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37th Cycle

Long-Range Low-Power Electronic System for Precision Agriculture

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Research context and motivation

- **WAPPFRUIT** regional project develops cutting-edge technologies for water management in fruit growing.
- This work follows one of the United Nations' global goals, 6.4 SDG (Sustainable Development Goal) – More efficient water use.
- The main goals are the **definition of the water requirements** and the **realization of a complete automation of a micro-irrigation system** in orchards.

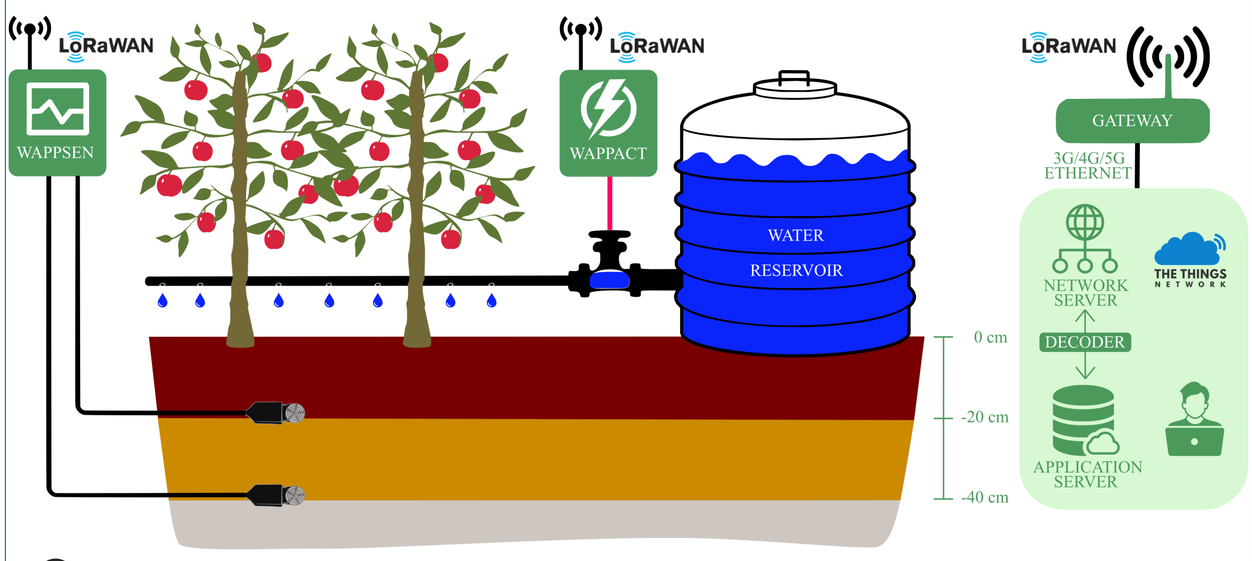
WAPPFRUIT

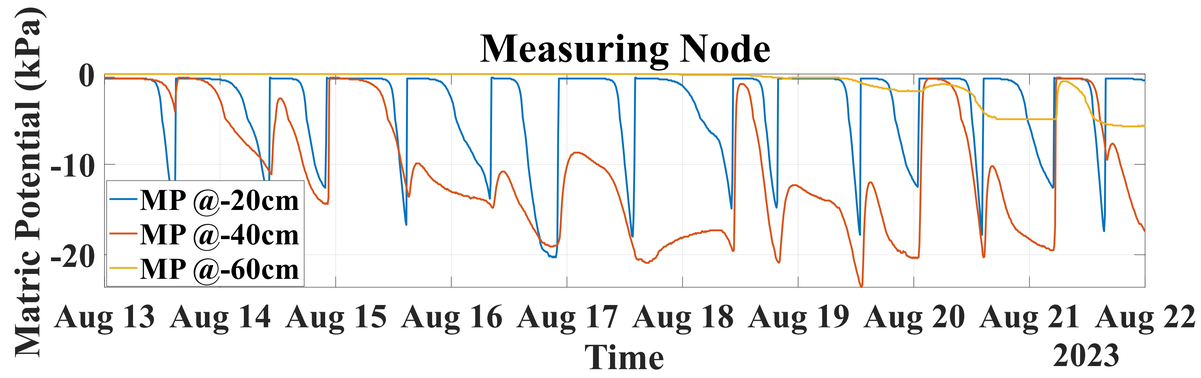
Addressed research questions/problems

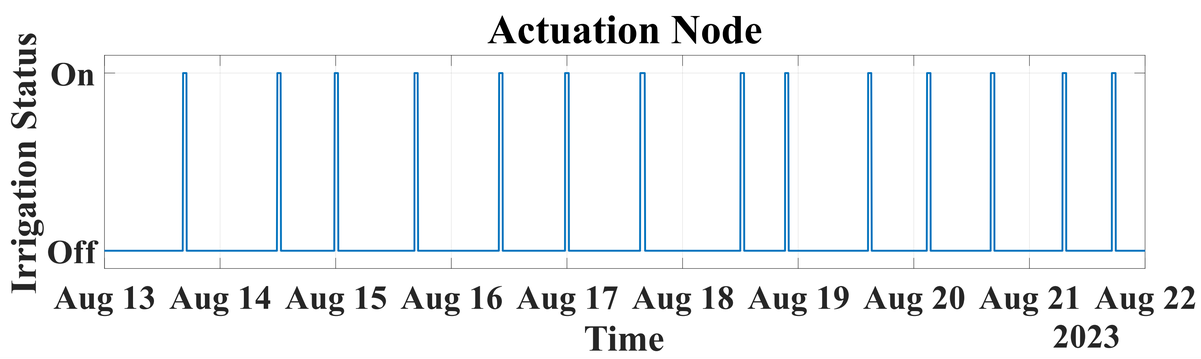
- Definition of optimal conditions where a plant could maximize its yield. **Plant**, **soil**, and **environment** are the main elements to define the correct requirements.
- Definition of useful **fruits parameters** to evaluate quantitatively and qualitatively their organoleptic features.
- Comparison between **smart irrigation** based on matric potential thresholds with respect to **manual and timed drip irrigations** based on the knowledge of the farmers.
- Methods to **reduce carbon footprint** in agriculture in such a way as to mitigate anthropological effects: **reduction of water usage** means **less energy** spent to supply water pumps.

Novel contributions

- A complete characterization of trunks and fruits (**dendrometers** and **fruitmeters**) is performed, correlated to the soil variables (**soil temperature**, **soil matric potential**, and **volumetric water content**)
- Data are sampled at various depths (-20, -40, and -60 cm) to characterize **root layers**.
- Optimize **Internet of Things (IoT) electronic systems** focusing on power consumption;
- **Design and testing of a cloud-based automatic irrigation system** working on specific plant varieties monitoring 24/7 an industrial sector composed by rows of orchards involved in the WAPPFRUIT project.



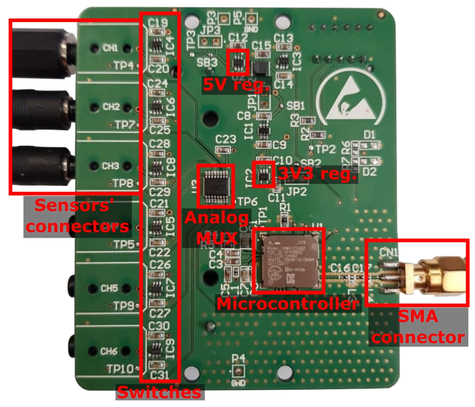




Adopted methodologies

Measuring Node

- Low-power IoT node designed to supply and read data from digital industrial soil sensors (soil temperature, soil matric potential, and volumetric water content).
- Radiofrequency protocol: **LoRa (Long Range)**.
- Custom firmware based on STM middleware.
- Supplied with a **single battery 3.6 V LiSOCl2** in AA package.
- Very low standby current draw: **1.89 µA**.

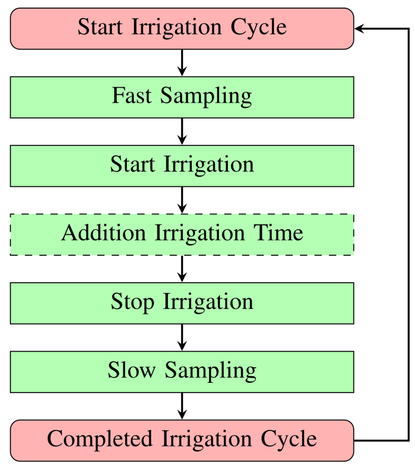


Actuation Node

- Low-power IoT shield in charge of driving an electrovalve connected to the drippers in the experimental rows.
- Radiofrequency protocol: **LoRa (Long Range)**.
- **Two power sources**: 3.6 V LiSOCl2 AA battery and 9 V ZnMnO2 1604 battery.
- Very low standby currents draw: **2.60 µA** and **317 nA** for processing and power section respectively.
- **Variable duty-cycling** to optimize consumption.

Irrigation Cycle

- Irrigation algorithm based on **multi-depth, matric potential thresholds** to perform **variable rate drip irrigation** on 3 experimental rows (apple and Actinidia).
- **Variable system duty-cycling** to save energy.
- Integrable on existing farmer's **water availability time slots**.
- **Fault tolerant**: automatic measuring node exclusion when IoT motes are broken/missing or soil sensors are out-of-service.
- **Event alarms**: automatic alarm generation when system is not correctly working.



Software Architecture

- **LoRaWAN network server**: The Things Network.
- **24/7 decision-making script:** Python on 24/7 server
- **Server agent**: Node-RED.
- **Visualization platform**: InfluxDB.
- **Storage platforms**: InfluxDB and private server.

influxdb
Node-RED
THE THINGS NETWORK
akenza.io

Future work

- **Improved measuring and actuation motes revisions**: lower power consumption in both runtime and standby, increasing range, and design of a battery monitoring stage.
- **Updated software architecture** towards a draft commercial product.
- Evaluation of **fruit figures of merit**: yield, quantitative parameters (Brix, water hardness, etc.) compared to the actual methodology.
- **Investigation innovative irrigation schemes** to overcome inertia of soil-plant system.
- **Evaluating energy and water savings** with respect to the non-automated crop by the farmer.

Publications

- Published works: 2 journals, 4 conferences
- Submitted works: 1 conference
- Garlando, U., Calvo, S., Barezzi, M., Sanginario, A., Ros, P. M., and Demarchi, D., "*A Plant-Wearable System for Its Health Monitoring by Intra- and Interplant Communication*", IEEE Transactions on AgriFood Electronics, 2023, pp. 1-11
- Garlando, U., Calvo, S., Barezzi, M., Sanginario, A., Ros, P. M., and Demarchi, D., "*Ask the plants directly: Understanding plant needs using electrical impedance measurements*", Computers and Electronics in Agriculture, vol. 193, no. 106707, 2022, pp. 1-13