International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Indoor Navigation Design Uses Beacons to Detect Point Locations of Flight Service Users

Fatmawati Sabur[1], Purnamawati[2], Abdul Muis Mappalotteng[3], Muhammad Yahya[4]

Submitted: 22/04/2023 **Revised:** 23/06/2023 **Accepted:** 04/07/2023

Abstract: The challenges that often occur at the departure terminal are flight service users who pay less attention to the estimated travel time, conditions on the way to the airport (congested), parking locations that are far from the departure terminal, the antigen validation process which takes more time. longer time in the process of administrative checks for passengers and baggage so that flight service users experience delays in registering at the departure terminal, checking in at the airline counter at the departure terminal. Flight delays are often caused by passengers getting lost and unable to find their way to some of the airport facilities provided in a timely manner. The purpose of this study is to provide information on alternative routes for users of the nearest flight service. The research method used is the type of Hasunuddin Airport Case Study research, the research design uses the CIPP model. The population of this study is all public facilities at Sultan Hasanuddin Airport Terminal, while the research sample is the route from the departure gate to the waiting room gate. The data collection technique is through Literature Study and Field Observation, while the data collection instrument is by conducting interviews with passengers as outlined in the questionnaire, making observations/observations, and documenting the area of public facilities in the airport terminal, data analysis techniques with data processing using the RSSI approach, utilizing the MQTT protocol and using a 2-dimensional mapplic application. The results of the research are in the form of a system design that can determine the position of passengers in the departure terminal area by utilizing RSSI (Received Signal Strength Indication) and BLE (Bluetooth Low Energy) and can provide route direction and distance information on the smartphone screen using the mapplic application

Keywords: *Navigation, Flight Service Users, Beacons*

1. Introduction

Airports provide services for the movement of passengers and goods by air [1]. or air transportation, where the challenges that frequently occur at the departure terminal are flight service users not paying attention to the estimated travel time, conditions on the way to the airport (congested), parking locations far from the departure terminal, the antigen validation process taking longer so that flight service users experienced a delay in registering at the airline check-in, and the antigen validation process taking longer so that flight service users experienced a delay in registering at the airline check Passengers who become disoriented and cannot locate the required facilities in a timely manner frequently cause delays. During the pandemic, when several access movements are diverted for automatic measurement of passenger body temperature, passengers are separated to prevent congestion. accumulated at a single service point and supported by technological advances. There are currently several technologies that can be used to assist passengers determine their terminal location.

[1]*S3 Student of Engineering Vocational Education, Makassar State University, Indonesia*
[2]*Department of Electronic Engineering Education, Faculty of Engineering, Makassar State University, Indonesia*
[3]*Department of Electrical Engineering Education, Faculty of Engineering, Makassar State University, Indonesia*
[4]*Department of Automotive Engineering Education, Faculty of Engineering, Makassar State University, Indonesia*
Email: purnamawati@unm.ac.id

Because GPS technology cannot be used to monitor indoor positions, the Indoor Positioning system is implemented [2]. It is possible to determine the location of smartphone users' required amenities by utilizing smartphones and Wifi devices that are commonly available in the room and typically possessed by visitors. However, when employing Wife technology, the presence of numerous impediments in the room impedes the acquisition of a stable and accurate RSSI value. Therefore, other approaches are required to increase accuracy, including the use of the Djistra algorithm and iBeacon BLE (Bluetooth Low Energy) as a hybrid technology related to its use as a shared indoor positioning system with Wi-Fi technology [3]. To provide comfort for passengers in knowing their position in the room, a smartphone-compatible interface is required where the visualization of the floor plan can be enlarged, such as with a map application. SVG technology, which is an interactive vector-based visualization, can be used as an alternative to creating floor plans that can be enlarged without sacrificing display quality and are lighter than using a floor plane image derived from a raster image. MQTT is chosen as a lightweight protocol for data transmission in order to prepare real-time information [4].

2. Related Works

Trilateration techniques [5]. By smoothing and filtering data from beacons, positioning accuracy can be enhanced. [6] The object insertion and positioning system is designed using the SVG image format [7]. Comparison of HTTP and MQTT data transmission protocols [8]. Mesh network application on heterogeneous networks [9].

2.1 Our Contribution

Using a small optimized subset of each facility deployed at the airport departure terminal, passenger positioning is designed using BLE and Wi-Fi to pinpoint the user's approximate location relative to the needed terminal facility location. The IPS (Indoor Positon System) method involves drawing a floor layout and noting the terminal's precise location relative to each facility. And using the MQTT protocol, we developed a system for continuous monitoring in real time. The solution is comprised of two independent systems that talk to one another using a smartphone-friendly web interface. The first component locates smartphone users inside the airport departures area. The Wi-Fi network is used in this component because it is a publicly available, cost-effective option. In addition, all of the amenities in the airport departures area have BLE (bluetooh low energy) installed.

2.2 Paper Structure

The design for tracking passenger traffic inside the terminal makes use of a Received Signal Strength Indicator (RSSI) filter to minimize noise when calculating the distance between a receiving node and a sending node. The next topic up for discussion in RSSI is the idea of a mesh network, which consists of nodes in a network that are directly connected to each other. combined with Indoor Positioning System to pinpoint precise location inside a building. The user's position can be estimated using Trilateration, which involves calculating the user's distance from the signal transmitter and the position of the transmitter coordinates using the intersection of the beacon nodes, then discussing the floor plan as a vector based on 2D visualization in the room, and finally calculating the path and travel time from the smartphone location to the coordinates of the location of the required a.i. beacon.

3. Methods

This study's research is a form of research and development (R&D) for the hardware, with the end goal of creating new products or enhancing existing ones, while the software adopts the Waterfall model as a system design. The System Development Life Cycle (SDLC) is a common method for creating software, and it includes the following steps: planning, analysis, design, implementation, testing, and management (maintenance). The Waterfall model of the software development life cycle (SDLC) consists of five (5) distinct steps. The following is a proposal for a model for developing educational apps on mobile devices:

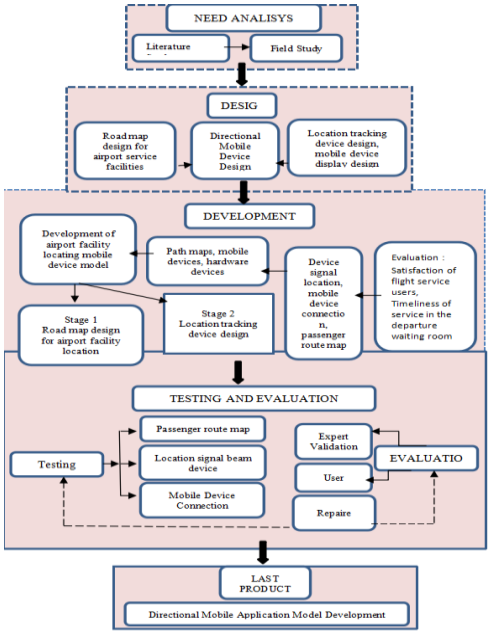


Fig 1. Targeted Mobile Application Development Model

The development stages as shown in Figure 1 are a process that can take place continuously starting from the needs analysis to the design process that produces product designs that will be developed through the development of a direction-determining mobile application model, after that the process continues with testing and evaluation, system testing using the waterfall approach.

[10], while the evaluation used the ADDIE model approach [11].

This research, especially in the testing and evaluation process, requires testing and evaluation instruments, for testing passenger route maps, namely testing algorithm A [12] and errors from the source code side of the program when testing signal emission applications can use the tracking filter test method [13], while the evaluation using 2 instruments, namely expert evaluation and user evaluation, namely limited user test and larger field test.

3.1 Development Model

Research and Development (R&D). The R&D method is research that is intentionally, systematically directed at finding, formulating, developing, producing, and testing the effectiveness of a particular product that is superior, new, effective, efficient, productive, and meaningful. Meanwhile, according to [14] Development research is a research method used to produce certain products and test the effectiveness of these products. From this opinion, it can be concluded that development research is not research carried out to produce theories but to produce certain products. This development research aims to design an android application that is feasible and reliable to support services at the airport. The research implementation of the R&D method used refers to the procedure developed by Sugiyono with the following stages:

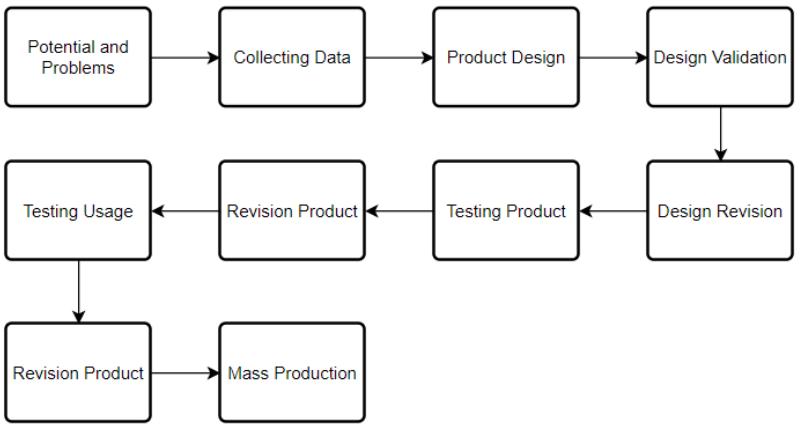


Fig 2. Research Steps Research and Development Methods (R&D)

The development model or research design is the basis for developing Development Procedures Referring to the development model of the 10 steps of research implementation of the R&D method, this research takes seven steps in Potentials and Problems, Data Collection, Product Design, Design Validation, Product Trial, Design Revision, Revision Products, and Usage Trials. This is done with several considerations adjusting to the characteristics, limitations of time, effort, and cost.

3.2 Research and Development Procedure

Analysis, design, development, implementation, and evaluation are the five phases of the ADDIE development paradigm, which was adapted for this hardware research approach from Dick and Carry. as was mentioned before. However, the scope of this study is confined to preparation for implementation. To help departing passengers find their way through the airport, researchers at Sultan Hasanuddin Airport Makassar created a mobile application concept. At Sultan Hasanuddin Makassar Airport's departure terminal, the following steps make up the process of creating a mobile application model for the location of airport facilities for passengers:

3.2.1 Analysis Phase (Analysis)

The analysis stage is the stage of collecting information that can be used as material for making products, in this case the product produced is a mobile application model for directions. This information collection is in the form of needs analysis, hardware analysis, and software needed to make products, namely: a). needs analysis aims to identify products that match the target, b). hardware analysis includes determining hardware components or equipment used in the development of mobile application models for directions, and c).

Software analysis was carried out to identify the programming language used in synchronizing indoor transmitter equipment with smartphones.

3.2.2 Design Stage (Design)

The development stage begins with creating a product design in the form of an Android application. The design stage is carried out to facilitate researchers in developing a mobile application model for directions to be built. The application developed is an android application to support the improvement of airport services at the terminal. The design phase includes data collection criteria and

storyboards. The design stage can be seen in the following figure:

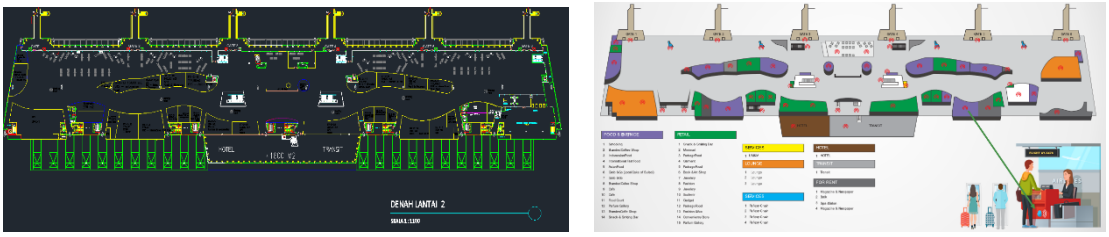
(a) (b)

Fig 3. Service Improvement

a. Storyboard information display

b. Smartphone Information Display

To build an application as shown in Figure 3 above, the steps that must be taken are to find autocad drawings from the airport location which is the locus of this research. The next step is to make a floor plan with a 2-dimensional building drawing according to the original plan. Specifically the area traversed by flight service users or passengers as shown in Figure 4.



(a) (b)

Fig 4. 2-dimensional floorplan

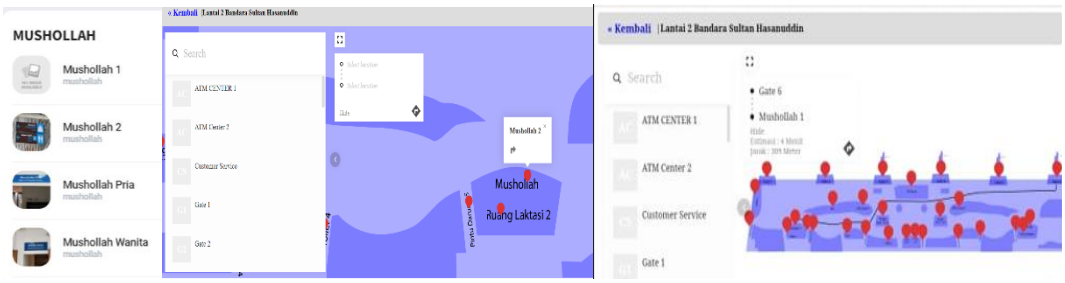
a. autocad view

b. Storyboard Display

The current condition, the form of information related to the location of the facilities available in the terminal building is only displayed in the form of a story board, where flight service users are only able to see the location plan and estimate the travel time from the point where the passenger is to the location of the required facility. This story board is a reference for designing a 2-dimensional display and then determining the coordinates of each possible path or route that passengers will take to the location of the intended facility.

3.2.3 Development Stage

Application Development is the stage of realizing the plan at the design stage until it becomes a product. The final result of this stage is a mobile application product model for directions that will be tested. Shown in Figure 5, application development which is the result of the design stage that can be used via the web and can be viewed using a smartphone device**.**



(a) (b) (c)

Fig 5. Design development stage

a. Selectable facility locations

b. Display of the selection of the coordinates of the smartphone location against the coordinates of the location of the facility to be addressed

c. Display of destination location information

Based on the picture above, it can be explained that the development of a smartphone model that is built using a 2-dimensional mapplic application can be done by setting the coordinates of each area contained in the terminal according to the floor plan design, the availability of the location of facilities provided by the airport manager in the terminal building. Figure a shows the types of airport facilities needed by flight service users, then in Figure b shows the location of the facility to be addressed as well as the column of origin coordinates (smartphone location position) and the coordinates of the destination airport facility. Figure c shows the directions and paths that can be taken by flight service users in finding the location of the airport facilities they need towards the last position of the flight service user in the terminal.

3.2.4 Application

This stage can be done if the results of the expert test have met the good criteria. The implementation phase is a trial phase for users, namely flight service users who will make flights in the waiting room of the departure terminal. The instrument given is a development application that has been compiled in the previous stage. Where in the early stages of testing by flight service users who will fly in small groups, the product received a proper response to use and is very helpful for flight service users while in the terminal even though currently they are still using the mapplic application according to the airport terminal floorplan with reference to on the autocad display of Sultan Hasanuddin Airport Makassar, the next step is to implement the product for flight service users. who will fly a large group, which is as many as 100 people by notusing the mapplic application anymore, but the smartphone device of flight service users will receive a signal from a beacon device that is installed at several points according to the range of the beacon emission. Criticisms and suggestions from IT experts, airport technicians at the Airport Electronics/ELBAN unit as well as flight service users who will fly, at this stage can be taken into consideration for product revisions so that they are better perfect and can be implemented in several airports.

The system implementation stage is the system operation stage. In carrying out the implementation of this mobile application development activity, several stages must be carried out, namely a). System preparation, b). Training, c). System testing, and d). operation. System testing is the stage of system testing, to ensure the system can work optimally, this stage is carried out after all application support facilities are available.

4. Results and Discussion

The discussion can be done in several sub-sections.

4.1 RSSI (Receive Signal Strength Indicator)

The primary idea behind the RSSI coverage method is to calculate the distance between a signal's sending node and its receiving node by monitoring the strength of the received signal after it has been weakened by propagation loss. The formula for the log distance distribution model, which describes how Bluetooth signals travel, is given below:

$$RSSI = -10n \log_{10}(\frac{d}{d_0}) + A_0$$

Where PL(d) is the received signal strength indicator at the node d distances from the transmitter, and PL(d0) is the received signal strength indicator at the node d0 distances from the transmitter. The path-loss propagation exponent is determined by the value of distance d0; which varies with the conditions of wireless transmission. For example, consider the following equation [15], where is the distance between the flight service smartphone user and the bluetooth beacon transmitter, is the average power of the signal received by the user at a distance of one meter, and n is the propagation constant in a room. Variation in received signal strength (RSSI) at wireless receivers is commonplace because of the effects of fading and shadowing. The received signal strength indicator (RSSI) is measured at the terminal or indoor location using the vendor-specific value to determine the distance between the access point and the receiver.

Variations in RSSI reading values cause unreliable distance estimates. To avoid this condition, it is necessary to filter the RSSI value to smooth the noise value from RSSI reading. Where by eliminating values that are too high and values that are too low, using a band pass filter approach, the approach used in this study is to remove 10% of the upper and lower noise values, then filter the data using the kalman filtering method [2]. Kalman filter is used to estimate the location of the coordinates using repeated feedback control [5]. The Kalman filter equation is divided into two stages, namely time update and measurement update. By comparing this value, the x and y coordinates of each location can be known. As shown in the graph below.

Sample	Menit	Meter
1	1	120
2	2	180
3	7	600
4	9	700

75,531
41,229

1	100
2	200
3	300
5	400
6	500
7	600
9	700
10	800
11	900
13	1000
14	1100
15	1200
17	1300
18	1400
19	1500
21	1600
22	1700

(a) (b)

Fig 6. Test results using linear regression analysis

a. Calculation of time and distance using linear regression

b. Calculation of time and distance based on the goggle map application

Based on the data obtained according to Figure 4 (a), it appears that the scale of the terminal area in the AutoCAD drawing is 1:1100, and if measuring the step speed of a passenger using flight services, it will be different for each person so that the comparison used is the ranking of distance and time information. displayed through the goggle map application by selecting the pedestrian icon, so that the normal standard of movement of flight service users is found which can be included in the regression calculation where the travel time is adjusted to an area scale of 1:1100 autocad drawings.

4.2 Low Energy Bluetooth

Bluetooth is a wireless communication technology used to exchange data using radio waves with a frequency of 2.4 GHz. This technology can enable connectivity between different devices, such as headsets with smartphones, cars, or computers. Bluetooth can work by utilizing small chips and software and also has a system architecture, namely Controller, Host, and Application. Multiple BLE beacons must be used in the environment. The person being tracked is equipped with a smartphone that periodically scans the signal messages from the beacons and identifies each beacon by its signal beam. Scan Time is also a parameter that must be optimized. Since sending and receiving messages is the dominant factor in power consumption, Scan Time should be set as short as possible [14].

4.3 Trilaterasi

Trilatera [2] is a method for estimating the position of a mobile phone user by calculating the distance between the user and the signal transmitter and the coordinates of the transmitter's position. The triangulation method forms a circle centered on the signal source where the radius of each circle of the signal source is determined by the signal strength received by the device [6] or object in this case RSSI. The strength of the signal captured by the object is affected by various obstacles so that in practice it is almost impossible to get a single point of intersection. The concept of trilateration is shown in the figure below.

Fig 7. The concept of trilateration

In the figure, the user's position can be calculated by the general circle equation shown in (1), (2), and (3). In this equation, the variables and are the coordinates of the user's position to be searched, 1, 2, 3 are the coordinates of each Bluetooth transmitter, 1, 2, 3 are the coordinates of the

Bluetooth transmitter and 1, 2, 3 are the distance between the Bluetooth transmitter and the user.

4.4 SVG Floor PlansVG

Floorpan SVG is a floor plan in SVG (Scalable Vector Graphics) format. It is based on the XML language and file format, which makes it possible to encode two-dimensional graphics. Files can be designed using CSS or JavaScript applications. The appearance of the 2-dimensional airport terminal floorpan design can be seen as shown in the following figure.

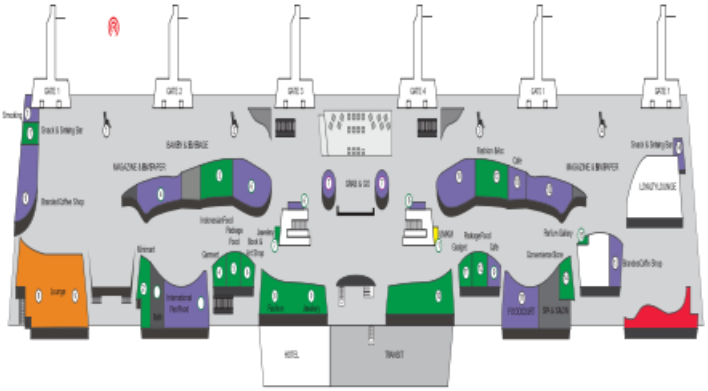


Fig. 8. Departure Terminal floorplan Makassar Sultan Hasanuddin Airport

The floorpan design of the Makassar Sultan Hasanuddin airport terminal is designed according to the real conditions in the field while still referring to the autocad drawings of the 1st and 2nd floor airport terminals. The purpose of making the floorpan design is intended as a basis for determining the coordinates of the beacon signal beam which is amplified by the BLE device. This floorpan is designed with 2 dimensions by first installing the sticky mobile and mapplic applications, while taking into account the designed terminal area.

4.5 Message Queue Telemetry Delivery

MQTT (Message Queuing Telemetry Transport), a protocol is a protocol that runs on top of the TCP/IP stack and is specifically designed for machine-to-machine applications that do not have a specific address. The MQTT work system implements Publish and Subscribe data. And in its implementation, the device will connect to the broker and have a specific topic. The broker at MQTT functions to handle publish and subscribe data from various devices, which can be likened to a server that has a special IP address. Some examples of existing Brokers such as Mosquitto, HiveMQ and Mosca.

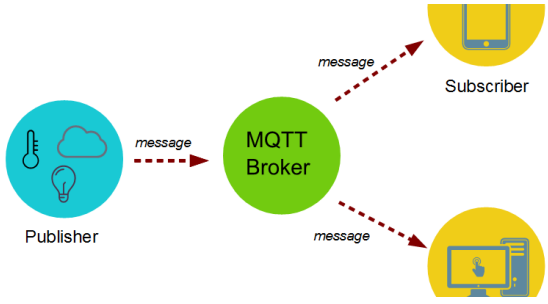


Fig 9. MQTT protocol for IoT

The picture above shows that the emitted signal emitted by the publisher which in this design is in the form of a beacon beam that is amplified by BLE is sent to MQTT and transmitted to the subscriber (smartphone user of aviation services). because the beacon equipment is installed at several points according to the area of the terminal, the beacon signal beam by applying the concept of trilateration can provide information on the coordinates of several points that are emitted and received by smartphone devices.

4.6 System Architecture

System architecture image display, the whole system consists of five roles: Smartphone, Beacon, Mesh Router, Gateway, Webserver, MQTT Broker. The five roles are described as follows; (a) Smartphone: in the form of a floorplane application that will capture information signals from the becon and receive messages from MQTT Broker; (b) Beacon: a beacon device that can send, receive and send messages on the network bluetooth beacon. In

particular, it not only transmits beacon messages, but also receives messages transmitted from mobile devices, and relays those messages to the Server; (c) Mesh Router: a network router that receives beacon emitted data via smartphones, is also responsible for collecting RSSI and Mac Address information from smartphones; (d) Gateway: serves as a liaison between the local network at the airport departure terminal to the internet network to handle data transmission between beacons, and mobile applications on smartphone devices for flight service users.

In detail can be seen in the following image

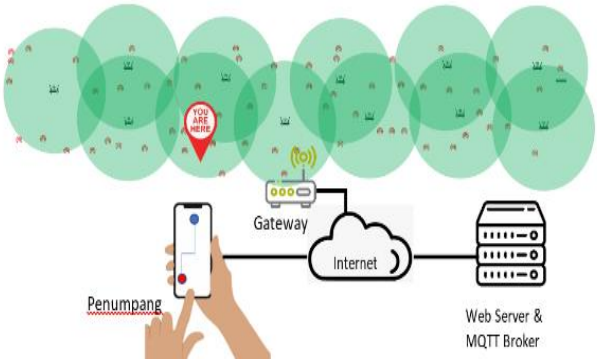


Fig 10. System Architecture

5. Conclusion

In this research, we advocate for a Bluetooth Low Energy (BLE) and Message Queuing Telemetry Transport (MQTT)-based Indoor Positioning System (IPS). The location of a mobile device can be estimated using a 2-part linearization algorithm and the RSSI method in conjunction with the trilateration methodology. Using a microcontroller, a number of experiments were performed to examine distance precision and trilateration throughput. Delays in user-mobile device communication were also investigated using MQTT. According to the study's findings, the developed system provides an approximation of location that may be shown in real time and tracked using a mobile device.

Thank-You Note

This research was supported by obtaining a Doctor's Dissertation Research Fund from the Ministry of Research and Technology, Makassar State University, in particular the Vocational Engineering Education Study Program, Makassar Aviation Polytechnic and PT. (Persero) Angkasa Pura I, Makassar Sultan Hasanuddin Airport.

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