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INTEGRATING IOT AND MOBILE APPLICATIONS FOR EFFICIENT PLANT WATERING: THE IOT SMART WATERING SYSTEM (SWS)

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ABSTRACT

The absence of smart detection in the existing system is insufficient for watering the plantation. This brought some problems, as no one knew about the condition of the plantation, and caused overwatering and under-watering problems. Therefore, combining IoT concepts and mobile applications has adapted to make the system a more innovative automated system. Generally, the Internet of Things (IoT) is the connection between networks and devices that can exchange data through the Internet without human intervention. Meanwhile, the mobile application is a software system that runs on a mobile device. Specifically, developing an IoT Smart Watering System (SWS) focuses on building an intelligent watering system that will sense the humidity of the soil and the temperature of the environment using the sensor. Then, the data will be sent to the user's mobile application using the internet to allow users to view it. The objective of this project is to let the user know about the condition of the plant and smart watering based on the condition. The advantage of this system is that it allows users to automatically monitor the status of the data from mobile phones compared to the existing system. In addition, this system was developed for homeowners, farmers, and students who use Android mobile devices. In this project, the waterfall method was implemented as a software development process to ensure the successful development of the system and meet the user's requirements. The existence of the IoT Smart Watering System will benefit society by preventing water waste and minimising human intervention. This could save time and enhance the effectiveness of watering the plants. A notification and view data graph feature will be integrated into this system for future work.

Keywords: IoT, Smart Watering System, Mobile Application, Sensor, Automatic.

INTRODUCTION

Agriculture is the foundation of Malaysia's economic growth. It has played an important role and worked hard to meet the country's consumer demand (Khairani & Afifi Noordin, 2018). There are two types of agriculture, plantation and food production; however, due to some issues which cause many problems, such as crop production in the agriculture sectors in Malaysia. These issues have significantly affected agriculture, including climate change, diseases, and pests. Small-scale agriculture also contributes to greenhouse gas (GHG) emissions and is a victim of climate change (Abegunde et al., 2019). Climate changes have affected Malaysia, which has hot weather all year round. This caused the plantations in Malaysia to wither and damage due to the severity of water shortages. The water consumption of agriculture has gradually increased. Based on the environmental circumstances, improving the agricultural sector is necessary to catch up to meet the fast-growing demand for food from global population growth. Advanced technology tools such as IoT technologies can be used to increase the quality of the plantation and production by collecting the environmental temperature, humidity, and soil moisture.

The potential of IoT technologies can be seen through smart farming, smart homes, smart transportation and smart cities by implementing the new intelligent concept soon (Putjaikal et al., 2016). The way that can be implemented to improve agriculture is by collecting accurate data from sensors such as weather, conditions, humidity, temperature, and water level. Environmental parameters such as the humidity of the soil, environmental temperature, and water level affect the plantations. Besides, a mobile application is also a convenient platform that can let users monitor the data. Forming a combination of mobile applications and the IoT technology network helps to achieve the goals of helping in the agricultural field by monitoring the conditions and water regulation.

In this paper the primary goal of this project is to develop an IoT Smart Watering System using a combination of mobile applications and IoT technologies. The system is developed to monitor the condition of the plantations, such as environment temperatures and soil humidity, through mobile applications. The system also controls and supplies the water to the plantation by the conditions.

LITERATURE REVIEW

This section describes the background of the IoT Smart Watering System and related studies. Automated systems have played an important role nowadays, and the same goes for the agriculture sector. However, although it is widely used, an existing automated system such as smart irrigation is still insufficient.

Figure 1

Analysis of a similar system IoT Smart Irrigation System using NodeMCU ESP8266 & Adafruit IO

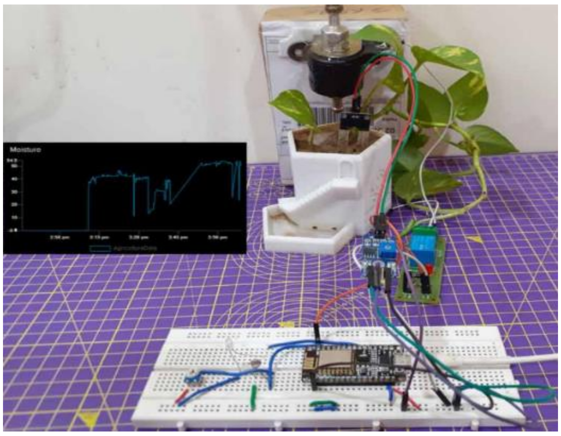


Figure 1 shows an IoT Smart Irrigation System circuit using NodeMCU ESP8266 and Adafruit IO. This system controls irrigation to the plantation based on the moisture value. It also lets users keep track of the land condition through the Adafruit IO Server by sending moisture data. The system also uses a solenoid valve to supply water to the plantation based on requirements.

Figure 2

Automatic Plant Irrigation System based on Arduino with Message Alert

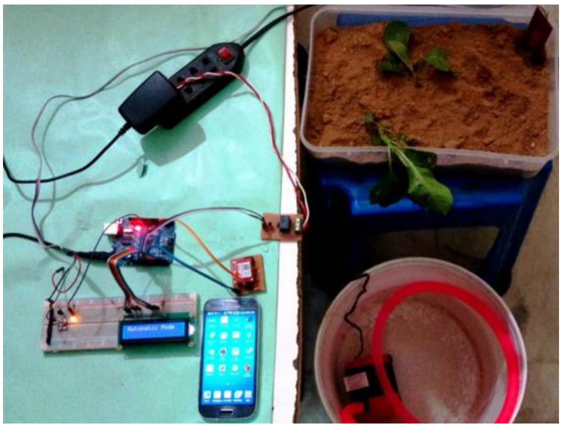


Figure 2 shows the architecture of an automatic plant irrigation system based on Arduino with a message alert. This system provides automatic watering to the plantation due to the soil moisture level and keeps updating the plantation status for users by sending a message to their mobile phones. IoT and Android, mobile application platforms, are needed in this study to build an IoT Smart Watering System.

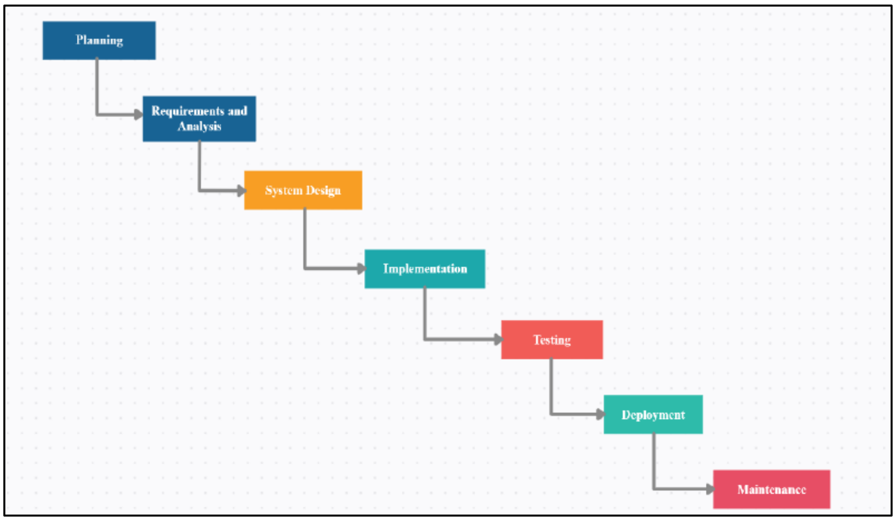
IoT comprises interconnected computing devices, machinery, digital machines, objects, animals or people. This device has a Unique Identifier (UID) that can be used without human-to-human or humancomputer interaction (HCI) in the case of data transmission through the network. Android is an open development platform. An Android platform is a platform for mobile devices that uses a modified Linux Kernel. Most mobile applications on the Android platform are written using Java programming language. The developer needs an Android SDK that includes tools and APIs to create an application for the platform. Typically, Android developers integrate the SDK into graphical user IDEs (Integrated Development Environments) to shorten the development time.

METHODOLOGY

The Software Development Life Cycle (SDLC) is the central foundation pillar for this study. To develop a project system that produces a satisfying result, a systematic methodology approach is required. An ideal software development methodology, such as the waterfall model, is selected to complete the system. In a waterfall model, each phase must be completed before the next phase, with no overlapping with other phases. The waterfall model is frequently used to illustrate the software development process to ensure the system's success and is easier to understand. The waterfall model design can be classified into seven phases: planning, requirements and analysis, system design, implementation, testing, deployment, and maintenance. Each phase has represented a different series of tasks and objectives. Figure 3 shows the phases of the waterfall methodology.

Figure 3

Waterfall Methodology



In the planning phase, a discussion has been held to identify the requirements of the system. The system is implemented for homeowners and farmers to monitor the condition of the plantation and automated watering system. In the requirements and analysis phase, research of previous or similar projects has been done to identify the system's requirements in more detail and specifically. The functionality and non-functionality requirements are included in this system. The system's illustration and requirements specifications have been defined in more detail for the system design phase, such as Unified Modelling Language (UML) diagrams. UML is commonly used to define the system's requirements in this phase. In the implementation phase, the natural system is starting to transmute based on the design by applying the coding. The IoT technology is also implemented to determine the condition of the plantation

(Temperature, humidity). Android Studio is used to design the mobile application for the users to monitor the condition of the plantation. After the implementation phase, the functionality and design of the system is tested in this phase. Users can verify to ensure the system's functionality is run correctly to avoid bugs. Once the testing is done, the system will be handed over during deployment. In the maintenance phase, if there is an error in the system, the modification and maintenance will be done based on the user's feedback.

DESIGN AND DEVELOPMENT OF IOT SMART WATERING SYSTEM

This section describes the design and development of the IoT Smart Watering System. It will be divided into two sub-sections: (A) the functional and non-functional requirements and (B) the prototype development of the IoT Smart Watering System, a mobile application and IoT technology implemented to validate the requirements.

List of requirements of IoT Smart Watering System

Two methods are used in the requirements gathering process, which are (1) discussion and (2) studying and analysing the existing or similar documentation and application from the Internet. The requirements for the mobile application's design, hardware, functionalities, and IoT technology are identified. In the secondary requirements gathering process, all the documentation that has been searched by using the Google search engine by entering keywords such as "smart watering system", system irrigation", "smart watering system using IoT", and "automatic plant watering system". Studies on the articles are done to gain and extract the ideas and requirements for the mobile application that can monitor the condition of the plantation and the way to implement the IoT technology to get the data.

Table 1

Functional Requirements

No	Requirement ID	Requirement Description	Priority
1.	SWS_01_01	The system allows users to key in their username and password to register an account with the system.	M
2.	SWS_01_02	Users must agree to the terms of the registration.	M
3.	SWS_02_01	The system allows users to key in the correct username, email and password to log in.	M
4.	SWS_02_02	The system must verify the information of the username, email and password of the user.	M
5.	SWS_03_01	The system allows user to edit their profile.	O
6.	SWS_04_01	The system allows users to view the plantation's latest conditions, such as environmental temperature and humidity.	M
7.	SWS_04_02	The system allows users to view the data history based on the date.	O

8.	SWS_05_01	The system allows the admin to update the table information.	M

Table 2

Non-functional Requirements

No	Requirement ID	Requirement Description	Priority
1.	SWS_06_01	The system should be available 24 hours per day, 365 per year.	M
2.	SWS_01_02	The system should connect with Wi-Fi.	M
3.	SWS_02_01	The background colour of the screen shall be green.	M

Based on Table 1, the functional requirements were transformed into information processing for the system's functionality. Once requirements are developed, they will be visualised and modelled using the Unified Modelling Language (UML). This is to conceptualise and model the requirements. The models used in this part are the use case diagram, sequence diagram and class diagram. Draw io was used to draw the diagram. Figure 4 shows the use case diagram representing the interaction between the use case and actors for the mobile application. Five major use cases are register, login, edit profile, view data, manage data and log. The manage setting use case only allows admin users to edit the table content. According to Figures 5, 6, 7, 8, and 9, the flow shows how the function of each use case is detailed more clearly. Figure 10 shows the attributes and the operations of the IoT Smart Watering System.

Figure 4

Use Case Diagram

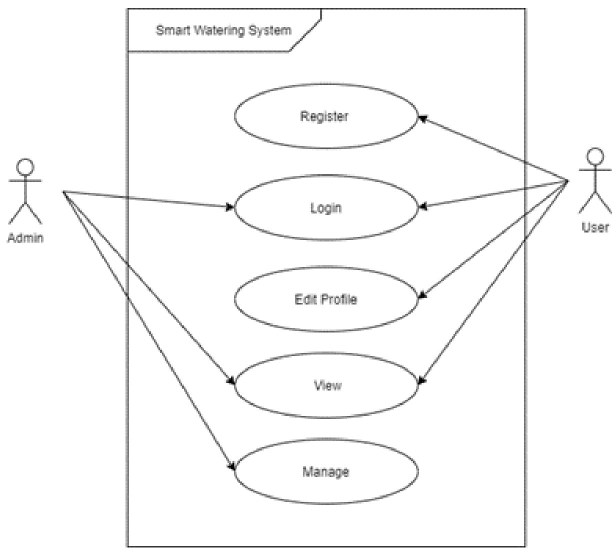


Figure 5

Sequence diagram of Register

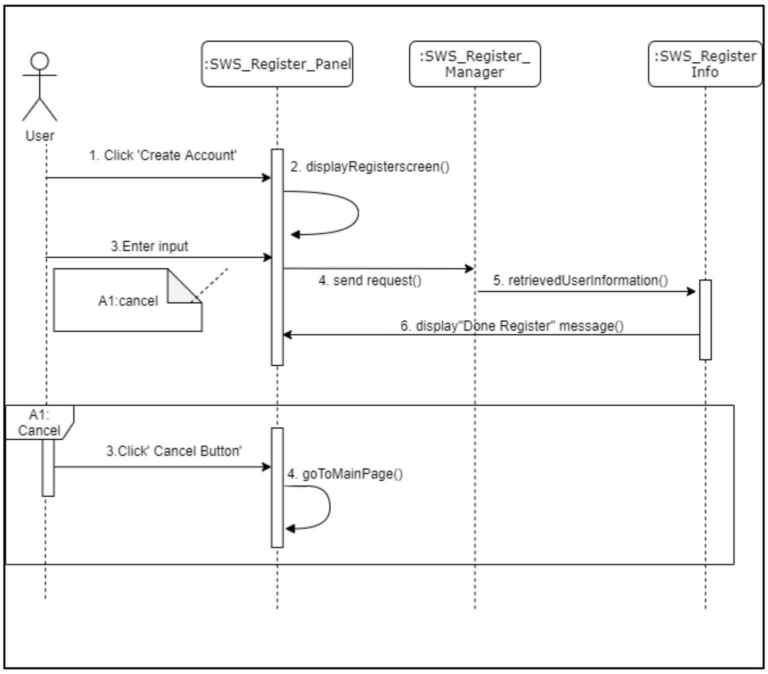


Figure 6

Sequence Diagram of Login

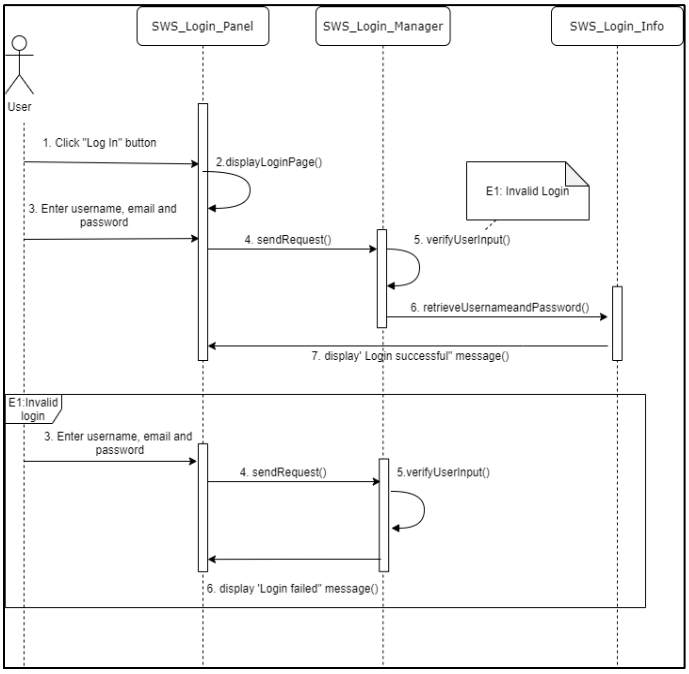


Figure 7

Sequence Diagram of Edit Profile

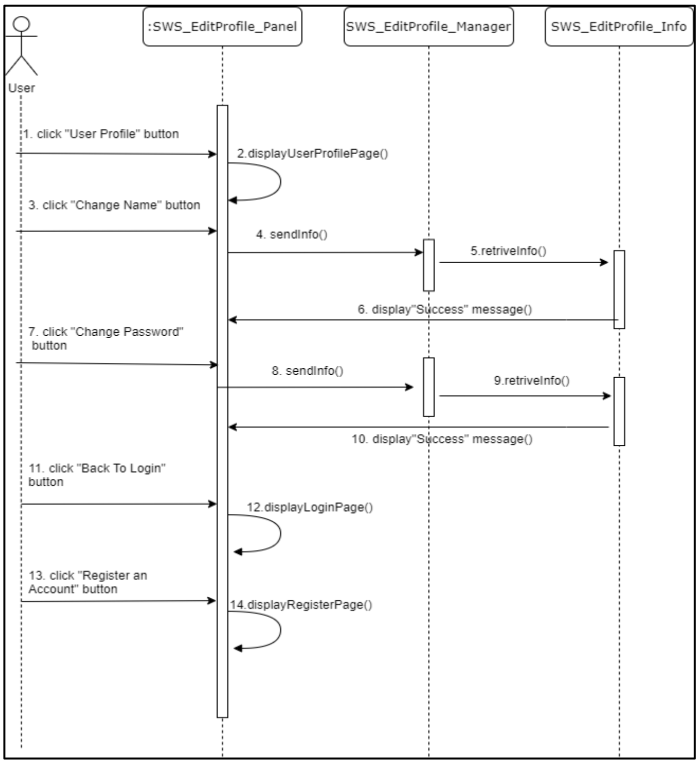


Figure 8

Sequence Diagram of View Data

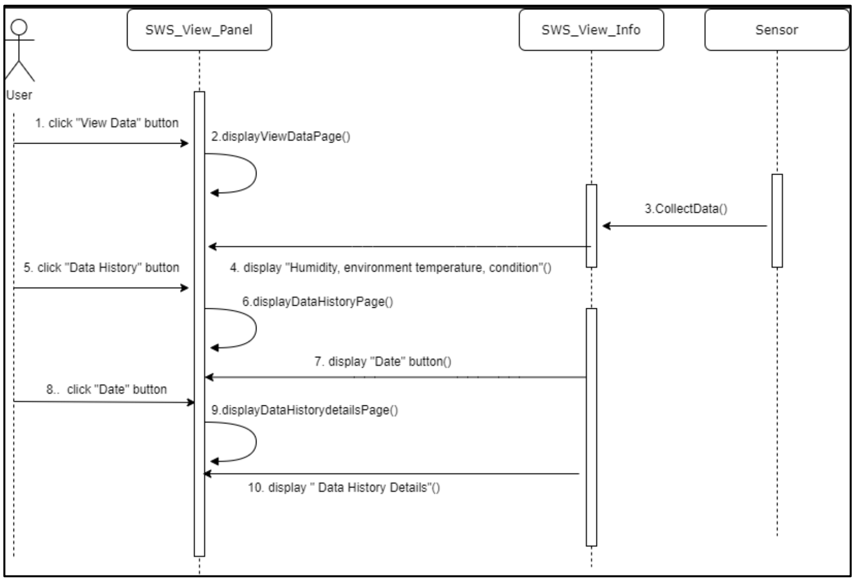


Figure 9

Sequence diagram of Manage Setting

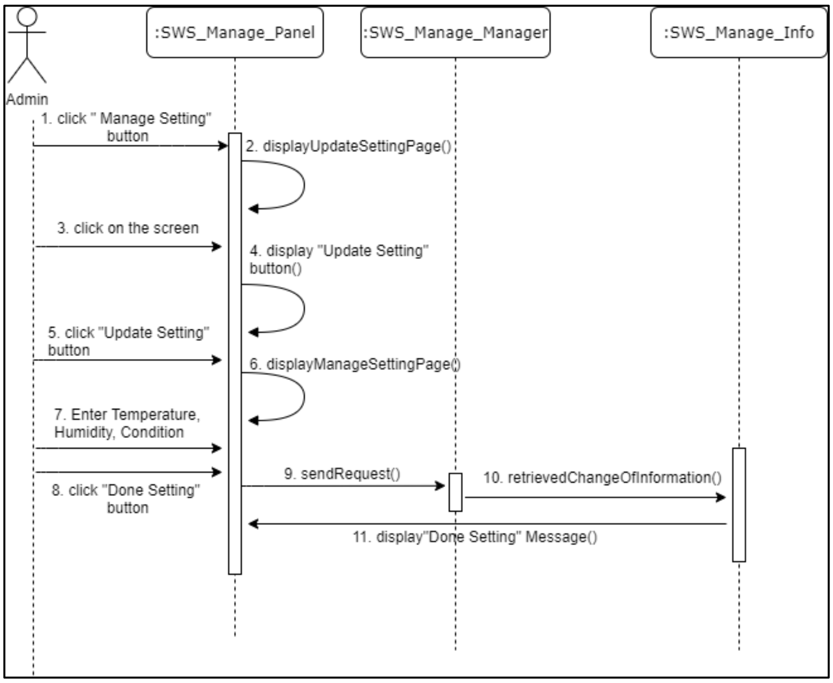
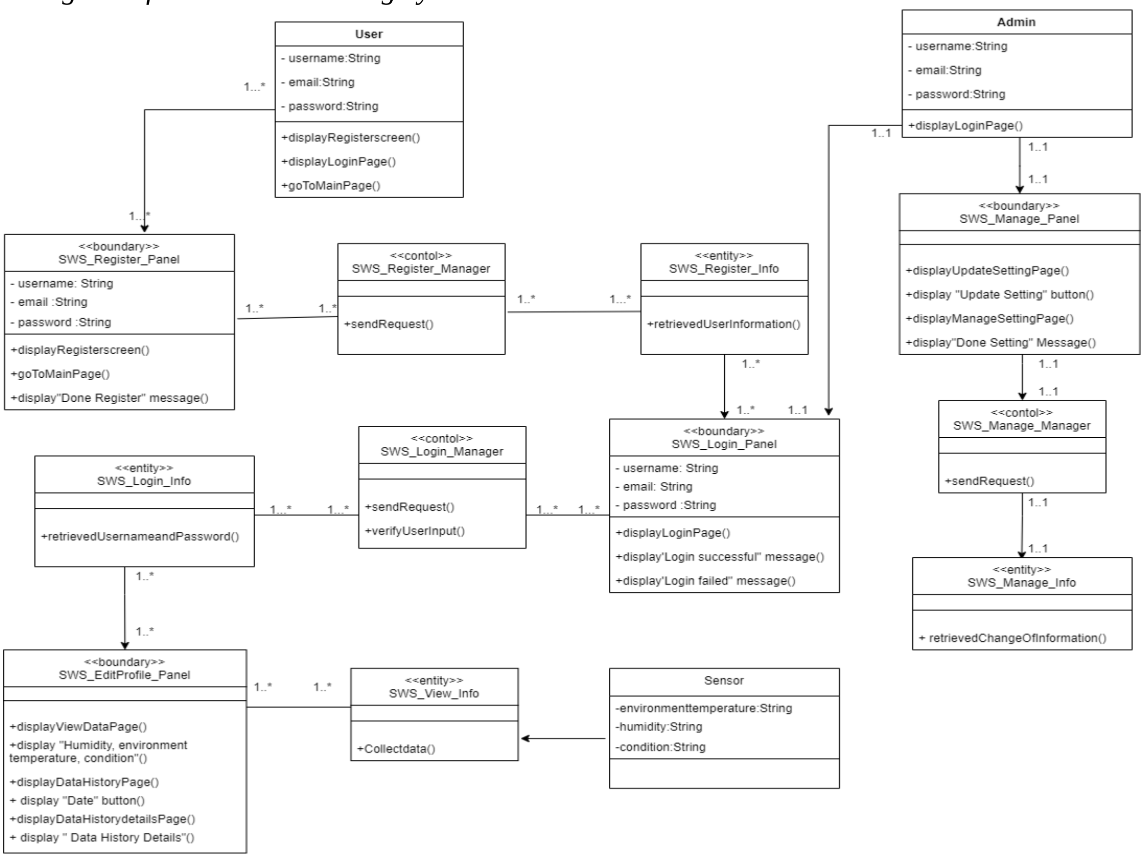


Figure 10

Class diagram of IoT Smart Watering System



Prototype and architecture development of the IoT Smart Watering System.

A prototype of the mobile application, Smart Watering System (SWS), was developed to monitor the condition of the plantation. The leading Integrated Development Environment (IDE) used to develop the prototype was Android Studio. The JOMHosting platform enabled vital functions such as user authentication and database as data storage. Figure 11 shows the Smart Watering System (SWS) interface for homeowners, farmers, and students, while Figure 12 shows the selected interface for admin. The architecture of IoT technology for collecting the data from the plantation was built and shown in Figure 13. The hardware of IoT technology such as NodeMCU Version 2 ESP8266 WiFi, DHT11, Soil Moisture Sensor, Jumper, Red LED, Single Channel 5V Relay Breakout Board and DC 3-6V Micro Submersible Mini Water Pump was used to enable vital functions such as collecting temperature, the humidity of the plantation.

Figure 11

Interface of Smart Watering System for user application

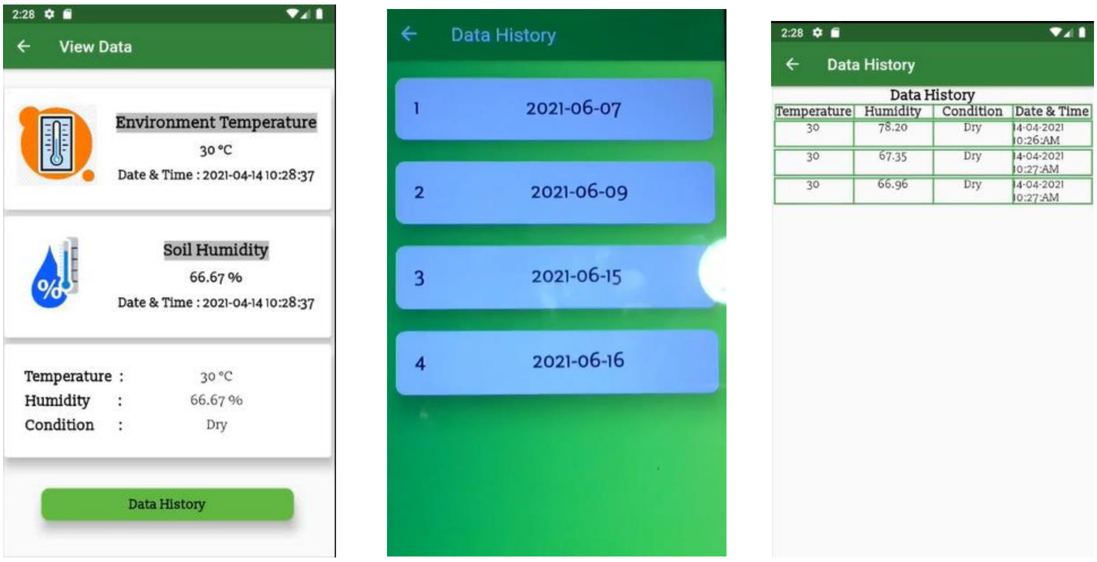


Figure 12

Interface of the Smart Watering System for Admin application

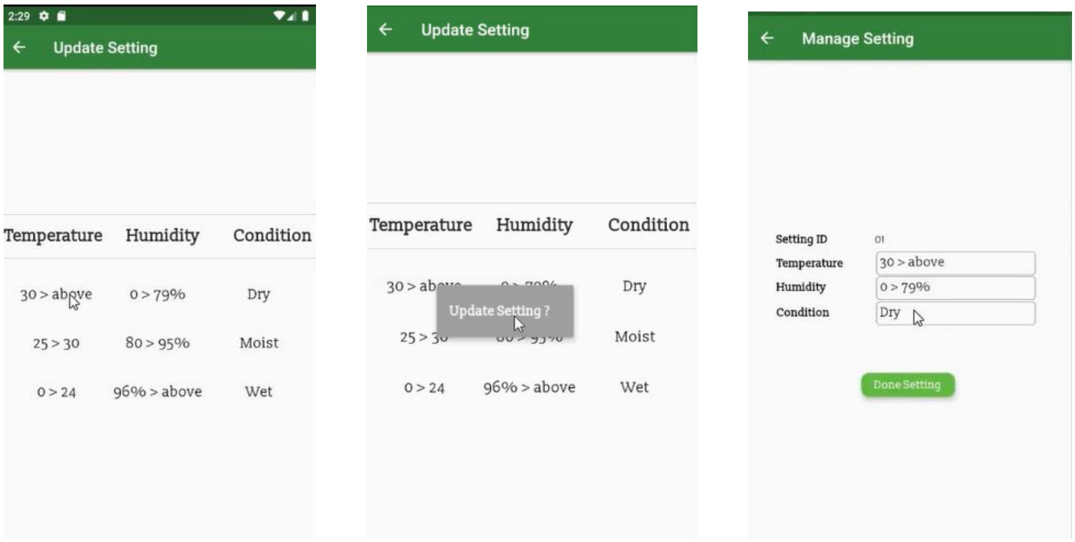
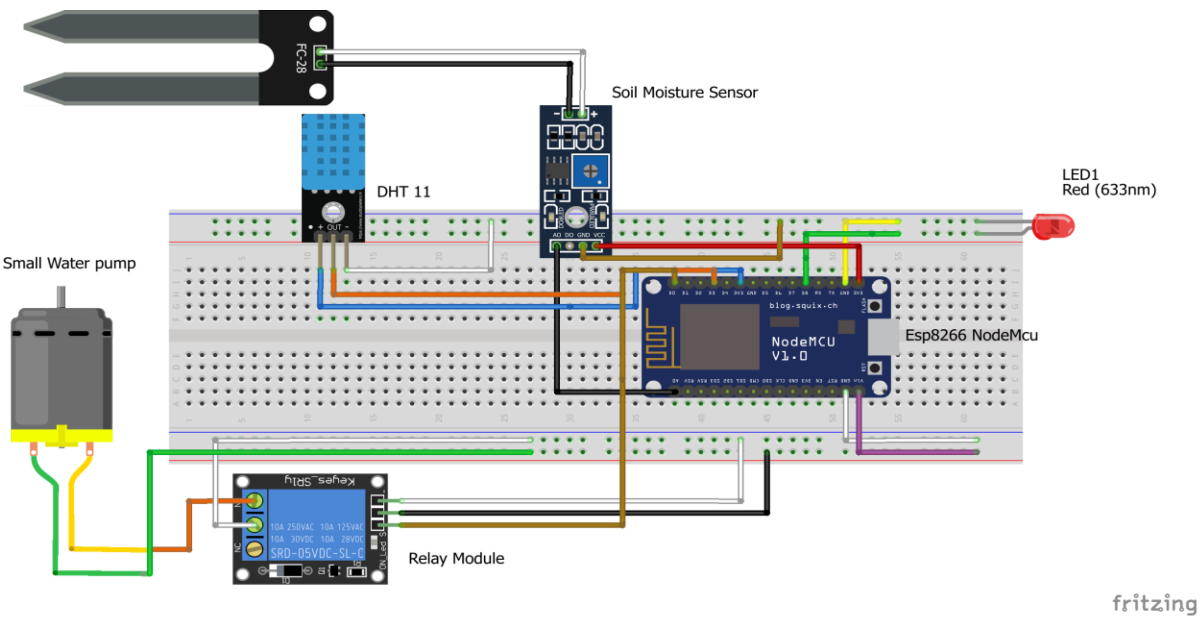


Figure 13

The Architecture of IoT Smart Watering System



EVALUATION OF IOT SMART WATERING SYSTEM

The Evaluation Setting

Usability evaluation is used to evaluate this system application. There are some representative users involved in this testing. It focuses on how users can learn to use the product to achieve their goals. It also refers to how satisfied the users are with that process. There are 30 respondents are involved in this testing to do the evaluation. The respondents were picked among the students, surrounding homeowners and farmers. The instrument used to evaluate the system is the post-task questionnaire. Those who interact with IoT Smart Watering System (SWS) can use the system and answer the post-task questionnaire. The post-task questionnaire consists of two sections. Section A is about the respondent's demographic and background information. At the same time, Section B is the opinion on IoT Smart Watering System (SWS) using a five-point Likert scale, in which one represents strongly disagree and five represents strongly agree. Those respondents have been provided with a Google form link to the following step-by-step procedure for the evaluation: (1) read the instructions listed in the Google form, (2) Install and interact with the Smart Watering System SWS application based on the task, (3) answered the post-task questionnaire.

Respondents Demographic and Background Information

Based on the results of the respondents' demographic information, it shows that 66.7% of the respondents are students. 26.7 % are homeowners and 6.7% are farmers. In this test, 56.7% of the respondents are female, and 43.3% are male. Most respondents were aged 21-25, comprising 60% of the total. The age group of 36-45 years old consists of only two respondents (6.7%) and five respondents (16.7%) for the age group of 26-35 years old and over 46 years old. Regarding the watering plantation, 50% of them, 15 out of 30 respondents, are watering once a day. Six respondents (20%) never water their plantation, five respondents (16.7%) water 2 to 3 times a day, and four respondents (13.3%) water weekly. The respondents also reported that more than half of respondents, which is 17 respondents (56.7%), responded that it is difficult to know about the condition of the plantation, six respondents (20%) responded that there is not much problem with knowing the condition of the plantation and seven respondents (23.3%) are not sure. 53.3% of respondents would not have heard about the Smart Watering System before, but 36.7% have heard about it before, and many are unsure. However, only one respondent has ever used an automated system before to water the plantation, and 29 respondents, which is 99% of them, have never used an automated system to water the plantation before.

The Usability of the IoT Smart Watering System

An analysis was conducted on the respondents' responses in Section B of the post-task questionnaire. This section measures the respondents' perception of the usefulness, ease of use, satisfaction, and functionalities of the IoT Smart Watering System (SWS). Tables 3, 4, 5, and 6 demonstrate the percentage of the responses. The respondents rated 3, 4, or 5 of the post-task scales for the four usability aspects. Only three respondents rated it as two, and none responded as one.

Table 3

The responses for the usefulness of the IoT Smart Watering System

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
IoT Smart Watering System enhances my effectiveness in watering plants.	0%	0%	28%	48%	27%
IoT Smart Watering System increases my productivity.	0%	3%	23%	30%	43%
IoT Smart Watering System saves me time when I use it.	0%	0%	3%	50%	47%
IoT Smart Watering System meets my needs	0%	3%	37%	37%	23%
IoT Smart Watering System is applicable in overall.	0%	0%	7%	53%	40%

Table 4

The Responses for Ease of Use of the IoT Smart Watering System

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
IoT Smart Watering System is easy to use.	0%	0%	10%	60%	30%
IoT Smart Watering System is user-friendly.	0%	0%	3%	60%	37%
I can use the IoT Smart Watering System without written instructions.	0%	3%	33%	40%	23%
I do not notice any inconsistencies when using an IoT Smart Watering System.	0%	0%	13%	60%	26%
I can use the IoT Smart Watering System successfully every time.	0%	0%	27%	57%	17%

Table 5

The Responses for the Satisfaction of the Smart Watering System

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am satisfied with the IoT Smart Watering System.	0%	0%	23%	37%	40%
I would recommend the IoT Smart Watering System to my friend.	0%	0%	30%	43%	27%
I feel I need to have an IoT Smart Watering System.	0%	0%	30%	37%	33%

Table 6

The responses for functionalities of the IoT Smart Watering System

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
IoT Smart Watering System get the humidity correctly.	0%	0%	7%	60%	33%
IoT Smart Watering System get the temperature correctly.	0%	0%	17%	40%	43%
IoT Smart Watering System display the condition correctly.	0%	0%	10%	60%	30%
I prefer to use IoT Smart Watering System	0%	0%	23%	36%	40%

Based on all the evaluation results, most respondents are satisfied with the ease of use and functionalities of the IoT Smart Watering System. However, some results show that this system does not fully meet their needs, and it is a little bit that they can't use it without written instructions. Therefore, it still needs some improvements in the system application's navigation to let users easily navigate.

CONCLUSION AND FUTURE WORKS

This paper describes the design and development of mobile applications and IoT technology, which can monitor the condition of the plantation by using the mobile application. There are still many aspects that can be studied. In future work, a notification and view data graph feature will be integrated into the system, which can improve to be a better system. The limitation of this application is that the user needs to have internet access to this application.

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