IoT Based System For Monitoring Plant Environments.

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Introduction

This artefact is an Internet of Things (IoT) based monitoring system with a specialised application implemented for monitoring miniature greenhouses and their plants. The artefact utilises three sensors, monitoring sunlight exposure, temperature, and moisture levels which are then sent and displayed within a mobile application. This system provides a proof of concept for the implementation of an enclosed IoT based plant monitoring system such as a miniature greenhouse.

Background

The Problem

"Either directly or indirectly, most plant problems are caused by environmental stress" [1]. This identification from the Oregon State University defines environmental stress and the factors that cause it. These factors are insufficient growth variables quantities, such as water, temperature, sunlight exposure, air humidity, and even Co2 levels. This is often the result of vital information about the plant often being hard to interpret, as supported by a study from OnePoll saying, of 2000 millennial's, 46% said the most challenging part of taking care of plants is how much water is needed [2].

Previous Works

There are many systems previously made and implemented for ecology and conservation biology. A paper by J. J. Lahoz-Monfort and M. J. L. Magrath titled 'A Comprehensive Overview of Technologies for Species and Habitat Monitoring and Conservation' discusses the systems already implemented within ecology. [3]. However, the implementations discussed in this paper are for larger scales such as habitats, dissimilar to this artefact. In terms of small-scale projects, M. Salazar et al. have also implemented another plant monitoring system in the form of a *'smart plant pot.'* [4] This system utilises sensors, a display, a water pump, and a mobile application.

Typically greenhouse monitors are developed for large scale versions, not miniature. A good example of this is M.Danita et al. 'IoT Based Automated Greenhouse Monitoring System' [5]. An example of miniature greenhouse monitoring however, is BMonster Laboratory [6] who utilise sensors within a closed environment and display the information via a screen.

This artefact aims to combine certain aspects of these previous works, implementing the main premise but with different execution. This artefact remains similar to BMonster Laboratory's miniature greenhouse monitoring system [6], but differs in the data presentation.

I2C Communication

This artefact is comprised of multiple sensors that utilise Inter-Integrated Circuit (I2C) communication. I2C communication is a chip-to-chip protocol that utilises buses to communicate between peripherals, typically low-speed peripherals such as sensors and clocks. The peripherals (known as slaves) and the main chip (known as the master) communicate via the SDA and SCL channels.

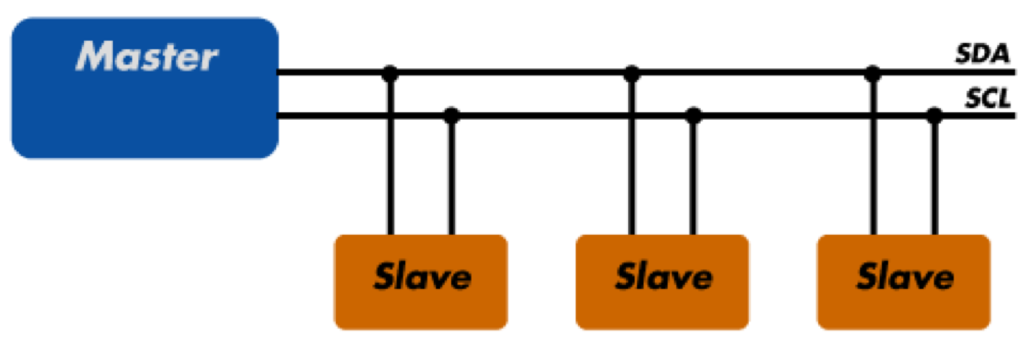

Figure 1. I2C Communication Diagram [7]

Figure 1 illustrates the communication between the peripherals and the main chip using the SDA and SCL channels. This communication controls when the peripherals will gather data and allows the data to transfer to the main chip.

Hardware

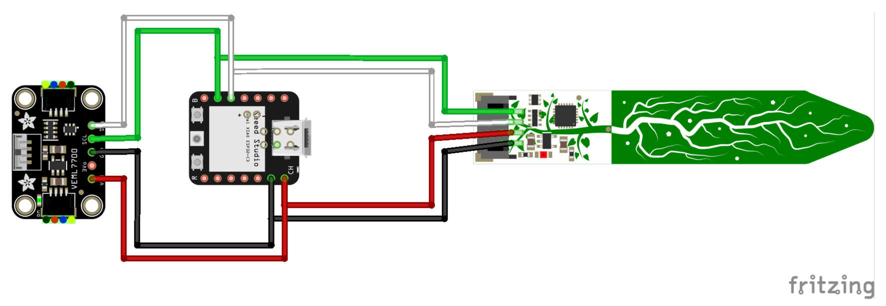

Figure 2. System Circuit Diagram

- **Main Processor:** Seeed XIAO ESP32C3
- **Light sensor:** Adafruit VEML7700 Lux Sensor - I2C Light Sensor - STEMMA QT / Qwiic
- **Moisture and Temperature sensor:** Adafruit STEMMA Soil Sensor - I2C Capacitive Moisture Sensor

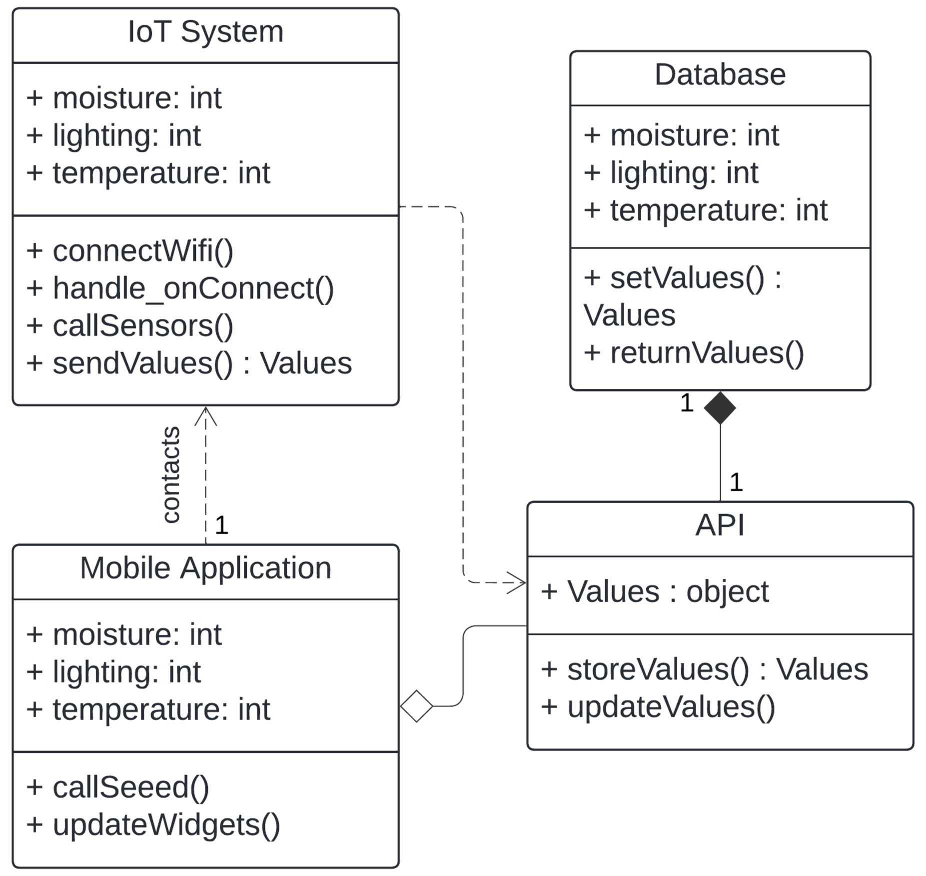

Figure 3. UML Class Diagram

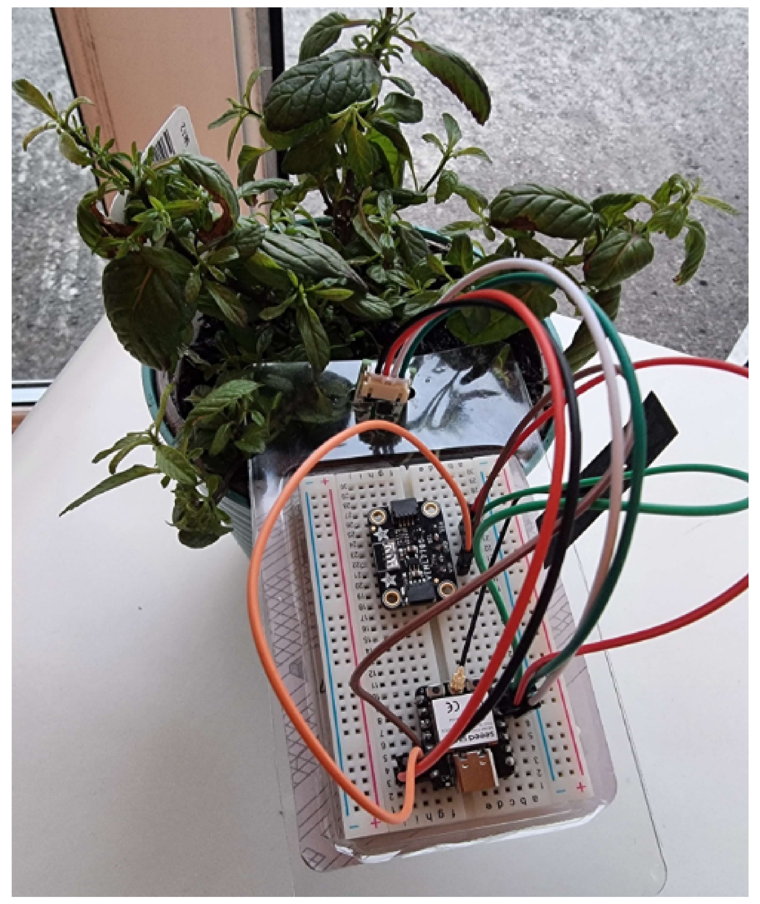

Figure 4. Image of Components

Front-end

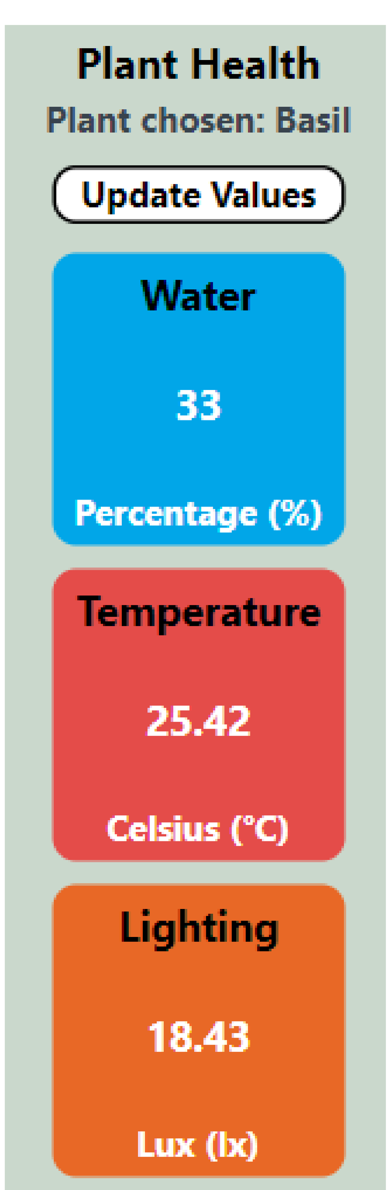

Figure 5. The App UI

The application was made in React Native, allowing use on handheld devices to grant easy access to the artefact. The app features a simplistic design which users will open up and instantly see the information displayed, eradicating the need for traversing across multiple pages. The information is displayed in 'widgets', each with an appropriate colour for their information. The widgets display a title for the value, the value itself, and a unit that the value is measured in. Finally the app includes an 'Update Values' button which calls the artefact and soon after, updates the values within each widget.

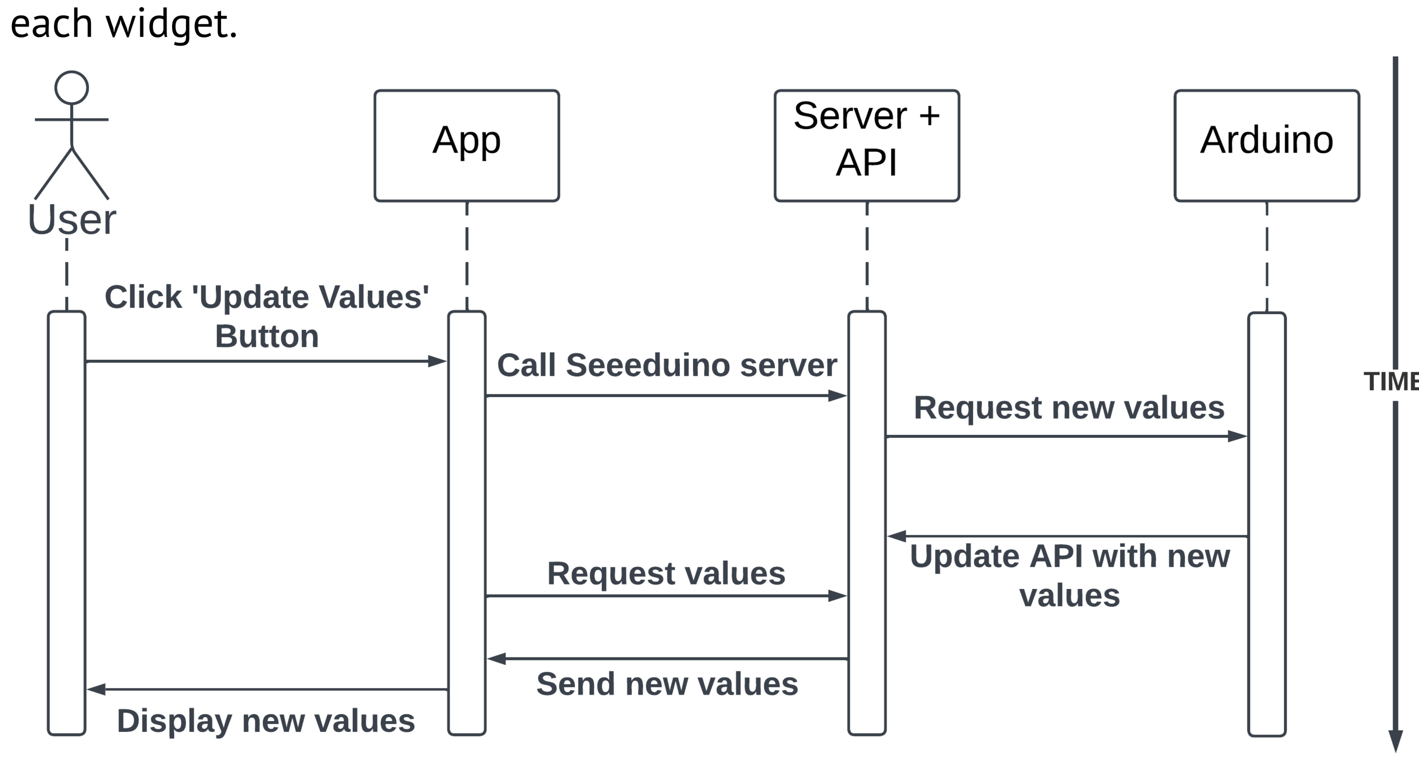

Figure 6. UML Use Sequence Diagram

Back-end

The back-end of the artefact features a Representational State Transfer Application Programming Interface (RESTful API or API) which works alongside an SQLite database. This database stores the sensor values in a custom-made table, which is then accessed by the API. The API and database are containerised using Docker and can be hosted on a server, allowing constant access.

The Seeed XIAO features WiFi capabilities such as WiFi connectivity and server hosting. Using this, the XIAO hosts its own server which monitors connections to and from it using the function "handle_onConnect". This function calls all the sensors, retrieves their values, and forwards this to the Dockerised API, running the system when the user calls it.


```
[{"lighting":"18.43","temperature":"25.42","moisture":"33"}]
```


Figure 7. Values stored in the API

Outcome

This artefact shows a working proof of concept for monitoring plant environments using IoT systems. This proof illustrates the successful communication between devices: retrieving values, sending them to an API and database, and displaying them within a mobile application.

Development

By three months, the artefact should be fully functional within an enclosed environment. By four months additional peripherals such as Co2 and humidity will be implemented. At four months along, the artefact will undergo acceptance testing on different levels including functionality, integration, experience and so forth evaluating its domestic use. After which, the artefact will be A/B tested, against M. Salazar et. al's 'Monitoring System for Plants Based on a Smart Plant Pot' as their implementation does not include an enclosed environment [4]. These systems will be tested over a period of time using G*Power to determine the number of iterations until the optimal statistical power has been reached.

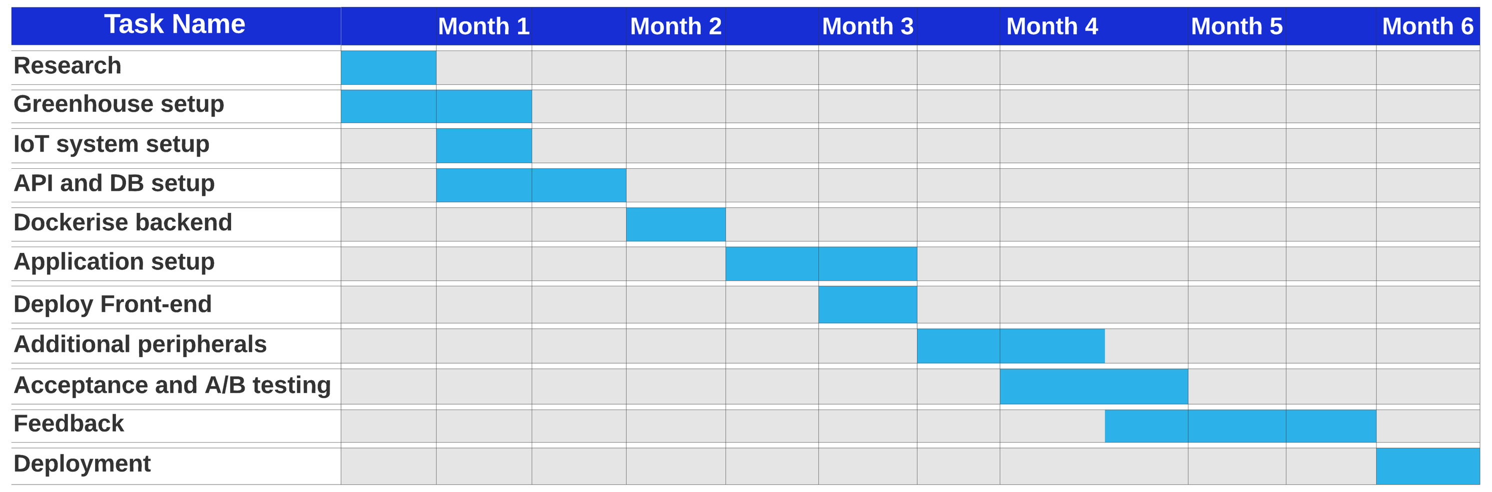

Figure 8. Development Gantt Chart

References

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