UC Davis and Opus One
Using Fledge to
Produce Word Class Wine in Safer Conditions

The UC Davis Teaching and Research Winery was designed to be the most sustainable winery in the world. The facility holds a LEED (Leadership in Energy and Environmental Design) Platinum certification and houses the advanced, sustainable processing technology for the wine industry. Inside, teaching and research is performed with state-of-the-art fermenters. All process and facility data are recorded in an OSIsoft PI historian.

Opus One is the realized dream of two men: Baron Philippe de Rothschild of Chateau Mouton Rothschild in Bordeaux and Napa Valley vintner Robert Mondavi. Together, the founders set out to create a single wine dedicated to the pursuit of uncompromising quality.

The Problem

During fermentation of juice to wine, the conversion of sugar to alcohol produces CO_2 – about 64 liters of pure CO_2 per 1 liter of juice. If not properly managed, the buildup of CO_2 from fermentation actives can create a hazardous work environment. The OSHA permissible exposure limit of CO_2 is 5000 ppm for 8 hours.

Typically, CO_2 in wineries is measured by a single or a few hard-wired sensors, however, the inherent variability of CO_2 across a floor plan can be better monitored by a distributed network of sensors. Additionally, the use of batteries enables sensors to be easily installed anywhere in the winery. Temperature and humidity should also be measured, as these parameters give insight into the growth of unwanted microbials in the facility, the operation of the building HVAC and the evaporation of wine from barrels.

Creating an Accurate, Automated Safe Work Environment

A distributed sensor to cloud system in a winery has several inherent challenges.

- The environment contains highly insulated rooms and many metallic objects, making RF communication challenging
- Power is not generally available where sensors are required
- Wine makers are not electrical engineers nor computer scientists
- Visualizing spatial and temporal data from many sensors is challenging
- Battery powered sensors increases maintenance costs – the battery life should be maximized
- Margins are low – controlling cost means survival

The Solution

A Custom printed circuit board (PCB) was designed and manufactured with the optimal components, form factor and price. A microcontroller with an integrated transceiver (CC1352r; TI) was used to create a Zigbee® mesh network. A low-power architecture was implemented to completely disconnect the microcontroller and sensors from the battery between measurements. A PCB antenna was designed to lower bill of material costs. A non-dispersive IR sensor

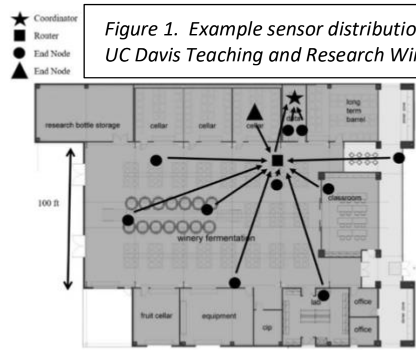

Figure 1. Example sensor distribution at UC Davis Teaching and Research Winery.

measured CO_2 while temperature and humidity were measured with a combined sensor from TI (HDC1080; TI).

UC Davis deployed the Linux Foundation's Fledge on multiple gateways (TI's BeagleBone Black and Raspberry PI) for four functions. First, to collect and transform the sensor data from the end nodes. Second, to buffer the data preventing any data loss. Third, to process the data on the edge, eliminate duplicate MQTT measurements and alert if CO_2 levels are exceeded. Last, to integrate the data with a PI historian operating in the UC Davis Teaching and Research Winery and with Azure running InfluxDB and Grafana for Opus One's operations.

Originally developed by Dianomic Systems, Fledge joined LF Edge, an umbrella organization that aims to establish an open, interoperable framework for edge computing independent of hardware, silicon, cloud, or operating system. Fledge is an open-source Industrial IoT framework to collect sensor/machine data, transform, buffer and analyze the data on the edge, run edge ML models and reliably integrate the data with operational systems, OEE, MES, ERP, historians and the cloud. In a matter of weeks, UC Davis successfully built their custom sensor to cloud software IIoT solution using Fledge.

Results

A multi-node wireless sensor network was developed and deployed in both the UC Davis Teaching and Research Winery and Opus One's facility. The system successfully measured the CO_2 levels distributed across the floor plan, alerted on excessive CO_2 levels and integrated the information with both OSIsoft's PI and Azure. Figure 2 shows how the sensor network recorded the temp, humidity and CO_2 readings. The cost, battery life, easy provisioning and minimal operational requirements were all met. The main limitation on the scalability of the wireless sensor network is the cost of the CO_2 sensor at $109.00, whereas the rest of the node's cost quickly decreases as production scales.

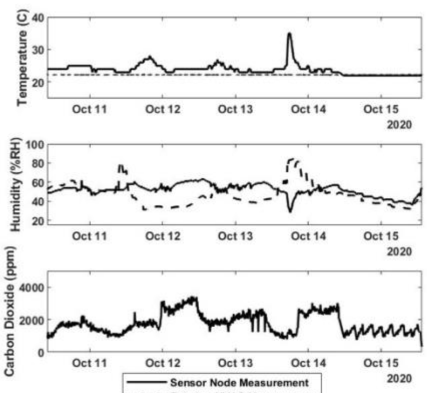

Figure 1. Data recorded from a cellar sensor compared to the data used by an HVAC sensor to control the room's temperature and humidity [1]

What's next for CO_2 Safety

Fledge's new control functions and support for BACnet will enable an automatic control signal to the winery's HVAC system to turn on fans when CO_2 levels exceed safety limits.

What's Next for IIoT and Winery Production?

Compared to other fermentation products in the pharmaceutical and food and beverage industry, the grape juice chemistry between vintages, variety and vineyards is highly variability. This variability leads to variable fermentation patterns and can possibly create fermentation complications. Real-time measurements of the chemical and physical properties of fermenting grape juice enables wineries to detect fermentation complications before it is too late to take correct action. The UC Davis Teaching and Research Winery is researching new sensors and systems to monitor and control wine fermentations, as well as manage the energy and water required to produce wine. Fledge, combined with the OSIsoft PI system, is enabling the UC Davis winery to research data-driven solutions for the wine industry.

Reference

(1) J. Nelson et al., "Wireless Sensor Network with Mesh Topology for Carbon Dioxide Monitoring in a Winery," 2021 IEEE Topical Conference on Wireless Sensors and Sensor Networks (WiSNeT), 2021, pp. 30-33, doi: 10.1109/WiSNeT51848.2021.9413797.