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Design of Fuel Monitoring Application for Reservoir Tanks in Army Fuel Supply Point on Military Logistics Corps Based on Internet of Things

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ABSTRACT

The Bekang Corps, a vital component of the Army responsible for logistics and transportation, is crucial in maintaining the military's operational readiness and mobility. In the intricate landscape of military operations, the seamless integration of strategy, logistics, and tactics becomes imperative for success. Integrated logistical support, encompassing maintenance, supply, personnel, education, training, and base facility support, is the backbone of effective military operations. However, the manual monitoring of underground fuel tanks at Storage and Supply Points (SPBT) presents challenges regarding potential errors, time consumption, and significant efforts. **This research aimed** to address these issues by focusing on leveraging Internet of Things (IoT) technology to design and implement a monitoring application specifically tailored for the SPBT environment within the Army's Bekang Unit. This research method aimed to provide a real-time solution for efficiently monitoring and managing fuel levels. **This research established** a foundation in IoT by integrating the Float Level Switch sensor and NodeMCU ESP 8266 microcontroller. The Android application, developed using Android Studio, serves as the user interface, while Firebase functions as the real-time database, facilitating seamless communication and data exchange. **The results of this research** were the successful implementation of this IoT-based solution, which enhanced the accuracy and responsiveness of fuel level monitoring and contributed significantly to military operational efficiency. The anticipated **significant contribution** of the application includes the enhancement of military operational efficiency, the reduction of human error risks, and an increased sense of responsibility regarding fuel availability for operational needs.

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1. INTRODUCTION

The Bekang Corps is one of the sections of the Army that manages logistics and transportation, supplies food, equipment, and fuel, and provides transportation for Army personnel. They ensure that all logistical needs are met to maintain the mobility and readiness of the military, particularly in urgent situations, and must be executed quickly and precisely. Strategy, logistics, and tactics are inseparable in conducting an operation. The success of an operation is greatly influenced by integrated logistical support at a base. Integrated logistical support can be categorized into five aspects: maintenance support, supply support, personnel support, education and training, and base facility support [1]. Therefore, Bekang plays a crucial role in coordinating logistics management for the success of Army operations. This is outlined in the Regulation of the Chief of Staff of the Army Number Perkasad/74/XII/2013, dated December 31, 2013, regarding the Main Guidance Book on Logistics. This regulates logistics management, including crucial fuel (BBM) for military operations. According to Fatima et al. [2], logistics planning occurs at several levels. The first is the national strategic level, where senior leaders determine strategies, focus, and programs to be pursued in logistics management. Second, capability planning aims to identify the logistical needs required by the military to support national strategy. Third, programming involves allocating planned resources to programs over time to create future strength with the expected capabilities to support operations. Finally, logistics is the process of monitoring the implementation of logistics plans and programs that have been formulated while supporting the flow during the ongoing process.

Fuel (BBM) is one of the logistics managed by the Army. Usually, fuel will be stored in underground tanks at SPBT in large quantities. The reliability and security of these tanks are crucial because fuel filling or distribution disruptions can impede military operations that depend on them. Therefore, monitoring and managing the fuel level become highly important. Currently, fuel level monitoring in SPBT underground tanks is done manually by SPBT personnel. They use specialized measuring tools inserted into the fuel tank and check the fuel level by observing how deep the measuring tool sinks. Manual fuel level measurement is still considered impractical, as it involves locating the submerged limit of the measuring tool in the fuel, and it also allows for potential reading errors on the meter scale [3]. The risk of human error can lead to data inaccuracy. The manual approach also requires significant time and effort, especially for large-capacity fuel tanks or periodic monitoring. In this context, IoT technology promises an innovative and reliable solution. IoT involves equipping objects with technologies such as sensors and software to communicate, interact, and exchange information with other devices through internet connections. The goal is to enable these objects to be connected and centrally controlled [4].

The research [5] focuses on the design of IoT in the water flow monitoring system using MIT App Inventor and WhatsApp. The research results revealed that network quality testing for data transmission to Firebase and WhatsApp was conducted during peak hours. Transmission to Firebase achieved a throughput of 15,635 Kbps with 0% packet loss, a delay of 87.76367 ms (excellent category), and a jitter of 73.82095 ms (good category). On the other hand, transmission to WhatsApp had a throughput of 3,9293 Kbps with 0% packet loss, a delay of 245.3492 ms (good category), and jitter of 236.6453 ms (information priority resulting in poor jitter). Both tests indicated poor network quality during peak hours, but the transmission performance to Firebase was better than WhatsApp regarding throughput, delay, and jitter. The subsequent research [5] on monitoring fuel level gauges in gas station tanks based on IoT. In this study, the data obtained from the HC-SR04 ultrasound sensor was not yet displayed in the Blynk application. As a result, there was no visual representation showing real-time measured information to users through the Blynk application.

The uniqueness of this research lies in several factors:

(1). Utilization of IoT Technology: This study leverages Internet of Things (IoT) technology to monitor the fuel levels in underground tanks within the Army's SPBT environment. The use of this technology demonstrates an effort to harness the latest innovations in improving military logistics management processes.

(2). Integration of Firebase as a Real-Time Database: Using Firebase as a real-time database allows direct data collection from sensors and its display through the Android application. This creates a responsive system capable of providing immediate information to users.

(3). Development of Android Application: This research develops an Android application using Android Studio, providing a user-friendly interface for SPBT operators to monitor fuel levels, access fuel in/out history, and adjust other settings.

(4). Focus on Military Operational Efficiency: The study specifically focuses on military operational efficiency, particularly in fuel management and monitoring. This underscores a commitment to enhancing military readiness and mobility through cutting-edge technological solutions.

Research aims to design a monitoring application based on IoT technology, enabling users to effectively monitor and manage various parameters and devices within a system. By leveraging connected sensors, the goal is to provide a comprehensive monitoring solution that enhances system control and efficiency [6, 7]. **This research aims** to address these issues by leveraging Internet of Things (IoT) technology to design and implement a monitoring application specifically tailored for the SPBT environment within the Army's Bekang Unit. By integrating critical military needs with technological advancements, **this research aims to significantly**

contribute to operational efficiency, precise management, and the availability of measured and reliable fuel in the context of the Army's Bekang Unit's SPBT. By leveraging integrated IoT technology, it is anticipated that information regarding fuel availability can be obtained in real time. This enables faster and more accurate decision-making in fuel management within the military environment.

2. RESEARCH METHOD

In this study, a Float Level Switch is employed, which operates continuously by utilizing a magnetic float that moves up and down with changes in the liquid level. The movement of the float generates a magnetic field that activates a switch to open or close [8]. The use of NodeMCU as an IoT platform and an open-source development kit that leverages the Lua programming language to support the creation of IoT product prototypes or even sketches using the Arduino IDE. This device integrates a processor, memory, GPIO (General Purpose Input/Output), PWM (Pulse Width Modulation), IIC (Inter-Integrated Circuit), 1-Wire, WiFi module, and ADC (Analog to Digital Converter) [9]. Android Studio is used for application development. As an Integrated Development Environment (IDE) for Android applications, this IDE aids developers in the processes of writing, testing, and publishing applications. On May 16, 2013, Google released Android Studio under the Apache 2.0 license, and the application is available for free. Android Studio replaced Eclipse, a previous Android application development IDE. Android Studio supports developers in creating attractive and useful Android applications by providing the necessary tools [10] Meanwhile, its database uses Firebase, a service provider for IoT that allows users to upload data to the server and store it in the database provided by Firebase. The stored data can be accessed and displayed through an Android application connected to Firebase. This Android application can be created using Android Studio or Kodular, and the stored data can be read in real time through the application [11].

To support the development and smooth operation of the application, software, hardware, and human resources are crucial. The analysis of the required system components is as follows:

1. Software
   a. Android Studio
   b. Java Development Kit (JDK)
   c. Android Software Development Kit (SDK)
2. Hardware
   a. Monitoring devices installed on the tanks connected to the internet according to technical standards 802.11 b/g/n.
   b. To run the application smoothly, a stable internet connection is required.
   c. This application can be operated on Android devices with Lollipop or newer operating systems.
   d. The Android phone used must have a minimum of 3 GB RAM.
   e. The selected Android phone for this application must have at least 1 GB of available internal storage.

2.1. Usecase Diagram

The Use Case Diagram is a graphical representation that illustrates the functions of the system to be developed, providing an overall view of the desired system objectives [12]. In the use case diagram, each use case depicts the interaction between users and the system itself. Its purpose is to provide an overall understanding of how the system is expected to operate and how users will interact with it. Therefore, the use case diagram is useful for providing a visual understanding of the dynamics and expected functionality of the designed system. The design of the Use Case Diagram can be seen in Figure 1.

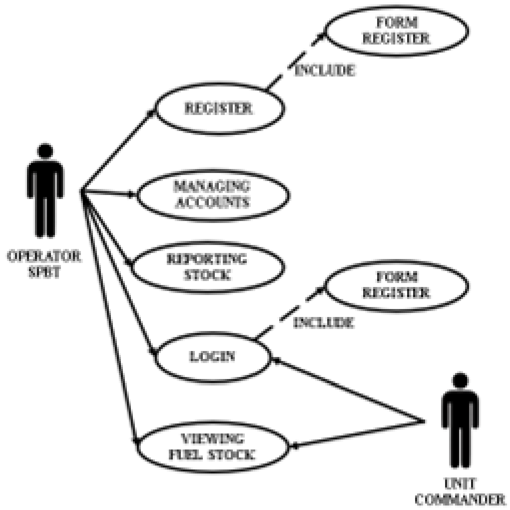

Figure 1. Usecase Diagram

Figure 1 above shows that the SPBT Operator acts as an actor who can perform actions according to their access rights, such as managing accounts, reporting stock, and monitoring fuel stock. Meanwhile, the unit commander can only view stock monitoring, enabling them to formulate specific policies beneficial for the Bekang unit.

2.2. System Block Diagram

The hardware used to create the fuel monitoring application for underground tanks in the Army's Bekang Unit SPBT involves the NodeMCU microcontroller, Float Level Switch, and Firebase as a real-time database. Additionally, Android Studio is used to develop the application that will be presented to users. In Figure 2, all interconnected components are explained.

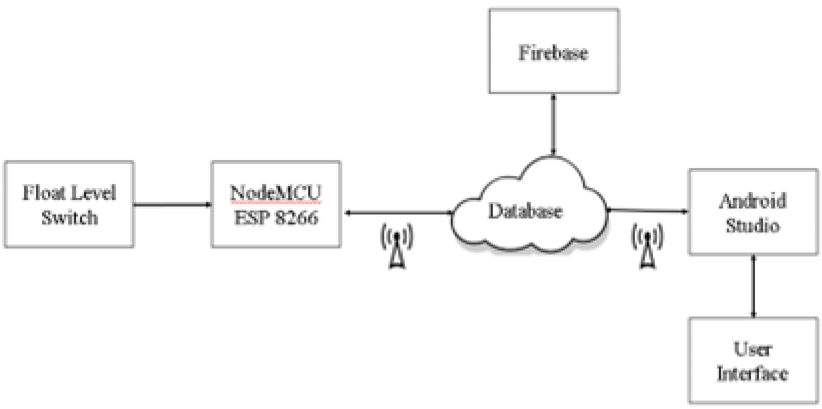

Figure 2. System Block Diagram

2.3. System Flowchart

The Float Level Switch installed in the underground fuel tank is connected to the NodeMCU ESP8266 and will transmit its measurements to the designed application. Figure 3 depicts the overall system flowchart.

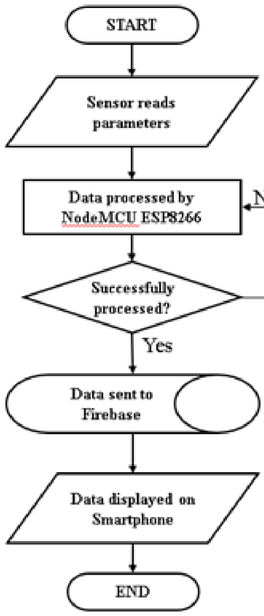

Figure 3. System Flowchart

2.4. System Implementation Method

System implementation explains the application of the designed system (See Figure 4). The goal is to determine whether the created tool conforms to the design or if there are any inconsistencies.

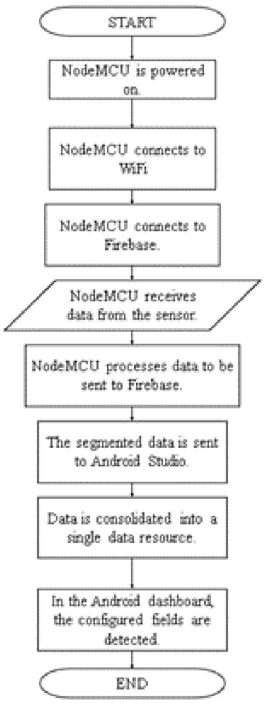

Figure 4. System Implementation Method

2.5. System Application Design

1. Android Application Design

Figure 5 displays the design of the Android application that has been created. It starts with the login page. If you don't have an account, you can register first. However, if you already have an account, you can directly choose the underground tank from which unit you want to view.

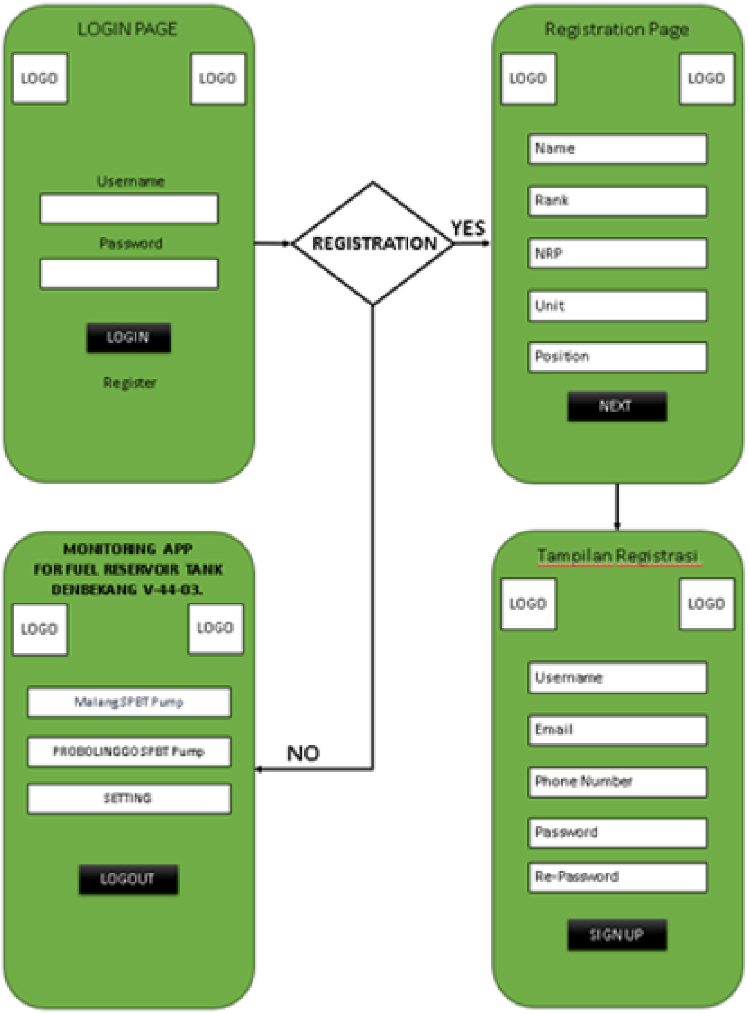

Figure 5. Android Application Design

2. Application Flowchart

The flowchart for the Android application is illustrated in Figure 6. When the application is opened, it will automatically display an initial loading screen to establish a connection to the internet. Once connected, the Login Screen will appear. If the user already has an account, they can enter their username and password. However, if they don't have an account, they can press the "Register" button and will be directed to the account registration page, where they fill in the required fields. After registering an account, they will be redirected back to the login page to enter their registered username and password. Next, they will be directed to the main page, where three options are presented: SPBT A (Malang), SPBT B (PROBOLINGGO), and settings. If they choose one of the SPBT options, the data for that specific SPBT will be displayed. However, if they choose "Settings," they will be directed to the application's settings page.

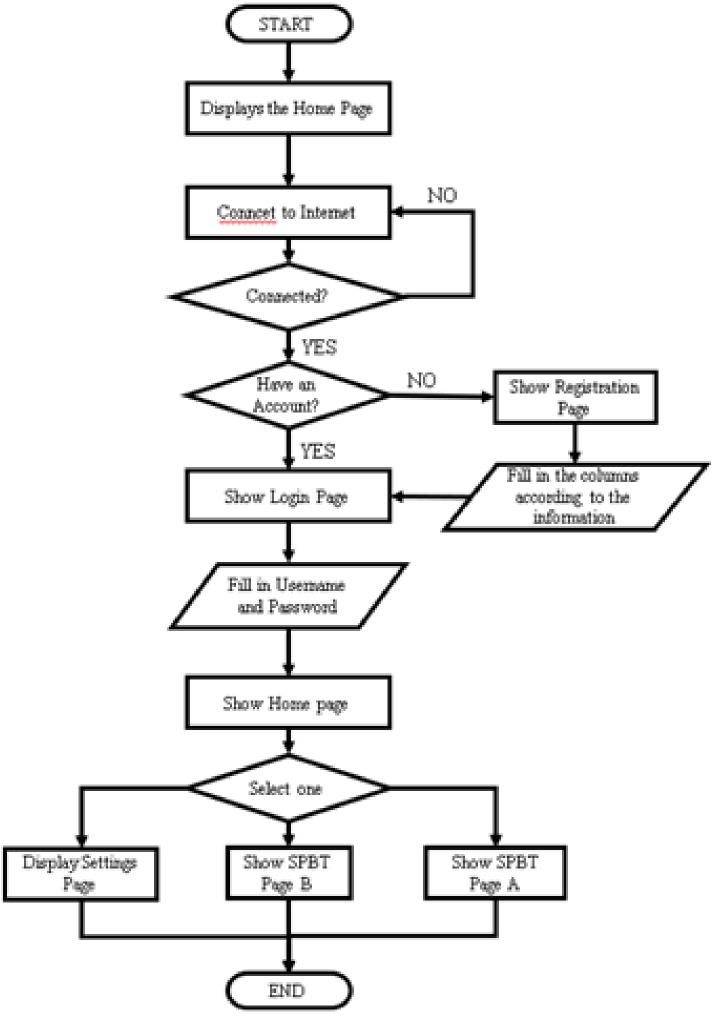

Figure 6. Application Flowchart

3. RESULT AND ANALYSIS

This research's findings are the successful design of an Android application to monitor the fuel level in storage tanks in the TNI Army logistics unit (SPBT Satuan Bekang TNI AD) based on the Internet of Things (IoT). Utilizing a Float Level Switch sensor connected to NodeMCU ESP 8266, the fuel level measurement data is sent in real-time to the Firebase Database, and the Android Studio application is used to display this information to users.

In military logistics management, the availability and management of fuel play a crucial role in the Army's operations. The current manual supervision method conducted by SPBT personnel carries the risk of human errors and requires significant time and effort, especially for large-capacity fuel tanks. This research can serve as a foundation for further developments, such as integration with a broader logistics management system or adding features like predicting fuel consumption based on historical data. Therefore, the application can continue to evolve and provide added value in supporting the efficiency of military logistics management.

3.1. Login Page

The login page is the interface that will be used by SPBT Operators or supervisors with different access rights. This can be seen in Figure 7.

Figure 7. Login Page

3.2. Registration Page

On the registration page, as shown in Figures 8 and 9, users can register an account for the monitoring application. In this process, each registered account will be able to monitor directly.

Figure 8. Registration Page

Figure 9. Next Registration Page

3.3. Main Page Display

The Main Page will display the main menu, which includes several registered units and the settings option. This can be seen in Figure 10.

Figure 10. Main Page Display

3.4. SPBT Page

This display will display data taken by the sensor and processed by the NodeMCU, displayed on this page as in Figure 11.

Figure 11. SPBT Page

3.5. Setting Page

On the settings page, SPBT operators can view the history of fuel inflow and outflow from the registered tanks and configure the connected IP settings, which can be seen in Figure 12.

Figure 12. Setting Page

3.6. Tank Log Page

The Log menu in the Android program displays all activities related to all tanks. In this menu, users can only view the log without the ability to print it. Figure 13 is the Android program login page.

Figure 13. Tank Log Page

3.7. IP Setting Page

The IP Server menu is used to configure the IP address (see Figure 14). In this menu, users need to set the IP address so that the Android program can connect and perform monitoring.

Figure 14. IP Setting Page

The results of this research can make it easier for the Indonesian Army to monitor fuel tanks in the Logistics Unit remotely with the help of an IoT-based Android application, **as the research results align with researchers** [13, 14].

4. CONCLUSION

This research successfully designed and implemented an Internet of Things (IoT)-based monitoring application to monitor the fuel level in the storage tanks within the logistics unit of the Indonesian Army (SPBT Satuan Bekang TNI AD). Utilizing a Float Level Switch sensor connected to NodeMCU ESP 8266, the fuel level measurement data is sent in real-time to the Firebase Database, and the Android Studio application is used to display this information to users. In military logistics management, the availability and management of fuel play a crucial role in the Army's operations. The current manual supervision method conducted by SPBT personnel carries the risk of human errors and requires significant time and effort, especially for large-capacity fuel tanks.

This research can serve as a foundation for further developments, such as integration with a broader logistics management system or adding features like predicting fuel consumption based on historical data. Therefore, the application can continue to evolve and provide added value in supporting the efficiency of military logistics management. The application is expected to contribute significantly to operational efficiency in the military environment. With real-time information provided by the application, decision-making regarding fuel management can be done quickly and accurately, reducing the risk of human errors and enhancing responsibility in maintaining fuel availability for operational needs.

5. DECLARATIONS

AUTHOR CONTIBUTION

All authors contributed to the writing of this article.

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COMPETING INTEREST

The authors declare no conflict of interest in this article.

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