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Flood Monitoring and Alerting System

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Abstract: *Flash flood is one of the terrifying natural disasters that happen in Malaysia. There are many states in Malaysia that experienced flood every year such as Kelantan, Perlis, Kedah, Johor and Kuala Lumpur. The existing floods alerting system can trigger alarm when flood water level has reached dangerous level. However, only a few approaches that can alert the administrator. Flood Monitoring and Alerting System is proposed that can ease both citizens and involved authorities. The objectives for this project are to design a system that can do early detection on flash floods so citizens can evacuate and secure their assets. Moreover, the proposed system can calculate distance from water to sensor and it will prevent casualties and assets damaged. In addition, the proposed system can generate a warning message to system administrator via Telegram application. The proposed system is monitored by administrator and system technician of Jabatan Pengaliran Sungai (JPS). The proposed system is built using NodeMcu which integrated with web-based system that connect to database. The proposed system can provide system administrator with indicator of water distance can warn and alert citizens with LED light and warning message when flood water have reached dangerous level. It is hoped this proposed system will help citizens to evacuate before flood reached their residence and can avoid casualties and assets damaged.*

Keywords: *Flash Flood, Early Detection, Calculate Distance, Warning Message*

1. Introduction

Flood is an overflow of water onto normally dry land [1]. The inundation of a normally dry area caused by rising water in an existing waterway, such as a river, stream, or drainage ditch [2]. Ponding of water at or near the point where the rain fell. Flooding is a longer-term event than flash flooding, it may last days or weeks. Flood monitoring and alerting system is an internet of things project that use NodeMcu with water sensor to predict flood and alert respective authorities and sound instant alarm in nearby villages or urban cities to instantly transmit information about possible floods using IOT [3]. The water sensors are used to measure water level and provide information over the IOT using

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NodeMcu. An example of existing flood monitoring system is Domestic Flood Emergency Security Alarm System (D'FESAS). D'FESAS operate hydraulically, where flood detector circuit and the detector unit will send a signal using a sensor installed on every level of flood measurement [4]. The alarm was installed at the most dangerous flood level. The problem from existing system is the system will alert the administrator only when flood have reached the most dangerous level. Whereas, the system should alert the administrator when it is at the first stage of flood where the citizen can evacuate from cities or villages before the flood happen. Therefore, this project proposed a system known as flood monitoring and alerting system that can predict the distance it would take to flood in particular area and alert citizens that could be affected by it.

The idea of proposing this project was based on issues faced by the existing system which only trigger alarm when the water level have reached at dangerous level. Furthermore, another major issue faced by the existing system is there are no digital water level and water distance reading in the system. In addition, there are no electronic message send to system administrator. The objectives of this project are to develop a system that can do early detection on flash floods so that resident can evacuate and secure their assets before flood reach residence area. The other objective is to design a system that can calculate distance from water to specific area before flood reach the residence area. The last objective for the proposed system is to design an Internet of Things system which follow the technology trend in generating warning message to system administrator via Telegram application. The scope for this project is only focusing on Jabatan Pengaliran Sungai (JPS) in Sungai Buloh area. Then this system will be used by system administrator and system technician in Jabatan Pengaliran Sungai (JPS). This proposed system built by using NodeMcu and integrate it with web-based system.

This paper consists of 5 sections that are introduction, related work, methodology, result and discussion, and conclusion. Section 1 is the introduction part where this section explains problem statements, objectives, project scope, and expected outcome. Following with chapter 2 is focus on related work that is the literature review. This section explains the comparison of the overall system and components of the proposed system and the existing system. The comparison was conducted to find out what advantages and disadvantages of the existing system for reference in developing the proposed system. Next, section 3 explained about software process model that has been chosen to develop this system. Every activity in each phase will be explained in detail to ease the development process of this system. Subsequently, section 4 explains the design of the system that is data flow diagram (DFD), entity-relationship diagram (ERD), system architecture, and user interface. This section also includes the system testing that consists of functional testing and user acceptance testing. Then, section 5 explains a summary of the system that has been established.

2. Related Work

It is important to do some analysis on previous study in getting knowledge of the current technology and identifying advantages and disadvantages of previous system which can be used to improve further the propose system. Therefore, literature review covers the comparison between the existing system and proposed system and some general information about the technology used in proposed system.

2.1 Web based system

Web based system is a user interface that is using the internet with a web browser for instance Google Chrome, Mozilla Firefox, Internet Explorer and many other web browsers. The main purpose of web-based system is to produce and manage data using hypertext-based principles. The flood monitoring and alerting system web based consist of water distance reading and water level reading. The proposed system web based will be used by system administrator and system technician.

2.2 NodeMcu

NodeMcu is an open-source electronic technology that is easy to use and consist of hardware and software. NodeMcu board can attach with many components such as ultrasonic sensor, water level sensor, Liquid Screen Display (LCD) screen and many other electronic components. NodeMcu board capable to read input and process it into an output like generate a message or turning input into data in web-based system. The flood monitoring and alerting system used NodeMcu board to attach ultrasonic sensor that is used to read water distance from sensor to river water. The function of water level sensor that is attach on NodeMcu is to read the river water level and display the reading on web-based system. Then, LED light that is attached on NodeMcu board will trigger when water distance has reached dangerous level. Next, network module that include in NodeMcu board allow network connection and send warning message to nearby residence. The programming language used to configure NodeMcu is the Arduino IDE. Arduino IDE is used to tell the NodeMcu what to do by sending set of instruction that is command in Arduino IDE.

2.3 Study of existing system and proposed system

The three existing system are analyzed and studied and compared to features of flood monitoring and alerting system. The comparison results from all the systems are shown in Table 1

Table 1: Study of existing system and proposed system

Module / System	Smart IoT Flood Monitoring System [5]	Domestic Flood Emergency Security Alarm System [6]	Smart Flood Monitoring and Detecting System [7]	Flood Monitoring and Alerting System
System Type	Web based and Micro Controller Technology	Integrated Circuit	Web based and Micro Controller technology	Web based and Micro Controller technology
Micro Controller	Arm Mbed	Not available • Use Integrated circuit as the main board	Node MCU	NodeMcu
Water level sensor	Not available	Not available • Use probe as water level reading	Not available	Available • To measure water level
Ultrasonic sensor	Available • As water level reading	Not available	Available • As water level reading	Available • To measure water distance

Module / System	Smart IoT Flood Monitoring System [5]	Domestic Flood Emergency Security Alarm System [6]	Smart Flood Monitoring and Detecting System [7]	Flood Monitoring and Alerting System
Temperature sensor	Not available	Not available	Available • Act as temperature detector	Not available
Humidity sensor	Not available	Not available	Available • Measure humidity of soil	Not available
LED	Available • Indicate water level	Available • Indicate water level	Not available	Available • Indicate water level
Buzzer	Available • Act as alarm	Available • Act as alarm	Available • Act as alarm	Not available
LCD	Available • Display occurred process	Not available	Not available	Not available
Wifi module	Available • ESP8266	Not available	Available • ESP8266	Available • ESP8266
Database	Not available	Not available	Not available	Available • Xampp
Cellular module	Not available	Not available	Not available	Not available

3. Methodology/Framework

This project selected prototyping model as the methodology of developing this system. In prototyping model, the process will start with the development of a prototype, evaluated, and reconfigured until it is appropriate. It also serves as a foundation for the development of the final framework or programme [8]. It's better used in situations where the project's specifications aren't fully understood. It is an iterative, trial-and-error process that occurs between the customers and developers.

3.1 Requirement gathering and analysis

- Search for a project title that related to Information Technology field
- Determine project objective and scope
- Identify problems and requirements to develop a new flood monitoring and alerting system
- Plan and analyzed on how to develop a new system that better than previous existing system

3.2 Quick design

- Design web-based user interface using a suitable programming language.
- Design the database system using MySQL
- Conduct study on hardware specification to determine the most cost-efficient component part can be installed

3.3 Build prototype

- Configure NodeMcu and all the hardware component part that attached on it
- Develop web-based user interface and establish database connection

3.4 User evaluation

- Conduct testing on the prototype and gather feedback from user regarding the prototype system

3.5 Refining prototype

- Refine the prototype system based on user feedback and suggestion
- If user satisfied with the prototype then proceed with system implementation

3.6 Implement and maintenance

- Develop full system based on final prototype
- Do annually maintenance for the system for both hardware and software

4. Results and Discussion

In results and discussion, it can be divided into few sub topics which are functional requirements and non-functional requirements. Other than that, this chapter will discuss about Context Diagram (CD), Data Flow Diagram (DFD) and Entity Relationship Diagram (ERD) that relates to propose system. Moreover, this chapter includes system architecture, web-based user interface, functional testing and user acceptance testing.

4.1 Functional and non-functional requirement

Analysis focus on study of the issue and requirements rather than finding way to get solution while design focus on finding the solutions that will lead to fulfills the requirements rather than do implementation [9]. Functional and non-functional requirements investigation occur in analysis phase. Functional and non-functional requirements will be shown in Table 2 and Table 3.

Table 2: Functional requirements

No.	Module	Function
1	Registration	• This feature allow administrator or concerning user to register their details.
2	Login	• This feature allows administrator and other concerning users to gain access to the system.

No.	Module	Function
3	Water level reading	• This feature detects the river water level and resulting it in numerical form in web-based system.
4	Water distance reading	• This feature detects the water distance from sensor to water surface and resulting it in numerical form in web-based system.
5	LED	• This feature will trigger when the water level has reached dangerous level.
6	Telegram Message	• This feature will send warning message to administrator and household leader when water have reached dangerous level.
7	Logout	• This feature allows administrator and other concerning users to logout from the system.

Table 3: Non-functional requirements

No.	Requirements	Descriptions
1	Performance	• The service is available for 7 days a week, 24 hours a day.
2	Operational	• This system is friendly user (easy to use). • This system will be maintained annually or when there is faulty happen in the system. • This system web-based should be able to work on any web browser.
3	Security	• Only administrator and authorize user can gain access the system. • Only administrator can alter the database system

4.2 **Context diagram**

Context diagram, data flow diagram (DFD), and entity relationship diagram (ERD) are explained in this section. In context diagram there will be three entities involved that are administrator, NodeMcu and resident (non-member). Figure 1 shows the context diagram for flood monitoring and alerting system.

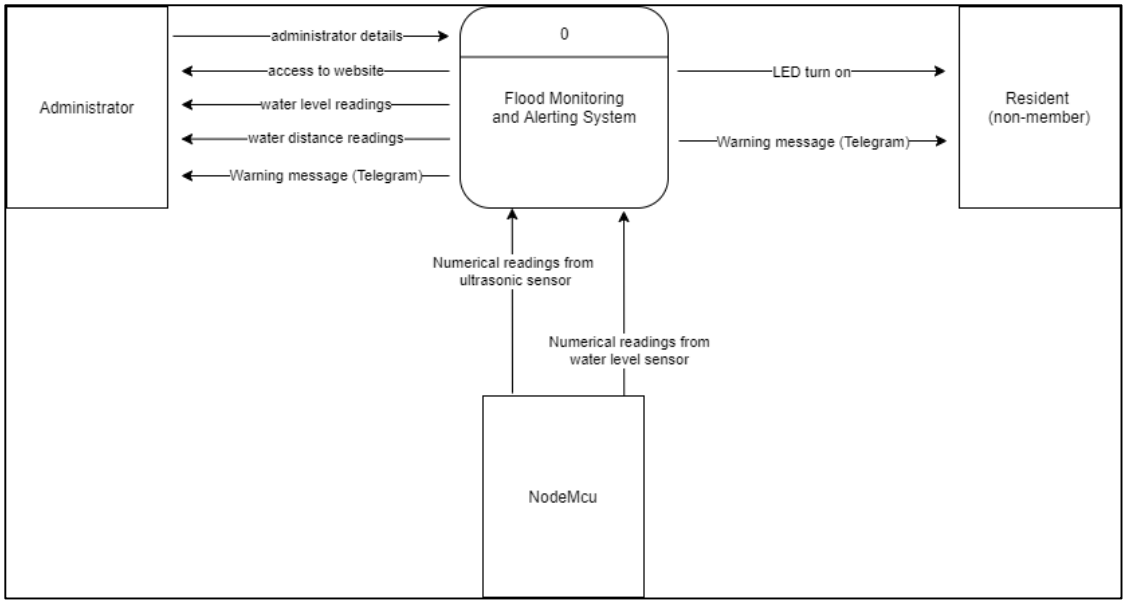


Figure 1: Context diagram

4.3 **Data flow diagram**

Data flow diagram (DFD) level one is the extended version of context diagram that includes with processes in the proposed system. The flood monitoring and alerting system consists of seven processes. Figure 2 shows the data flow diagram for flood monitoring and alerting system.

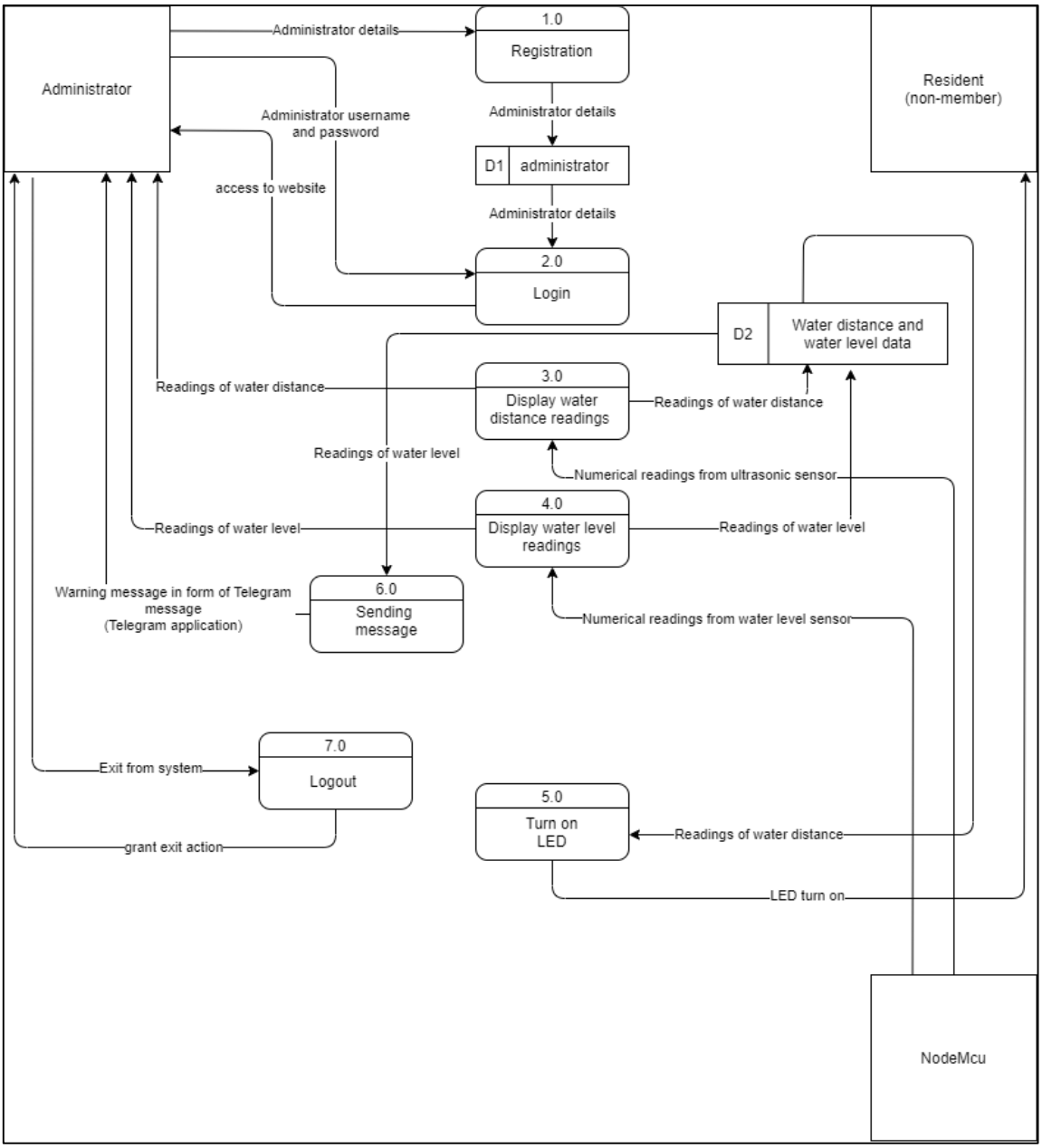


Figure 2: Data flow diagram level 1

4.4 Entity relationship diagram

Entity relationship diagram (ERD) shows the relationship between entities and attributes. ERD is a drawing form of database before implementation in database server. Figure 3 shows the entity relationship diagram for flood monitoring and alerting system.

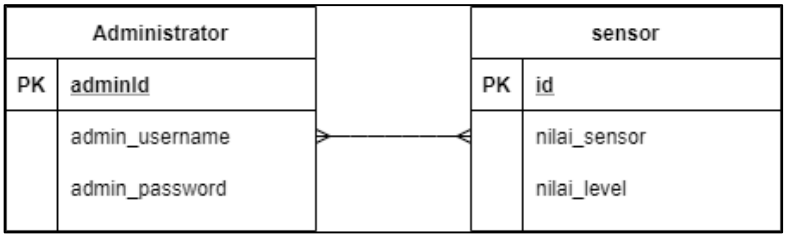


Figure 3: Entity relationship diagram

4.5 System architecture

System architecture is a diagram that show the flow of the system from devices or sensors to end users. System architecture describes the structure of Internet of Things system. System architecture also explains the services, components, layers and interactions [10]. Figure 4 shows the system architecture for flood monitoring and alerting system

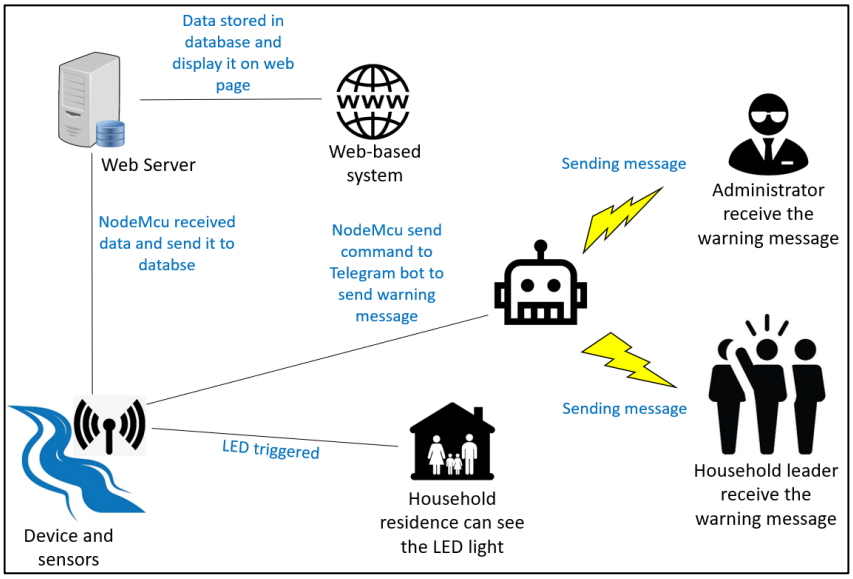


Figure 4: System architecture

4.6 Interface design

Interface design is concentrates on looks, style, and designs of web pages. Interface design is created to show how the actual user interface will looks like [11]. An interface should be easy and convenient to use. Figure 5 shows the user interface design for registration and login page. Subsequently, the main page and access denied page will be shown in Figure 6.

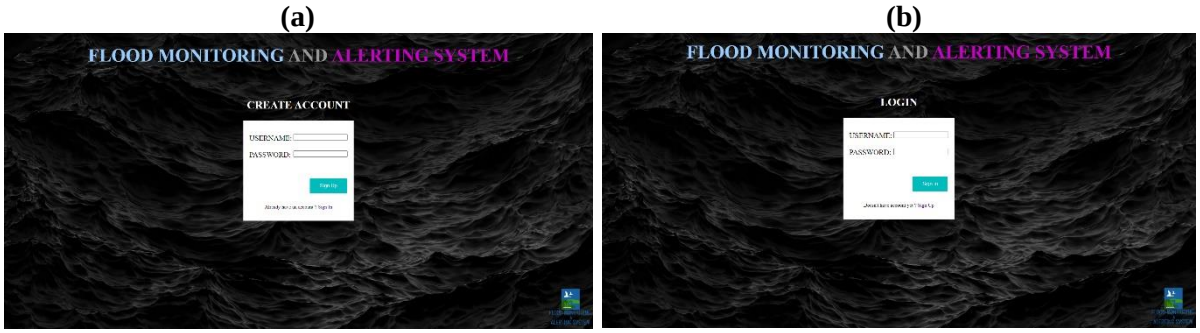


Figure 5: User interface for registration and login page

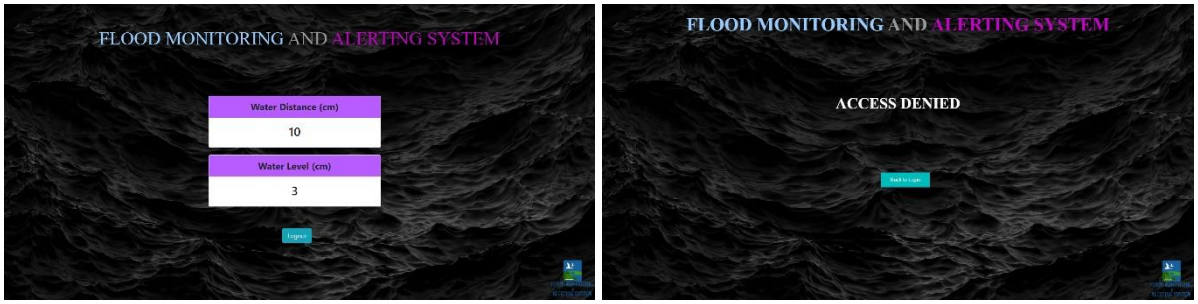


Figure 6: User interface for main page and access denied page

4.7 Hardware device

Hardware device is focus on the placement of the sensors and other hardware component. The hardware device placement should be orderly and neat. Figure 7 shows the hardware device for flood monitoring and alerting system

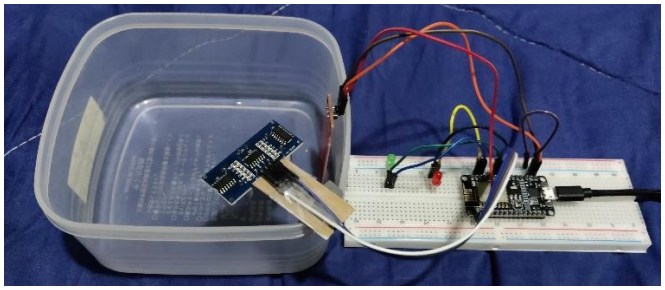
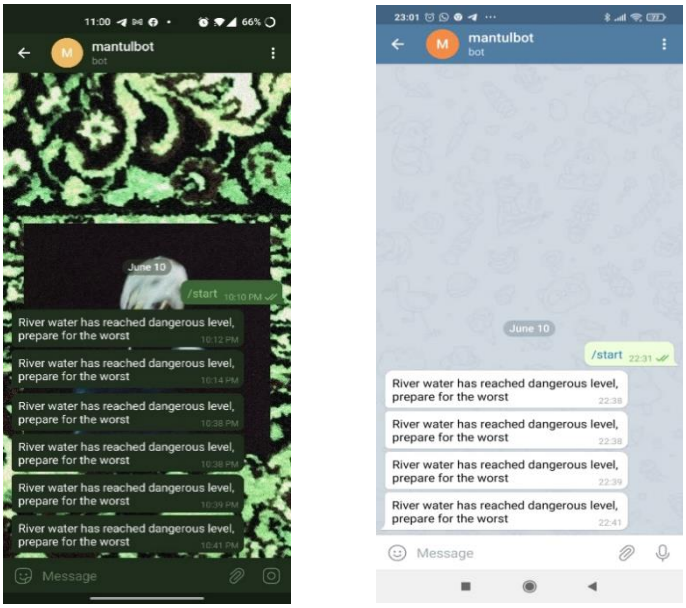


Figure 7: Hardware device for flood monitoring and alerting system

4.8 Warning message (Telegram)

Warning message function is used to deliver warning message to both system users and residence that live near the proposed system. Every leader in a household need to give their telegram id and activates the telegram application bot in order to receives the warning message. Figure 8 shows the warning message received by system administrator and household leader that delivered from telegram bot.



(a) (b)

Figure 8: Warning message received by system administrator and household leader

4.9 Functional testing

The flood monitoring and alerting system's functionalities have been tested to confirm that it meets the system's specifications and user requirements. The system has been integrated with a website page that allows users to engage directly with the system. A test strategy is necessary to ensure that the application produces the desired result. Table 4 until Table 8 shows the functional testing for flood monitoring and alerting system.

Table 4: Test plan for login function

Test Plan for Login Function			
No	Test Case	Expected Output	Actual Output
1.	Insert valid username and password	Redirect user to main page of the system	Same as expected output
2.	Insert invalid username and password	Redirect user to access denied page of the system	Same as expected output

Table 5: Test plan for register function

Test Plan for Register Function			
No	Test Case	Expected Output	Actual Output
1.	Insert username and password	Redirect user to login page of the system	Same as expected output
2.	Did not insert any username and password	Show error message	Same as expected output

Table 6: Test plan for water distance and water level reading

Test Plan for Water Distance and Water Level Reading			
No	Test Case	Expected Output	Actual Output
1.	User login the system with correct username and password	User can see the water distance and water level reading in the main page	Same as expected output
2.	User click the logout button	Redirect user to login page	Same as expected output

Table 7: Test plan for LED trigger action

Test Plan for LED trigger action			
No	Test Case	Expected Output	Actual Output
1.	User fill up water in tank until it reached dangerous point	LED will light up	Same as expected output
2.	User fill up water in tank but not reached dangerous point	LED will not light up	Same as expected output

Table 8: Test plan for warning message

Test Plan for warning message			
No	Test Case	Expected Output	Actual Output
1.	User fill up water in tank until it reached dangerous point	NodeMcu will send warning message to the user	Same as expected output
2.	User fill up water in tank but not reached dangerous point	NodeMcu will not send warning message to the user	Same as expected output

4.10 User acceptance testing

This test is required to ensure that the user's requirements are met and that the outcome fulfils their expectations. A total of ten people participated in the acceptance testing. The design and function of the website system component of the test is separated into two components. Figure 9 shows the outcome of a user acceptance test for a website user interface design.

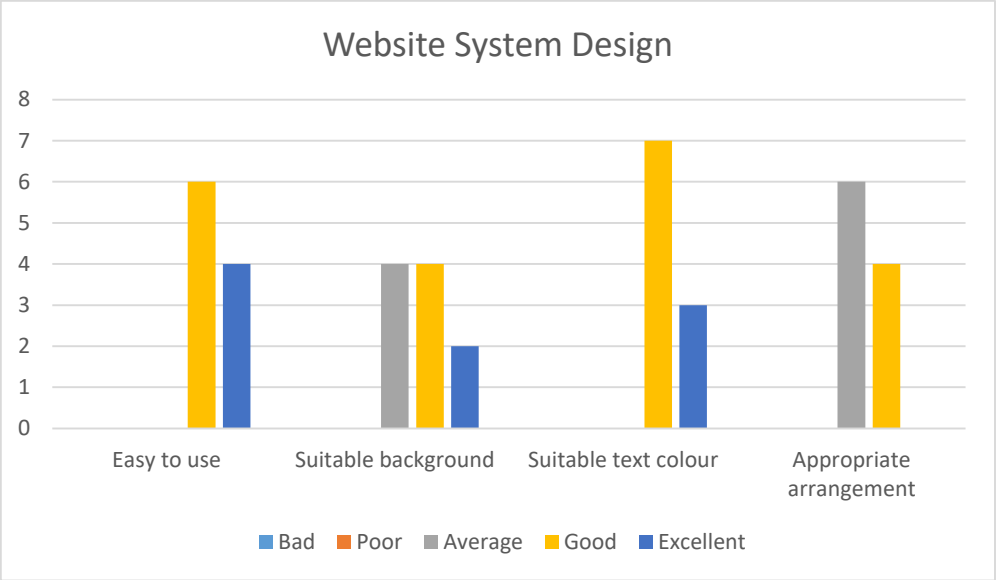


Figure 9: User acceptance test on website system design

The outcome of the functional test of the system user and resident is shown in Figure 10. The aggregate outcome falls into three categories: average, good, and excellent. The LED trigger action component achieved a good level, resulting in the highest level of satisfaction. The quality of the warning message is rated as average, good, and excellent. Average, good, and excellent are the water distance and water level readings.

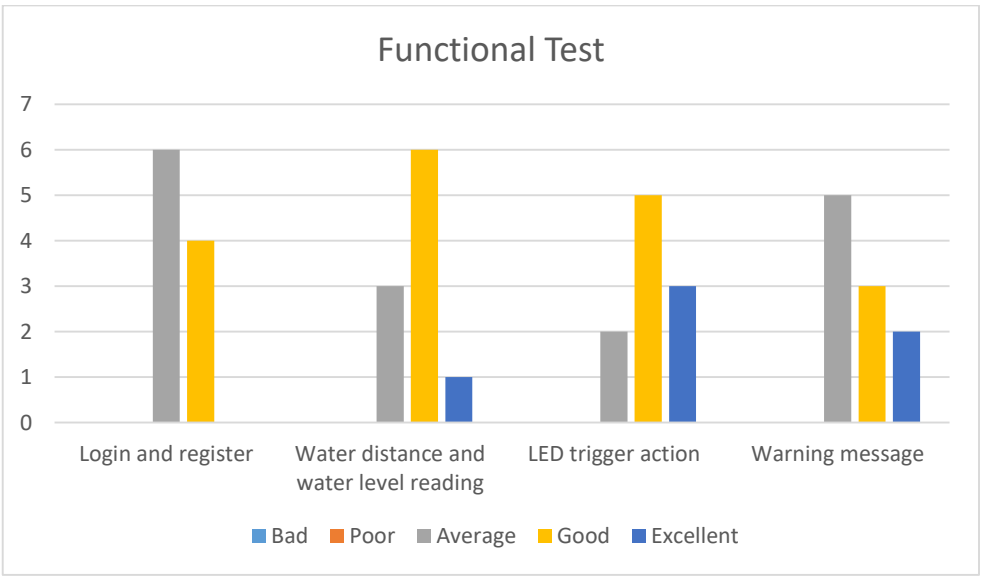


Figure 10: User acceptance test on system functionalities

5. Conclusion

As demonstrated above, all objectives mentioned in the earlier section have been achieved by the developed system. The flood monitoring and alerting system provide early flood detection to the people who live in frequent flooding area. This system not only benefits the end-user but also benefits the system administrator by providing the accurate water distance and water level reading as well as alert the system administrator with a flood warning message. The developed system not only give an early warning on flood detection but also remind the end-user to take precaution measure for the upcoming flood. The proposed flood monitoring and alerting system are relevant for both east and west Malaysia due to the rainy and hot season throughout the year that could cause a flash flood. It is hope that the proposed system can fulfill the market requirement, improving the quality of life and provide an efficient way for people to detect upcoming floods so that life casualties can be avoided.

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