WINE LEVEL MONITORING SYSTEM FOR INDUSTRIAL CELLARS

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Abstract. *Winemaking culture originated at least three thousand years ago. However, its technical side has not drastically changed over time. This project combines modern technology with the ancient art of winemaking to improve and facilitate the industrial process by using smart cask corks.*

Keywords*: internet of things, winery, winegrowers, smart vineyard, humidity sensors.*

Introduction

From the earliest vintages made in what is now called the Middle East, the story of wine can be traced alongside the history of most of the civilized world. Archaeological discoveries suggest that wine has been made in Egypt for at least 3,000 years and, according to records, Marco Polo enjoyed the wine that was imported into China from Persia in the 1400s. When European emigrants travelled to the New World, they took wines with them, so that by the late 19th century it was clear that nothing could stand in the way of the production and gradual spread of wine around the world [1].

Global demand for wine has hit nearly three billion cases a year and is rising fast, but the industry has been going through a few changes. The mature grape is the result of complex physiological and biochemical phenomena, which themselves are intimately linked to environmental conditions [2]. Global warming is expected to add further changes to the industry. Wine grapes are generally grown in places where frost is rare, temperatures are moderate and a certain amount of rain and humidity. Any increases in temperature could have a negative effect on this delicate balance.

In order to give a solution to these issues, this project will provide an innovative architecture based on the concept of *the Internet of Things*, which allows combining wireless and distributed specific sensor devices. It also supports integrating different wireless sensor technologies with advanced analysis, remarkable information from the environment such as soil condition, vines growth or fermentation status can be retrieved and further allowing interaction, personalization, and management of different devices deployed over the scenario. However, for the present we are going to focus on wine level monitoring only with the possibility of further development.

Unfortunately, nowadays winegrowers mainly use digital tools for commercial and marketing activities only and just a few of them use digital for their cellar and wine. According to a barometer about connected winemakers in a French wine region, 77% of winemakers are doubtful or not convinced about spending time and money in digital [3].

System architecture

This part of the document describes in detail all the parts of the system used to monitor a winery: the smart cork used to instrument the casks and obtain valuable information from them, its implementation, the communication architecture used to transmit the information from the casks to the cloud, and the cloud platform created to store the data obtained from the casks and provide the end users (e.g., winemakers) with an intuitive, understandable, and flexible way of visualizing this data.

While every IoT system is different, the foundation for each Internet of Things architecture as well as its general data process flow is roughly the same. First of all, it consists of the Things, which are objects connected to the Internet which by means of their embedded sensors and actuators are able to sense the environment around them and gather information that is then passed on to IoT gateways. The next stage consists of IoT data acquisition systems and gateways that collect the great mass of unprocessed data, convert it into digital streams, filter and pre-process it so that it is ready for analysis. The third layer is represented by edge devices responsible for further processing and enhanced analysis of data. This layer is also where visualisation and machine learning technologies may step in. After that, the data is transferred to data centres which can be either cloud-based or installed locally. This is where the data is stored, managed and analysed in depth for actionable insights.

The IoT architecture for the system consists of three stages: *physical*, *communication* and *application*. The first layer features multiple-sensor network that evaluates the wine's level in the cask, also in the in the physical layer could also be temperature and humidity sensors, but while we are focusing just on wine level monitoring, we will not use them for now, but they could be included as a further development. The second layer includes OT devices that collect the information gathered by the sensors, translate it into meaningful data streams and transfer them to a back-end destination. The third layer is where data is received, stored, and processed using cloud-based data analysis engines and machine learning mechanisms. The resulting insights can be used to recommend the proper action that has to be done for preventing further spoil of the wine and that is for each specific situation or applied in further research or management purposes (Figure 1) [4].

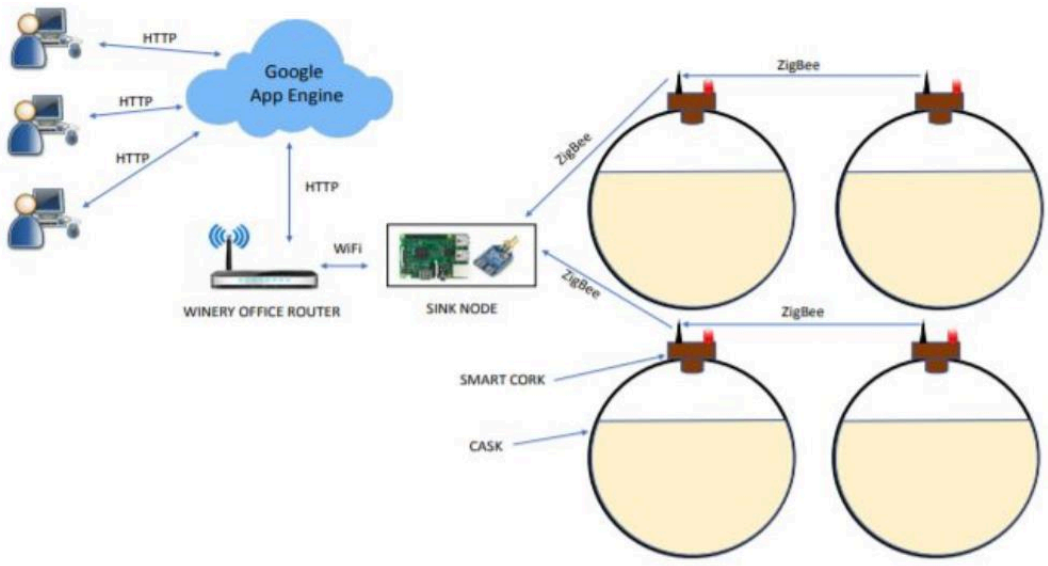

Figure 1. General System Architecture

The cork of the cask is probably one of the best places to integrate the hardware needed to instrument a cask. The surface area of the traditional cork has been replaced with a hollow box where the hardware is installed, and the bottom part has been perforated to wire sensor, an ultrasonic distance sensor with a microcontroller placed in the hollow side. The proposed cork provides us with a non-invasive monitoring device that offers the following advantages:

1. The hardware is not in contact with the wine.
2. If the monitoring system needs to be fixed, it can be easily removed without affecting the cask and its wine.
3. The price of the new cork (without hardware) and that of the traditional one are similar.
   4. Winemakers do not have to change the way they work, which means that the adaptation process is expedient [5].

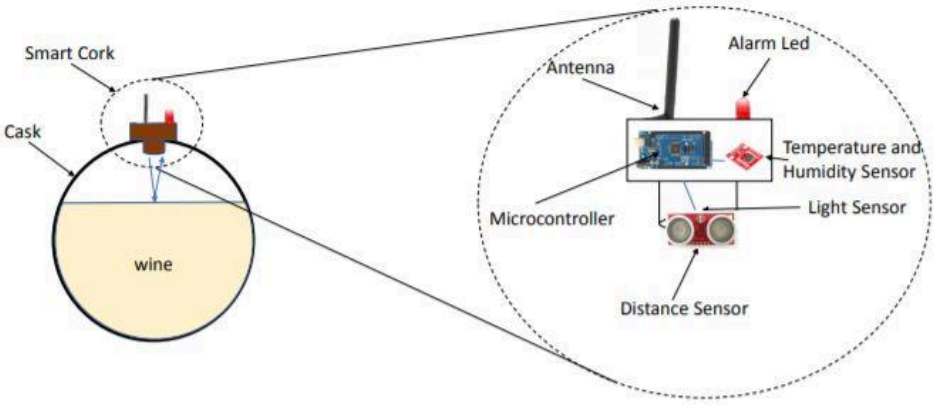

Figure 2. Hardware Architecture

The prototype can be implemented using the Arduino open-source prototyping platform due to its wide community support and the high number of available libraries. In future work, it could use another one, a low-energy variant, in order to extend the lifetime of the system. *Figure 2* summarizes the hardware architecture that has been installed in the smart cork. The sensors provide information about important parameters that are essential during the wine elaboration process and whose alteration has a negative effect on the quality of the wine.

Another communication module would necessarily have to be placed in the sink node. The sink node could be deployed on many more powerful IoT devices such as a Raspberry Pi or a PC. *Figure 3* shows a simple diagram of the firmware architecture. The firmware installed in the microcontroller is a simple event-based middleware that carries out actions based on different events that can be defined by the developer. Events are raised by the developer or can be automatically raised by the event-processor module. This module uses a real-time clock module to raise time-programmed alarms. After the event will be triggered by the event-processor module, the firmware carries out the following steps:

1. All the sensors in the board are read together with a timestamp.
2. The data collected from the sensors are stored
3. The data is read from the storage and sent to the sink node.

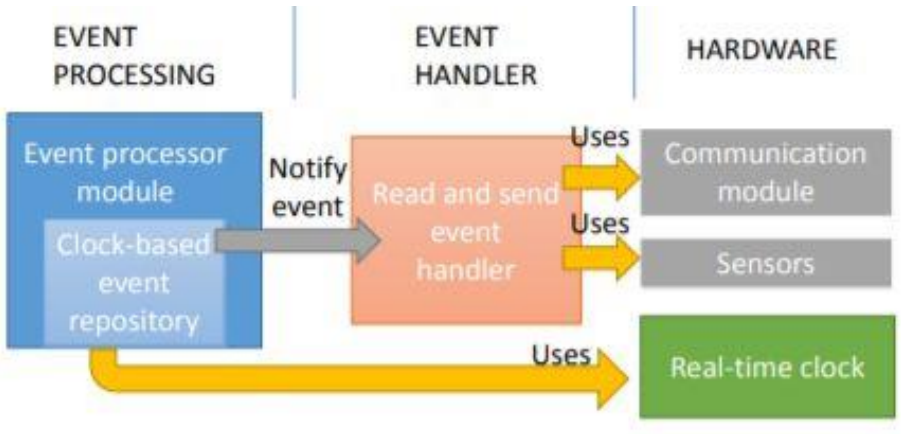

Figure 3. Firmware Architecture

The communication architecture can be structured in two levels. In the lowest level, there could be a powerful node acting like a gateway, that collects all the information generated by the smart corks (end-nodes). In a large winery (which is not our case), where distances are greater, adapting this communication level so that all the casks are able to communicate with the gateway

may be necessary. At the highest level, the gateway is connected through a network device in the winery's office, and the information received is sent from smart corks to the cloud using a protocol.

The data generated by the smart corks are received and managed by the cloud. The cloud is a platform as a "device" that facilitates application development for developers, abstracting the hardware, scalability, and high availability requirements of their applications. Application developers only need to focus on what they do best, the application logic, whereas aspects such as an unexpected application growth and a peak demand are dynamically.

Conclusions

The presented system architecture is the first beta-version of the project. This document will suffer some modifications during the process of the project development implementation. However, the key parts of the presented system architecture will remain the same.

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