Thomas Maloney
Dan DellaFave
Ethan Williams
Jack Walsh

Senior Design Proposal

1 Introduction

In various dorms at the University of Notre Dame, the pipes used for water transfer are prone to freezing when students leave their windows open during periods of cold weather. To address this, the aim of our senior design project is to alert students whenever their water pipes are in danger of freezing.

2 Problem Description

The primary problem we are attempting to solve is the issue of pipes freezing within the student dorms. Freezing pipes can lead to the dorm rooms flooding, and this can not only damage the rooms themselves including furniture, but it can also destroy student items within the room such as clothing and even electronics. The root cause of this issue however is a combination of cold weather and students leaving their windows open. While an obvious solution is to ensure that students close their windows, it is inevitable that some will forget, and as such, it is necessary to have a warning system that can alert students even when they are far away from their dorms.

3 Proposed Solution

Our solution to this problem is to implement a temperature sensing system that can alert students through wireless communication whenever their pipes are in danger of freezing. The system implements three primary functions

- **Temperature Sensors**: These sensors will be placed in close proximity to the pipes in order to accurately measure their surface temperature. In order to attach them to the pipes, the sensors will be strapped to them with velcro or some other adhesive mechanism. The sensors will provide this temperature data through wired communication with a control unit.
- **Control Unit**: This control unit will primarily consist of the microcontroller and central power source attached to a PCB. It will be used to interface between the sensors and the wireless communication devices. The power source will be a battery pack attached to the control unit that provides power to the sensors, microcontroller, and wireless communication devices. The microcontroller will process the quantitative data from the sensors and determine whether alerts need to be sent through the wireless transmitter. The microcontroller will communicate with both the sensors and wireless communication devices through SPI or I2C. The microcontroller will monitor the battery level and determine whether alerts need to be sent for a replacement battery. Finally, the

microcontroller will monitor the operational status of the sensors and determine whether maintenance alerts need to be sent.

- **Wireless Communication**: This unit will produce the actual communication with the user. Whenever the microcontroller determines that a temperature alert, power level alert, or maintenance alert is needed to be sent, the wireless transmitter will send either an email or text to the user through WIFI.

4 Demonstrated Features

Temperature Sensing

- The system will contain two sensors attached to the pipe to read temperature. The control unit will average the data to get a temperature.

Control Unit / Alert System

- If the sensors read a lower than normal temperature, a warning alert will be sent to the student so they can shut their window.
- If the temperature gets critically low, another alert will be sent, and the system will continue to alert them every few minutes until the temperature gets back over the critical threshold.
- If the sensors read different enough values, one of them is broken, and the system will send a maintenance alert.
- If the microcontroller measures that the battery level is below a certain threshold, it will alert users that a replacement is needed.

5 Available Technologies

The bulk of our system will be reliant on a board built with a 44 pin PIC32MX1xx2xx microprocessor allowing for SPI and I2C communication. This microprocessor will interface with temperature sensors located offboard (such as the AT30TS750A) on the pipe. We will also need a wifi chip on board such as the ATWILC1000-IC to allow the system to wirelessly communicate and send an email or text to the student. Both of these parts are in stock and well within cost constraints.

6 Engineering Content

Eagle: We will use Eagle to design a board with all of the components, such as sensors, the microchip controller, and the wifi chip. This board design will require research and selection of sensors that fit our requirements and can handle temperature variation consistent with expected pipe temperatures.

MPLAB / Wireless Interface: We will use MPLAB to program the chip to periodically monitor temperature, and when temperatures cross below our freezing thresholds to

send alerts through the Wifi chip. We will have to learn the communication protocol to communicate with the Wifi chip, and set up a system of wireless messaging to send alerts directly to students by either email or SMS.

CAD: We may also use a CAD software such as Solidworks to design a custom mounting system for the temperature sensors so that we are easily able to attach them on the pipes. We will need to survey the structure of the pipes to determine the ideal mounting system for our unit.

Soldering / Board Manufacturing: Extensive work will need to be done to put the PCB together once it is manufactured. This will involve applying solder paste to pads on the board with a stencil, placing all parts on the board including the microcontroller and passive components, and putting the board in the solder oven to attach the parts. Additionally, if there are certain mistakes in the design of the board, manual soldering may be necessary to correct these errors.

7 Conclusions

The next steps for our project will be to begin ordering the technology, designing the board, and assembling the system. Then we will need to conduct testing for viable methods to effectively measure the pipe's temperature and notify the student with an adequate amount of time to correct the issue.