SANTA CLARA UNIVERSITY

SU 2.0: A Marketable Low-Power Wireless Sensing Unit for Hydration Automation

Ethical, Pragmatic, and Intelligent Computing (EPIC) Laboratory

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Introduction
Problem Statement
Design Criteria
Proposed Solution

Introduction - Agriculture

Terrain, distance, and environmental elements are all major obstacles for any agricultural or aquacultural automation

The Problem

Introduction
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- Physically / Manually Checking and filling water tanks 1 by 1 is very time consuming
- Remote monitoring of water level via a sensor would save a lot of time
- Automating both the checking and filling of water tanks would save even more time

Problems with Existing Industrial Solutions on the Market

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- Cost prohibitive (purchase/installation/maintenance) for
  - Small scale farmers
  - Low income farms
  - Farmers in developing countries
- Extremely large!
- Require
  - Power grid connection
  - Wired data transmission
  - Expert installation and maintenance

Design Requirements

Introduction
Problem Statement
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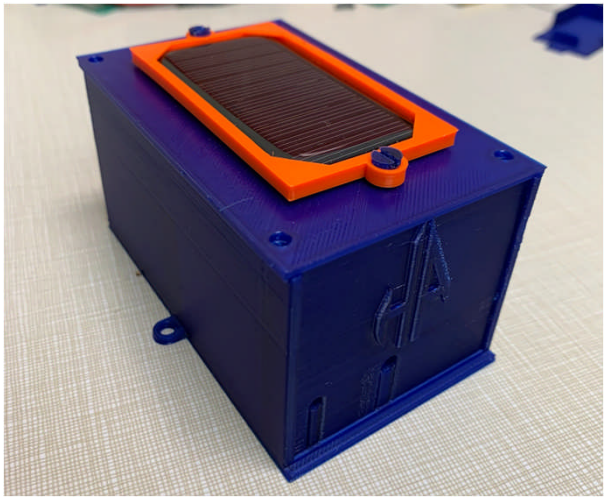
Proposed Solution

- Automated
- Cost effective
- Low Power
- Sturdy
- Sustainable
- User-friendly
- Waterproof
- Wireless



More details in our previously published paper presented at the 2019 IEEE 9th Annual Computing and Communication Workshop and Conference (CCWC):

A Low-power Wireless Sensing Unit for Hydro-System Automation

Solution - System Architecture

Introduction
Problem Statement
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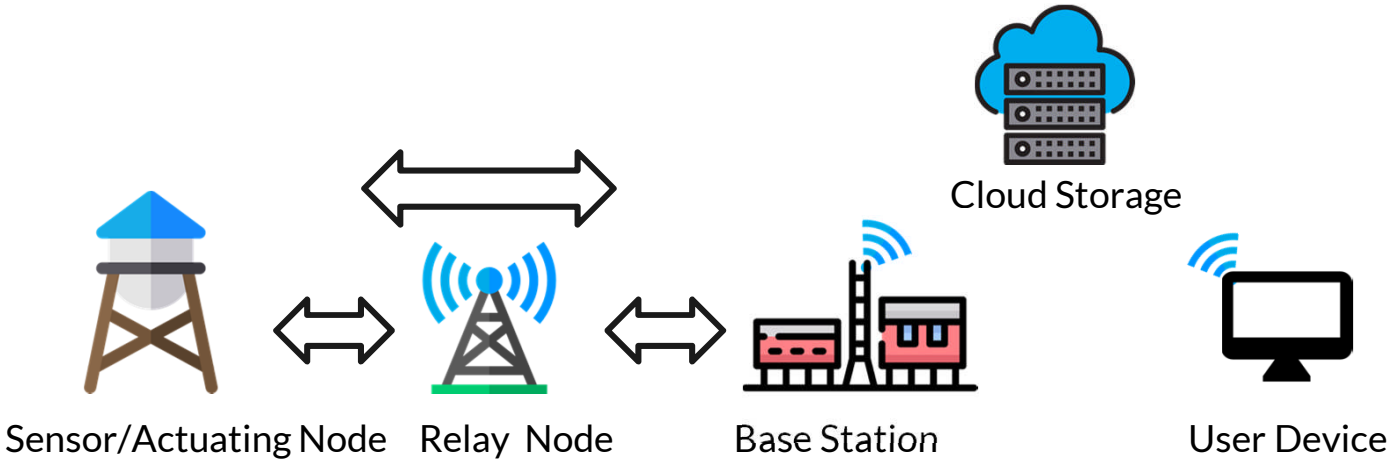
- Sensing Unit (SU): Measures water level and collects other data and sends it to the Base Station.
- Relay Unit (RU): Passes SU data along path to the Base Station and vice versa.
- Actuating Unit (AU): Receives information from the Base Station (or SU directly) and open / close valves or turn on / off pumps.



Solution - SU Architecture

Introduction
Problem Statement
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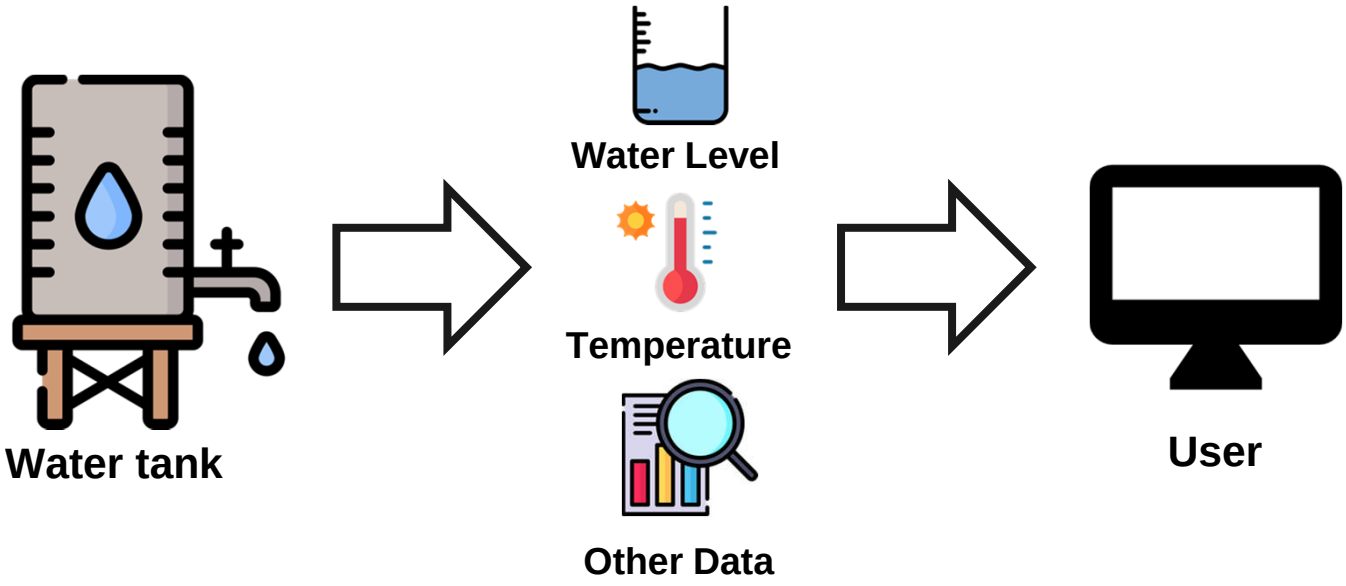
- Sensing Unit (SU): Takes water level readings and other data and sends it to the Base Station for User to see.



Solution - Hardware

Introduction
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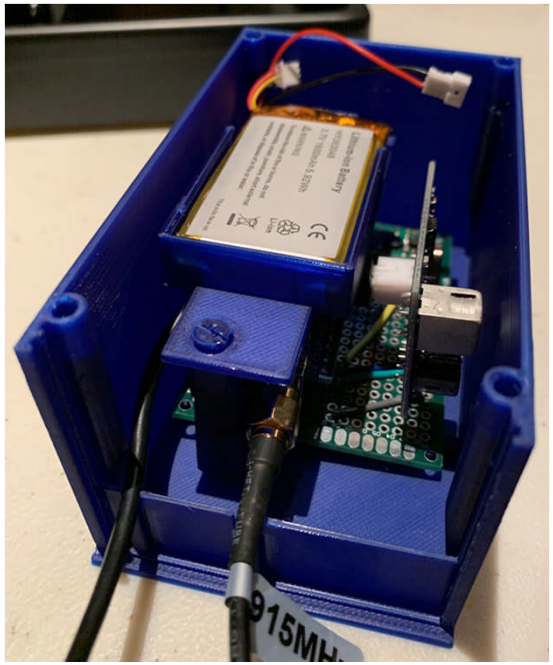
Sensing Unit Major Hardware Components:

- Whisper Node with on board LoRa radio transceiver and Real time Clock (RTC)
- Communication Antenna
- JSN-SR04T ultrasonic sensor
- Rechargeable Lithium battery and charging mechanism
- Solar panel



Solution - Sensor Unit Capsule Interior

Introduction
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Solution - Software

Introduction
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SU Device Software

- Arduino C

Communication Stack:

- Link layer Protocol: LoRa
- Network Layer Protocol: ÂB - a custom Energy Aware Communication Protocol (EACP) built in house

ÂB: An Energy Aware Communications Protocol (EACP) for the Internet of Things (IoT)

Solution - 3D Printed Capsules

Introduction
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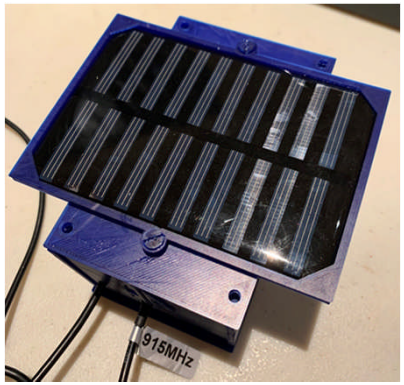
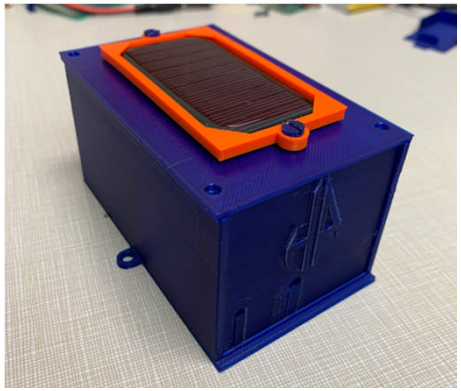
- 3D printing allows for fabrication of custom capsules to better suit the system needs and save on the cost of production.
- 3D printed SU capsules use PETG filament because this material is well known for its resistance to prolonged exposure to sun, water, and acidic conditions.
- In addition, PETG is very strong like ABS but more flexible and requires significant deformation before breaking.

Solution - Sensor Unit Solar Panel Mounting

Introduction
Problem Statement
Design Criteria
Proposed Solution





- Solar panel is mounted to the lid section with a frame which screws into the lid.
- A divot in the lid houses the soldered power cables which then enter the capsule through the hole in the center. After assembly this hole is sealed for waterproofing purposes.

Solution - Sensor Unit Waterproofing

Introduction
Problem Statement
Design Criteria
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- Tightly toleranced overhangs between the top and bottom sections protect the capsule from water leakage.
- After assembly the cable holes can be sealed with weatherproof caulking or aquarium sealant.

Solution - SU Interior and Battery Separator

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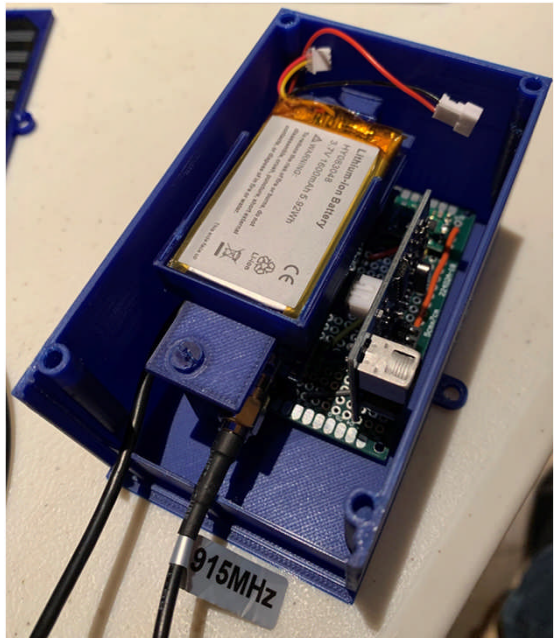
- To safeguard from hazardous interactions between the circuit and the battery a custom battery tray is used to separate them.
- The tray is held balanced by divots in the side and back wall and the raised screw hole allows for immobilizing the tray and circuit board underneath.
- Curved walls on top of the separation tray allow the battery to be easily snapped into place and held tightly.



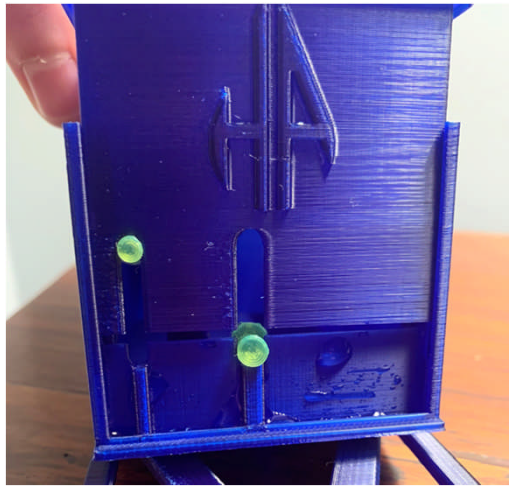
Sensor Unit Water Testing

Proposed Solution

Water Testing

Cost Analysis

Next Steps



- Exposing the sealed SU capsules to 30 minute intervals of being doused in a shower resulted in no water entry at any of the joints.
- The overhangs and interior protective wall served their purpose.

Cost Analysis

Proposed Solution

Water Testing

Cost Analysis

Next Steps

Part	**Price (US$)**
Whisper Node	26.27
PCB / Wires / Pins	0.10 / 0.50 / 0.25
Antenna/SMA connector	5.35 / 1.22
Ultrasonic Sensor	3.71
RTC	7.63
Temp/Hum Sensor	2.10
Solar Panel	1.00
Battery	7.00
Casing 3D Printing	2.27
Total	**57.40**

Next Steps

Proposed Solution

Water Testing

Cost Analysis

Next Steps

- Smaller Sensor Capsule Redesign.
- Designing and building the Actuating Unit.
- Recycling or Reuse.
- Real world deployment and testing at Red Thistle Ranch in Northern California.

Hydration Automation Sponsors

- Cost Analysis
- Next Steps
- Sponsors
- Questions

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Questions?