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Smart Storage: Rancang Bangun Sistem Peminjaman dan Pengembalian Barang Otomatis Menggunakan Teknologi RFID dan IoT di Lingkungan Kampus Dengan Metode Unified Modeling Language (UML)

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Abstrak

Sistem peminjaman dan pengembalian barang di lingkungan kampus masih banyak dilakukan secara manual sehingga berpotensi menimbulkan kesalahan pencatatan dan keterlambatan informasi. Penelitian ini bertujuan untuk merancang dan membangun sistem *Smart Storage* berbasis *RFID (Radio Frequency Identification)* dan *Internet of Things (IoT)* dengan pendekatan *Unified Modeling Language (UML)*. Sistem ini menggunakan ESP32 sebagai pengendali utama, modul RFID sebagai identifikasi pengguna, sensor warna dan sensor infrared sebagai pendukung identifikasi barang, serta mekanisme conveyor untuk proses distribusi barang secara otomatis, yang terintegrasi dengan aplikasi berbasis web melalui protokol *HTTP* untuk monitoring secara *real-time*. Berdasarkan hasil implementasi dan pengujian, sistem mampu menjalankan proses peminjaman dan pengembalian barang dengan tingkat keberhasilan mencapai 100% setelah dilakukan optimasi pada sistem, serta komunikasi *IoT* memiliki tingkat akurasi dan stabilitas mencapai 100%. Dengan demikian, sistem *Smart Storage* dapat meningkatkan efisiensi, akurasi, dan kemudahan dalam pengelolaan inventaris di lingkungan kampus.
Kata kunci: Smart Storage, RFID, Internet of Things, ESP32, Sistem Otomatis, Inventaris

Abstract

Item borrowing and return systems on college campuses are still largely managed manually, which can lead to recording errors and delays in information. This study aims to design and develop a Smart Storage system based on RFID (Radio Frequency Identification) and the Internet of Things (IoT) using the Unified Modeling Language (UML) approach. This system uses an ESP32 as the main controller, an RFID module for user identification, color sensors and infrared sensors to support item identification, and a conveyor mechanism for automated item distribution, all integrated with a web-based application via the HTTP protocol for real-time monitoring. Based on the results of implementation and testing, the system is capable of executing item borrowing and return processes with a success rate of 100% following system optimization, and the IoT communication achieves 100% accuracy and stability. Thus, the Smart Storage system can enhance efficiency, accuracy, and ease in inventory management within a campus environment.
Keywords: Smart Storage, RFID, Internet of Things, ESP32, Automated System, Inventory

1. Introduction

Inventory management is a vital component of facility management on campus, particularly in supporting practical sessions and laboratory operations. The manual system currently used for borrowing and returning items often leads to various problems, such as recording errors, delays in information, and difficulties in monitoring data in real time [1], [2].

Several previous studies have developed web-based borrowing systems as a solution to manual systems. These systems have proven capable of improving efficiency and simplifying inventory data management [3]. Furthermore, RFID technology has been widely adopted for identification processes due to its ability to read data quickly and accurately without direct contact, making it highly suitable for automated systems [4], [5].

Advances in Internet of Things (IoT) technology enable the integration of hardware and software to facilitate real-time data exchange. IoT-based systems can improve the efficiency of centralised data monitoring and recording [6], [9]. Therefore, this study proposes an RFID and IoT-based Smart Storage system using the Unified Modelling Language (UML) approach to produce a structured and easily developable system [7].

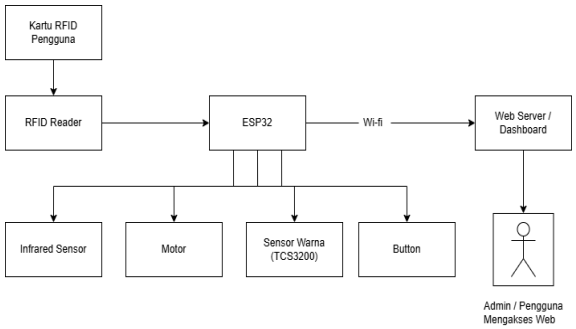
2. Reseacrh Method

2.1 Design of a Smart Storage System

The Smart Storage System is designed as an IoT-based system that integrates hardware and software to support the automated borrowing and returning of items. RFID is used as a means of user identification because it can read data quickly and accurately without requiring direct contact, thereby improving the efficiency of the inventory system [4], [6].

Data from the RFID tags and sensors is processed by an ESP32 microcontroller, which has wireless communication capabilities and supports the implementation of IoT systems

[9]. The data is then sent to a server using the HTTP protocol to be stored in a database and displayed via a web-based application. This system enables real-time



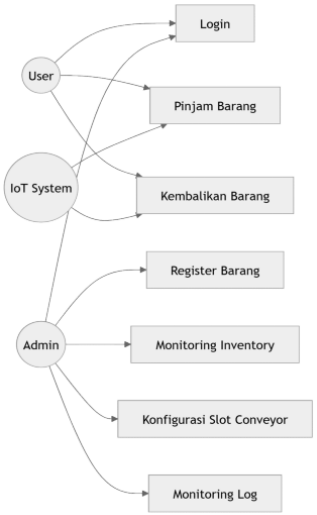
monitoring and simplifies inventory data management.

Picture 1. System Block Diagram

2.2 System Design Using UML

The system design was carried out using the Unified Modelling Language (UML) to model the system's structure and workflow. UML was used to visualise the interactions between users and the system, as well as the relationships between components in a structured manner [7].

The UML diagrams used include use case diagrams, activity diagrams, sequence diagrams, and class diagrams. The use of UML aims to facilitate the system development process, improve understanding of the design, and reduce errors in system implementation.

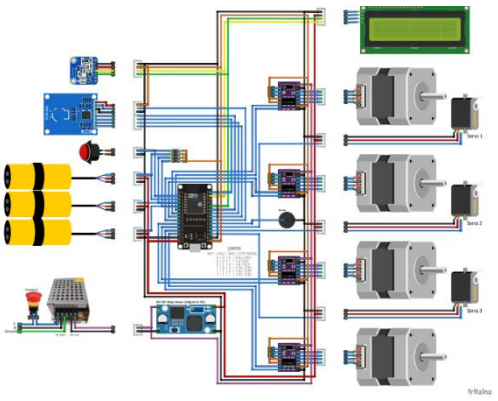


Picture 2. Use Case Diagram

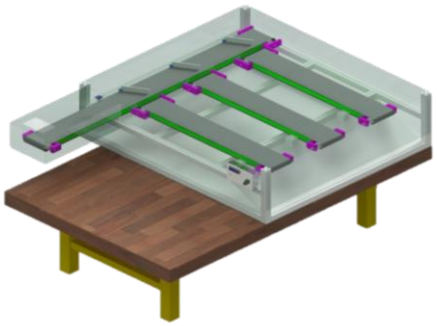
2.3 Mechanical and Electrical Design

The mechanical system design utilises a conveyor as a means of automatically distributing goods. Conveyors are widely used in automation systems as they enhance the efficiency of goods handling processes and reduce direct human involvement [11].

In the electrical section, the ESP32 is used as the main controller, connected to an RFID module, a colour sensor, and an infrared sensor. The colour sensor is used to detect the characteristics of goods, whilst the infrared sensor is used to detect the presence of objects within the system [14], [15]. Additionally, an LCD is used as an information display to show the system status to the user [10].



Picture 3. Electrical Design



Picture 4. Mechanical Design

2.4 IoT Data Communication

Data communication within the system uses the HTTP protocol between the ESP32 and a local server. The ESP32 sends data using a POST request, after which the server processes and stores the data in a MySQL database [8].

This method was chosen because it is easy to implement and compatible with web-based systems. Furthermore, the system enables real-time monitoring, thereby improving the efficiency of inventory management [10]. The components involved in data communication using the HTTP protocol are shown in Table 1.

Table 1. Use of HTTP Components

Components	Role	Explanation
ESP32	Client	Send user/item UID data to the web server via the HTTP protocol using a POST request.
Web server	Data connector	Receive data from the ESP32, process it using a PHP script, and send it to the database.
Database (MySQL)	Data storage	Storing transmission data from the ESP32 for display on a web dashboard.

3. Results and Discussion

In this study, the author conducted several tests, which are described below.

3.1 Testing the Item Loan System

The item loan testing was carried out to ensure that the system could execute the loan process automatically in accordance with the designed workflow. The process begins with user identification via RFID, after which the system verifies the user's data and activates the conveyor to dispense the item. The test results showed that the system was able to execute the loan process with a 100% success rate, with all stages running smoothly without any errors.

Table 2. Testing the Goods Loan System

No	Name of Tool (Colour)	Testing					Success Rate(%)
		1	2	3	4	5	
1	Arduino Uno (Green)	✓	✓	✓	✓	✓	100%
2	ESP32 (Red)	✓	✓	✓	✓	✓	100 %
3	PLC Omron (Blue)	✓	✓	✓	✓	✓	100%

3.2 Testing the Return System

Return testing was carried out to ensure that the system could accept and record items returned by users. The process begins with user identification, after which the system detects the items using sensors and directs them to the appropriate storage slot. The test results showed that the system was capable of carrying out the return process automatically with a 100% success rate following optimisation of the mechanical system.

Table 3. Return System Testing

No	Name of Tool (Colour)	Testing					Succes Rate (%)
		1	2	3	4	5	
1	Arduino Uno (Green)	✓	✓	✓	✓	✓	100%
2	ESP32 (Red)	✓	✓	✓	✓	✓	100 %
3	PLC Omron (Blue)	✓	✓	✓	✓	✓	100%

3.3 RFID Module Testing

RFID module testing was carried out to assess the system's ability to read user identity cards. The testing involved several trials using cards that were both registered and unregistered in the system. The test results showed that the RFID module was able to read data accurately and distinguish between valid and invalid users, thereby supporting the authentication process within the system.

Table 4. Testing Table for the RFID Module

No	Reading Distance (cm)	Card Position	Number of trials	Total Successes	Success Rate (%)	Description
1	1 cm	Place in front of the reader	5	5	100%	The reading is very stable
2	2 cm	Slightly sloping	5	5	100%	Stable reading
3	3 cm	Skewed / misaligned	5	3	60%	Sometimes you need to adjust your position
4	4 cm	Far from the reader	5	0	0%	The reading is unstable

3.4 Testing the ESP32 Module in Data Processing

Testing of the ESP32 module was carried out to verify the microcontroller's ability to process data from RFID tags and sensors, as well as to control output devices such as conveyors and LCDs. The test results showed that the ESP32 was able to execute the entire process successfully, from data reading and processing to data transmission to the server, without encountering any issues.

Table 5. Testing the ESP32 Module in Data Processing

No	Testing Features	Test Conditions	Results	Status	Description
1	RFID reading	The ESP32 reads the UID from the RFID	Data sometimes appears late	Less	Delay in the reading process
2	Data Processing	The ESP32 processes RFID data	The data has been processed but is unstable	Less	The process is not yet optimal
3	Control Output	The ESP32 activates the conveyor	The conveyor is not currently active	Failed	Output response delay
4	LCD display	The ESP32 sends data to the LCD	Data not displayed	Failed	Communication is not yet in sync
5	Retest	Following the system upgrade	All functions are working	Successful	The system is starting to stabilise

3.5 System Testing Based on UML

System testing based on UML was carried out by comparing the system implementation against previously designed diagrams, such as use case diagrams and activity diagrams. The test results showed that the system's workflow was consistent with the UML model, with each process—such as borrowing and returning items—operating in accordance with the specified scenarios.

Table 6. System Testing Based on UML

No	Types of UML	Test Case	Results of the System Implementation	Compliance with UML	Description
1	Use Case Diagram	Users log in, borrow items and return them; administrators register items, monitor stock levels, configure conveyor slots and monitor logs	All features can be accessed according to user permissions	In accordance with	The feature works as intended
2	Activity Diagram (Loan)	Borrowing process: RFID scan, user validation, select item, check availability, activate conveyor	The process proceeds in stages within the system	In accordance with	There is no difference in the plot
3	Activity Diagram (Return)	Return process: user verification, item input, colour sensor reading, slot selection, conveyor movement	The system executes the process as shown in the diagram	In accordance with	The returns process is going smoothly
4	Sequence Diagram (Borrowing)	Communication between the RFID, ESP32, server and conveyor during the borrowing process	Data is read, processed, and goods are dispatched	In accordance with	The correct sequence of processes
5	Sequence Diagram (Return)	Communication between the RFID, colour sensor, ESP32, server and conveyor	System for reading colours and storing data	In accordance with	Communication is going smoothly
6	Class Diagram	The User, Item, Transaction and Inventory data relationships	Database structure as implemented	In accordance with	Interconnected data

3.6 HTTP-Based System Testing

Data communication testing using the HTTP protocol was carried out to ensure that the data transmission process between the ESP32 and the server was functioning correctly. The testing involved sending data via a POST request and verifying whether the data was successfully received and stored in the database. The test results showed that the system was able to send and receive data correctly, and demonstrated a high level of accuracy and stability in data communication.

Table 7. HTTP-Based System Testing

No	Test Parameters	Test Description	Test Results	Description
1	Response Time	Measuring the time from when the ESP32 sends data until it is received by the server	±1.2 second	Prompt response
2	Data Accuracy	Comparing the UID data from the ESP32 with the data on the server	100% accurate	The data remains unchanged
3	Connection Stability	Testing data transmission repeatedly (10 times) to see if the connection remains stable	10 out of 10 successful (100%)	Stable connection

Based on all the tests carried out, the Smart Storage system has demonstrated good performance in carrying out the functions of automatic item borrowing and return. All system components, from user identification using RFID and data processing by the ESP32 to HTTP-based data communication, operate seamlessly in accordance with the design specifications. These test results indicate that the system has a high level of reliability and is capable of supporting inventory management processes more efficiently and effectively.

4. Conclusion

Based on the results of the design, implementation and testing carried out, an RFID- and Internet of Things (IoT)-based Smart Storage system has been successfully developed to automate the process of borrowing and returning items. This system is capable of integrating various components such as RFID for user identification, ESP32 as the main controller, sensors to support item detection, and a conveyor system as the mechanism for the automatic distribution of items. Test results indicate that the system can perform all functions in accordance with the design, including the item borrowing and return processes, with a high success rate.

The RFID module is capable of identifying users effectively, the ESP32 processes data optimally, and data communication using the HTTP protocol operates stably and accurately. Furthermore, the system implementation is consistent with the previously created UML design.

Consequently, the developed Smart Storage system is capable of enhancing efficiency, accuracy, and ease in inventory management, and can serve as an effective solution to replace manual systems within the campus environment.

Daftar Pustaka

[1] M. Nugraha dan J. Yaskurniaam, "MIND (Multimedia Artificial Intelligent Networking Database Sistem Informasi Peminjaman Barang Berbasis Web dengan Metode Waterfall," *Journal MIND Journal | ISSN*, vol. 5, no. 1, hlm. 14–23, 2020, doi: 10.26760/mindjournal.v5i1.14.

[2] Mulyanto Dwi J dan Apriliyanti Windi, "Perancangan Sistem Informasi Peminjaman dan Pengembalian Buku Perpustakaan Berbasis Web di SMK Tujuh Lima 1 Purwokerto," hlm. 117–124, Agu 2023.

[3] M. Z. Nabilah *dkk.*, "Rancangan Sistem Peminjaman Barang Digital Berbasis Web (Studi Kasus : di Lingkungan Jurusan Teknologi Informasi Politeknik Negeri Samarinda)," 2025.

[4] Putra Kurniawanto Eko dan Azhari Mairiza, "Perancangan Radio Frequency Identification (RFID) Pada Transaksi Peminjaman dan Pengembalian Buku di Perpustakaan," *Edik Informatika*, vol. 8, no. 2, hlm. 125–134, Apr 2022, doi: 10.22202/ei.2022.v8i2.5566.

[5] M. Lutfi dan R. Z. Abidin, "Rancang Bangun Sistem Peminjaman Tablet Menggunakan Metode RFID Untuk Meningkatkan Efisiensi Data Dengan Memanfaatkan Kartu Tanda Santri," 2024.

[6] D. Ariyanto, "Rancang Bangun Sistem Peminjaman Peralatan Laboratorium Menggunakan RFID Berbasis IOT," Online, Sep 2023.

[7] Putri Aprilia, "Analisis Sistem Dengan 4 Diagram UML Perancangan Aplikasi Penjualan dan Pembelian (Studi Kasus : Rumah Makan Uni Kapau Jaya)".

[8] Abdi Firdaus Muhammad, Susanto Agung, Utami Ema, dan Kusnawi, "Implementasi Sinkronasi Database SQL Dengan Replikasi Pada Aplikasi Finance PT.XYZ," vol. 12, Apr 2021.

[9] J. Susanto, M. W. Aji, Q. I. Supardi, dan Y. B. Adyapaka Apatya, "Sistem Monitoring Suhu Block Heater Sealing Pada Mesin Packaging Berbasis IOT Menggunakan Mikrokontroller ESP32," Online, 2023.

[10] F. Rizakir dan S. A. Sukarno, "Sistem Kunci Otomatis Pada Casing Rokok Berbasis Arduino Nano Dengan LCD I2C," *Jurnal Informatika dan Teknik Elektro Terapan*, vol. 13, no. 1, Jan 2025, doi: 10.23960/jitet.v13i1.5661.

[11] Halim Ananda, fat Joni, dan Calvinus Yohanes, "Rancangan Kendali Konveyor Otomatis Berbasis Arduino dan Monitoring Melalui Aplikasi Android Untuk Meningkatkan Efisiensi Sistem Produksi," vol. 1, hlm. 81–88, Feb 2021.

[12] D. Ariyanto, "Rancang Bangun Sistem Peminjaman Peralatan Laboratorium Menggunakan RFID Berbasis IOT," Online.

[13] T. Informasi, S. Balikpapan, J. Z. A Maulani No, dan B. Balikpapan Selatan, "Rancang Bangun Man-Machine Interface Berbasis Web Untuk Servo Posisi Motor DC Dengan Menggunakan Mikrokontroller AT89C51," vol. 1, no. 1, 2017.

[14] S. F. Athifa dan H. H. Rachmat, "Evaluasi Karakteristik Deteksi Warna RGB Sensor TCS3200 Berdasarkan Jarak dan Dimensi Objek," *Jetri : Jurnal Ilmiah Teknik Elektro*, hlm. 105–120, Feb 2019, doi: 10.25105/jetri.v16i2.3459.

[15] A. Akbar Rahmat Ramadhan, W. Indra Bayu, dan H. Yusfi, "Pengembangan Alat Ukur Tes Kelincahan Berbasis Teknologi Sensor Infrared," vol. 10, hlm. 294–304, 2022, doi: 10.32682/bravos.v10i4/2777.

[16] S. Nugroho Utomo dan R. Winarso, "Rancang Bangun Conveyor Mesin Planer Kayu Dengan Sistem Penggerak Motor Stepper," Online, 2019.