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Internet of Thing Implementation in The Library System (A Case Study of STMIK Bina Bangsa Kendari)

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Abstract

The subject of this article is the Internet of Things (IoT), particularly in the context of libraries. The author explains the definitions and concepts of IoT, the importance of IoT in libraries, and the potential applications of IoT for libraries. This research is located at the STMIK Bina Bangsa Kendari campus. The goal of this research is to design and simulate a prototype of an IoT-based library system utilizing UHF RFID technology. The research method used in this study is the development of a research and development model. The design of the intelligent library system development is based on two components: system hardware architecture and software development. The development approach uses a prototype development model. The library system can monitor the condition of books in real-time, whether they are available on the shelves, loaned out, or not on the shelves. The library system can provide information in the form of shelf monitoring if a book is misplaced on the shelf. The use of UHF RFID technology allows the application to read tag labels up to a maximum distance of 6 meters, while to support optimal QR Code reading in a room measuring 4 x 4 x 3 meters (L x W x H), a minimum of one bulb with a power of 18 watts is required.

Keywords: Internet of Things, Libraries, UHF RFID, Prototype

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I. INTRODUCTION

UNIVERSITIES need libraries because they are crucial in supporting the educational process. The existence of a library in a university serves as a means of supporting the achievement of the Tri Dharma of Higher Education, which encompasses education, research, and community service. In support of the realization of the Tri Dharma, the library must provide access to the scientific information required. The STMIK Bina Bangsa Kendari Library is situated in Kendari City, Southeast Sulawesi Province. This library is specifically designed for the academic community of STMIK Bina Bangsa, which manages approximately 2,500 library materials, including books and theses, stored on 15 available shelves.

Services at the STMIK Bina Bangsa Library, such as registration, borrowing, searching, and returning books, are still carried out manually for users. This is a problem in serving students. Manual services require energy, time, and thought, and it is not easy to obtain accurate data or information. Therefore, the application of information technology, utilizing the Internet of Things, at the STMIK Bina Bangsa library is necessary to improve library services and achieve a safe, fast, stable, and high-performance system, thereby optimizing asset management and inventory.

In today's digital era, the development of information technology is progressing at an increasingly rAPId pace. Its emergence can change and influence the future of science in everyday life. This requires libraries to be active in improving modern services, such as innovations in independent book lending and returning, book search engines and computers, library communication facilities, technology support services, and library assistance services [1] .

Although most libraries have used barcode technology, computer networks and information systems in their service innovations, there are still many problems in library management, such as book inventory, searching for books on shelves, borrowing, returning, and so on, the problems have not been resolved properly, this hinders the improvement of library management and its service levels [2][3]. To support the success of service and library system management, it is necessary to apply technology that does not require human interaction, but rather high connectivity between devices, namely by implementing Internet of Things (IoT) technology [4][5].

IoT as a dominant phenomenon today is a transformation in daily activities through the utilization of intelligent device capabilities such as Wireless Sensor Networks (WSN) and Radio Frequency Identification (RFID) technology [6]. RFID is a smart technology that can be used to recognize an object [7][8]. Currently, RFID is one of the best auto identification technologies [9], and code capture, on the other hand, has been the subject of extensive literature discussing it as one of sixteen technological developments for the next decade [10].

The use of RFID technology in library management systems can optimize and intelligently integrate automation within library management and its network [4]. RFID is used for the independent book borrowing/returning process, speeding up the search for book locations, minimizing the time needed in the circulation process of borrowing and returning books, each sensor at the exit is connected to the RFID System and the book borrowing/returning circulation system to find out books that come out of the library and reduce theft, the process of handling library materials is carried out automatically, including the process of sorting library materials according to the type of book to be stored in its place, a fast data collection process, namely the ability to scan library materials that are on the shelf without pointing to the book being borrowed or on the shelf, the use of RFID tags has a longer life than barcodes, because there is no direct contact with the RFID tag [3] [4] [11][12][13]. Research into the use of IoT for libraries has been conducted by [8], who proposed theoretical examples related to Internet of Things-based library automation systems, created a framework for utilizing IoT technology in libraries [14], and introduced the concept of utilizing IoT in libraries [15]. So, the goal of this research is to design and simulate a prototype of an IoT-based library system utilizing UHF RFID technology.

II. RESEARCH METHOD

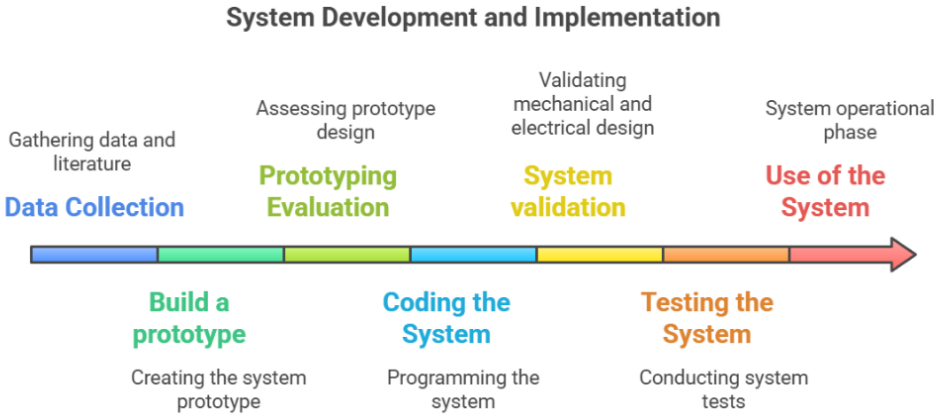

Fig. 1. System Development and Implementation

The research used in this study is the development of the Research and Development model [16]. Designing the development of a smart library system is based on two components, namely: System hardware architecture and software development. The development approach uses a prototype development model.

1. Data Collection: At this stage, the author collects data and existing literature studies. The aim is to identify input and deficiencies in the previously built System and collect journals related to the research, so that the data produced will be more accurate and follow the objectives of this study.
2. The author builds a prototype according to the concept of the System being built.
3. Prototyping Evaluation. At this stage, the author evaluates the prototype design that was built.
4. Coding the System. At this stage, after the prototype design is complete from both the mechanical and electronic perspectives, the programming coding continues into the System that has been built.
5. The author validates the design System mechanically, electrically, and programmatically.
6. Testing the System. At this stage, the author tests the System that has been built. The first test determines whether the book borrowing and returning process is successful. The second test is whether the book search process from the web is successful. The third test is whether this System is easy to use.
7. The System can be used properly.

III. RESULTS AND DISCUSSION

A. System Design

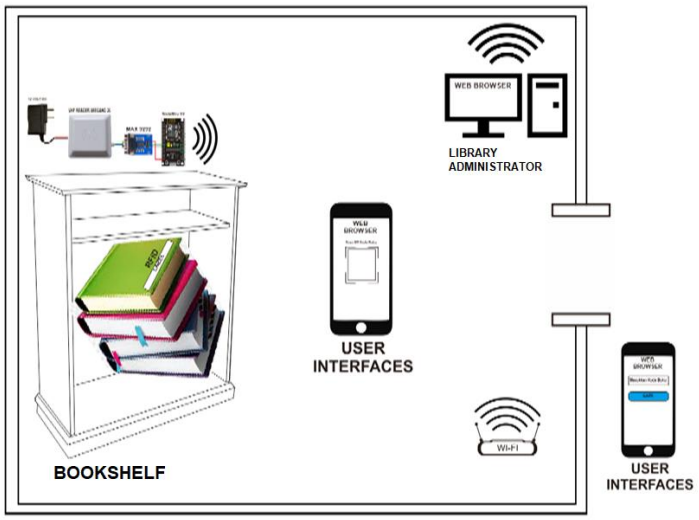

Fig. 2. System Design

In Figure 2, it can be explained that the working principle of the tool used in the library system designed by the researcher is:

1. The process for entering the library is as follows: when a user enters, each user already has an ID assigned by the librarian admin. If not, please register with the librarian admin.
2. Book search process. In this process, the librarian can search for the desired book through the web application from anywhere. When logging in, the system displays recommendations for the most frequently borrowed books to the user. After logging in, the user searches for a book, and the system provides the librarian with information on whether the book is available or not.
3. Borrowing Books: Books available on the shelves can be borrowed by scanning the QR Code on the book, and the book will then automatically display a borrowed status.
4. Book Return Process: In the book return process, the user directly brings the borrowed book to the librarian for scanning and checking for late fines.

B. Schematic Diagram

From Figure 3 it can be explained that the UHF RFID is connected to the DB 9 female connector (red cable on pin 2 - RX, green cable on pin 3 - TX, brown cable on pin 5 - GND), then the DB 9 connector is connected to the RS 232 TTL Male Connector, then the RS 232 is connected to the NodeMCU (on the RS 232 the blue cable is on the RX pin, the yellow cable is on the GND pin, the

gray cable is on the VCC pin) then the cable on the RS 232 is connected to the NodeMCU pin (the blue cable is attached to pin D2, the yellow cable to pin 3V, the gray cable to G)

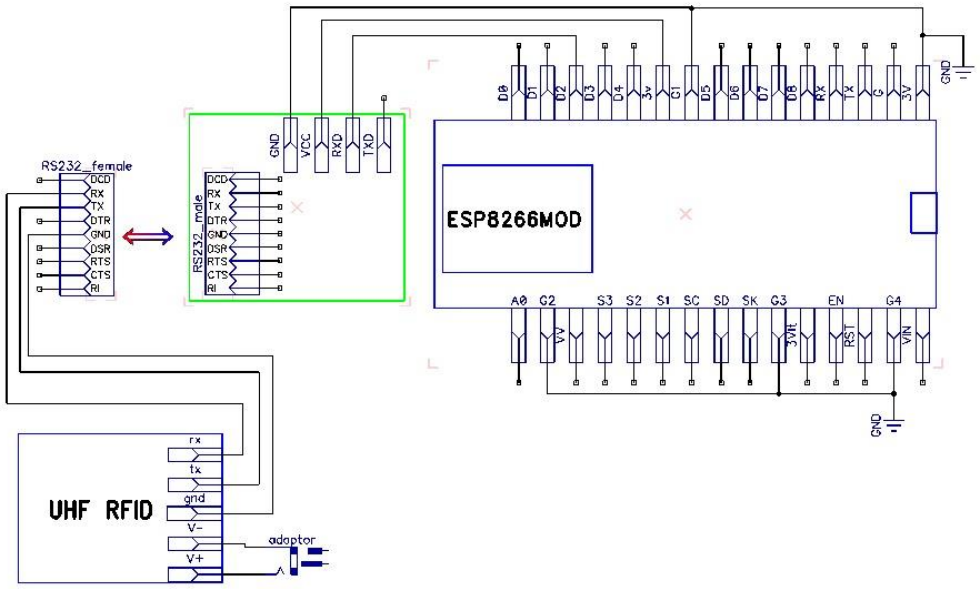

Fig. 3. Schematic Diagram

C. *System Usecase*

1. Library Automation System Use Case

In Figure 4, the use case diagram explains the activities that occur in the library. In the diagram, three actors play roles in the system: the user, the librarian, and the head of the library. The user can only perform activities such as searching for books, borrowing, and returning books that have been previously registered or signed up as library members. The librarian is responsible for managing all activities within the library system, and the head of the library will receive regular reports from the librarian.

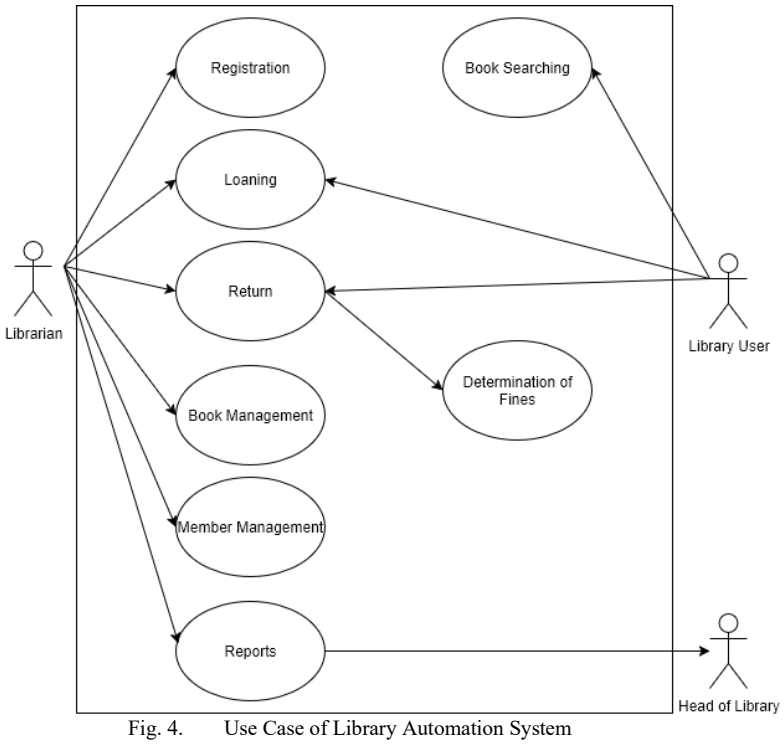

Fig. 4. Use Case of Library Automation System

2. Usecase Report

In Figure 5, the diagram explains the activities in the report use case. The librarian is responsible for generating reports that encompass library data, member reports, loan reports, return reports, and fine reports. All reports are addressed to the library's head.

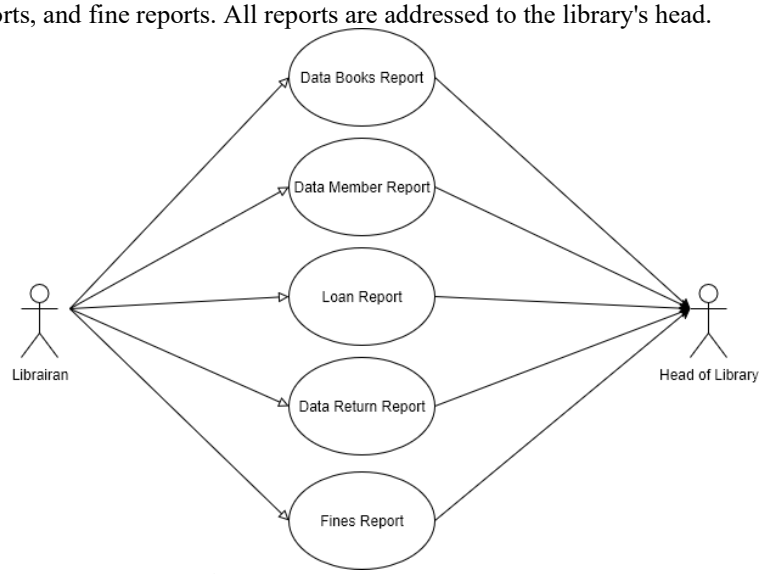

Fig. 5. Use Case Report

D. Hardware Implementation

1. Hardware Design Schematic

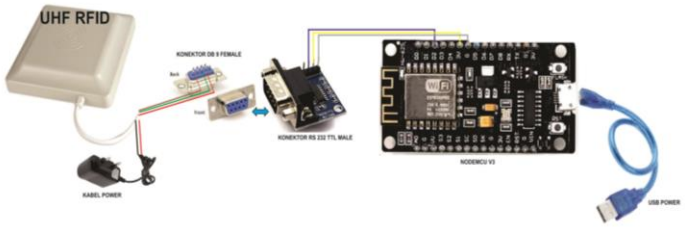

Fig. 6. Hardware Design Schematic

In Figure 6 above, it can be seen that the design of the tool in the library system, specifically the UHF RFID, is connected to the DB-9 female connector. The DB9 connector is connected to the RS232 TTL Male Connector. Then, the RS232 is connected to the NodeMCU. Finally, the cable from the RS232 is connected to the NodeMCU pin.

2. Hardware Diagram Blog

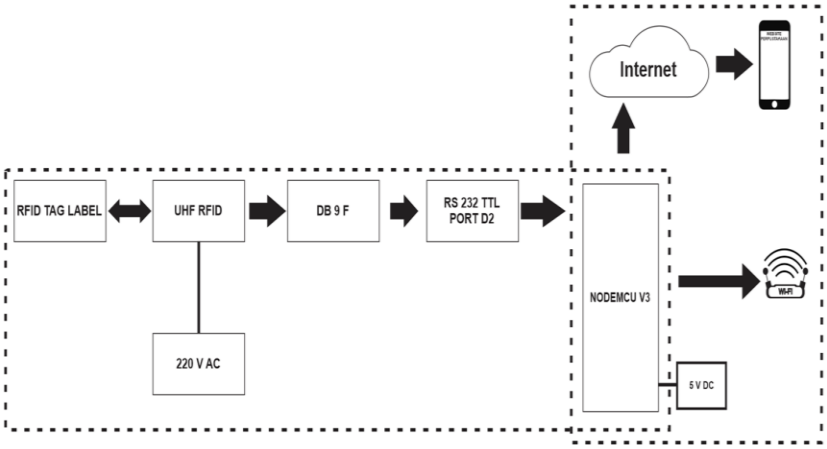

Fig. 7. Hardware Diagram Blog

Based on the block diagram in Figure 7, it can be explained that the working principle of the designed system consists of two blocks. The first block describes the process of reading the tag label code by RFID, the tag label code is forwarded via the RS232 connector to be converted into a hexa number in the NodeMCU in the NodeMCU, then in the second block the tag label code and the NodeMCU serial number that has been created will be sent to the web API to obtain book data (book code, book title, shelf number, book status and book condition) that matches the tag label code and SN provided, then the user can access the web via a smartphone or laptop device connected to the internet.

3. Tool Set on Bookshelf

Fig. 8. Series of tools on the Bookshelf

Figure 8 describes the hardware circuit that has been installed in a rack with UHF RFID connected to NodeMCU via a Max RS232 TTL converter.

E. Flowchart System

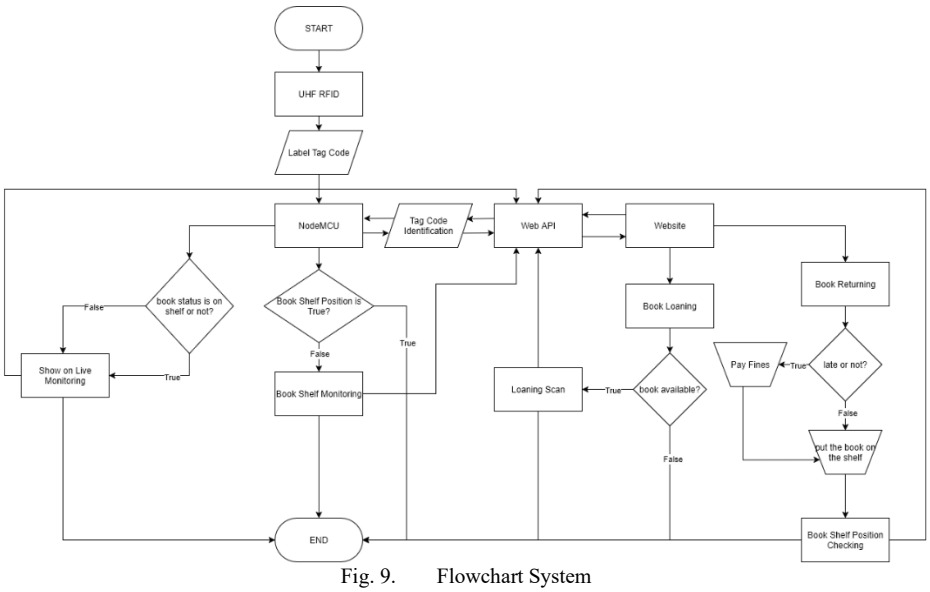

Fig. 9. Flowchart System

Explanation of the flowchart of Figure 9 of how the library system works:

1. Turn on all installed hardware.
2. Connect NodeMCU to the internet by entering the SSID and wifi password.
3. UHF RFID uses radio waves to read the code stored in the tag label, and the arrangement of each tag label's number will not be the same as others.
4. The tag label code is forwarded to the NodeMCU for conversion into a hexadecimal number.
5. The tag label code that has been read by RFID and the SN that has been embedded in the NodeMCU on each shelf are sent to the Web API to be matched with the book data (book code, book title, shelf number, condition, status) that has been input into the website database.

6. Then the website provides information to NodeMCU regarding book data via the web API.
7. Next, NodeMCU provides two conditions: the first condition concerns the status of the book being available on the shelf or borrowed, and the second condition is the position of the book on the shelf, whether it is correct or incorrect.
8. In the first condition, the timestamp is set to 1 hour to update the book's condition, indicating whether it is on the shelf or not. If RFID does not read the book within 40 minutes, its status will be displayed on live monitoring as 'not on the shelf'.
9. In the second condition, the NodeMCU will only read the SN and tag label code on each shelf that has been registered on the web API, so if there is a book that is read not on its shelf, the RFID will check the tag label and then forward the information to the NodeMCU, the NodeMCU sends the data to the web API to be displayed on the website in the shelf monitoring menu on which shelf it is located and where the correct shelf position of the book is.
10. On the website, there are two processes, namely borrowing and returning books.
11. In the borrowing process, if the book is available on the shelf, the librarian can borrow it by scanning the QR code, and the book's status will change from available to borrowed. Then the status change is updated in the web API data to 'borrowed'.
12. In the process of returning books, the librarian submits the book to be returned. Then, the librarian scans the book to see if it has been borrowed. The system then processes the book return. Suppose the system imposes a fine. If not, the librarian will return the book to its shelf. Then, the position of the book on the shelf will be updated in the web API data.

F. Library Application Design

1. Login Page

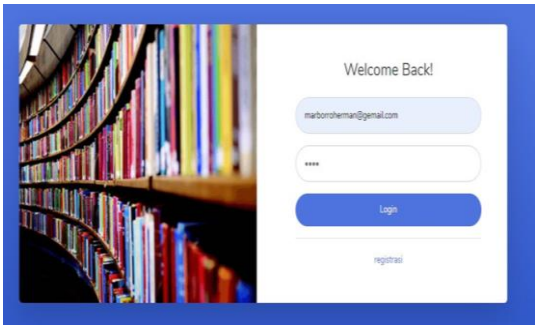

Fig. 10. Login Page

In Figure 10, in the login form, the librarian logs in as an admin. The librarian enters the correct username and password. If the username or password is incorrect, the librarian will not be able to log in to the system.

2. Library Dashboard Page

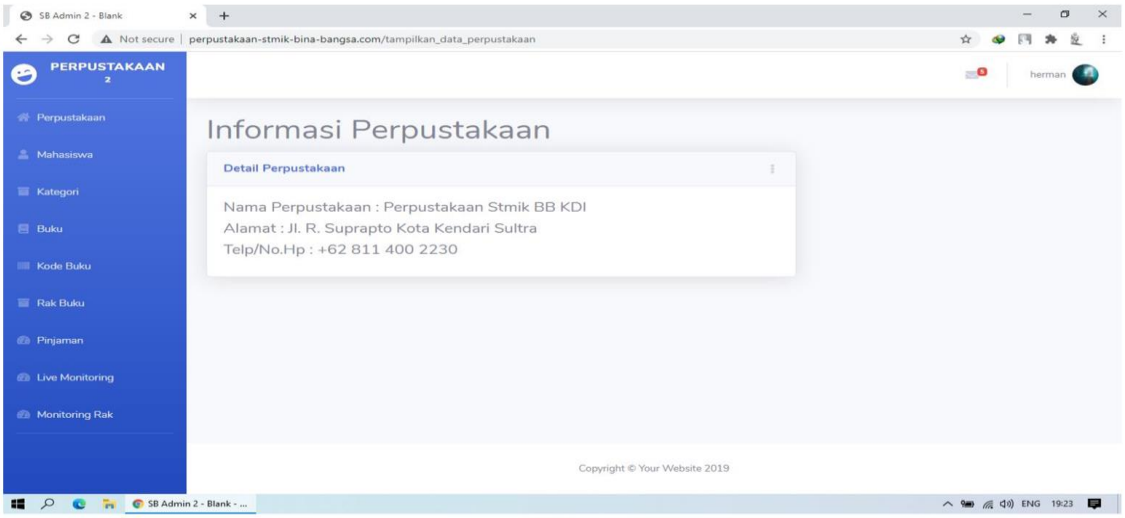

Fig. 11. Dashbord Menu

After successfully logging in, the admin will be shown the dashboard page as shown in Figure 11.

3. Library Member Menu

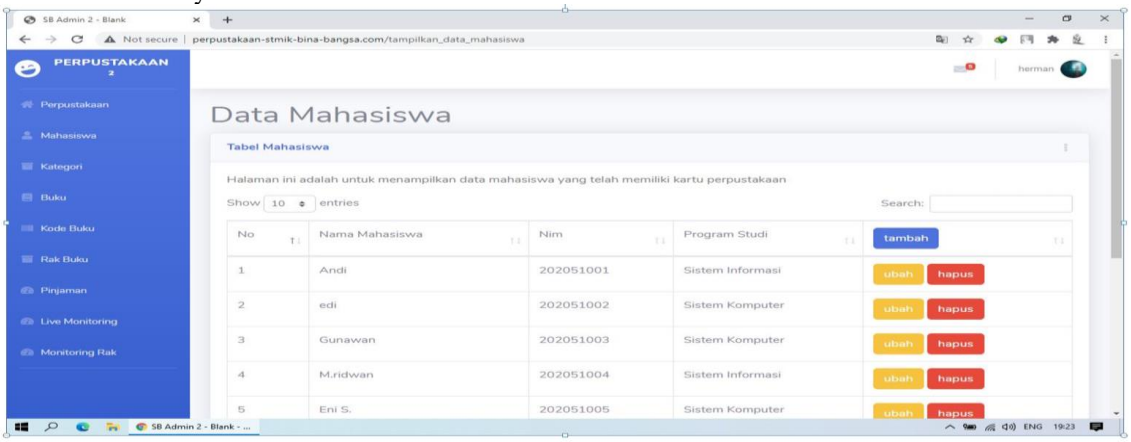

Fig. 12. Library Member Menu

Figure 12 is a menu that librarians can add and delete registered memberships in the library.

4. Book Data Menu

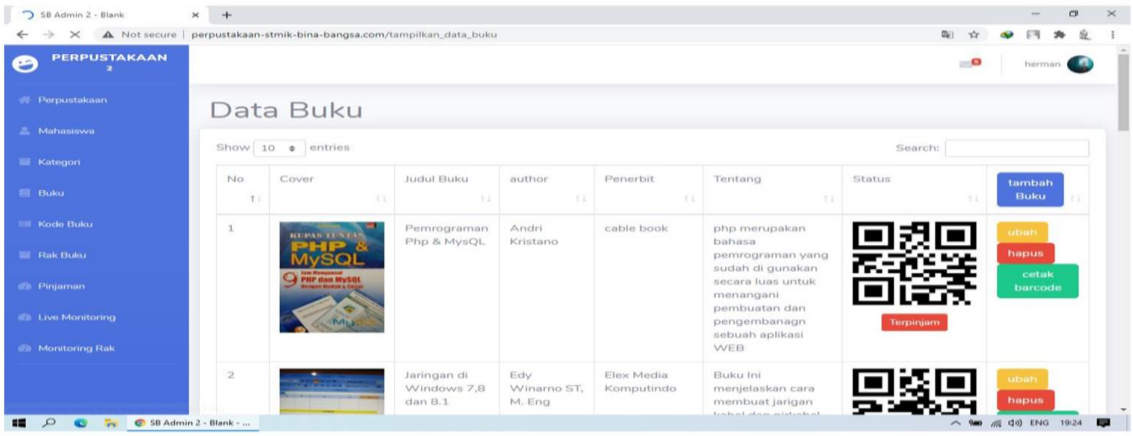

Fig. 13. Book Data Menu

Figure 13 is a menu that the admin can add, change and delete the cover, book title, author, about which contains the book synopsis.

5. Book Loan Menu

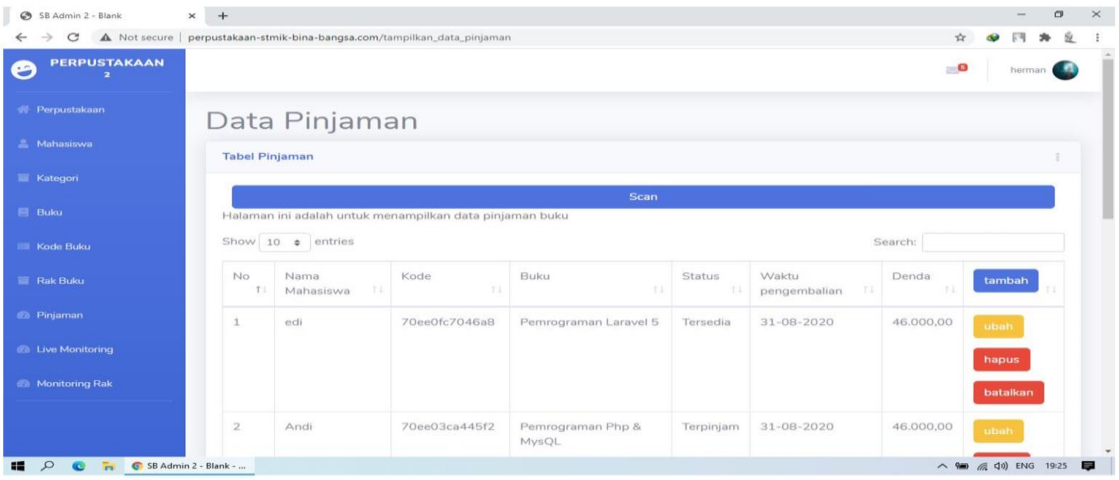

Fig. 14. Book Loan Menu

Figure 14 is a menu that contains Loan Data, borrower name, Loan book code, Loan status and repayment time. In this menu, the admin can add, change and delete borrower name data, Loan book code, Loan status and repayment time.

6. Live Monitoring Menu

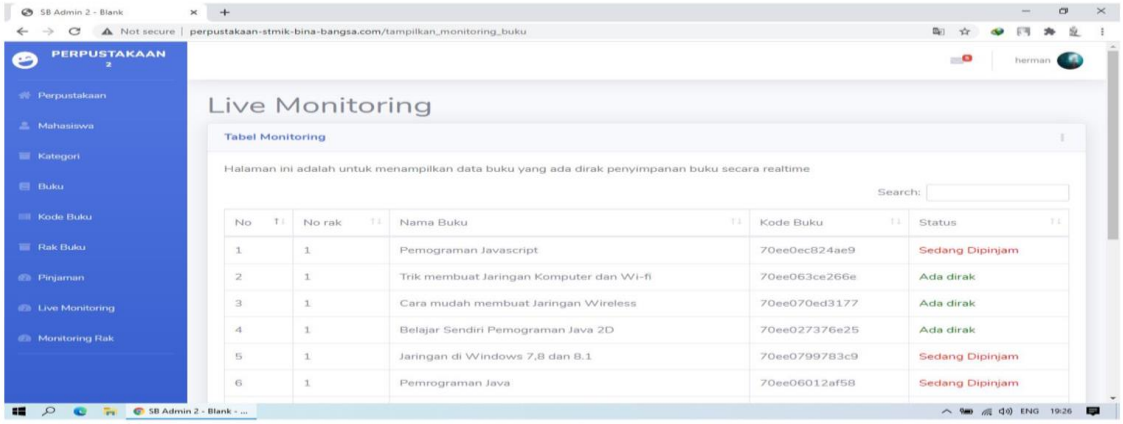

Fig. 15. Live Monitoring Menu

Figure 15 is a menu that displays the condition of the book in real time. The condition of the book is divided into 3, namely: on the shelf, not on the shelf, and being borrowed.

G. *System Testing*

1. Sensor Testing by Distance

TABLE I. SENSOR TESTING BY DISTANCE

No	Distance (meter)	Time response	Status
1	1	0.16 seconds	Read
2	2	0.24 seconds	Read
3	3	0.4 seconds	Read
4	4	1.4 seconds	Read
5	5	2.59 seconds	Read
6	6	3.45 seconds	Read
7	7	-	Can not read
8	8	-	Can not read
9	9	-	Can not read
10	10	-	Can not read

In this test, the researcher read the label tag based on the distance using a manual meter, then calculated the reading time of each size tag using a stopwatch. Table 1 explains that the process of reading the tag label at a distance of 1 to 6 meters is possible, while at a distance of 7-10 meters, the tag label can no longer be read. The maximum distance for reading the tag label is 6 meters. According to [1], this is due to environmental sensitivity factors such as cellphone wave factors, the number of obstacles.

2. Manual testing comparison process testing using the system

TABLE II. COMPARISON TABLE USING THE SYSTEM AND MANUAL METHOD

NO	MANUAL METHOD		USING THE LIBRARY SYSTEM	INFORMATION
	Number of books	Time required	Time required	
1	1	1 minutes 29 seconds	14 seconds	Books taken to be borrowed at once 5 pieces
2	2	2 minutes 25 seconds	26.12 seconds	
3	3	2 minutes 64 seconds	35.26 seconds	
4	4	3 minutes 05 seconds	42.78 seconds	
5	5	4 minutes 73 seconds	51.74 seconds	

The test conducted in Table 2 was conducted in a room measuring 4 x 4 square meters. The distance from the entrance to the shelf is 2 meters, and the distance from the shelf to the admin is 2 meters. The test was conducted by comparing the time it takes to borrow up to 5 books manually with the time it takes to use the system-built feature. In the manual method, it begins with students entering the room, then looking for books on the shelf. After a book is found, it

is brought to the admin to be recorded as a borrowed book. Then, the test was conducted using the system that had been built. The process before students enter the library involves searching for books online first. Students then enter the library, knowing the bookshelf number and title of the book they are searching for, and take the book to be scanned and loaned to them independently.

According to the test above, the average time required to borrow one book using the manual method is 48.146 seconds per book, while using the built-in system is 10.348 seconds per book. It can be concluded that the borrowing process using the automated borrowing system in the library is faster than the manual system.

IV. CONCLUSION

The developed library system can monitor the status of books in real time, whether they are available on the shelves, being borrowed, or not on the shelves. This system can also detect errors in book placement on the shelves and provide information about the most frequently borrowed books, along with their corresponding shelf positions. Through the web platform, students can easily search for the desired book and locate it on the shelf from anywhere. The use of UHF RFID technology allows the application to read tag labels up to a maximum distance of 6 meters, while to support optimal QR Code reading in a room measuring 4 x 4 x 3 meters (L x W x H), a minimum of one bulb with a power of 18 watts is required.

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