Project Proposal for Project and Seminary 2022/23

IoT System for pH Monitoring in Industrial Facilities

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1 Introduction

The Internet of Things (IoT) is revolutionizing the way machines work and communicate with people and other systems. Our main objective consists in the creation of a smart and automated system, using IoT technology, to enhance the efficiency and accuracy of an industrial filtration process. By incorporating sensors into these filters, we can detect problems before they lead to costly downtime or safety hazards. The sensors will collect data relative to the filtration system's environment, such as the water temperature and pH. All this data is to be sent to a central server, and through real-time data analysis, we will identify if the filtration system is not working optimally or is closer to failure. In these situations, an alert will be sent to a device controlled by the filtration system operator or manager, enabling them to take prompt action to resolve the issue. Our project seeks to improve efficiency, reduce costs and increase safety by automating the fault detection process of filtration system inspection.

2 Requirements

- Low cost and long battery life devices
- Low false alarm frequency
- Visual alarm to indicate that the system is running
- System documentation

3 Objectives

3.1 Main routes

- Programming the MCU to collect and send sensor data

- Setting the (MQTT?) message broker
- Implementing the back-end service to manage system logic (data analysis and alert system)
- Implementing a user-friendly interface to interact with the system (visualize data, adding devices, etc)
- Implementing the database to store system data

3.2 Optional routes

One possibility to enhance the functionality of the system is to contemplate the inclusion of supplementary sensors, such as those for measuring humidity and ambient temperature. Another route could be to develop an Android app as an additional option for users, providing an alternative to the web-based application. Finally, it would be interesting to develop an AI algorithm, which would improve the resulting data.

4 Justification

The development of this project will provide us with valuable experience in one of the fastest growing areas of technology in the world -Internet of Things (IoT). By utilizing an industrial setting as inspiration, we aim to develop new skills, commencing with the programming of an embedded system, which is the core of IoT contexts. We will work on an environment which requires ultra low power mode consumption, and the handling of multiple peripherals.

We will also learn alternative network protocols, mainly used in IoT systems. By doing so, we hope to gain a deeper understanding of how these protocols work and their benefits compared to traditional HTTP protocols.

The implementation of this project will provide us with an opportunity to further our understanding of various topics covered during our academic course. These include web programming, database design and usage, and the design architecture of small to medium scale software projects. By applying these concepts in a practical setting, we will gain a deeper knowledge and appreciation for their importance and relevance in the real world.

5 Scope

The functional scope of the project is limited to the collection and analysis of relevant data, related to the target device, and the interaction with the system to configure preferences and to obtain collected data, namely:

- Associate/remove IoT devices to/from the IoT platform
- Having the ability to visualize collected data, in a graph form
- Notification systems to alert the admin/manager of a possible filtration system malfunction
- System alarm thresholds configuration (PH or/and water temperature critical level)

6 Approach and Deliverables

6.1 Approach

We will use an ESP32-S2 development kit, which supports all technologies and peripherals necessary for the success of our system, including WiFi, built-in security, and very good community support, despite being a relatively inexpensive board. It will involve integrating a pH sensor and water temperature sensor into a small 3.6V battery-powered board. To program the board, we will utilize the C language, along with the ESP-IDF framework, which offers robust hardware control capabilities, specific to this board family.

We will either implement the Broker ourselves or evaluate the potential benefits of subscribing to a third-party Broker based on the project's scale. The data that is published will be stored in a database utilizing either the PostgreSQL or MySQL engine.

We have opted to use Kotlin as the programming language for our back-end server due to its modern and robust features. Additionally, we have decided to leverage the Spring framework for building our back-end service since it is widely considered one of the top server-side frameworks for the Java (and thus Kotlin) programming language, considering our previous experience and proficiency in this technology.

We aim to develop a user interface either by creating a website using React and Bootstrap from scratch, or by utilizing open-source software to build a web application that allows for efficient management of the sensor data.

6.2 Deliverables

The end solution will comprise:

- A MCU (micro-controller) firmware, which will collect and transmit (collected) data from the sensors to the IoT platform
- An IoT platform, composed by:
  - A Broker server, that receives the data, from the MCU
  - A relational database to store system data (records, devices, etc)
  - A back-end service to:
    - Manage system logic
    - Analyze data
    - Send user notifications
    - Manage user data (ex: devices)
- Unit tests for all system modules
- A fully functional Web App, to interact with the system (covering the functionalities defined in the scope)

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7 Constraints and assumptions

Our team has limited experience in programming MCUs, and is relatively new to IoT platforms. It is also new to alternative network protocols, in particular the MQTT. It is also relevant that all hardware has to be possible to acquire in a timely manner due to the time bound nature of the project.

8 Resources

For our project, we will need a suitable development board, such as the ESP32-S2, and sensors to measure environmental parameters, such as water temperature and pH. Also, we plan to utilize open software which is easily available, at no additional cost, on our personal devices or university.

9 Risks

- Due to our limited experience with IoT platforms, we expect to encounter a significant learning curve during this project, particularly in programming the MCU and utilizing the MQTT network protocol.
- Like any other hardware project, unforeseen issues may arise, that are beyond our control and inherent to the hardware's nature. These issues could potentially impact our project timeline and organization.

10 Project Organization

The project will be carried out by Pedro Silva and Miguel Rocha, under the guidance of Professor Rui Duarte. The project is sponsored by Mommertz, a German company. The project is managed through Basecamp, a cloud-based project management tool that offers a centralized platform for team collaboration and project management. Basecamp allows us to log all project-related information such as developments, communication, and scheduling in one place, making it easier to coordinate efforts and track progress.

11 Major Milestones

- Project Proposal - March 20, 2023
- Progress presentation - April 24, 2023
- Beta version (report, poster, and organization) - June 5, 2023
- Final version (Academic Calendar 2022/2023) - July 10, 2023

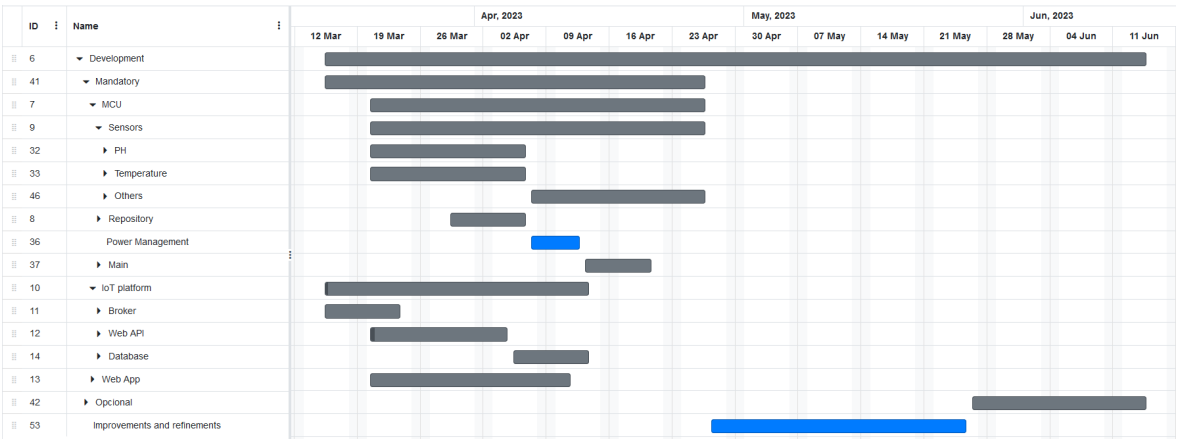

Figure 1: Gantt chart for the expected project execution