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PLANTENNA: 3D-sensor networks monitoring plant environment. An application for fruit frost protection

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Environmental field conditions are highly variable in three-dimensions and unsuitable to be probed by a single sensor or weather station. In PLANTENNA, a team of electronics, precision and microsystems engineers and plant and environmental scientists collaborate to develop and implement 3D-sensor networks that measure plant and environmental parameters at high resolution and low cost. A first problem we aim to tackle in the field is 3D-monitoring of fruit farms for detection and mitigation of fruit frost damage. The objectives are two-fold:

- To quantify the time-dependent effects of frost mitigation measures on the 3D temperature profile, and to determine the resulting plant-physiological response to get a better understanding of the underlying mechanisms leading to frost damage.

- To develop low-cost, low power, wireless, distributed sensor networks, with automated mathematical data handling to give real-time visualization of subzero temperature regions as decision support system for the farmer.

Field implementation: A fruit farm will be equipped with optical fibre cables for Distributed Temperature Sensing, along horizontal and vertical profiles in the field. This will reveal how cooling penetrates the canopy as a function of time, and how this is influenced by changing atmospheric conditions and mitigation efforts. Detailed temperature monitoring is related to spatio-temporal physiological monitoring at the level of individual trees.

In a next step, the cables will be replaced by a 3D-network of temperature sensors. The aim is to develop an accurate (±0.5°C accuracy with a resolution << 0.1°C), low cost sensor with ultra-low power consumption (~ 100 nW). The sensor is based on a PCB-based node that consists of a PV module to collect solar energy, a power management integrated circuit (PMIC), a supercapacitor to store energy, a temperature sensor, a microcontroller (μC), a timing control unit (TCU) to enable/disable the system, and a radio frequency IC (RFIC) + antenna to transmit data to the

network. To reduce energy consumption, it should operate in low-power “sleep mode” as much as possible, while still being able to capture sudden temperature changes as by ventilator activation: the sensor must decide when to “wake up” and how frequently to measure. The often “power-hungry” MCU and RF radio should operate in an event-driven mode and only “awakened” when the sensor detects a temperature change above a certain threshold.

We chose LoRa for its low power consumption and long-distance capability, which is a perfect match with our application.