Remote Water Pump Monitoring System

Raynaldi Yose Iskandar
Masaki Sato
Yun Mo Kang

Team #18

1 Introduction

1.1 Objective

In the remote regions of Indonesia, many rural villages are located very far from clean water sources. This makes the villagers take a three-hour daily trip to get clean water. The country's infrastructure is not developed enough to support these villages, but a non-profit organization named *Solar Chapter*, which one of our team members is a part of, have resolved this issue by building a system that pumps clean water from its source to villages in the vicinity. Further problems arise in terms of maintaining the water pumps that run the system. Any sort of downtime would have adverse effects on the villagers' well-being, therefore maintaining the system through water pump inspection and maintenance is crucial. However, due to the remoteness of the location, having regular inspection is troublesome. Having the local villagers managing the pump would not be suitable, either, since they have limited knowledge on how to handle the pumps.

Our team is proposing a solution in the form of a remote monitoring system for these water pumps. The system takes the pump's basic operating data such as water flow and up-time measurement to monitor the pump's behavioral trend. The device would also regularly measure safety parameters including vibration and temperature of the water pump. The system would send an alert when it receives undesired values so the operator can send in maintenance. Performing these precautions can extend the longevity of these water pumps and prevent them from breaking down unexpectedly. This would also prevent any downtime and greatly improve the sustainability of the water system. The values measured from the sensors would then be transmitted remotely through a cellular network to a cloud-based database system, which then will be visualized through a website or an app. This will allow high accessibility for the operator. This system minimizes the need of physical on-site personnel presence to only emergency maintenance and longer-term physical inspections, while still keeping the water system foolproof.

1.2 Background

The Eastern region of Nusa Tenggara, Indonesia, is still very undeveloped for the most part. One specific village by the name of Nibaaf is in an especially tough situation: around 800 villagers reside there, yet the nearest access to clean water source is located more than one hour away by foot [1]. This situation forces villagers, including children, to spend a big portion of their daily time to go on a trip for clean water, instead of spending it on academics or village development. In the long run, it becomes harder for an already undeveloped village to move forward and improve the quality of their lives. With this in mind, it is crucial to relieve some of the villagers' burden by securing them constant access to clean water. Through the monitoring system we proposed, any signs of error can be dealt with swiftly, easing the villagers from any fear of water shortage.

1.3 Physical Design

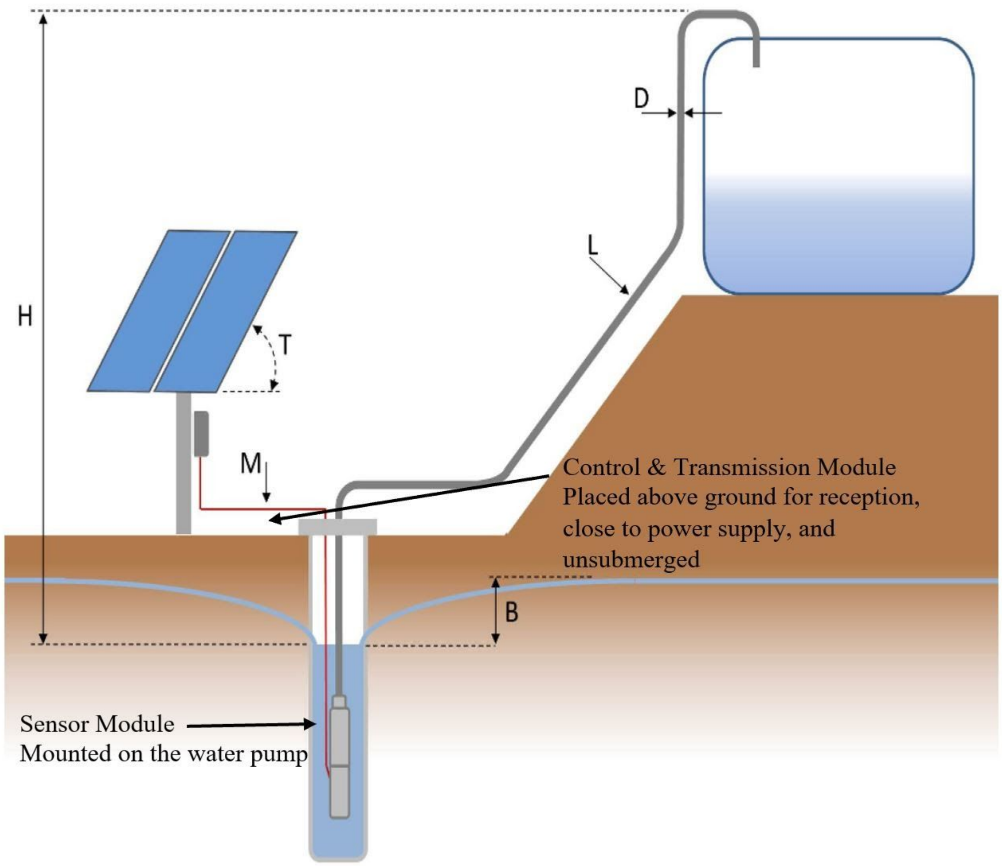

Figure 1. Placement of Physical Design on water pump system [2]

For the prototype we are going to build, we are not going to concern ourselves with a waterproof design, as we believe that specification is rather trivial to implement. The real-life application also requires a rather long wiring between sensor module and control module, another aspect we are going to ignore in the prototype.

1.4 High-Level Requirements

- Microcontroller must process the output signal of each sensor of varying form and translate them to a quantitative value with the appropriate unit for the parameter.
- Collected data must be transferred successfully without corruption through cellular networks to AWS.
- Whenever the databases are updated, AWS Lambda should update csv files on AWS S3. These updates should be reflected on our website hosted on AWS S3 in real time.

2 Design

2.1 Block Diagram

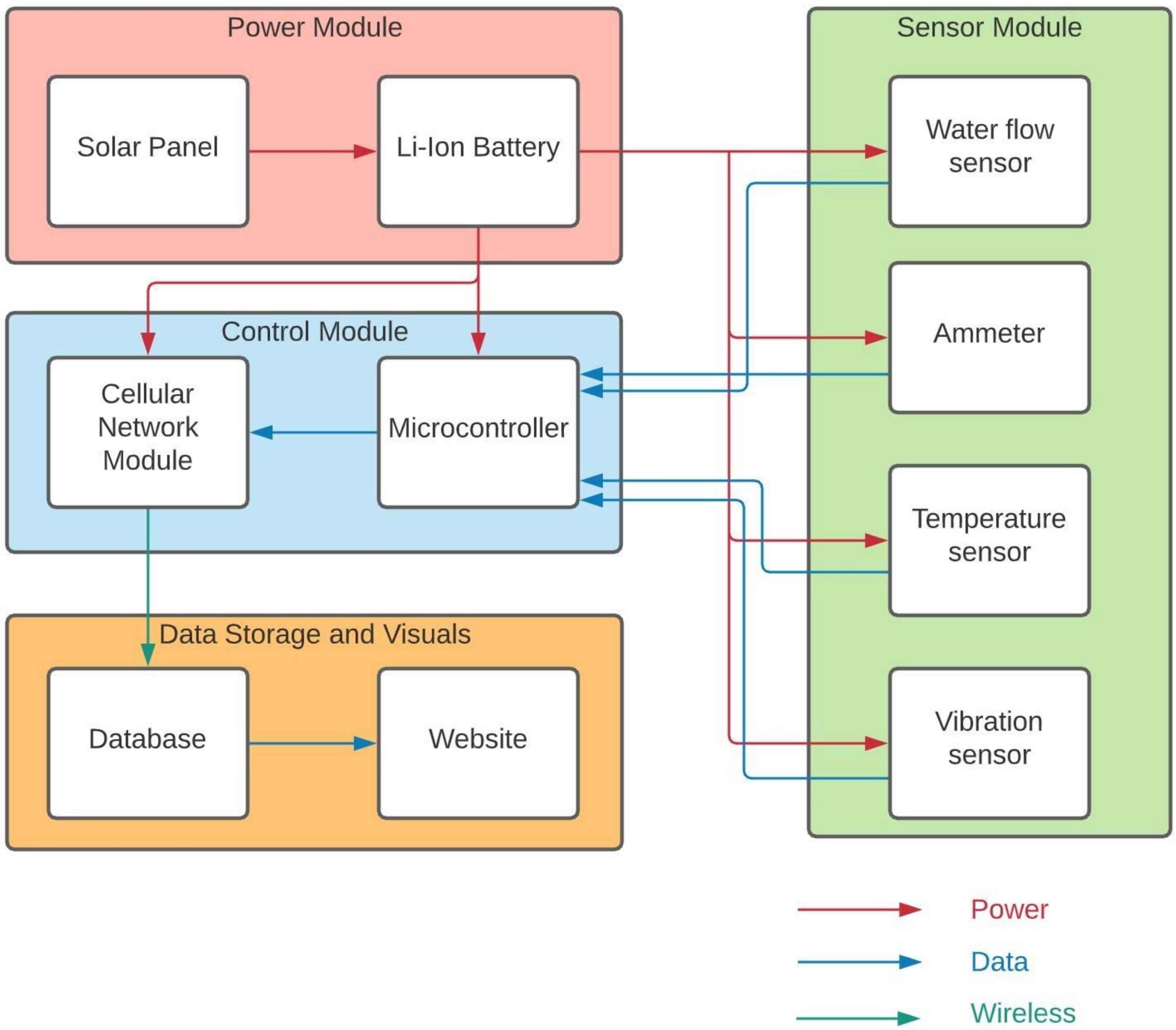

Figure 2. Block diagram of the system

The sensor module, which acts as the input to the system, outputs various forms of signals depending on the sensor. It will be up to the microcontroller to process these varying signal forms and translate them into readable values corresponding to the parameter measured. These data are stored temporarily in the microcontroller memory and then packed into a JSON format for the cellular network module to transmit to a database. Once the database receives said data, the website should update and change to reflect the newly received information.

2.2 Block Descriptions

2.2.1 Power Module

The power module is responsible for powering the whole system. In the real application, ideally a Li-Ion rechargeable battery should be used to utilize power from the solar panel, but in our testing stage there are no solar panels so a simple battery will be used.

2.2.1.1 Lithium Ion Battery

The Li-Ion battery acts as the power source for the monitoring system.

Requirement: Able to provide a 5V DC power to all components.

2.2.2 Sensor Module

The sensor module contains an array of sensors to act as inputs to the monitoring system. Four parameters classified into operational and safety are measured and then the output signal will be processed by the control module.

2.2.2.1 Water Flow Sensor

ALLPARTZ 2-100L/min water flow sensor will be used, chosen based on the historical operational data of the water pumps [2]. The sensor operates based on the Hall principles, outputting a square signal of varying frequency based on the flow rate.

Requirement: *Outputs a square signal for the microcontroller to read and process if there is water flow.*

2.2.2.2 Ammeter

The ammeter here indicates if the pump is running at any given time, and also gives information about power consumption.

Requirement: Value translated by microcontroller is within +/-5% of value shown by sensor output.

2.2.2.3 Temperature Sensor

The temperature sensor serves as a safety precaution to indicate if the pump is overheating.

Requirement: Visible distinction between output of operating temperature and overheating temperature.

2.2.2.4 Vibration Sensor

Vibration sensor acts as a secondary safety precaution to indicate if the pump is shaking excessively, which is likely to cause pump failure if prolonged.

Requirement: Visible distinction between output of operating vibration and excessive vibration.

2.2.3 Control Module

The Control Module manages sensor data processing and data transmission. Data from sensor modules need to be processed into the format that is suitable for transmission, and the data needs to be transferred through cellular networks.

2.2.3.1 Microcontroller

The microcontroller will act as the brain of the system, handling the output signal of sensors and translating them to readable values, then sending them to the cellular network module to be transmitted into the database.

Requirement 1: Microprocessor should be able to process data from Sensor Module into format that is suitable for transmitting data. This will probably be JSON.
Requirement 2: Microprocessor successfully stores processed data into SD card.
Requirement 3: Microprocessor can send data to cellular networks modem for transmission.

2.2.3.2 Cellular Network Modem

Cellular networks modem receives data from the microprocessor and sends data to the database through cellular networks. SIM800C is the cellular modem that we are planning to use.

Requirement 1: Modem receives data from the control unit.
Requirement 2: Modem can send data through cellular networks without corruption.

2.2.4 Data Storage and Visuals

This module receives data that is sent from the cellular network module. It also processes and stores the data into a database. The website should display data and warnings of the water pump.

2.2.4.1 Database

AWS Lambda will be used for processing data sent from the Transmission Module, and store data into a database. Relational database is suited for our data, and we will use Amazon Aurora. Since the website is static, it cannot read data directly from the database. So, csv files on AWS S3 bucket needs to be updated whenever the database is updated.

Requirement 1: AWS Lambda receives data given that the transmission module successfully sent data.
Requirement 2: Data is processed by script on AWS Lambda correctly, and processed data is stored into the database without corruption of data.
Requirement 3: Whenever the database is updated, AWS Lambda script should be executed to update csv files on AWS S3 bucket.

2.2.4.2 Website

The website is a static website hosted on AWS S3. It will be used to visualize data and warnings in real time.

Requirement 1: Javascript component of website can read and process data from csv files on AWS S3 through ajax in real time.
Requirement 2: Warnings should be generated through analysis of data read from csv files.
Requirement 3: Data and warnings can be visualised on the website using d3.js.

2.3 Risk Analysis

Control Module has the highest risk in our design because collected data cannot be viewed by the user if data cannot be sent through cellular networks. Wireless data transmission also leaves more room for error compared to its physical counterpart, and loss or corruption of data over transmission might cause the database to have difficulty processing the data received. Considering the background problem of this project, the "remote" part of this project is a significant part, and thus is the biggest concern in terms of risking the project completion. This will require us to design the system so that the control module is kept safe from any extraneous materials such as water or dirt.

3 Ethics and Safety

3.1 Ethics

This project is mainly focused to help maintain a clean water source for undeveloped regions of Indonesia. Our effort is a direct practice of the IEEE Code of Ethics, #1: "To hold paramount the safety, health, and welfare of the public...” [3]. This project will not only ensure clean water to the villagers, but will also allow children to attend school instead of taking hour long trips to gather water. Hopefully, this will enable them to pursue better lives and break the cycle of poverty.

3.2 Safety

Corrosion on the sensor modules is a serious safety concern. Since this module will be underwater, parts can corrode and dissolve into water, which can contaminate the water. This problem can be solved by building cover that can insulate hardware from water. Any water damage to the power source is another major safety concern. Although this part will not be submerged, the weather tends to be rainy in Indonesia. Therefore, building a quality water-proof system for the monitor will be important.

Lithium-ion batteries also may be a safety concern. If it is not handled properly, it may explode and cause severe damage to hardware and possibly anyone near it. Any debris may drop into the water source and contaminate the water. To counter this concern, we will build a casing for the batteries so that they are well-protected against external impacts and fluids.

References

[1] Solar Chapter. “Water for Nibaaf.” , 2020. [Online]. Available: https://solarchapter.com/chapter/one/water-for-nibaaf [Accessed 16- Sep- 2020].

[2] G. Karina, “Project Timor Tengah Utara,” Reja Aton Energi. Sidoarjo, Indonesia. Feb. 07, 2020.

[3] Ieee.org, "IEEE IEEE Code of Ethics", 2020. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 16- Sep- 2020].