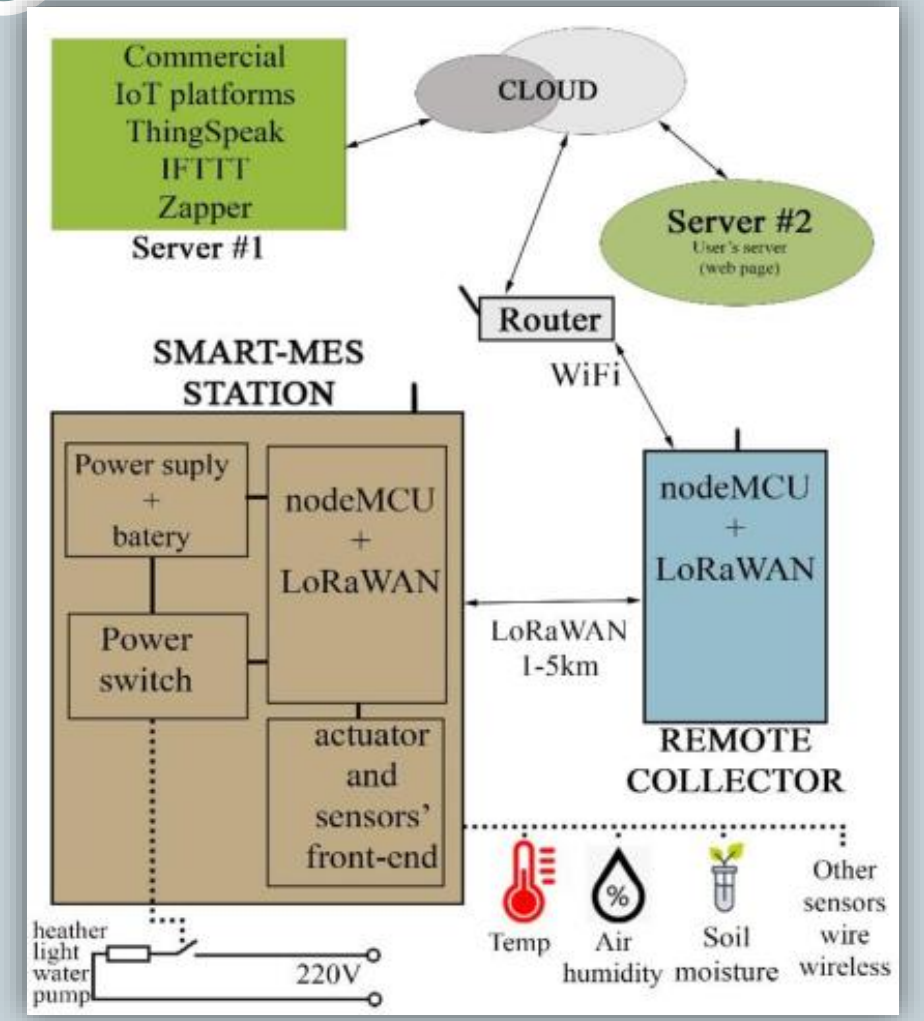
- Target areas and features
  - Agriculture
  - Telemonitoring
    - Long range communication (LoRa)
  - IoT
  - Remote control
  - Low cost
- Components
  - Solar panel + battery
  - ESP32 based microcontroller
  - Sensors:
    - DHT11 – air temperature and humidity
    - Developed soil moisture sensor

- Goal
  - Autonomous telemonitoring agricultural station
  - View data and send commands remotely
  - Analyze data and improve agricultural program

Methods/Approach

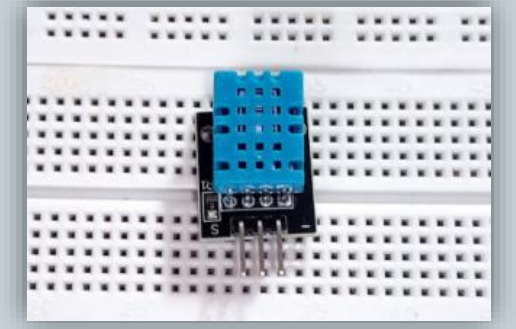
- Two identical MCUs
- LoRa, Wi-Fi and Serial communication protocols
- Cloud connection
- Two-way communication between user and devices
- Agricultural related sensors

The working principle

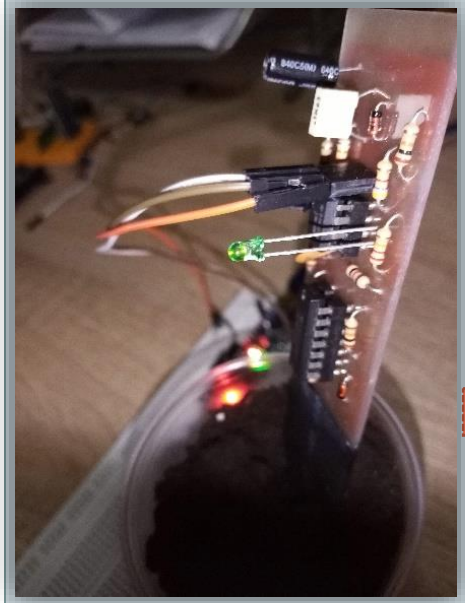


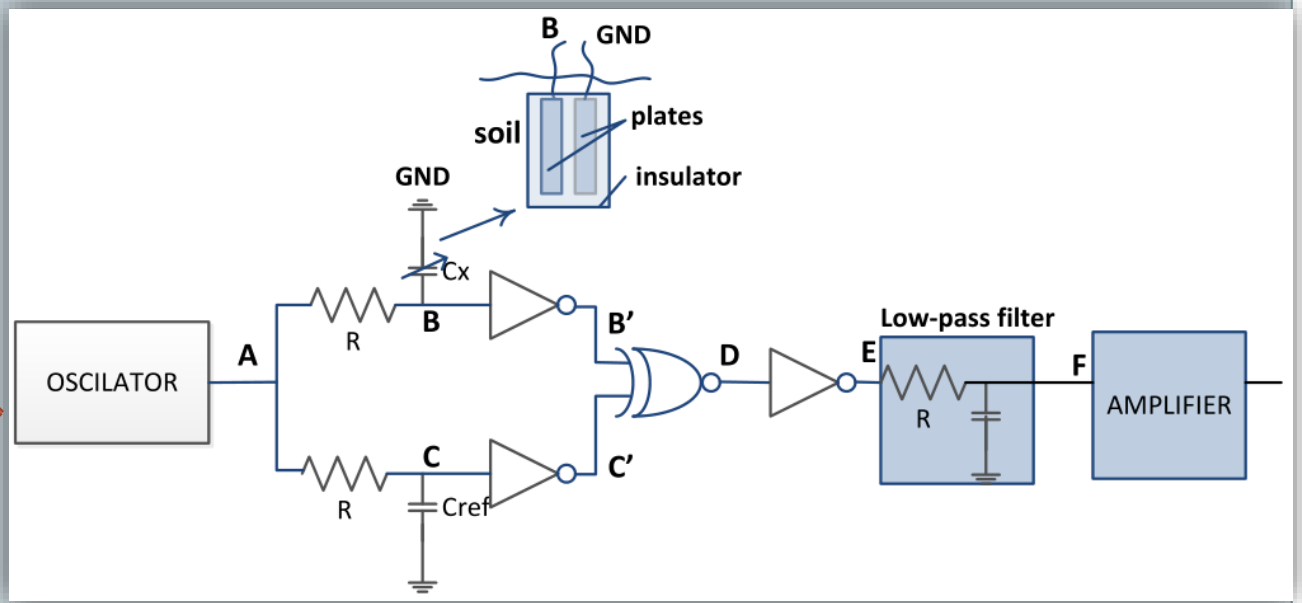
Methods/Approach

- Sensors
  - DHT11 – air temperature and humidity



  - Soil moisture



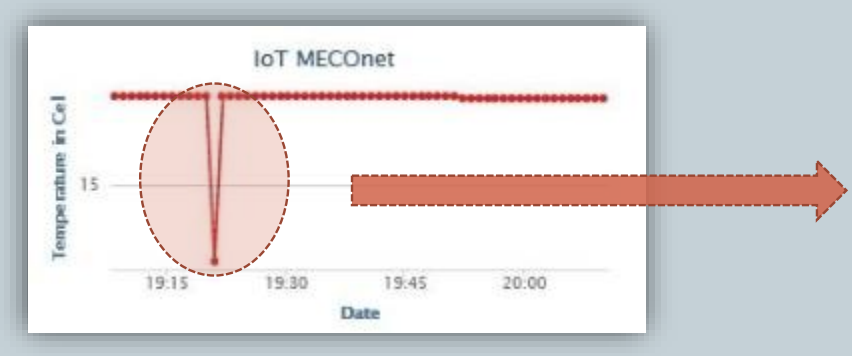


The experiment

- The system was being tested and improved for months and now is fully operable and reliable
- Testing was conducted both in a viticulture field and indoors
- Commands regarding external devices power management were sent using two-way communication over an IoT server; and feedback response was watched
- High precision capacitive soil moisture sensor was developed and calibrated

Results

- Testing
  - The initial message size had to be reduced to a bare minimum in order to achieve suitable distance between two nodes. It's final size is now 32 bits which contain only the needed data.
  - When error occurs, the message usually looks like randomized characters on a receiver node. Digital filters had to be implemented to decide whether it is a good message or not; bad messages are ignored.

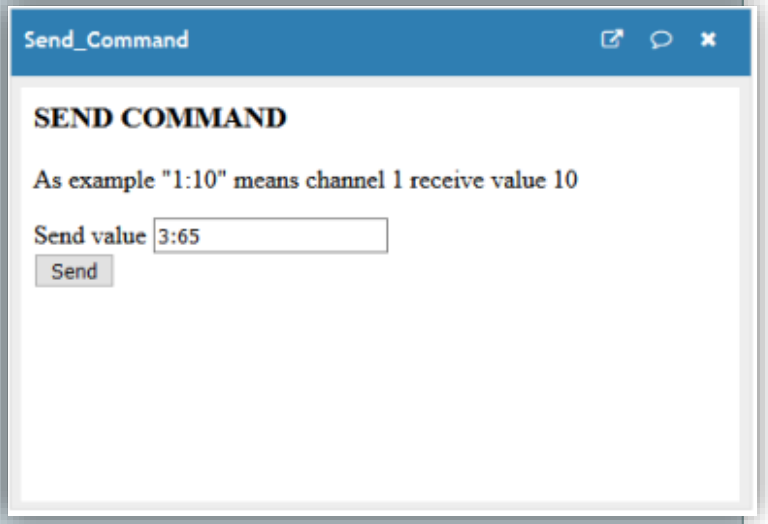


misinterpreted message result

Results

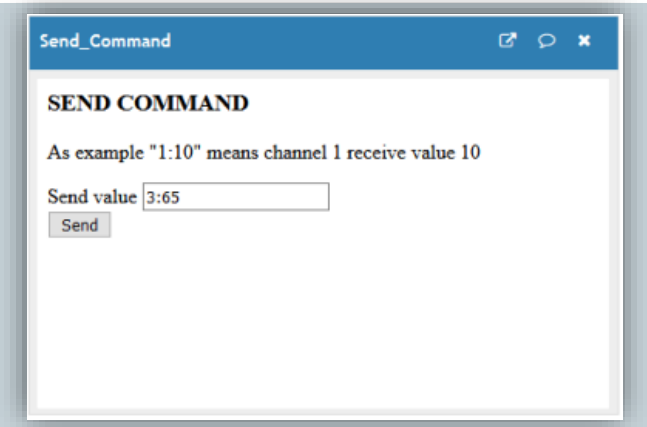
- Control
  - Power management of three devices is built in using an IoT platform; one for each measuring parameter
    - The MCU's signal is too weak to power big devices, but can be used as an excitation signal
  - Entered value tells whether a device should be turned on or off compared to a measured value

Demonstration: lighting LEDs

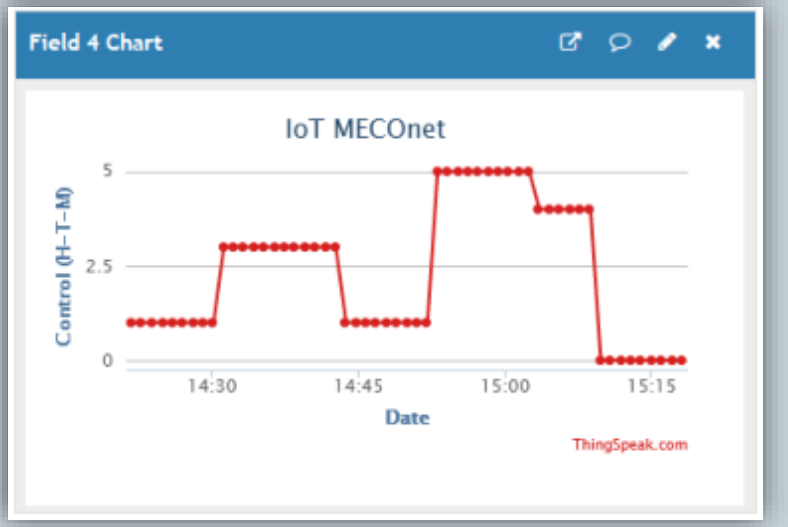


Results

Demonstration: three LEDs

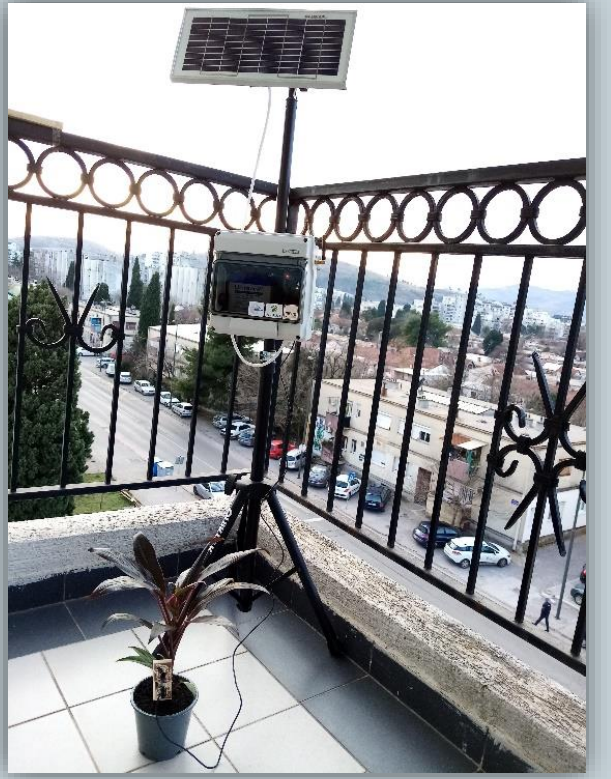


- Control, visual feedback
  - LEDs were remotely controlled while watching their corresponding binary combination on internet



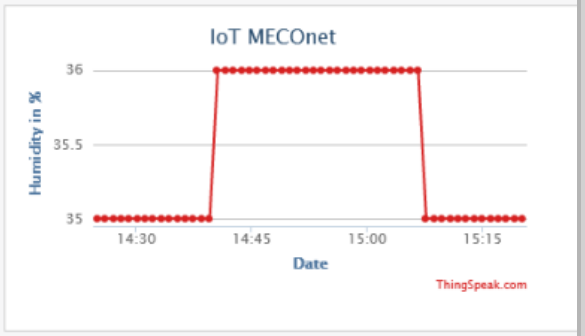
Results

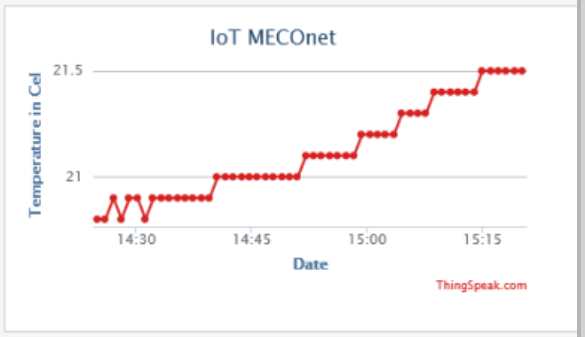
- Live data
  - a field
  - an apartment

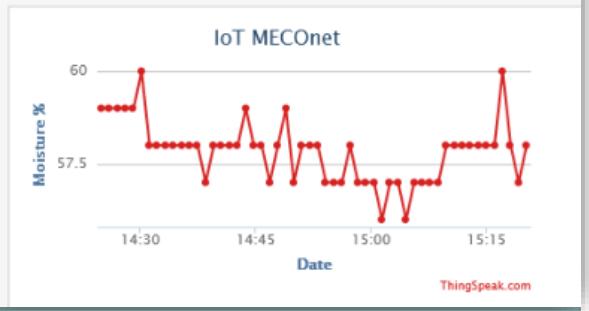


LIVE diagrams

Wed Mar 24 2021 15:21:00 GMT+0100 (Central European

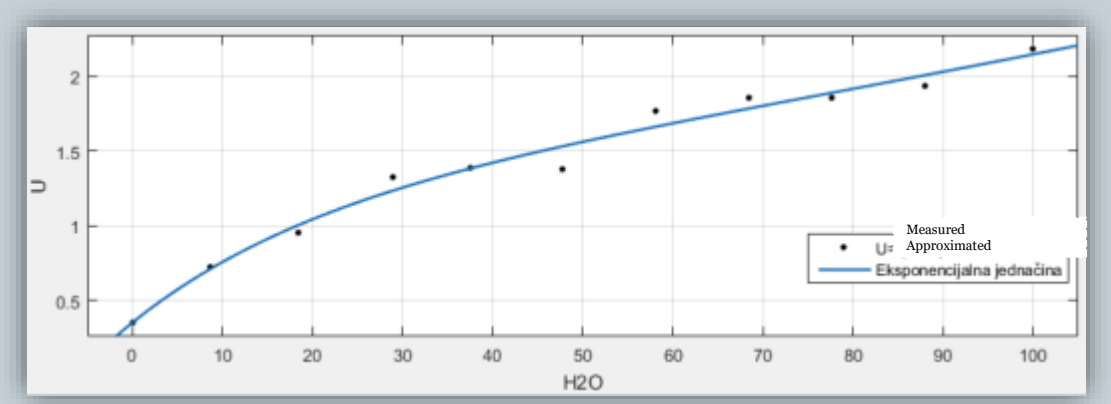






Results

- Soil moisture sensor calibration
  - Drying and weighing method
    - A soil sample was completely dried and then gradually moisturized, weighed and measured
    - The voltage output of a sensor was matched with the corresponding moisture level
    - A fitting curve was made with Matlab



$$f(x) = 1.64 * e^{0.175} - e^{-1.5}$$

Conclusions

- The system has proven reliable and can be used on a field as is
- Features to improve:
  - power consumption
  - filtering the data
  - a bigger transmission range
    - more powerfull antenna
    - more advanced communication protocol
  - adding viticulture-specialised sensors
  - design

THANK YOU

Q&A

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