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Optimizing IoT-Based Real – Time Monitoring Systems for Personnel Conducting Jungle Patrols : A Case Study of Indonesian Army

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INDEXING

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ABSTRACT

This study aims to explore the application of an Internet of Things (IoT)-based monitoring system in jungle warfare, focusing on the Indonesian Army. Through a methodological approach that combines the development of an IoT-based communication system prototype, this study identifies the challenges faced in real-time communication in a jungle environment. Key findings suggest that the use of advanced sensors and communication protocols such as LoRa (Long Range) can provide real-time information needed for fast and accurate decision-making, while minimizing the risk of fatigue and accidents that can occur during patrols. These findings imply that adopting an IoT-based communication system can significantly improve the effectiveness of military operations by the Indonesian Army in challenging jungle environments. This study also provides recommendations for further development of military communication infrastructure with real-time data delivery.

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INTRODUCTION

The Indonesian Army plays an important role in maintaining the sovereignty and security of the nation, especially in the context of modern warfare, which is increasingly complex and dynamic (Manoppo *et al*, 2021). In military operations, the Indonesian Army faces various challenges, especially in difficult environments such as forest terrain. The dense vegetation and varied topography in forest settings create challenging conditions for military operations, requiring troops to adapt to unpredictable situations (Daud *et al*, 2018).

Jungle warfare presents unique obstacles that can hinder the effectiveness of operations (Lesmana *et al*, 2022). Jungle warfare is a form of military tactic often applied by the Indonesian Army (TNI AD) in dealing with various threats in Indonesia's vast and diverse forest areas (Gregorian, 2017) and also (Faesol *et al*, n.y). This tactic involves rapid movement, control of the terrain, and effective defensive strategies. In this context, monitoring the position and heart rate of personnel carrying out forest patrols is a crucial aspect that cannot be ignored (Sari and Hartini, 2021).

Forest patrols are often carried out in extreme conditions, where difficult terrain and the risk of threats from the enemy can cause significant physical and mental stress for

soldiers (Heryadi *et al*, 2020). Faced with existing communication systems, such as military radio has limitations in range and data collection (Taufik *et al*, 2021), and the use of GPS at this time is generally not accessible to higher units in real time (Faesol *et* al, n.y).. These limitations delay decision making and reduce coordination between units, endangering personnel safety and mission success (Sari and Hartini, 2021).

Therefore, monitoring of position and heart rate is not only intended to ensure the safety and effectiveness of operations, but also to maintain the health and safety of personnel in the field. The right monitoring technology can provide real-time information needed for fast and accurate decision making, and minimize the risk of fatigue and accidents that can occur during patrols.

In this article, the importance of integrating an efficient monitoring system in Indonesian Army jungle patrol operations will be discussed. This study aims to provide an overview of strategies that can be applied to improve the effectiveness and safety of patrols, as well as provide recommendations for the development of technology and procedures that support mission success in this challenging terrain. Thus, it is hoped that this journal can provide a positive contribution to the development of military tactics and strategies in Indonesia, as well as data collection as evaluation material.

LITERATURE REVIEW

The use of IoT-based technology can help carry out military tasks. One of them is the development of combat robots for remote operation tasks using PID (Raharjo *et al*, 2021). Data communication is carried out using a wifi network to send data from Raspberry Pi to the target monitoring tablet. This study produced a combat robot that can be controlled from a maximum distance of 60 meters. This kind of technology is very much needed in addition to helping operational tasks, it can also reduce personnel losses on the battlefield. However, there are shortcomings in using this system, namely the robot cannot be controlled if it is not connected to a wifi network.

In the military world, a system is needed that is able to send information in real time to facilitate monitoring of personnel locations. With the rapid development of technology, it can support the implementation of a real-time troop coordinate tracking system ((Faesol *et al*, n.y). In this study, technology based on Messege Queueing Telemetry Transport (MQTT) is used to create a real-time coordinate tracking system on Android. Data from GPS and Arduino sensor processing is sent using the internet network. The web server is used to display tracking results in the form of maps and user paths of the designed application. This system cannot be used if the user is not connected to the internet.

Development of IoT-based technology to improve communication efficiency in the aspect of tracking moving objects (Angriawan and Anugraha, 2019). The purpose of this study is to create a tracking system using LoRa to send data from Node to Gateway in areas that cannot be reached by cellular networks. Data is obtained from GPS sensors processed by Arduino and uses Lora (Transmitter) to be sent to the gateway. In the design on the gateway side there is LoRa (receiver), Arduino and SIM900 Mini components which are used to receive data from nodes and send them to the server. The test results of the system created show that this system is able to send data from nodes to gateways with a distance of 2.5 kilometers with RSSI -128, the number of lost packets is 19. Utilization of LoRa in forest areas can be implemented in monitoring forest fires (Azwar *et al*, 2023). The LoRa (Long Range) wireless communication module is able to send data from sensor nodes

placed in the forest to the server. This study uses smoke sensors, temperature sensors, GPS uBlox Neo 6M and Arduino microcontrollers as the brain of the data processing system. Data from the sensor can be viewed via the server computer and the test results of this system work well.

RESEARCH METHOD

Research Goals

This study aims to analyze and develop an Internet of Things (IoT)-based communication system tailored to the needs of the Indonesian Army in jungle operations. The objectives include identifying challenges in forest communication, such as signal interference and limited range, evaluating current data transmission limitations and their impact on military effectiveness, developing a reliable IoT communication system that utilizes sensors and protocols, providing recommendations for the development of a monitoring system for the location and physical condition of Indonesian Army personnel carrying out jungle patrols.

Research Questions

The following research questions are answered in this study:

1. What are the main challenges faced by the Indonesian Army in communication when operating in dense jungle environments?
2. How the limitations of existing communication systems can affect the effectiveness of Indonesian Army operations in challenging environments such as jungle?
3. How important is monitoring the location and condition of personnel in real time to support fast and accurate decision making during patrols in the jungle?
4. Can Internet of Things (IoT) technology provide a better solution to the monitoring problems that exist in jungle warfare?

Method

This study uses qualitative and quantitative research approaches to evaluate and optimize an IoT-based communication system to facilitate monitoring of Indonesian Army personnel in areas with no internet connection. The qualitative approach will be used to understand the challenges faced in the field, while the quantitative approach will involve the application and analysis of data collected from the prototype IoT devices implemented.

A. Protocol to be used

The communication protocols used in this system include LoRa (Long Range) and MQTT (Message Queuing Telemetry Transport). LoRa is used for long-range communication with low power consumption, while MQTT enables efficient communication between IoT devices and a central server, with the ability to support real-time communication and reliable message delivery.

B. Selected IoT Based Communication System Architecture

IoT-based communication systems can be implemented for the Indonesian Army, designed to monitor personnel who are patrolling in forest areas or areas with no signal. The following components are needed to create this system:

1) Pulse Sensor

Pulse sensor is a heart rate sensor designed to detect every heartbeat from the skin.

Calibration on this sensor is compared with an oximeter to produce accurate sensor output according to medical devices. If the heart rate is in the range of 60 - 100 BPM, the system will interpret the personnel in a normal state. Meanwhile, if the personnel's heart rate is in the range of 1 - 59 BPM, the system will interpret that the personnel is in an abnormal state. However, if the personnel's heart rate is in the range of 0 BPM, the system will interpret that the personnel is dead (Melyana and Sarotama, 2019).

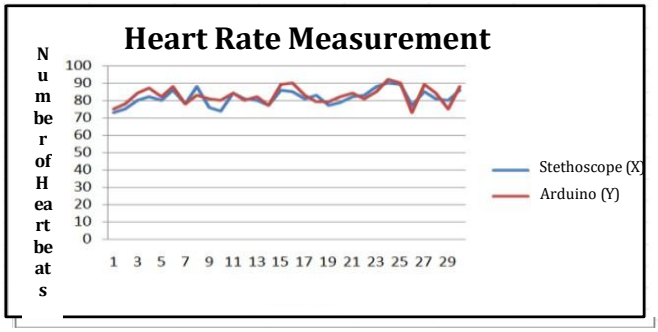

Figure 1. Comparison of heart rate measurement between a stethoscope and an Arduino-based pulse sensor (Septiani and Adi, 2015)

2) Global Positioning System (GPS)

The GPS navigation system utilises satellites to provide real-time position, speed, and time information in almost all areas of the Earth. With the ability to operate in various weather conditions, this system utilizes satellite signal synchronisation to determine locations on the earth's surface (Afdhaluddin and Palingga, 2023). To determine a position, GPS requires a minimum of 3 satellites to measure positions in 2 dimensions (latitude and longitude), and 4 satellites for positions in 3 dimensions (latitude, longitude, and altitude). One of the GPS components that can be operated using Arduino is the Ublox 6M GPS Module. This high-sensitivity GPS module is capable of receiving signals transmitted by each satellite.

Figure 2. Module Ublox 6M (Yudho *et al*, 2022)

3) Arduino Uno

Arduino Uno is a microcontroller board that uses the ATmega328 chip (datasheet). Arduino is an electronic prototype device based on a microcontroller, flexible, and open-source, with user-friendly hardware and software (Azis and Kartika, 2021). Arduino can be programmed using the Arduino IDE software. There are 14 input pins from digital output, where 6 pins can function as PWM outputs and the other 6 pins as analog inputs. In addition, there is a 16 MHz crystal oscillator, ICSP header, USB

connection, power jack and reset button. To operate the microcontroller, you only need to connect the Arduino Uno Board to a computer using a USB cable, or connect it to an AC power source via a DC adapter or battery (Sokop *et al*, 2016).

Figure 3. Arduino Uno (Setiawan, 2022)

4) Raspberry Pi

Raspberry is one of the open source microcontrollers and in terms of physical appearance is a mini computer with a Linux operating system (Ghael *et al*, 2020). Raspberry Pi can connect to a web server so that the platform can be used as a server (Rachmawan, 2023).

Figure 4. Raspberry Pi physical board (Rachmawan, 2023)

5) Long Range (LoRa)

Long Range (LoRa) is a wireless communication technology that requires low power and has a long range, introduced by Semtech in 2013 (Azwar *et al*, 2023) . By using chirp spread spectrum modulation and low power characteristics, the LoRa communication range reaches 10 kilometers (Anggraini *et al*, 2023). The network architecture that utilizes LoRa communication devices consists of three components: End Device or Node, Gateway, and Server. Lora has a frequency range that is set between 433 MHz to 1020 MHz. One of the popular Lora devices is the LoRa type SX 1278 because of its small size and is classified as high quality (Aroeboesman, 2019).

Figure 5. SX 1278 Lora Module
(Daud *et al*, 2018)

A. Communication With Command Center

IoT devices will communicate with the command center through a network that utilizes LoRa and MQTT protocols (Azwar *et al*, 2023). Data collected from sensors and devices will be sent to a central server for analysis and decision making. The data transfer process involves the following systems:

1) General system design

The operating scheme of this system requires a gateway to receive data from sensors and then send the data to the server (Azwar *et al*, 2023). The communication mechanism can be seen in the following image:

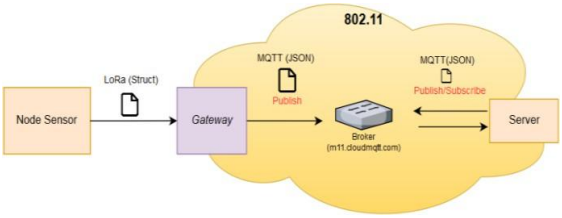

Figure 6. The overall design of the system. (Arijuddin *et al*, 2019)

The system design is based on literature study and has 3 main components, namely Sensor Node, Gateway and server (Yudho *et al*, 2022). Data communication from the sensor node to the gateway is done via the LoRa sx1278 transceiver. The data sent from the sensor node to the gateway is in struct data format. After the gateway receives the struct data, it is then converted into json format which will be sent to the server. The gateway and server use the MQTT protocol to communicate.

2) Node sensor design

On the node sensor using Arduino Uno as a microcontroller. The results of processing GPS sensor data and heartbeat from Arduino will be sent to the gateway using LoRa (Hashim *et al*, 2021). In this system LoRa is used as a transceiver (Tx) module.

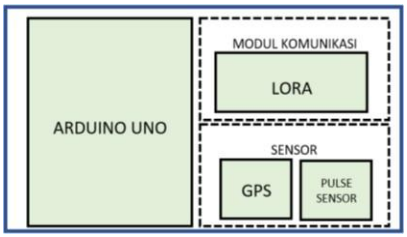

Figure 7. Node sensor architecture (Source : Researcher, 2024)

3) Gateway architecture

Communication between node sensor that forward data to the server through a gateway. The Gateway uses a Raspberry Pi microcomputer. Raspberry Pi in this system is the brain that runs the program code. LoRa in this system functions as a receiver to receive data from the transmitter.

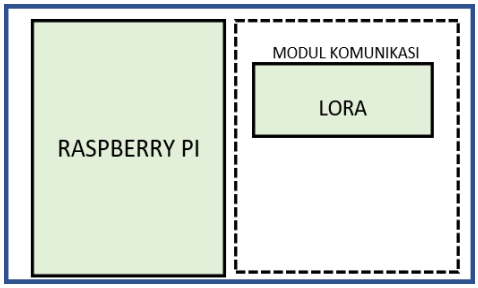

Figure 8. Gateway architecture
(Source : Researcher, 2024).

B. Search Result

From the literature study that has been collected and the design of the system that has been created can be the basis for monitoring personnel who are patrolling in areas that are not covered by the internet. The use of the LoRa module and the creation of a gateway on this system can be accessed by the central command through data that has been sent to the server in real time.

C. Limitations

This study selected five popular databases for literature searches, which may exclude some relevant literature. Another limitation is that only conference papers and journals written in the United Kingdom were included in the study.

RESULT AND DISCUSSION

In this section, we will review the findings from the literature review that has been carried out, oriented to case studies. The concentration of this literature review lies in introducing research trends in data transmission in the Internet of Things (IoT), where the Queen Honey Bee Migration method is the main focus.

A. System Design Implementation

A The system created can be applied to monitor personnel in the field of operations with the following scheme:

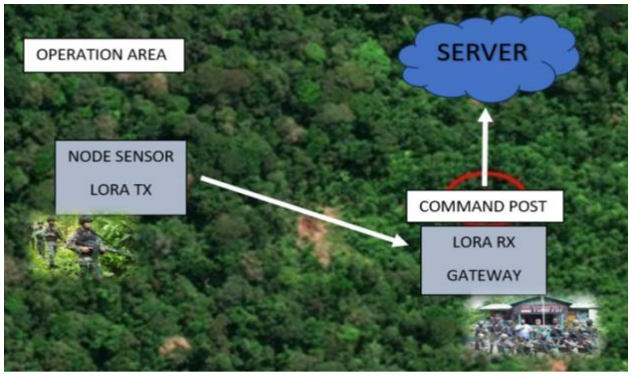

Figure 9. Application scheme of the system created
(Source : Researcher, 2024)

The system components on the sensor node are attached to the vests of personnel on patrol duty. So that the position and condition of the personnel can be monitored in real time. Here is an overview of the use of the sensor node system on personnel:

Figure 10. Sensor node system applied to personnel vests
(Source : Researcher, 2024)

Data that has been sent from the gateway to the server can be opened anywhere with a signal/wifi area. So that monitoring is not only done at guard posts but also up to the command level. Monitoring can be done quickly and in real time by the central command.

B. Comparison of the use of the LoRa tracking system with conventional systems

Indonesian army in general when patrolling in determining the position using location detection tools. The use of the tool is as in the following picture :

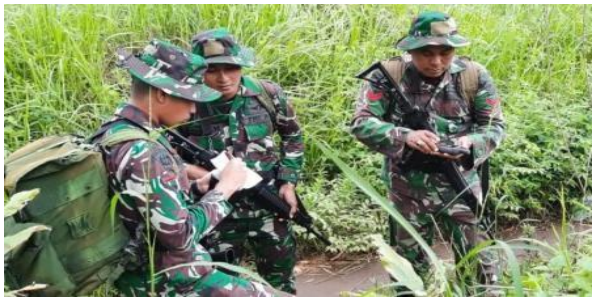

Figure 11. Use of GPS by the Indonesian army.
(Source : Researcher, 2024)

In the use of GPS equipment, TNI personnel are generally only used to find out the coordinates of personnel and determine the coordinate points of the location that will be passed by patrol personnel. While the system designed based on existing research using LoRa can store data on the server so that the central command can directly monitor the position and condition of personnel. The Central Command does not need to wait for information from guard posts, thus speeding up decision making. Data stored on the server can be used as evaluation material. A comparison of the use of GPS in general and the designed LoRa system can be seen in the following table:

Table 1. Differences in The Use of GPS and Lora Tracking Systems

Features	GPS	LoRa system
Sending Location data to the upper command	Unable to send user coordinates	Can send user coordinates to the server
Live user tracking	The upper command cannot know the user's coordinates	The upper command can monitor the user's coordinates in real time
Data storage to server	Unable to save data to server	Able to save data to server
Additional features	-	Heart rate Monitoring

CONCLUSION

Real-time personnel monitoring is very much needed by the Army that is conducting patrols. In addition to knowing the coordinates of personnel who are conducting forest patrols, the upper command can also monitor the physical condition of personnel through data from heart rate sensors. LoRa requires low power so it is very flexible and easy to use when personnel are patrolling in the forest. With the design of a system that is based on the results of existing research and implemented for military needs, the central command can track the location and physical condition of soldiers to make decisions and of course can use the stored data as an evaluation to create battle scenarios. Thus, it is hoped that the results of this system planning can help the development of Indonesian military technology based on IoT to make a positive contribution to the development of military tactics and strategies in Indonesia.

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REFERENCES

Articles from the Journals

Afdhaluddin, M., & Palingga, I. (2023). Analisis Rancangan Sistem Monitoring Posisi Hewan Menggunakan Lora. *Journal of Information System Research (JOSH)*, *4*(4), 1155-1167.

Anggraini, N., Dinillah, M. R., Wardhani, L. K., Shofi, I. M., Hakiem, N., Fadhillah, K., & Saputra, D. (2023). Sistem Penyiram Tanaman Paralel Multikarakter dengan Logika Fuzzy Metode Sugeno dan LoRa Ra-02 SX1278 Berbasis IoT. *PETIR : Jurnal Pengkajian dan Penerapan Teknik Informatika, 16 (2)* : 216-227.

Angriawan, R., & Anugraha, N. (2019). Sistem Pelacak Lokasi Sapi dengan Sistem Komunikasi LoRa. *Inspiration: Jurnal Teknologi Informasi dan Komunikasi*, *9*(1), 33-39.

Arijuddin, H., Bhawiyuga, A., & Amron, K. (2019). Pengembangan sistem perantara pengiriman data menggunakan modul komunikasi LoRa dan protokol MQTT pada wireless sensor network. *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, *3*(2), 1655-1659.

Aroeboesman, F. N., Ichsan, M. H. H., & Primananda, R. (2019). Analisis kinerja LoRa SX1278 menggunakan topologi star berdasarkan jarak dan besar data pada WSN. *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, *3*(4), 3860-3865.

Azis, A., & Kartika, I. (2021). Rancang Bangun Alat Cuci Tangan Pintar Menggunakan Sensor Infrared Berbasis Arduino. *Electrician: Jurnal Rekayasa dan Teknologi Elektro*, *15*(3), 224-238.

Azwar, H., Diono, M., & Darwis, R. S. (2023). Sistem Telemetri Nirkabel Menggunakan Long Range (LoRa) untuk Deteksi Dini Kebakaran Hutan. *Jurnal ELEMENTER (Elektro dan Mesin Terapan)*, 9(1), 103-112.

Faesol, A., Ashar, I., Yulisusianto, G., Poltekad, J. T., Poltekad, S., Poltekad, A., ... & Batu, J. Implementasi System Tracking Secara Realtime Pada Android Untuk Mengirim Koordinat Pasukan Berbasis MQTT.

Ghael, H. D., Solanki, L., & Sahu, G. (2020). A review paper on raspberry pi and its applications. *International Journal of Advances in Engineering and Management (IJAEM)*, *2*(12), 4.

Hashim, N., Idris, F., Ab Aziz, T. N. A. T., Johari, S. H., Nor, R. M., & Ab Wahab, N. (2021). Location tracking using LoRa. *International Journal of Electrical and Computer Engineering*, *11*(4), 3123.

Heryadi, A., Jayanti, A. M., & Bantam, D. J. (2020). Pelatihan Konseling Dasar Bagi Komandan Regu Yonif 403/WP. *Dharma Bakti*, 80-87.

Lesmana, A. H., Kholid, F., & Aulia, W. (2022). Elektronika Sistem Senjata Sistem Monitoring Pengintai Jarak Jauh Robot Tree Climber Menggunakan Gps Dengan Kendali Android Metode Internet Of Things: Teknologi. *Jurnal Elkasista*, *3*(1), 35-43.

Manoppo, R. T. S., Pati, A., & Kimbal, A. (2021). "Implementation of State Defense Policies to Realize National Resilience in the 1309 Military District Command / Manado Region. *Agri-SosioEkonomi UNSRAT, 17 (1)* : 103-114.

Rachmawan, A. (2023). Studi Komparasi Platform Open-Source Internet of Things. *Jurnal Teknologi dan Manajemen*, *21*(1), 43-48.

Raharjo, A., Eko, K., & Imam, A. (2021). Rancang Bangun Tracking Arah Tembakan Menggunakan Sensor Posisi Berbasis PID Design and Implementation of the Shot Direction Tracking System Using a PID-Based Position Sensor. *TELKA-Jurnal Telekomunikasi, Elektronika, Komputasi dan Kontrol*, *7*(1), 43-48.

Sari, N. A., & Hartini, N. U. R. U. L. (2021). Hubungan Beban Kerja dengan Stres Kerja Anggota TNI AD yang Bertugas di Wilayah Rawan Konflik. *Buletin Penelitian Psikologi dan Kesehatan Mental (BRPKM)*, *1*(2), 1298-1305.

Septiani, A. D., & Adi, S. S. (2015). Perancangan Alat Pemantau Kondisi Kesehatan Manusia. *Edu Elektrika Journal*, *4*(2).

Setiawan, W. (2022). arduino uno Analisis Sistem Pengukur Tinggi Badan Pengunjung Butik XYZ menggunakan Microcontroller Arduino Uno dan Sensor Ultrasonic HC-SR04: Analisis Sistem Pengukur Tinggi Badan Pengunjung Butik XYZ menggunakan Microcontroller Arduino Uno dan Sensor Ultrasonic HC-SR04. *Journal Information Technology Engineering And Science*, *1*(2).

Sokop, S. J., Mamahit, D. J., & Sompie, S. R. (2016). Trainer periferal antarmuka berbasis mikrokontroler arduino uno. *Jurnal Teknik Elektro Dan Komputer*, *5*(3), 13-23.

Taufik, M. E., Huda, M. M., & Candra, T. D. S. (2021). Implementasi Management Server Pada Radio Hybrid Cigra Menggunakan WEBRTC. *Jurnal Telkommil*, *2*(Mei), 26-33.

Yudho, S., Rusjdi, D., Putra, R. P., & Siregar, R. R. A. (2022). Integrating LoRa SX178S with GPS Sensor for Free Geolocation. *Kilat*, *11*(1), 64-70.

Proceeding

Daud, S., Yang, T. S., Romli, M. A., Ahmad, Z. A., Mahrom, N., & Raof, R. A. A. (2018, March). Performance evaluation of low cost lora modules in iot applications. In *IOP conference series: materials science and engineering* (Vol. 318, No. 1, p. 012053). IOP Publishing.

Melyana, M., & Sarotama, A. (2019). Implementasi peringatan abnormalitas tanda-tanda vital pada telemedicine workstation. Prosiding Semnastek.," pp. 1–9, 2019.

Published Book

Gregorian, R. (2017). 'Jungle Bashing'in Malaya: Towards a Formal Tactical Doctrine. In *Modern Counter-insurgency* (pp. 29-50). Routledge.