Research Article

Elderly Location Monitoring System with LoRa (iLocation)

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Abstract: *The Wireless Long Range (LoRa) technology is a wireless communication system that provides extended range and energy efficiency. Renowned for its exceptional energy efficiency and extensive coverage, this technology surpasses the limitations of GPS and BLE. The objective of this research is to enhance the surveillance of the whereabouts of elderly caregivers by employing LoRa devices. The primary aims of this research are to showcase the use of the iLocation system for elder caretakers and to offer real-time displays of position coordinates. The present study utilizes a research methodology based on the Internet of Things (IoT) framework, with a particular focus on the application of LoRa technology for the purpose of tracking locations in real-time. IoT leverages connectivity to provide communication, instantaneous data analysis, and intelligent decision-making among diverse objects. This system showcases the advantages of LoRa technology, encompassing its energy efficiency and wide-ranging coverage, while also illustrating its potential application in monitoring the elderly population. This technology enables caregivers to monitor the real-time whereabouts of elderly individuals. In addition, elderly individuals have the choice to send a warning message to their carer in case of any unexpected situation. The use of LoRa technology in the Elderly Location Monitoring System offers a unique and practical solution to meet the needs of caregivers.*

Keywords: LoRa; IoT.

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1. INTRODUCTION

Population aging occurs when the percentage of elderly people aged 60 and over reaches 15% of the total population. Seniors who want to live independently in their own home or in an assisted living facility must have the care and supervision they need to ensure their safety. Using LoRa (Long Range) technology, the Elderly Location Monitoring System (iLocation) offers a state-of-the-art solution that fully addresses this issue.

LoRa (Long Range) is a long-range and low-power wireless communication protocol, to create a reliable and cost-effective way to track the location of the elderly. LoRa technology is also known for

its energy efficiency, and devices can have long battery life. In some cases, LoRa devices can last several years on a single battery. Battery life can be extended from a few months to potentially over a decade, depending on the factors that can affect it. The background of this project lies in the need to make it easier for caregivers to monitor the location of elderly people who want the freedom to go out (Fung et al., 2019).

The main goal of this study is to develop an Elderly Location Monitoring System with LoRa (iLocation). To achieve the main goal, three main objectives have been implemented in the development of the project, namely; *a)* Developing an Elderly Location Monitoring System using LoRa (iLocation) technology that can facilitate the affairs of elderly caregivers to track the location of the elderly. *b)* Design a web-based system dashboard that can display the location of seniors in real time.

2. METHOD & MATERIAL

The development of a software system has several phases called the software development life cycle, there are several types of development models that can be applied in the process of developing a project. System development methodologies that are often used to develop systems are waterfall model, Rapid Application Development (RAD), prototype model and unified modeling language. Each model has its own advantages.

There are several types of Agile methodologies such as Scrum, Kanban, Extreme Programming and Lean Software Development. The choice of methodology is based on the type and needs of the project. Therefore, the type of Agile methodology that has been chosen is Scrum. This technique has been chosen due to the dynamic nature of the technology and the specific needs of the elderly, the Agile technique approach allows continuous integration with LoRa devices and responsive adaptation to user needs. This iterative process ensures that this location monitoring system will evolve with technological advances and user feedback, resulting in a solution that is not only technologically robust and up to date but also tailored to the specific needs of users and seniors.

The phases of the development model process are as follows:

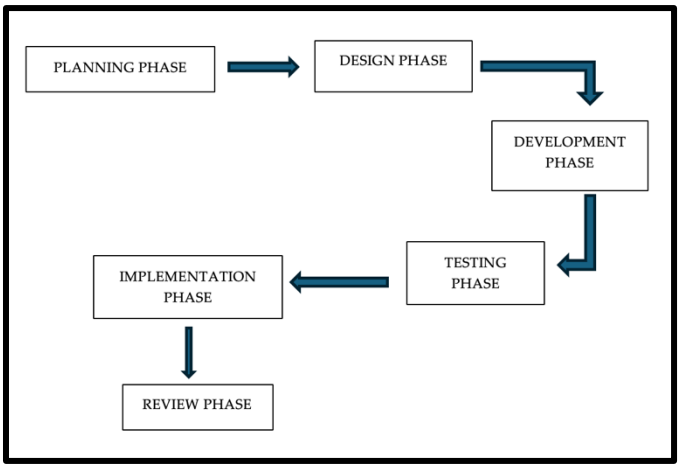

Figure 1: Development model process

2.1 LoRa Technology

LoRa technology is a Low Power Wide Area Network (LPWAN) technology, which has the advantages of low power consumption, long communication distance, anti-interference, and low cost, has been widely used in IoT. LoRa is a low-power wireless technology that operates at various frequencies depending on location, such as 915 MHz for North America. LoRa modulation is based on spread spectrum techniques and chirped spread spectrum (CSS) variation with integrated forward error correction (FEC) (Saari et al., 2018). The LoRa Alliance has standardized a MAC protocol called LoRaWAN. LoRaWAN defines the communication protocol and system architecture for the network while physical layer LoRa enables long distance communication links. The edge nodes of the LoRaWAN network can transfer data to several base stations.

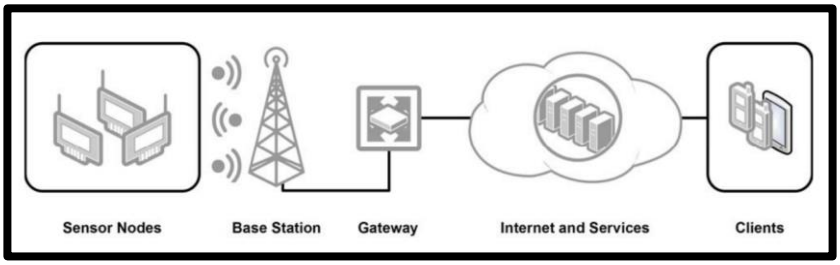

Figure 2: LoRaWAN communication protocol and system architecture (Saari et al., 2018)

This LoRa technology will use a trilateration algorithm that takes advantage of the long-distance wireless communication capabilities of LoRa devices to determine the location of a point by measuring its distance from a known reference point that is the receiver. In this method, each device measures the Received Signal Strength Indicator (RSSI) from a LoRa gateway or a fixed device nearby, estimating the distance based on the signal strength. At least three reference points with known locations are required for trilateration to work effectively (Pakanon et al., 2020). By calculating the approximate distance to this reference point and using the trilateration algorithm, the device determines its location by intersecting the circle (in two dimensions) or sphere (in three dimensions) formed by the reference point.

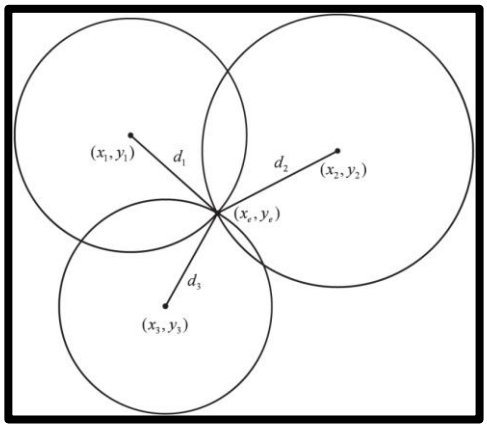

Figure 3: Positioning Using the Trilateration Method (Pakanon et al., 2020)

3. FINDINGS

Elderly Location Monitoring System with LoRa (iLocation) was developed to make it easier for caregivers to monitor the location of the elderly more efficiently. This section explains the system analysis study covering iLocation system sketches based on diagrams such as use case diagrams, sequence diagrams, flowcharts, and several sketches used to develop this system. These diagrams can depict the entire work process effectively and is easier to understand. In addition, system analysis is a method to find solutions to existing system problems by grouping existing components into smaller ones so that the solutions found are in line with the requirements of the iLocation system.

In addition, the system analysis is also to ensure that the developed system meets the requirements of the iLocation system. There are several contributing factors that the system analysis needs to be carried out, among which are: *a)* Describes the system flowchart as a guideline in developing the iLocation system. *b)* System analysis can ensure that the development process of the iLocation system can be carried out more efficiently, easily, and systematically.

3.1 Analysis Phase

The analysis phase in this system generally refers to the method of developing the system by examining every need and the system's requirements. This phase is also an important phase in system development. Any mistakes made in this phase can impact the system development process. There are four processes involved in this analysis stage, namely requirements modeling, data and process modeling, object modeling and finally, the transition to design.

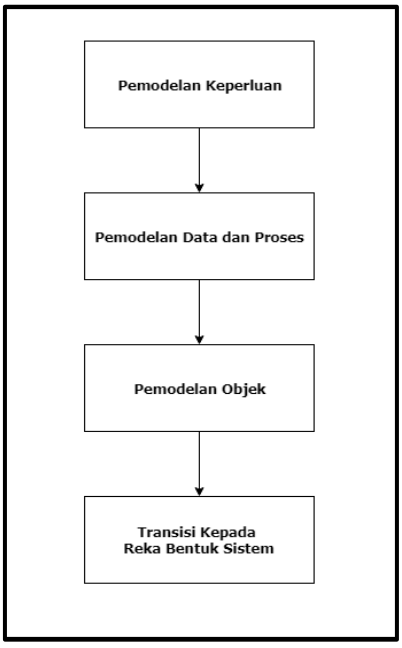

Figure 4: Process in the Analysis Phase

3.2 Data Modelling Phase

The Data and Process Modeling phase is an important stage in system development, it helps in creating a blueprint for the system, guides the development of the system and ensures that the final product meets the needs of the users. Through the data and process modeling phase, an in-depth analysis of how the system will manage, store and manipulate data and how each process will be carried out. For the simulation of the Elderly Location Monitoring System with LoRa (iLocation), Unified Modeling Language (UML) will be used. It is a very important part of developing object-oriented software and the software development process.

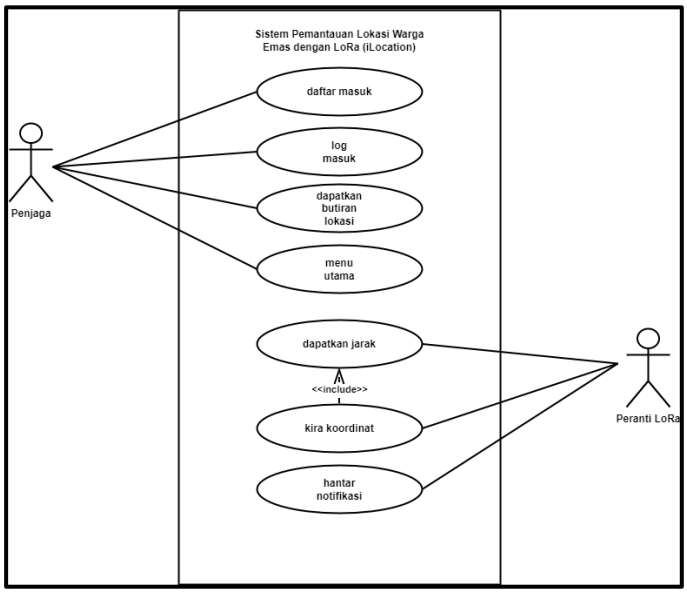

Figure 5: Use Case Diagram

3.3 UML Sequence Diagram

Sequence diagrams in UML are used to create an interaction model between actors and objects and between objects and objects in a system. A sequence diagram describes the dynamic behavior of a system by showing how objects work together to achieve a specific function.

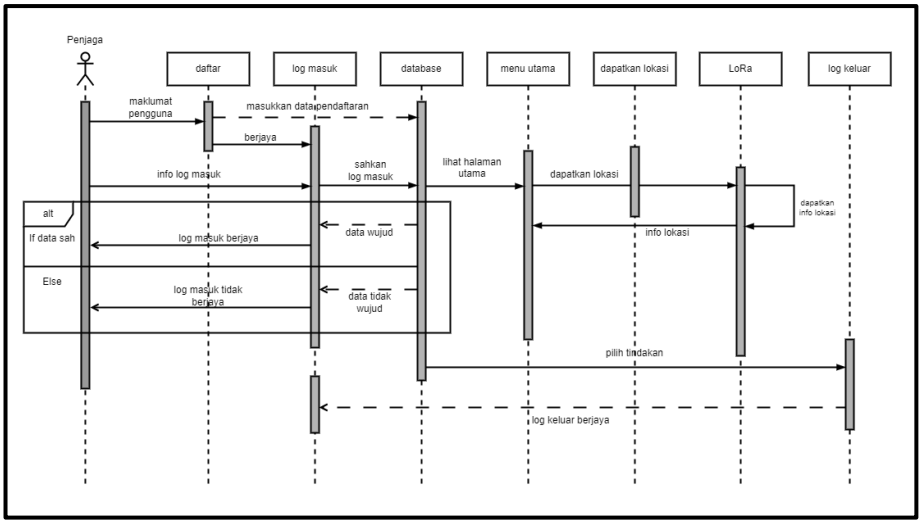

Figure 6: Sequence Diagram

Figure 5 shows the sequence of interactions that occur when users use this system. When guardians open this system, they need to make sure they log in by filling in the necessary information. Once successful, they can continue to log in by filling in the login details ie username and password. If the information entered does not match, the guardian will get an error message and if the information does not match, the guardian will go to the Main Menu display. In the main menu, the guardian can choose to get location details from LoRa and LoRa will calculate the coordinates and then the information will be sent back to the guardian. Finally, in the main menu there is also an option to log out.

3.4 Activity Diagram

The activity diagram is an important diagram in UML to describe the dynamic aspects of the system. An activity diagram is basically a flow chart to represent the flow from one activity to another. Such activities can be described as system operations. Control flow is taken from one operation to another. These flows can be sequential, branching, or simultaneous.

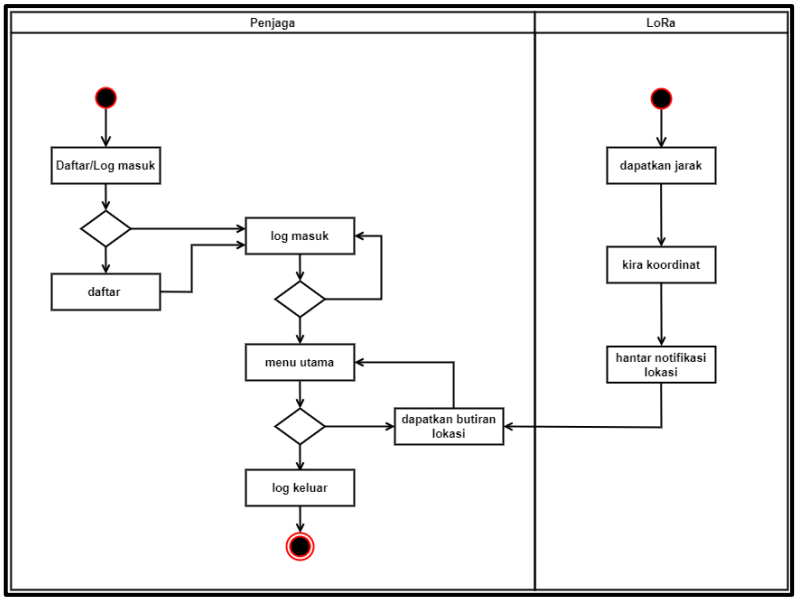

Figure 7: Activiy Diagram

Based on the diagram above, the guardian will start by choosing to sign in or log in. Once logged in, the main menu view is displayed and the guardian can choose to get the user's location details. Next, the system will get the distance of the LoRa device that is with the user with all other LoRa gateways. Then, it will calculate the coordinates and send the details of the location to the guardian.

3.5 Transition Phase to System Design

This phase is the transition from data and process modeling to the actual design of the system. It involves the transition from the initial phase to the final phase, where initial ideas and concepts are transformed into a more concrete and detailed form. In this phase, there is the formation of a hierarchy chart, the compilation of a data dictionary that includes a detailed description of each data element and a flow chart to illustrate the course of the work process in the system.

3.5.1 Hierarchy Chart

A system hierarchy chart is built to show the modules that have been displayed in the system to be developed. This chart is an overview of the information obtained when this system is used. It helps in presenting an overview of the functions used in the system. Figure 6 shows the hierarchy chart of the Elderly Location Monitoring System with LoRa (iLocation). Based on the hierarchy chart above, the guardian will log in and go to the main menu to select the get location menu or log out. The LoRa device will act to get the distance, calculate the coordinates, and send a notification to the guardian.

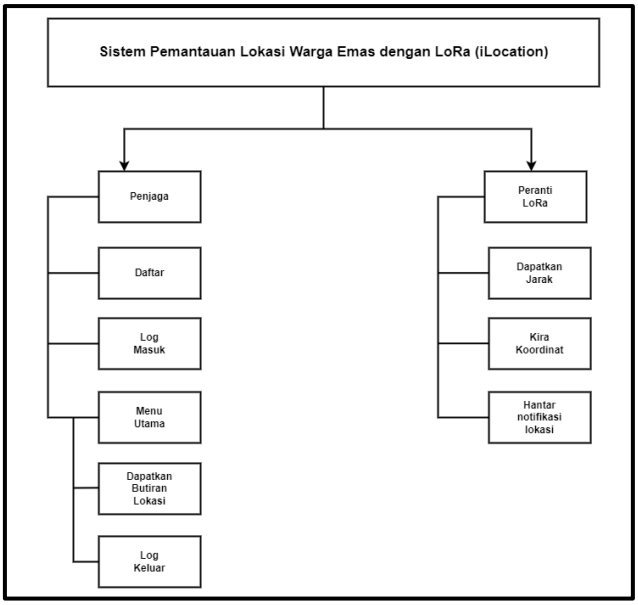

Figure 8: Hierarchy Chart

3.5.2 Flowchart

Flow charts are used to link the processes of the system. The main purpose of a flowchart is to provide a clear visual understanding of how a system or process works. Figure 7 shows the flow chart of users who will register and log in by entering the login details ie username and password before being able to access the system. In the main menu, the guardian will be given the option to get location information or log out. If, choosing to get location details, the system will ask LoRa to get the distance and then calculate the coordinates of the location. Finally, the location details will be sent back to the guardian.

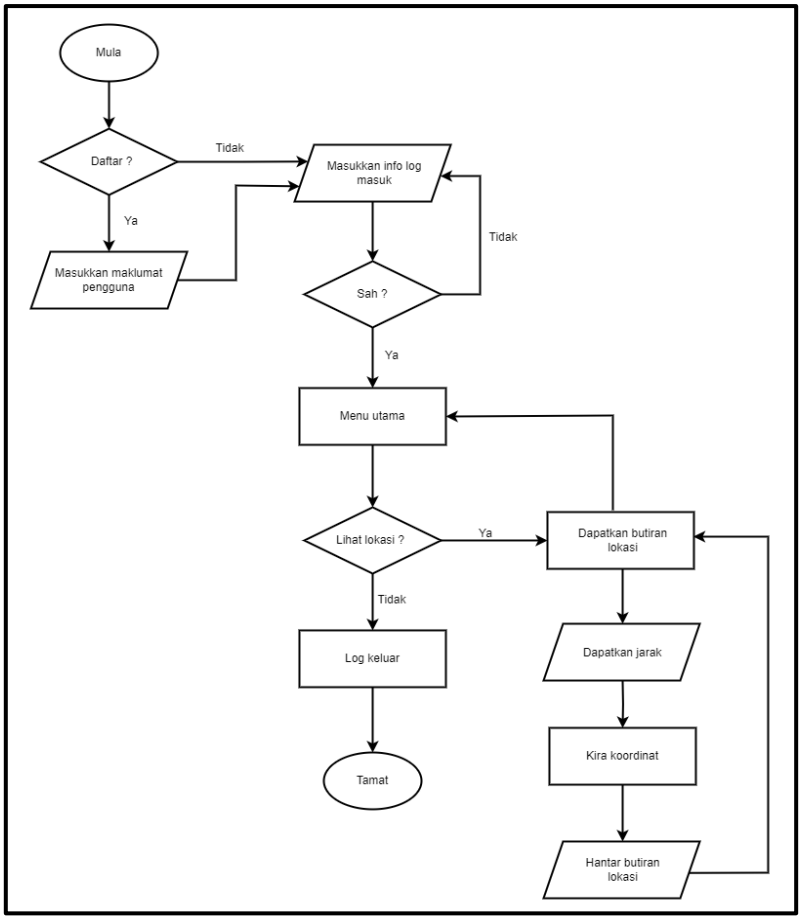

Figure 9: Flowchart

3.6 Interface

Figure 9, 10, 11 and 12 shows the interface design of the developed system.

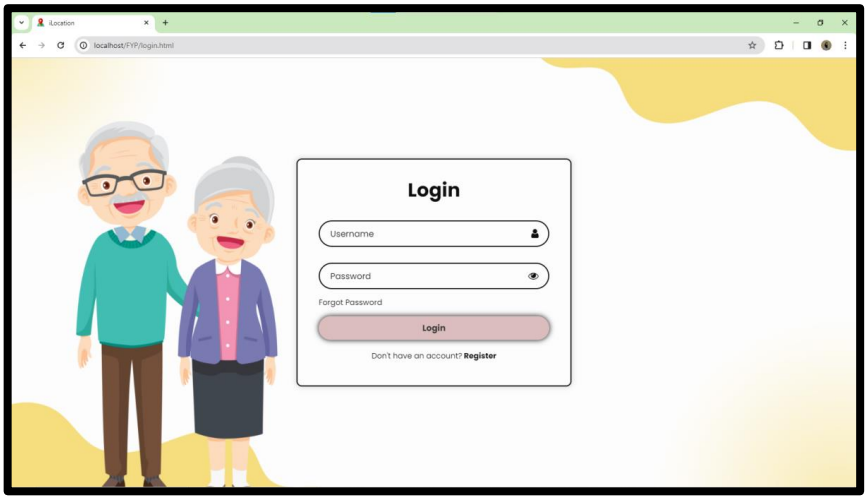

Figure 10: iLocation Login Interface

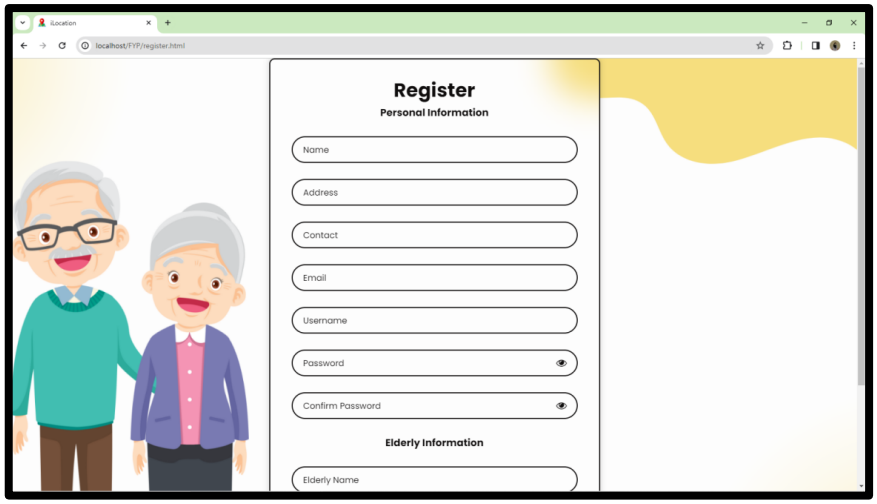

Figure 11: iLocation Register Interface

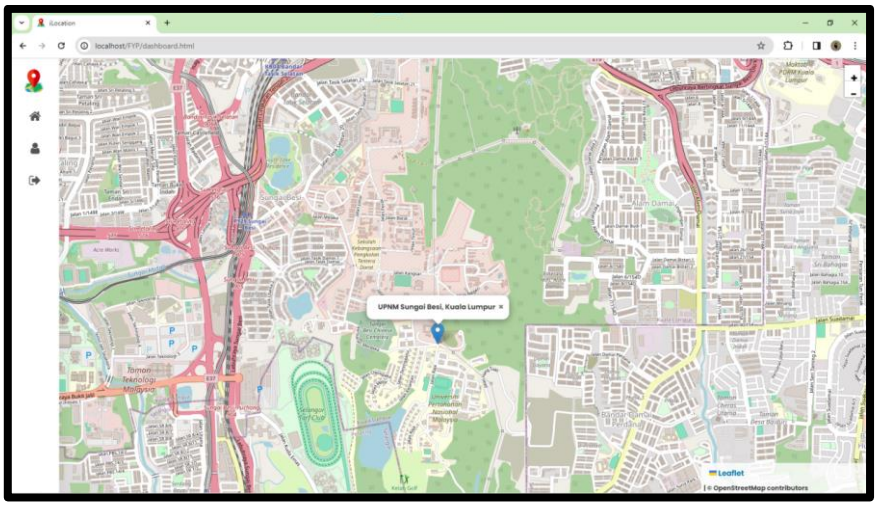

Figure 12: iLocation Main Interface

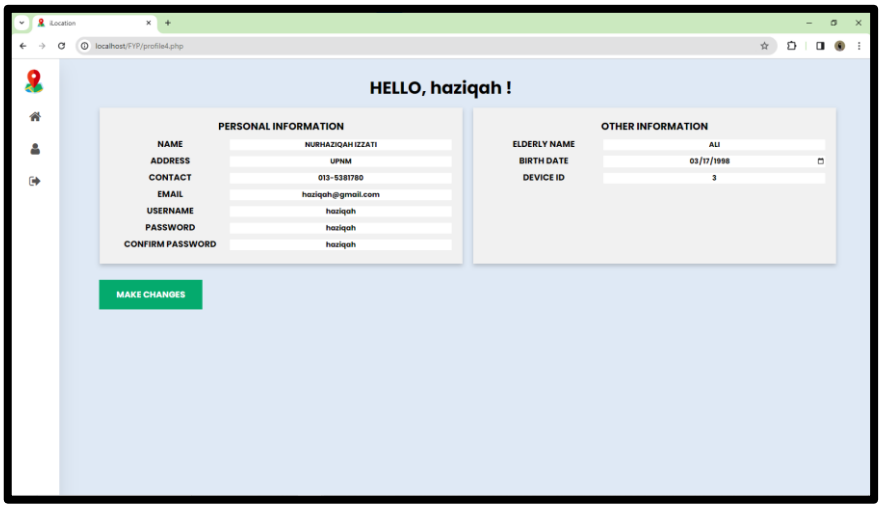

Figure 13: iLocation Profile Interface

4. DISCUSSION

The Elderly Location Monitoring System using LoRa (iLocation) technology will bring various benefits and advantages to every user of the system. There are several advantages in this location monitoring system. Among the advantages is that this system has a user-friendly interface where it can make it easier for users to operate this system. Next, LoRa technology has low energy consumption, making it ideal for battery-powered devices used in elderly location monitoring systems. Finally, this system can monitor the location of the elderly in real time and display that location to caregivers.

As a result of the study conducted on the Elderly Location Monitoring System Using LoRa Technology (iLocation), there are several suggestions that can be considered for the improvement of this system in the future. This is to make this system more efficient and effective. Among the suggestions that can be considered to strengthen this is the first by adding an emergency button that can be used by the elderly to give information when they are in danger. This can give them access to the immediate help they need in situations that require quick action. Next, change the web-based system to an application so that users will have easier and faster access to system functions and enable users to access information and services more efficiently and finally, make improvements to the trilateration algorithm used so that the location of the elderly will be more accurate.

5. CONCLUSION

The Elderly whereabouts Monitoring System with LoRa (iLocation) was developed in order to assist caretakers in tracking the whereabouts of the elderly in real time. As a result, it is envisaged that the difficulties that developed in the previous system would be solved by this system, notwithstanding certain inevitable limits throughout the development process.

Finally, it can be said that, altogether, this system accomplishes the objectives and aims, as well as the scope that has been defined, which are: a) To develop an Elderly Location Monitoring System using LoRa (iLocation) technology that can facilitate the affairs of elderly caregivers to track the location of the elderly while also strengthening surveillance and improving safety for the elderly as a whole. b) To build a web-based system dashboard designed to display the location of the elderly directly through online interaction by integrating web technology and LoRa devices to provide quick and easy access to the location information of the elderly.

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