

SEnviro for Agriculture: An IoT full stack for monitoring vineyards – Early steps

Sergio Trilles Oliver
Universitat Jaume I
Avd. Sos Bayna s/n
Castelló de la Plana,
Spain
strilles@uji.es

Alberto González Pérez
Universitat Jaume I
Avd. Sos Bayna s/n
Castelló de la Plana,
Spain
algonzal@uji.es

F. Javier Zarazaga-Soria
Universidad de Zaragoza
María de la Luna, 1
Zaragoza, Spain
javy@unizar.es

Joaquín Huerta Guijarro
Universitat Jaume I
Avd. Sos Bayna s/n
Castelló de la Plana,
Spain
huerta@uji.es

Abstract

The deployment of sensing devices has increased considerably in all areas; the field of agriculture is not an exception. This fact has led to a new concept called smart agriculture, and it contemplates activities such as field monitoring, which offer support to make decisions or perform actions, such as irrigation or fertilization.

In this scenario, this paper shows the initial months of a project to monitor vineyards. It is composed of two parts, one of them is a low cost sensorized node to monitor meteorological phenomena, called *SEnviro node*. And the other one is called *SEnviro connect*, it is able to collect observations from all *SEnviro nodes* following the Internet of Things and Cloud Computing paradigms and can offer some alerts in order to help farmers in his/her daily tasks. To achieve this, our work follows some advances from GIScience in order to increase interoperability and uses some real-time approaches to analyze sensor data as soon as it is produced.

Keywords: Wireless Sensor Networks; Internet of Things; open sensorized platform; precision agriculture; vineyard

1 Introduction

Traditionally, precision agriculture makes use of sensors to monitor environmental conditions. To attain this objective, networks of these sensors are created to monitor larger areas. Not only sensors, the precision agriculture has added all developments in the surroundings of the computer science. An example of this is the use of smartphones, which have been used to visualize on the field data provided by sensors and offering the possibility to apply different strategies to improve productivity.

More recently, a new approach to connect everything (sensors, actuators, etc.), as well as to monitor and act (INFSO, D., 2008) using the Internet, is implanted in every aspect of our daily lives; this process has come to be called the Internet of Things (IoT). IoT describes how in the real world, physical things are integrated into the digital world of bits and bytes Uckelmann, D., Harrison, M., & Michahelles, F. (2011). In general, it involves the integration of each object, such as a sensor or device that is connected via wired or wireless networks using the Internet. To connect things, the Internet Protocol (IP) is used, in which each device has its own IP address.

The IoT devices need a mechanism to communicate, it is called Machine to Machine (M2M) and it will work with new developments and contributes to the future of the Internet (Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. 2013). Actually, the future of the Internet will not only consist in connecting people, but also on the approach of a digital world where, ideally, everything will be connected.

The connection between the IoT and M2M with precision agriculture have produced a new concept called "smart agriculture" following other M2M based implementations such as smart cities. Using this approach, every day farmers are producing large amounts of data that are published on the cloud (Cloud Computing), with the aim of delivering benefits

in terms of data access, synchronisation storage and to apply some analysis in order to make decisions.

One of the fields in which greater adaptation of such technologies has been incorporated is the viticulture. Viticulture has historically been characterized by obtaining a high quality product. This has been made possible by a number of factors: the selection of suitable soil and climatic zones, the varietal wines and obviously the work of the winegrower in managing vineyards.

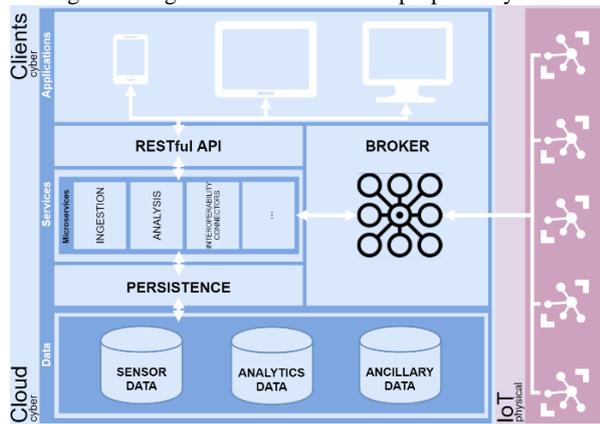
Within this context, we present a project called *SEnviro* for Agriculture, it consists in the development of a new version of *SEnviro node* presented in (Trilles, S., Luján, A., Belmonte, Ó., Montoliu, R., Torres-Sospedra, J., & Huerta, J., 2015) and a platform (to develop) to analyse sensor data and offer recommendations/alerts to farmers from *SEnviro nodes* in vineyard fields. This paper has the goal to reveal the work done during the initial months of the project, from a technological perspective.

2 *SEnviro* for Agriculture in a Nutshell

The main objective of *SEnviro* for Agriculture is to design and develop a full system for monitoring farm fields, particularly vineyards, in order to improve the quality and yield of the production. This is intended to put into value the recent advances in communication technologies and sensors, applying to the specific field of precision agriculture.

This system consists of two pieces, (1) a generic sensorized node, called *SEnviro node*, and (2) a platform capable of managing the different nodes and offering added value to sensor data from the nodes, called *SEnviro connect*. Figure 1 summarizes all project parts and how they are connected.

Figure 1: A general overview of the proposed system.



2.1 Hardware: towards *SEnviro node* and beyond

At the hardware level, purple part in Figure 1, the sensorized platform has been designed to be a node acting as a smart object, which provides environmental measurements. It follows the same parts than the version presented in (Trilles, S., Luján, A., Belmonte, Ó., Montoliu, R., Torres-Sospedra, J., & Huerta, J., 2015), in this way each *SEnviro node* is organized into four groups depending on their function: core, sensors, power supply and communication. The main differences from the previous version are the components used to create each node. More concretely, in this work, we developed an enhanced *SEnviro node* using the Electron board by Particle. The Electron board has an open source design with high performance. The board is based around a powerful ARM Cortex M3 microcontroller, it offers 2G and 3G connectivity. Pin-out is formed by 30 mixed-signal GPIO. It can be upgraded using OTA updates.

Each *SEnviro node* includes sensors to measure soil and air temperature, soil and air humidity, atmospheric pressure, rainfall, wind direction and speed. A lithium battery of 2200 mA and a solar panel to provide energy for each node, accompanied by energy saving techniques. A 3D model has been developed to protect and join all components. Figure 2 shows an example of *SEnviro node*.

Figure 2: *SEnviro node*.

2.2 Software: *SEnviro connect*

If we see *SEnviro* at the software level (blue part in the Figure 1), we can divide the *SEnviro connect* in three parts:

data, services and applications. The most important part resides in the services layer. In this part, we can split into four different components: *broker*, *persistence*, *restful* and *microservices*. First of them, *broker*, has the ability to connect the *SEnviro nodes* with the software platform and it is used as a bus between the other components. The broker offers a publish-subscribe base messaging protocol, called MQTT (Message Queuing Telemetry Transport). It is designed for connections with remote locations where the *SEnviro nodes* are located, usually the network bandwidth is limited.

The second component, *microservices*, is used to provide different functionalities or abilities that *SEnviro connect* can offer as a platform. In this moment of development, only three functionalities have been considered: *ingestion*, *analysis* and *interoperability connectors*. The *ingestion* is a process of accessing and importing sensor data for immediate use to analyse or storage in a database. The *analysis* microservice can process sensor data in order to apply some algorithms (meteorological alerts and vineyard diseases predictions such as mildew). The last microservice is called *interoperability connectors* and it has the responsibility to fulfil with standard interfaces. OGC defines standards in a wide variety of domains including environment, defence, health, agriculture, meteorology, sustainable development, and smart cities. The OGC has standardized Sensor Web Enablement (SWE) (Botts, M., Percivall, G., Reed, C., & Davidson, J., 2008). It is planned to offer an official OGC standard such as OGC SensorThings API (Liang, S., Huang, C. Y., & Khalafbeigi, T., 2016).

The third component is the *persistence*, it is used to store the different data from *SEnviro nodes* and other kind of data produced by some microservices or final users. And the last one part in the services layer, *Rest interface*, it features results or final outputs in order to visualize in the client layer.

The data layer stores all needed data in the platform, sensor, analytics or auxiliary data. These databases provide spatial features used to provide some spatial analysis.

In the last layer, we move from the cloud to the client. A web application based on HTML5, JavaScript and Cascading Style Sheets (CSS) is proposed. It offers the capacity for building a responsive client, as it can adapt to the device's features (desktop, mobile or wearable). This client will show sensor data, analysis results and will be used to manage all platform functionalities to monitor vineyard fields.

3 Conclusions

The main concern of this work is to apply the new improvements in the ICT area, within the smart farming context. This paper shows a work in progress to reach a full solution to monitor vineyard fields and predict some diseases like mildew or launch possible alerts when meteorological conditions are harmful to vineyard plants. The work is presented as early steps and taking a technological perspective.

The proposal presents two main pieces, an IoT sensorized platform called *SEnviro node*, and an IoT software platform, called *SEnviro connect*. Two parts are working together to monitor vineyards providing some advantages such as an autonomous (energy and connectivity) node, launching alerts to detect bad conditions in vineyard fields, detecting diseases

like mildew and providing standard interfaces to guarantee interoperability between systems, among others.

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