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Implementation of Internet of Things (IoT) in Tracking the Position of Search and Rescue Teams in Sukoharjo District Using LoRa

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Abstract

This research was motivated by communication problems and tracking the position of the SAR search team in Sukoharjo Regency, which was caused by limited connections and signals in remote areas. This limitation makes it difficult for the SAR command center to visually monitor the team's location on digital maps, thereby hampering the efficiency of search and rescue operations. The aim of this research is to implement Internet of Things (IoT) technology using LoRa to overcome these problems and increase the efficiency of search and rescue operations. The research method used is the prototyping paradigm, which involves developing and testing a prototype of an IoT-based tracking system. This prototype is designed to provide real-time location information for search teams, which can be accessed by the SAR command center even in areas with limited signal. The research results showed that the system developed was successful in providing real-time location information for the search team, which could be accessed by the SAR command center even though it was in an area with limited signal. In conclusion, this research succeeded in achieving its goal, namely improving the tracking and communication capabilities of SAR search teams in remote areas through the use of IoT and LoRa technology, so that it is hoped that it can increase the efficiency and effectiveness of search and rescue operations in the future.

Kata kunci: SAR; LoRa; IoT; Prototype; Position

1. Introduction

The SAR (Search and Rescue) team is a specialized unit that plays an important role in carrying out rescue operations and helping victims of emergencies in various situations, [1] ranging from natural disasters to accidents. Sukoharjo Regency, as one of the regions in Indonesia, has a need for an effective and responsive SAR Team [2]. The diverse geographical conditions of Sukoharjo Regency, covering lowlands to mountains, as well as the potential for natural disasters such as floods, landslides, and transportation accidents, emphasize the vital role of the SAR Team in this region. Responsiveness and alertness in handling various emergencies is crucial to ensure public safety.[3]

The Sukoharjo District SAR Team is dynamic and consists of well-trained individuals with multi-disciplinary skills, ranging from navigation, medical aid, to rescue techniques [4]. They are ready to work in dangerous conditions, requiring a quick response, as well as effective coordination with various related parties to ensure the success of search and rescue operations. Through good coordination efforts, readiness that is continuously maintained through routine exercises and simulations, as well as the utilization of modern technology, the Sukoharjo District SAR Team is determined to provide the best service in saving lives and handling various emergency situations that may occur in the region.

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The Sukoharjo District SAR Team faces serious challenges in tracking the position of search teams operating in remote areas [5]. Limited communication signals in areas such as mountains, forests, and areas without communication services are the main problems faced by the team [6]. This difficulty can hamper the effectiveness of search and rescue operations carried out by the Sukoharjo District SAR Team. In dealing with this condition, the SAR Team must find innovative and efficient solutions to ensure that position information and communication continue to run smoothly even in areas that are difficult to reach and lack communication signals. Collaborative efforts between team members, utilization of appropriate technology, and adaptation strategies are the key to solving these problems for the smooth running of rescue operations in Sukoharjo Regency [7].

This research focuses on creating a location tracking system for the Sukoharjo SAR search team. The location tracking in question is the location of the search team in real time. This tracking system will be assisted by tools in the form of GPS (Global Positioning System) and Mobile App (Flutter) based mobile device applications [8]. The transmitter will send coordinate point data to the receiver. The received data will be stored on the server (firebase) and will be accessed through the Mobile App [9].

2. Research Method

This research uses qualitative and quantitative methods. In the qualitative method, it starts from the stage of finding existing problems. While in the quantitative method, the stage begins by processing the data that has been obtained previously. The research flowchart is shown in Figure 1.

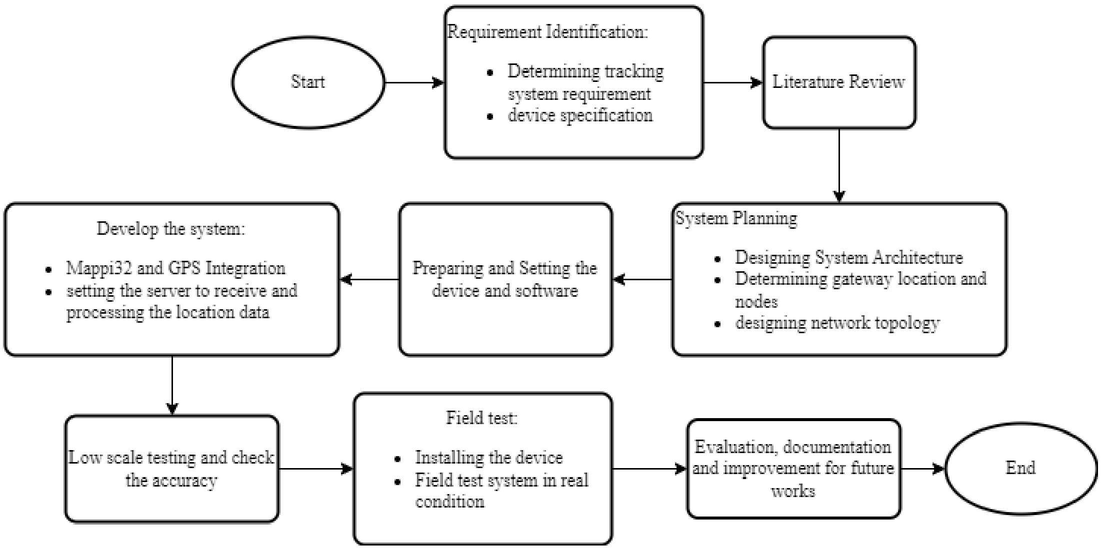

Figure 1. *Research Flow*

While the design and development of the system refers to the prototype paradigm [10] shown in Figure 2. Prototypes are needed to produce outputs that meet user needs in a relatively short time. from the results of research outputs will always be communicated and evaluated by users directly. the output produced is the data coordinate point location of the search team in the field.

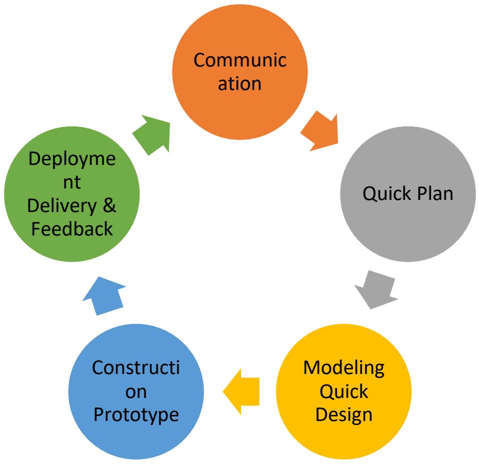

Figure 2. *Prototype Paradigm*

***Communication* (Determining requirement):**
This stage involves communication between the system development team and stakeholders to clearly understand the needs of the system to be developed. This includes identifying the desired goals, functions, and features of the system, as well as understanding the constraints and limitations that may exist.

***Quick Plan* (System Design):**
At this stage, initial planning is done on how the system will be designed and developed. This includes identifying the technologies and methods to be used, resource allocation, and general project scheduling.

The technology scheme built is related to the use of hardware devices and software. This research requires several devices connected to the internet network and each data access request will be served by the server.

a. First device is smartphone Android with minimal specification Android 7.0 Nougat, CPU Quad-core, RAM 2.0, GPS, dan Database Firebase.
b. Second device is transmitter from Mappi32 dan GPS.
c. Third Device is receiver Mappi32.
d. Fourth device is Firebase for database system to store the data

This tracking system is designed and implemented from several layer components that form a relationship between parts of the system in running the application on a system framework [11]. The layer components in this tracking system consist of a list view of input coordinate points from satellites continuously by the search team and send data to the receiver, database synchronization, view real-time search team position reports based on digital maps. The tracking system framework is illustrated in Figure 3.

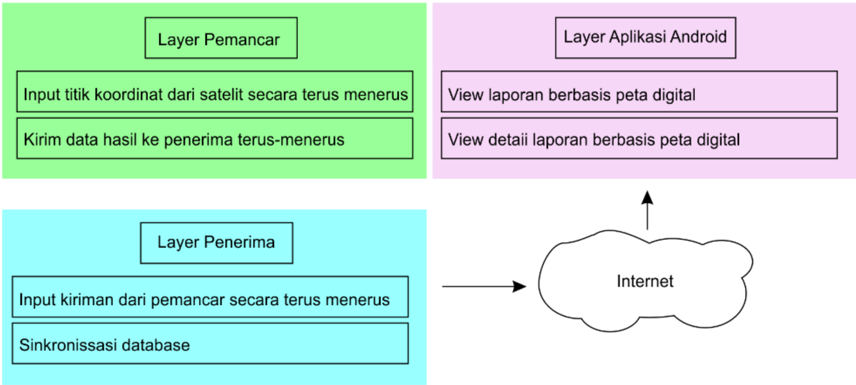

Figure 3. *System Frameworks*

Modeling Quick Design:
This stage involves creating an initial model or design of the system to be developed. This model helps in visualizing the structure of the system and understanding how the components will interact with each other.

Construction Prototype:
At this stage, a prototype or early version of the system is built based on the previously created design. This prototype is usually an incomplete or imperfect version, but is used for initial testing and evaluation.

Deployment, Delivery, and Feedback:
This stage involves implementing the developed system into a production or operational environment. In addition, the system is also delivered to end users. After implementation, the use of the system is evaluated to obtain feedback from users, which can be used for improvement and further development of the system.

3. Result

Communication
In the Communication stage (Determining requirement) this research will produce a document that records all the needs of the LoRa-based position tracking system for the SAR search team in Sukoharjo Regency in detail. The document will include:

a. System Functional: Describe in detail the desired functions of the position tracking system, such as the ability to track the team's position in real-time, automatic transmission of location data to the server, and an easy-to-use user interface.
b. Performance of System: Specifications about the expected performance of the system, such as accuracy in position tracking, speed of data transmission, and tolerance to disturbances or unexpected environmental conditions.
c. Technical Requirement: Technical requirements that the system must fulfill include the availability of LoRa technology, compatibility with mobile devices, and data security.
d. Limitation: Describe the limitations that may exist in the development of the system, such as the limited range and signal strength of LoRa, as well as the ability of the system to operate in different environmental conditions.

This document will be the primary guide for the development team throughout the design, construction and implementation process of the position tracking system. By ensuring that all needs and requirements are clearly understood from the outset, it is hoped that the developed system can match expectations and provide significant benefits to SAR operations in Sukoharjo District.

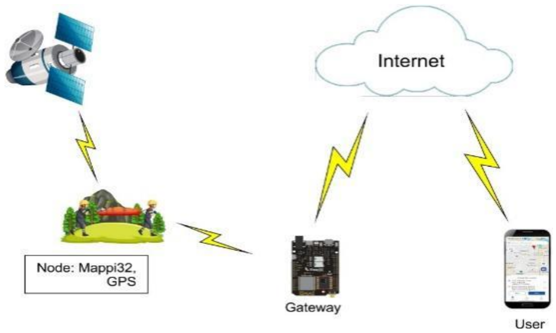

Figure 4. *Overview of the System*

The system flow is organized according to the illustration in Figure 4, which describes the working steps of the developed tool. The system uses the main components, namely the Mappi32 on the transmitter and receiver. First of all, the transmitter sends a request for the location data of the search team to the satellite via a GPS signal. The information processed by the transmitter includes date, time, latitude, and longitude. After getting the data, the transmitter will send it through LoRa technology to the receiver. At the receiver, the received data will be forwarded to the server via an internet connection. Furthermore, users can view the position or location of the search team through the available mobile application. Thus, the system allows real-time monitoring of the search team's movements during SAR operations. The implementation of this technology allows the coordinator at the operations center to supervise and coordinate search efforts more effectively, as well as provide faster assistance to teams that need it. By utilizing internet connection and LoRa technology, the system can provide accurate and fast information in emergency situations in remote areas that may have limited communication infrastructure. In addition, the ability to track the position of the search team in real-time also increases efficiency in the use of resources and speeds up the rescue process. Thus, the implementation of this system is expected to improve the performance and outcome of search and rescue operations in the field.

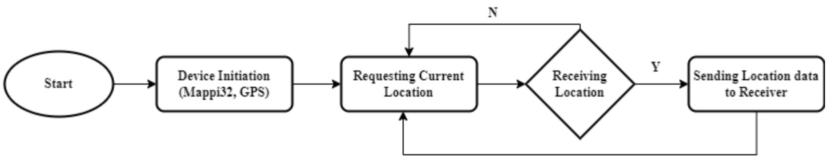

Figure 5. *Flowchart Node*

The sequence of the above process begins with turning on the device, then the Ublox 6M GPS module will request coordinate point data from the satellite via a GPS signal, the data is successfully received or not. If the data is not successfully received, the GPS module will repeat the process of requesting coordinate point data from the satellite until it successfully obtains the data. If the data has been successfully received, it will be forwarded to the stage of sending coordinate point data to the Gateway circuit or receiver. This procedure will be carried out continuously as long as the device is on.

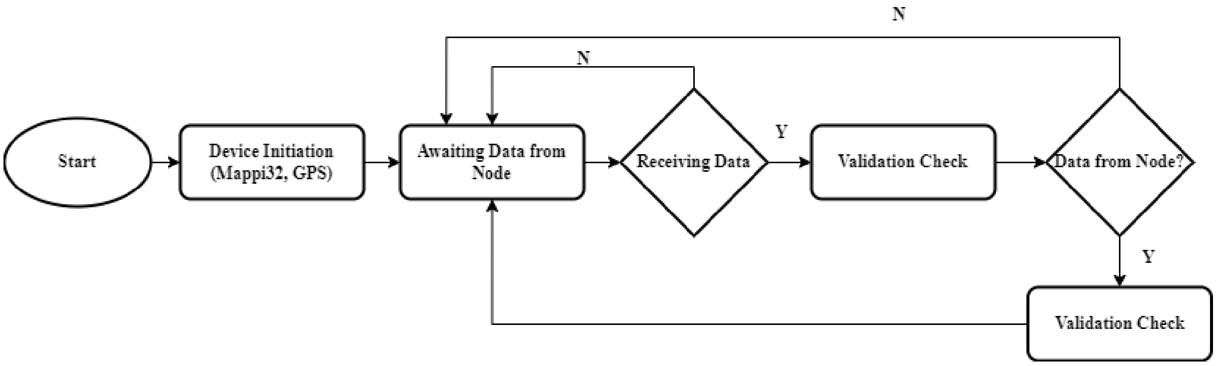

Figure 6. *Flowchart Gateway*

The procedure that runs in the Gateway circuit is, after the device is turned on, this circuit will wait for the delivery of coordinate point data from the Node circuit, if the data has not been received, the circuit will repeat the procedure of waiting for data delivery from the Node. If the data has been received, it will go through the check and validation stage whether the data sent is the coordinate point of the Node circuit or not. If the data is not from the Node submission, the circuit will repeat the procedure of waiting for data submission from the Node. If the data received is correct, the data will then be saved to the server (firebase) via the internet.

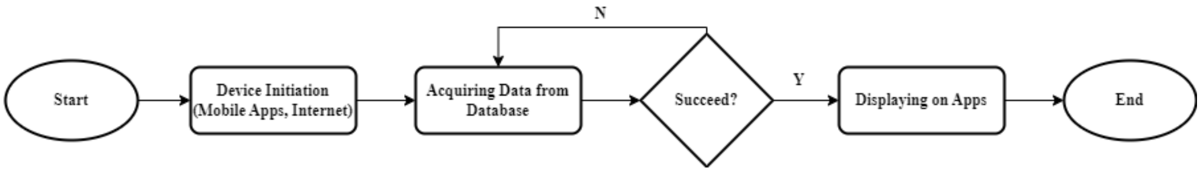

Figure 7. *Flowchart User*

For the user part, the sequence of procedures that run starts from the device being turned on, then connecting to the internet connection, entering the mobile app, waiting for the data to be successfully downloaded or not. If the mobile app has not gotten data from the database, the device will repeat this procedure until it gets data from the database. After the device has successfully obtained the data, it will then be displayed on the digital map display on the mobile app.

4. Discussion

Hardware design consists of two parts, namely the Node (transmitter) and Gateway (receiver). The components in the Node consist of Mappi32, Ublock 6M GPS and 18650 batteries. For the Node design can be seen in Figure 8.

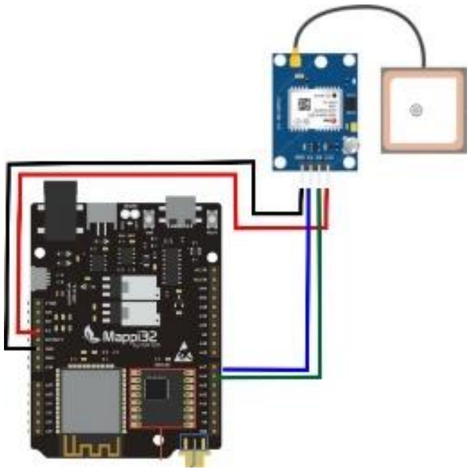

Figure 8. *Node Circuit (Mappi32 and GPS)*

The flow of data processing in the Node circuit above is that the Ublox 6M GPS module receives data in the form of coordinate points from the satellite continuously, after which the data is processed by the Mappi32 Node module and then the data output is sent to the Gateway with LoRa integrated in the Mappi32 module. For components on the Gateway, only the Mappi32 module. For the Gateway design can be seen in Figure 9.

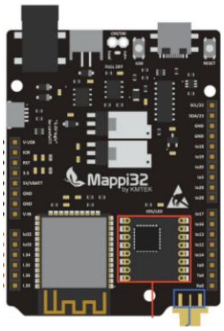

Figure 9. *Gateway Circuit (Mappi32)*

In the Gateway circuit above, the data processing flow starts from receiving continuous submissions in the form of data on the coordinate points of the Node circuit, then the data is processed in the Mappi32 Gateway and will be uploaded and stored to the Server (Firebase) in real time. To display the position tracking results using the Mobbile app application, the following application to display the location can be seen in Figure 10.

Figure 10. *Mobile App*

Data that has been stored in the database will be downloaded through the mobile app and displayed on a digital map on a mobile device. In the mobile app there is an area to display a map image of the tracking results, then the Show Location button to display on a digital map, the Send button to share coordinate point data via social media.

In this test, the Node successfully obtained the current location coordinates. Figure 11 shows the results of the current location received by the Node and then sent to the Gateway.

Figure 11. *Data Sent from Node*

Figure 12 shows the results of the data successfully sent by the Node at the Gateway.

Figure 12. *Data Sent from Node*

The results of tracking the position on the digital map are shown in Figure 13. Nodes move to provide different coordinate values at the location. Numbers 1 - 5 on the map show the location changes made in the field.

Figure 13. *The result of position tracking in maps*

Ublock 6M GPS when indoors successfully getting data from satellites takes 1200 seconds (20 minutes). Meanwhile, when outside the room takes 480 seconds (8 minutes).

Table 1. *The time span of getting a GPS signal*

Modul	Indoor	Outdoor
GPS Ublock 6M	20 minutes	8 minutes

Based on table 1, it can be assumed that location can affect the length of time to get GPS signals from satellites.

5. Conclusions

This research has successfully implemented an Internet of Things (IoT) system for tracking the position of SAR search teams in Sukoharjo Regency using LoRa technology. Through a series of experiments and tests, this system proved effective in providing real-time location information, which can be accessed by the SAR command center. The results show that the main objective of this research, which is to improve the efficiency and effectiveness of search and rescue operations through the use of IoT technology, has been achieved. The system not only improves the coordination of teams in the field, but also speeds up the response to emergency situations. This successful implementation proves the great potential of LoRa technology in position tracking applications in areas with wide coverage and limited communication infrastructure. Hopefully, this research can serve as a foundation for further development and application of similar technology in other areas.

Based on the results of the research and implementation of the IoT system for tracking the position of the SAR search team in Sukoharjo Regency, there are several suggestions that can be proposed for further development. First, it is important to pay attention to the durability aspect of the device used in the field. It is recommended that the tracking device be produced with waterproof, shockproof, and dustproof packaging to ensure the durability of the device against extreme environmental conditions, such as rain, impact, and dust. This will increase the reliability of the device during search and rescue operations that often take place in rugged terrain. In addition, further research could focus on improving the range and accuracy of the LoRa system as well as integration with other communication technologies to ensure data continuity and tracking effectiveness. These efforts will further maximize the benefits of IoT technology in supporting rescue and security missions in various regions.

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