Implementation of an IoT-Based Weapons Inventory System Using Barcode Technology for Weapons Inflow and Outflow Tracking at the Poltekad's Weapons Armory

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Abstract: *The security and efficiency issues in the management of weapons storage in military environments especially in the Indonesian Army (TNI-AD) have become a significant concern because many potential loss case or misuse of weapons that frequently happen. This research is aim to implement and develop an integrated system by using the IOT Infrastructure combining with barcodes to monitoring the inflow and outflow process at weapons armory. The method used microcontroller ESP32 as the control center to collect and deliver the data into the web server for recording and reporting. This method is tested through daily operational simulation to tested the accuracy and reliability of inflow-outflow weapons process. The result show that the system is capable of providing real-time and accurate weapons status information through a web interface and can be accessed via internet. This system is successfully reducing the manual recording process and is able to provide direct inventory condition to the officers. The barcodes system is successfully implemented on 104 SS-2 Pindad Rifles and 105 Pistols located in the Poltekad's Armory with 100% success reading rate at optimal read distance 2-5 cm.*
Keywords: Weapons Inventory, Armory, Internet of Things(IoT), Barcode, ESP32

Abstrak: *Masalah keamanan dan efisiensi dalam pengelolaan gudang senjata di lingkungan militer khususnya TNI-AD, menjadi perhatian penting mengingat potensi kehilangan dan penyalahgunaan senjata marak terjadi. Penelitian ini bertujuan untuk merancang dan mengimplementasikan sistem monitoring senjata berbasis Internet of Things (IoT) yang mengintegrasikan teknologi barcode untuk mengawasi arus keluar masuk pada gudang senjata. Metode yang digunakan melibatkan penggunaan mikrokontroler ESP32 sebagai pengolah data untuk meudian kemudian dikirim ke web server untuk pencatatan dan pelaporan. Sistem diuji melalui simulasi kondisi keluar-masuk senjata pada kegiatan rutin satuan guna mengevaluasi akurasi dan keandalannya. Hasil menunjukkan bahwa sistem mampu memberikan informasi status senjata secara real-time dan akurat melalui antarmuka web yang dapat diakses melalui jaringan internet. Sistem ini berhasil mengurangi kemungkinan kesalahan pencatatan manual dan mampu memberikan informasi kondisi inventaris secara langsung kepada Komandan Satuan. Sistem berhasil mengimplementasikan penggunaan barcode pada senjata ringan yang berada di Gudang Senjata Poltekad sebanyak 104 buah Senapan SS-2 Pindad dan 105 buah Pistol dengan tingkat keberhasilan pembacaan 100% pada jarak optimal pembacaan 2-5 cm.*
Kata Kunci : Gudang Senjata, Internet of Things(IoT), Barcode, ESP32

INTRODUCTION

Weapons Armory is an important place in military institution that use to store, manage and maintain various type of weapons and ammunitions. That's why the security system and the management process of the armory operations should be done strict and have no room for errors. Nowadays, the handling of weapons inventory management in Poltekad's Armory still rely on manual process and it prone to human errors. Digitalization is urgently needed to enhance the efficiency and fill the security gaps. Also the combination with IoT devices will allow the data to be presented and accessed by real time, it will help accelerating the decision making for the officer. The implementation of IoT Based for weapons inventory system will enhance the security of Poltekad's Armory and improve the operational efficiency.

Many studies show the digitalization of warehouse process have many benefits for the users. The implementation of barcodes can speed up the deliver of information/data reports obtained from the warehouse process(Istiqomah et al., 2020). One of the various options to digitalize the armory warehouse is by implementing barcode technology to identify each weapons for the inflow and outflow process. Each weapons has its own serial number, serial number is a unique identifier number and different from one to another. This number later will be transformed into a barcode so the data from each weapons could be read automatically. Barcode have 2 components, the barcode itself and the scanner. Scanner could be set to scan the data automatically and it will accelerate the armory warehouse process. For example, warehouse management using GM-65 barcode scanner has proven to be an effective method for automating the barcode scanning process and enabling real-time data transmission to a web-based platform (Nerol et al., 2024).

To handle large amount of weapons inventory data, a good and proper administration system is needed. Manual recording of weapons inventory prone to input errors and physical losses. Therefore the data should be structured in database and stored in high security cloud services. Real time data presentation is one of the important aspect in the armory warehouse operations, and IoT infrasctructure can solve this issue. The study developed and tested an internet-based inventory management system that integrates the warehouse's material database with QR codes for each material, enabling real-time tracking and more accurate data processing (Susanto et al., 2024).

The use of IoT can also reduce administrative workload such as the use of excessive personnel for monitoring and administrative recording. By recording using a barcode scanner and storing it directly into a database, this will reduce errors in recording and ensure that the data remains up to date. This will give personnel more time to monitor the weapon warehouse rather than just focusing on administrative matters. This improved workflow not only enhances efficiency but also contributes to overall organizational effectiveness (Fadzli & Nawawi, 2024).

Weapons is a sensitive materials and the use is restricted only to authorize personnel. Various case of weapons misuse happens because lack of oversight and administrative mistake. The implementation of IoT in Armory Warehouse process expected to improve accountability, efficiency and operational readiness. Several potential developments of IoT can be applied to the digitalization of this armory, such as creating Android app for monitoring, implementing RFID sensors and face recognition. For example recent development is allowing users to scan items directly using smartphones, these applications streamline the data entry process, uce human error, and make inventory systems more efficient and accessible, particularly in decentralized or field-based storage scenarios(Ipnuwati et al., 2022).

The implementation of an IoT based weapons inventory system using barcode

technology at Poltekad's Armory enhance the operations of managing sensitive military assets. Through the integration of barcode as identifier and real time data via IoT devices, this system significantly improves speed, accuracy and accountability of inventory tracking. Real time monitoring capabilities reduce the possibility of manual errors and potential data fraud, while also help the decision making for the users. Furthermore, there is a potential to make it has more features by implementing various sensors and device to make the system more reliable and transparent. This technology implementation is not only beneficial, but also ensuring the safety of weapons management at Poltekad's armory.

RESEARCH METHODS

In this research, a quantitive methods is used with an analytical and experimental approach to collect the data. In the implementation phase of the research, this device will be tested to see the effectiveness of barcode reading that attached to the weapons, including the success rate of barcode reading and find the optimal reading distance.

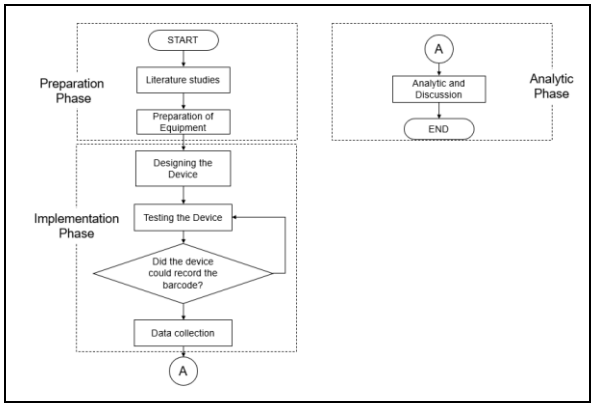


Figure 1. Flow Chart of the research

In the preparation phase, the research conduct a literature study and prepare the equipment that will be used to create this system. The equipment used is as follows:

Table 1. Preparation of equipments

No	Equipments
1	ESP 32
2	Arduino UNO
3	USB Host Shield
4	Barcode Scanner EPPOS 1400C
5	LED I2C
6	LED 3mm & Buzzer
7	Box X6
8	Weapons (SS2 Rifle / Handgun)
9	Barcode Sticker

The implementation stage is carried out by designing the device, testing and collecting data. The design of the device uses the following circuit:

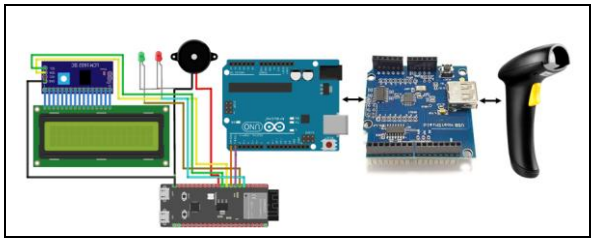


Figure 2. Barcode Scanner Weapon Circuit

After the device was successfully created, then it was placed next to the entry point of Poltekad's weapons armory to facilitate the responsible officers in scanning the inflow and outflow of weapons.



Figure 3. Barcode Weapon Scanner Device at Poltekad's Armory

In addition to device design, the development of backend in the form of a database for server-side data processing is also required. In this research, the databases uses a MySQL infrasctructure with the following table contents:

Table 2. Table structure of t_senjata

No	Name	Data Type
1	id	int(11) PRIMAY KEY
2	no_seri	varchar(20)
3	jenis_senjata	varchar(50)
4	lokasi	varchar(15)
5	kondisi	varchar(15)
6	pemegang	varchar(50)
7	pangkat	varchar(20)
8	nrp	varchar(20)

To identify the inflow and outflow process of every weapons at Poltekad's armory, the researcher use serial number of the weapons as an identifier. The choice is made because this number is a unique number attached to each weapons and it's different from one to another.

Table 3. Serial number format

No	Type	Serial Number
1	SS-2 Rifle	BACP015685
2	FN-46 Handgun	10898
3	P2 Pindad Handgun	ABO000453

The serial number of weapons sometimes comes in an alphanumerical format, this format later will be converted into Barcode-128. Barcode-128 is also known as Code-128 is a type of linear barcode designed to efficiency encode alphanumeric data. The barcode is printed on a sticker paper that is attached to the surface of the weapons with the following dimension (Length x Width):

1. Rifles : 3,3 cm x 1,4 cm
2. Handgun: 1,45 cm – 2,7 cm x 1,27cm



Figure 4. Barcode-128 Conversion Image

After the preparation and design phase were completed, testing was carried out to evaluate the ability of the barcode scanner to read the serial number in rifles and pistols and deliver the data into Poltekad Armory Website.

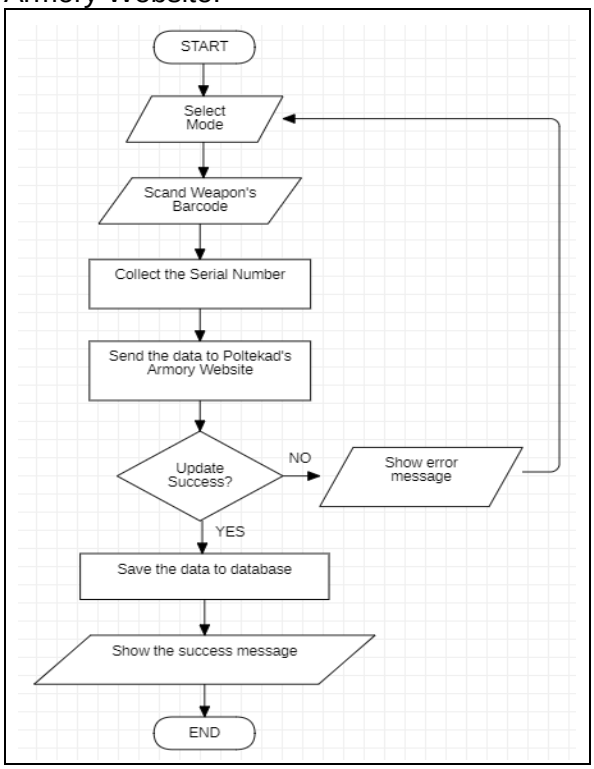


Figure 5. Flowchart testing on Poltekad Armory Barcode Scanner

The process is begin by turning on the weapons barcode scanner device powered by ESP32 and Arduino Uno. When the device is on standby mode, the user can select the scan mode between "MASUK" or "KELUAR". The differences between both modes is "KELUAR" used to record weapons being taken out of the armory while "MASUK" is used to record the weapons being returned to the armory. When the device is successfully scanned the barcode, the ESP32 will receive the raw data of serial number. This serial number data and the previously selected mode will be processed into a URL parameter and sent to the Poltekad Armory Website.

If the data sending is successful, the website will send an HTTP response code

(200) to ESP32 device, if it fails the error message will be send. The officers could check the result of the data submission on the Poltekad Armory Website by logging in using the provided username and password.

RESEARCH RESULTS

In the scanning process, a Barcode Scanner that support Barcode-128 format is required. This research uses the EPPOS 1400C 1D Barcode Scanner connected via a USB Host Shield integrated with the Arduino Uno device. Each character from the scanned barcode is stored in a variable called DataBarcode. The reading process continued until the ENTER character (ASCII 0x0D) is detected, which serves as an indicator that the entire content of the barcode has been finished.

For communication between the microcontrollers, Arduino is configured as an I2C Slave, When the ESP32 initiates a data request via the I2C protocol, the sendData() function is automatically executed. This function transmits the content of DataBarcode as a string and subsequently clears the variable, preparing it to store new barcode input for the next reading cycle.

```
Received Barcode : BACP016021
Received Barcode : BACP015778
Received Barcode : BACP015812
Received Barcode : BACP016255
Received Barcode : BACP016233
……
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Figure 6. Result of the scanned barcode

Below is the result of the barcode reading test on 104 rilfes & 105 pistols at the Poltekad Weapons Armory.

Table 4. Barcode testing result

No	Type	Amount	Success Read	Percentage
1	Rifles	104	104	100%
2	Pistols	105	105	100%

In addition to test the reading process, an experiment was also conducted to evaluate the effectiveness of barcode reading distance. The EPPOS 1400C barcode scanner is set to Auto Sensing mode, allowing it to automatically detect and read without the need to press the trigger button. This feature ensure a more efficient scanning process, particulary in scenarios that require continuous or hands-free operation.



Figure 7. Weapons barcode scan distance

During the experiment, the scanner was tested at varying distances to determine it's optimal reading range and accuracy. The data collected from these test provide insight into the scanner's performance and reliability in different operational conditions. These findings are valuable for ensuring that system can function effectively in daily operational that require speed and reliability.

Table 5. Barcode distance scan test on rifle

No	Distance (Cm)	Test Result
1	0	Not readable
2	0,5	Not readable
3	1	Not readable
4	1,5	Not readable
5	2	Read
6	2,5	Read
7	3	Read
8	3,5	Read
9	4	Read
10	4,5	Read
11	5	Read

Table 6. Barcode distance scan test on pistols

No	Distance (Cm)	Test Result
1	0	Not readable
2	0,5	Not readable
3	1	Not readable
4	1,5	Not readable
5	2	Read
6	2,5	Read
7	3	Read
8	3,5	Read
9	4	Read
10	4,5	Read
11	5	Read

DISCUSSION

After the barcode is successfully scanned and displayed, the ESP32 verifies the internet connection through Wi-Fi. If the connection is established, the device will construct the URL for the data transmission to the database, including the additional parameter that previously selected, which can be "MASUK" or "KELUAR". The "MASUK" mode is used to record weapons being moved from outside to inside the weapons armory and updating the weapon's location status to "GUDANG SENJATA".

26	BACP015977	Senapan SS-2 V1	GUDANG SENJATA	BAIK
27	BACP016036	Senapan SS-2 V1	GUDANG SENJATA	BAIK
28	BACP016182	Senapan SS-2 V1	GUDANG SENJATA	BAIK
29	BACP015907	Senapan SS-2 V1	GUDANG SENJATA	BAIK
30	BACP016193	Senapan SS-2 V1	GUDANG SENJATA	BAIK

Figure 8. Testing result of "MASUK" mode

Meanwhile the "KELUAR" mode is used to record weapons being taken out from the armory to outside. This mode updates the weapon's location status to "DI LUAR" on the Poltekad's Armory Website and highlight the row with red color. Rows in the table are highlighted in red if the weapon is located outside the armory, serving as a visual indicator that the weapon is not in storage. This color-coding system helps users quickly identify weapons that are currently in use or taken out for specific purposes

By providing this visual cue, the system enhances the efficiency of monitoring and reduces the chance of oversight. Users with authorized access can also track changes and verify the movement history of each weapon directly from the table. Overall, this structured and color-coded display ensures accurate, efficient, and secure monitoring of the entire weapon inventory.

26	BACP015977	Senapan SS-2 V1	GUDANG SENJATA	BAIK
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28	BACP016182	Senapan SS-2 V1	GUDANG SENJATA	BAIK
29	BACP015907	Senapan SS-2 V1	DI LUAR	BAIK
30	BACP016193	Senapan SS-2 V1	GUDANG SENJATA	BAIK

Figure 9. Testing result of "KELUAR" mode

The users of the weapons which is the regular soldier only granted access to perform weapons scanning. While the access to the website is restricted and only granted to the armory officers and the commander. This separation level of access ensures the data security and prevents unauthorized individuals from viewing or harming with the sensitive information stored in the system.

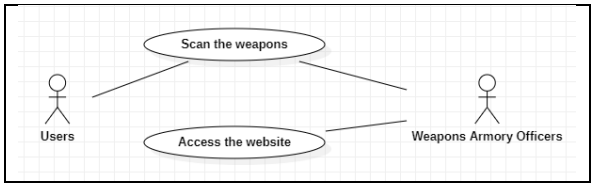


Figure 10. Use Case Diagram

After a successful login by the officer, system will display all weapons data stored in the database. The data is separated by types, there is rifles and pistols. To enhance the navigation and users experience, the information displayed in two selected tabs. Each tabs provides a summary of the total number weapons currently stored, and those are located outside the armory. Meanwhile the table in each tab presents key information such as the weapon's serial number, type, last known location, condition, holder's name, and holder's rank.

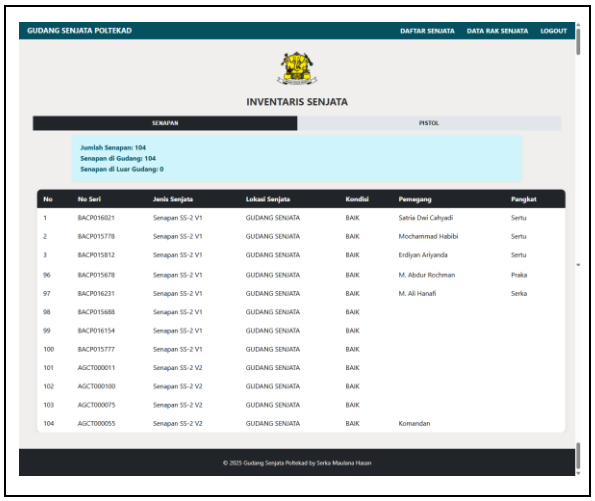


Figure 11. Poltekad Weapons Armory Website

CONCLUSION

This research successfully designed and implemented an IoT-based weapon monitoring system using Barcode-128 technology to record the process of weapons inflow and outflow at Poltekad's Weapons Armory. This system uses ESP32 as the microcontroller connected to a PHP-MySQL based web server, enabling it to record and display data in real-time and accurately. The implementation results show that the system can enhance the security of the Poltekad's Weapons Armory by automatically recording the inflow and outflow processes of weapons. Furthermore, this system can also reduce the risk of loss or misuse of weapons and help the Commander to monitoring the condition of the weapon inventory directly. However, the system built is still limited to recording weapons inventory without daily activity logs or details of the timestamps. Future development needs to include features for recording time and daily activity history to improve the quality of weapons inflow and outflow reporting, as well as the development of an integrated Android application to provide real-time notifications, making inventory monitoring more flexible and practical.

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