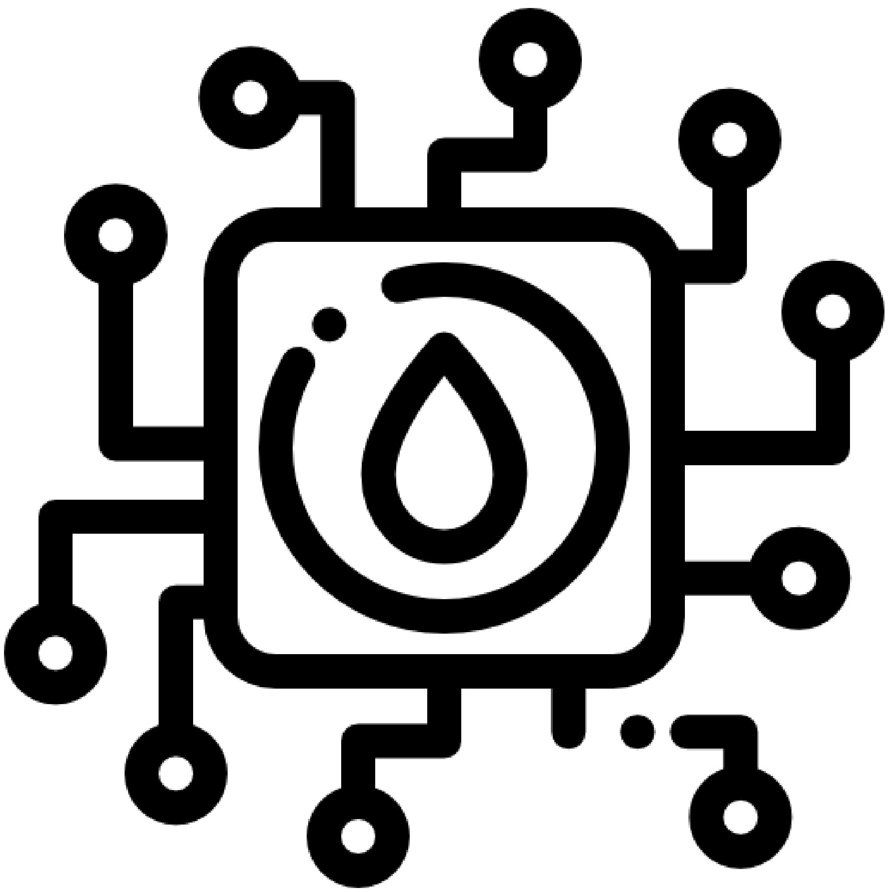
Oregon Institute of Technology
ESET Department

Design Project Proposal

Water Conservation Using Embedded Systems



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Oregon Institute of Technology
ESET Department

Design Project Proposal

ESET Senior Design Project

Department of Embedded Systems Engineering Technology

Oregon Institute of Technology

MEMORANDUM

June 3rd, 2022

TO: Phong Nguyen

PM ESET Instructor

FROM: Adin De'Rosier Adin De'Rosier

SUBJECT: Design Project Proposal Submission

Enclosed is my senior design project proposal, Water Conservation Using Embedded Systems. This proposal is submitted for fulfillment of the Senior Design Proposal requirement outlining the plan for the project and stipulations. Along with the problem formulation, solution generation with embedded system engineering approaches, project management, timelines, and deliverables.

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ABSTRACT

*Water Conservation Using Embedded Systems***:**

This project is an at home low-power in-line solution for collecting data on water usage for homeowners. Water flow rate, time of day, cost of water for the user's zip code will be gathered from multiple devices that make up this system and sent to an online database so that these metrics be easily viewed and interpreted by the homeowner. This will make collecting water usage per faucet much easier as it will be driven by accurate data gathered from each device and compiled in the online database. The microprocessors and associated sensors are low-power and in-line solution making this project and its multidevice system a great addition to any home.

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1. INTRODUCTION

1.1 Purpose

The purpose of this project is to provide homeowners and businesses with a fully packaged hands-free system designed for collecting water usage metrics.

1.2 Problem

Collecting water usage metrics at a specific faucet in a building can be costly and require special tools. There are six sub-problems for a single unit to make up the overall problem of collecting these metrics. These sub-problems are what time of day water is being used, which faucet is logging data, how much water is being used over a usage period, the specific water pressure, how to transmit this data, and how to display it in a meaningful way for the user to interpret. On top of these single unit problems, we must then solve the problem of communicating data between multiple singular units that make up a system as well as configuration of the system and its many devices.

1.3 Solution

The first step to solving these problems is to solve the issues associated with a single device. To solve these problems, I will design and develop a single device solution using a low-power ARM processor capable of transmitting data over a wireless connection and one with an accurate real-time system clock, a flow sensor capable of withstanding the pressure and flow of the real-world application as well as containing an accuracy variation of a reasonable percentage, and finally a system to give power to the unit depending on what configuration we choose.

Once the solution for a single device has been created, we can then solve the issue of the multi-device system. Since we are using an ARM processor with wireless connection capabilities, we will connect each device to a wireless home network for communication. Then each device can connect and communicate with a central database for data collection. Once our data has been collected, we can use graphs and charts with time as a scale to show the data to the customer in a meaningful way. The standard for meaningful data representation will be based on offerings already available for other IoT (internet of things) devices.

By combining all these solutions, we will have made possible a system of microprocessor-powered units that will be capable of interfacing our database with the data needed.

1.4 Identifying Markets

The IoT market is a large and growing market sector that includes many devices from smart thermostats to smart doorbells. When identifying the market for this system, we can assume that it will share this IoT market with these other devices.

Within the IoT market this system will target a sub-market of users that:

- Users that want the ability to track water usage on a per line basis
- Users that want the ability to split water bills based on usage
- Users that want the ability to see when a device connected to the water line is misbehaving and using too much water
- Professionals looking to secure installation deals with users of the device

Contacting professionals in the plumbing scene will help gauge the effectiveness of the device and any stipulations that may have been overlooked.

2. GENERAL TECHNICAL

2.1 Primary Functionality

The proposed device would enable users to access important data metrics about their water lines. This will be achieved through the system proposed which is made up of multiple devices capable of observational input of the flow of their associated water lines. The operation, control, and connectivity of the proposed system would be handled by a microprocessor based on the Raspberry Pi family by the Raspberry Pi Foundation. This microprocessor will be equipped with an ARM processor and dedicated wireless module.

2.1.1 Single Device Inputs

2.1.1.1 Flow Sensor

A scientific grade flow sensor would be used to capture water flow levels. This enables us to gather and extrapolate various data points with high accuracy to pass along to the user. The flow rate will be used to calculate the total water usage in gallons every time the device is used, when the device is used by timing the start and stop of flow with the system clock, and if the alarm should be triggered based on how long the user configures is an acceptable time for the device to be flow active.

2.1.1.2 Temperature Sensor

A temperature sensor would be used to capture the temperature of the pipe carrying water. This will allow us to tell the user about water temperature used and will also allow us to warn the user if the water temperature exceeds the restrictions of our flow sensor of -29 °C to 85 °C. This will ensure a proper operating environment for the device.

2.1.1.3 USB Debug Interface

The USB Debug Interface will be enabled on every device so that technicians can reconfigure or recover devices that may have failed. This will also be used to create a backup of user configuration.

2.1.2 System Inputs

2.1.2.1 Database

Singular devices will connect to the database and update their metrics. This will modularize the system and allow for any number of single devices to be used in a system. The user can then configure the system with any number of devices needed.

2.1.2.2 User configuration

User configurations will allow certain aspects of the system to be configured after the user has installed it. These user configurations will be input to the system and sent out to the respective device upon restart. User configurations will be kept in JSON (Java Script Object Notation) format for readability purposes.

2.1.3 Connectivity

2.1.3.1 Wi-Fi 80.11b/n/g

The microprocessor will have a dedicated Wi-Fi certified chip on board that will allow the device to communicate with the database. This chip will also let the device connect to the user's wireless network.

2.1.4 Additional Considerations

2.1.4.1 Enclosure

The device will be enclosed in a single container that will house all sensors and connectors needed. The enclosure will vary depending on the configuration of the device and whether it needs to be indoor or outdoor.

2.1.4.2 Power

The device will be powered depending on the configuration. It can be powered from the houses 110-120V power with a step-down transformer inside the enclosure. It can also be powered with a direct 5V power input. It will also be capable of being powered over the USB Debug Interface via USB power.

2.1.4.3 Database

The device will communicate with the database and will send its water usage metrics to the database for user display.

2.1.4.4 Web Application

The system will contain a web application/web page that will allow the user to view and interact with the data from the system.

2.2 Auxiliary Functions

With consideration of the above problems and solutions, I have identified some potential auxiliary functions to the main proposal. These functions would only be implemented if the functionality of the above components and systems were completed in their entirety. Each function below would contribute additional functionality to the system.

- Solar Powered Configuration – A configuration of the power system that allows the device to be powered from the sun

- Offline Configuration – A configuration of the networking and database that allows the system to be used when there is no suitable wireless connection.
- Ventilation/Fan – An addition to the enclosure that can ventilate the temperature of the microprocessor
- Debug Application – A tool that will allow easier debug and recovery for technicians
- Mobile Application – A application on the phone capable of enabling users to reconfigure the device from their phones

2.3 Concerns

There are some potential concerns to be considered during the operation of the device. Protecting the temperature of the components enclosed in the container with water that can be extreme temperatures will be considered in the design. The amount of current pulled by the microprocessor and its sensors is to be considered in the case of our power supply. Potential water leaks in the enclosure are also a concern that will be considered.

3. COSTS AND HARDWARE

3.1 Preliminary Hardware (Single Device)

- Atlas Scientific Flow Sensor
- Raspberry Pi Microprocessor
- Digital Temperature Sensor
- Plumbing Connectors

3.2 Preliminary Software

- GitLabs Source Control
- Visual Studio Code
- Python

- LT Spice
- KiCad
- Wireshark Packet Analyzer

3.3 Preliminary Cost

3.3.1 Labor

Using the market rate of $108,000 a year for software engineers in my area and an estimated 20 hours of work to be done each week for 30 weeks this brings our labor cost to approximately $32,000 for the entire project.

3.3.2 Parts

- Atlas Scientific Flow Sensor 3/4" Kit – Link – $301.99
- Atlas Scientific Flow Sensor 1/2" Kit – Link – $201.99
- Atlas Scientific Flow Sensor 3/8" Kit – Link – $191.99
- Raspberry Pi Zero 2 W Microprocessor (x3) – Link – $15 (x3)
- Temperature Sensor (x5) – Link – $15

3.3.3 Allowed Budget Deviation

At an average single unit total cost of $250 I expect to allow for 20% in budget deviation in the event of a minor part failure or board failure. This amounts to $50 for the deviation from the initial budget for parts per single unit. As for labor, I expect a deviation of about 25% in hours worked which would mean our labor has an $8,000 deviation.

3.3.4 Total Cost

With the total cost per unit of parts adding up to $250 (x3) with an additional $50 (x3) in deviation and labor adding up to $32,000 with an additional $8,000 in deviation. The total cost of the system amounts to a total of $41,000.

3.4 Alternate Parts

- Raspberry Pi 4 Microprocessor – More processing power with increased cost and size
- Step Down Transformer – Higher input power configuration for hardwiring to the house power grid
- DC Power Supply – Power supply that will allow for standalone usage

4. CONCLUSION

This proposal provides proof of concept for an IoT device and associated system capable of helping customers conserve water by being more aware of their water usage and associated metrics with real-time data. This project and associated system aim to meet the needs of the customer and market stated above and bring innovative designs to the IoT market.

5. BIOGRAPHY

Senior Embedded Systems Engineering Technology Student at Oregon Tech. Passionate about the semiconductor industry, SoC Design, and Autonomous Vehicles. SoC Design Intern at Intel Corporation. Years of C/C++ and Python experience (7 Years). Several embedded systems home projects.

Senior Engineering Design Project Proposal

Final Audit Report 2022-06-02

Created:	2022-06-02
By:	Adin DeRosier (adin.derosier@oit.edu)
Status:	Signed
Transaction ID:	CBJCHBCAABAADivI9fKHYKWJqlM-DZheXH2uviSLNub4

"Senior Engineering Design Project Proposal" History

Document created by Adin DeRosier (adin.derosier@oit.edu)

2022-06-02 - 4:16:53 AM GMT

Document emailed to Phong Nguyen (phong.nguyen@oit.edu) for signature

2022-06-02 - 4:20:52 AM GMT

Email viewed by Phong Nguyen (phong.nguyen@oit.edu)

2022-06-02 - 4:41:13 AM GMT

Document e-signed by Phong Nguyen (phong.nguyen@oit.edu)

Signature Date: 2022-06-02 - 4:42:15 AM GMT - Time Source: server

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2022-06-02 - 4:42:15 AM GMT