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Design of Automatic Attendance System Using RFID and ESP32 Based on Internet of Things (IoT)

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ABSTRACT

The development of RFID technology in the field of education is quite interesting, including the implementation of an automated presence system that is integrated with the database that supports the processing of information about the presence of lectures. The app consists of several major components, such as an RFID Tag, an RFID Reader, and the ESP32 microcontroller. RFID Tags are used to read data and serve as student IDs. This tool system is integrated into the website according to the concept of the Internet of Things. This concept is the communication between the tool system and the website; data is automatically stored directly into the database that has been provided. The mode used by the presence system consists of two modes, namely list mode and presence mode. The functionality of the system hardware and software has been tested to ensure that the tools and components work properly and can function as required. The test results showed that the distance required to be able to read RFID Tags was 0 to 2.5 cm, the read time of an RFID Tag was an average of 2.39 seconds, and the update time of website data was 3.33 seconds. The performance of the system in testing failed to read an RFID Tag three times, with a success rate of 85.71%.

1. Introduction

The manual attendance process for large classes is very disruptive to teaching and learning activities. Attendance is a very important activity in many human life processes including teaching activities so that it becomes a routine activity in the classroom every time the teaching and learning process begins. Manual attendance is certainly quite time-consuming, especially for classes with many participants [1].

Several researchers have conducted research on digital student attendance systems. The system can facilitate the process of recording students entering and leaving the school that has been systemized so that it is easier to find the required data. Research conducted by Ibrohim *et al* in the development of time and attendance systems using RFID technology using Arduino Nano microcontrollers, Borland Delphi 7 for application designers, and data storage with MySQL databases [2]-[5]. Research conducted by Bastian in monitoring student attendance with RFID technology and using the PHP programming language and Bootstrap [6]-[8].

To overcome some of the above problems, a solution is needed to avoid the negative impact caused when collecting attendance data. Therefore, research was conducted on the ability of RFID (Radio Frequency Identification) as a media access control that can identify student data through RFID tags in which a unique serial number has been encoded. As a control system, Arduino is used which is

implemented as a microcontroller in charge of programming RFID in order to identify the code on the tag card [9]-[12].

2. Methods

2.1. Hardware System Design

2.1.1. Block Diagram

RFID acts like a client with an RFID Tag that contains a unique number (UID) which is a unique code that can be read. When the RFID Tag is attached to the RFID Reader module, the tag automatically sends the unique code to the reader. In addition, the RFID Reader after the reading is complete, continues to send data to the ESP32 microcontroller. The data is sent to the server wirelessly via the ESP32 WiFi module [13]. The results in the form of RFID Tags are displayed on the LCD 16x2 I2C module with a character display and a buzzer sounds when the RFID Tag is successfully scanned. Green LED indicates presence mode. For yellow light, the RFID card registration scanning mode (new card or unregistered card) is active. While the red LED indicates that the attendance access failed because the number on the attached RFID Tag is not registered [14]-[15]. The block diagram will be explained in (Fig. 1).

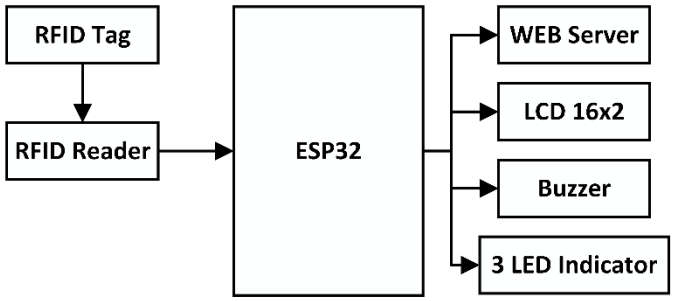

Fig. 1. Production Information System Development Method

2.1.2. Flowchart

RFID Tags that are attached to the RFID Reader are processed and identified by the system. If the RFID number is registered in the website system that has been provided, then the attendance process is complete and the attendance recapitulation data is then stored on the website [16]-[17]. However, if the RFID number is not registered when affixed, then the process that must be done is to register the RFID Tag number into the website system by entering the data provided on the website [18]. If the registration process is complete, the RFID Tag is affixed again, then the result will be successful and the data will be stored in the attendance recapitulation. The flowchart will be explained in (Fig. 2).

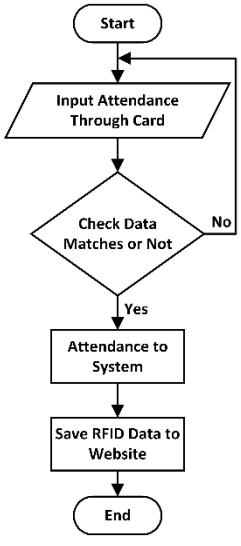

Fig. 2. Flowchart

2.1.3. Entity Relationship Diagram (ERD)

ERD is a level that describes data as a unit of relationships and attributes of the database created [19]. The database design of the system is very important and this design is usually described with ERD, as seen in (Figure 3).

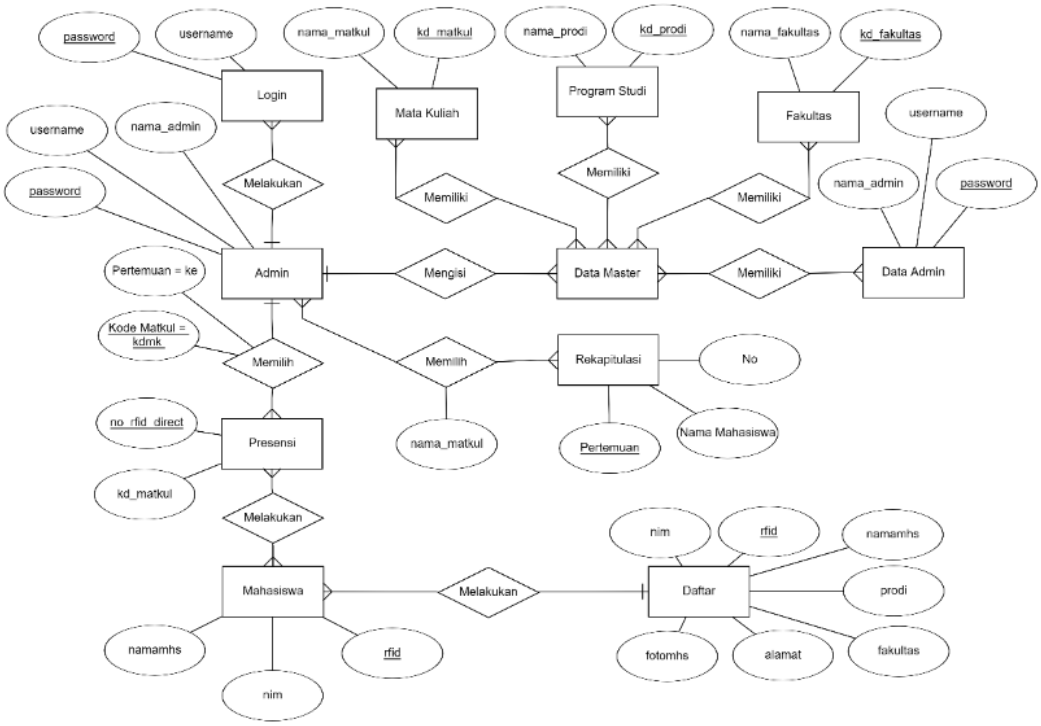

Fig. 3. Entity Relationship Diagram (ERD)

2.1.4. PCB Making

The purpose of making this PCB is to make it easier to assemble the components that will be used to make the automatic attendance device [20]. On the board, the components are connected to the designed path so that there is no need to use jumper cables. The PCB design is made using the Eagle application by entering the components used to make the attendance device.

2.1.5. Making the Attendance Device

The design of the attendance device made consists of several different circuit parts, namely the RFID Tag circuit, RFID Reader, push button, buzzer, 3 LEDs and LCD module [21].

1. RFID Tag, used as input for time recording is made and designed in the form of a student card. Each card has a different identifier to identify the owner of each card.
2. RFID Reader, used for RFID Tag readers, RFID Reader is connected to ESP32 for the data input process. The type of RFID Reader used in this tool is the RFID MIFARE RC522 type.
3. Push Button, used as a mode changer between modes when taking attendance and when registering students. When in attendance mode, the menu that is only used on the website is the "PRESENCE" menu. While when in registration mode, the menu that is only used on the website is the "STUDENT DATA" menu in the "ADD STUDENT" column. The settings on the website have also been set according to the mode on the attendance tool.
4. Indicator module (Buzzer and 3 LED lights) which functions as an indicator for the automatic attendance device. When in "Presence Mode", the registered RFID Tag is then installed on the RFID Reader, the bell will sound and the green LED will light up to indicate successful attendance. During this time, if an unregistered RFID Tag is attached to the RFID Reader, the red LED will light up to indicate that the attendance has failed and needs to be registered. What to do when the attendance fails is to change the "Presence Mode" to "Register Mode" by pressing the push button, the yellow LED will light up.

5. 16x2 LCD module, used as an additional indicator that functions to display whether the RFID Tag card attached during "PRESENCE MODE" can be accessed or not. The display that will be displayed is "Success" when successful and "Failed" when failed.

2.2. Software System Design

2.2.1. Arduino IDE Program Creation

Arduino IDE is an application for programming ESP32. This application has a C/C++ library. To simplify the programming process that uses supporting libraries provided by the programmer [22]. Choosing this method reduces the time needed to create a program and makes all tools easier to use.

1) The WiFi.h library functions to access WiFi functions.
2) The HTTPClient.h library to access an http request to the client.
3) The SPI.h library functions as Serial Peripheral Interface (SPI) communication on RFID.
4) The MFRC522.h library to access the Mifare RC522 type RFID.
5) The ArduinoJson.h library to access C++ programming for embedded systems.
6) The LiquidCrystal_I2C.h library to access I2C and LCD.

Each RFID Tag has a different unique number (UID) which functions as an identifier or identity. This UID is used as an attribute or identity for each student, as can be seen in (Fig. 4). Next, send the RFID Tag data that has been read to the web server. The program for sending data requests to the server can be seen in (Fig. 5).

```
void GetRFID()
{
lcd.setCursor(0, 0);
lcd.print("Silakan Presensi");

if (!mfrc522.PICC_IsNewCardPresent()) {
return;
}

if (!mfrc522.PICC_ReadCardSerial()) {
return;
}

String content = "";
byte letter;

for (byte i = 0; i < mfrc522.uid.size; i++) {
content.concat(String(mfrc522.uid.uidByte[i] < 0x10 ? " 0" : " "));
content.concat(String(mfrc522.uid.uidByte[i], HEX));
}
content.toUpperCase();
Serial.print("UID tag :");
Serial.println(content.substring(1));
```

Fig. 4. RFID Reading Program

```
void SendData(String data)
{
  if (WiFi.status() == WL_CONNECTED) {
    //Declare object of class HTTPClient
    WiFiClient client;
    HTTPClient http;

    //prepare request
    String postData = "UIDresult=" + data + "&reg=" + isRegister ;

//    lcd.setCursor(0, 1);
//    lcd.print("Sending...");

    http.begin(host);
    http.addHeader("Content-Type", "application/x-www-form-urlencoded");
    int httpCode = http.POST(postData);
    String payload = http.getString();

    Serial.println(httpCode);
    Serial.println(payload);

    if (httpCode == 200)
    {
      Beep(200);
      delay(100);
      Beep(100);
      digitalWrite(ledPinGreen, LOW);
      delay(2000);

      // get data
      for (;;) {
        if (GetData())
          break;
      }
    }
    http.end();
```

Fig. 5. Data Request Sending Program to Server

2.2.2. Database System Design

This step uses XAMPP and Sublime Text 3 to design a MySQL database system. The XAMPP application runs the server and opens a local area network to be used to modify database tables. Sublime Text 3 is used to create web applications on demand. The information obtained is collected and connected to the website, so that every change that occurs is also a database change or online.

2.2.3. PHP and HTML Program Design

The PHP program is used to display web pages and database views in the browser, making it easy to observe, add, edit, and delete data. The website interface display has several main displays, namely student data which contains all information about registered students, there is also a section for adding or registering students, master data which contains information about courses, study programs, faculty data, admin data, a recapitulation page displays the attendance list when the attendance ends, the attendance scan is used as a page to start the attendance and logout to exit the web.

3. Results and Discussion

The purpose of this test is to find out whether the system is working well, whether the results are in accordance with what has been achieved, or there is still room for improvement. In addition, this test also aims to find out how it works and analyze the weaknesses and limitations of the functional specifications of the application created. Then you will find out when testing the system. The following are some compilation and observation tools and test results for the presence and interface tools built on the web server.

3.1. Hardware System Testing

The purpose of this test is to find out whether the system is working well, whether the results are in accordance with what has been achieved, or there is still room for improvement. In addition, this test also aims to find out how it works and analyze the weaknesses and limitations of the functional specifications of the application created. Then you will find out when testing the system. The following are some compilation and observation tools and test results for the presence and interface tools built on the web server.

3.1.1. Local Network Testing

The results of this test are displayed in the form of a connection status and are displayed in the Sharing and Network Setting area on the computer. After entering the correct username and password, the network connection status is connected, which can be seen in (Fig. 6).

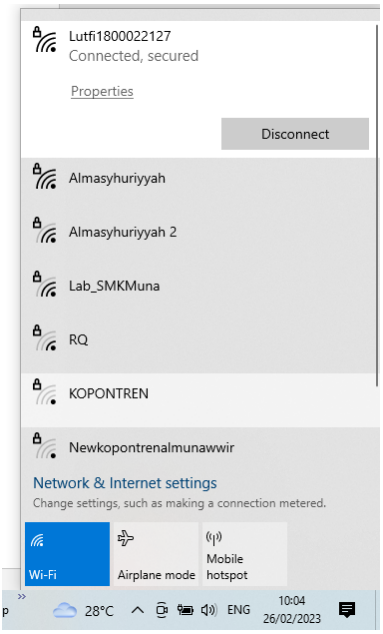

Fig. 6. Connected Local Network

In addition, the results of this experiment can be seen from the success message on the LCD screen of the device that is present. This message will appear as "Connecting" on the LCD screen when searching for a network. If successful, the next step will display the message "Please Presence". The display connected to the local network automatically switches to presence mode, as seen in (Fig. 7).

Fig. 7. Searching for Local Network

3.1.2. RFID Card Reading Testing

This test aims to test the functionality of the program and tools used to read the UID on the RFID Tag. UID readings are taken from all cards generated during testing to determine the identity of each RFID Tag. This test is carried out on 8 types of cards (5 registered cards, 3 unregistered cards). On the Arduino IDE serial monitor display, tags that have been registered or have not been registered will

appear because the program settings are limited to reading the RFID Tag number only. To find out which cards have been saved or have not been saved, you can see the screen that appears on the LCD, the display will show "Success" for cards that have been saved. While "Failed" for cards that have not been registered. In addition, it can also be seen by looking at the website which will be explained later in the software testing. RFID Card Testing can be seen in (Fig. 8).

Fig. 8. RFID Card Testing

In addition, there are also other indicators on the device, namely three LED lights, one push button and one buzzer. The function of the 3 LED lights is, the green light is on as an indicator of presence mode, the RFID reading is correct and the RFID number has been registered, the red LED light is on as an indicator of failed reading and the RFID number has not been registered, and the yellow light is on as an indicator of register mode. The push button itself functions to change modes, namely between register mode and presence mode.

In addition, the test results on the device for reading student identity cards are explained in Table 1 format. Table 1 explains the different UID numbers on each RFID Tag. Therefore, the UID can be used as a student ID card. Then a test is carried out to determine whether the RFID card is registered or not, explained in Table 2. In addition, there is a distance and time test to find out how far and how long it takes for the RFID Reader to read the RFID Tag. This test was carried out by taking 21 measured samples which will be explained in Table 3.

Table 1. Results of RFID Card Reading Tests

No	RFID Number	NIM	Student Name
1	E9 3B 6A B3	10001	Student 01
2	29 09 8C A2	10002	Student 02
3	29 C2 64 A3	10003	Student 03
4	ED 64 E6 23	10004	Student 04
5	89 99 66 A3	10005	Student 05
6	69 2A 04 E5	10006	Student 06
7	B9 2A 04 E5	10007	Student 07
8	29 C3 3B E8	10008	Student 08

Table 2. RFID Card Test Results

No	Student Name	Alat	LED	Website	Information
1	Student 01	Read	Green	Read	Registered
2	Student 02	Read	Green	Read	Registered
3	Student 03	Read	Green	Read	Registered
4	Student 04	Read	Green	Read	Registered
5	Student 05	Read	Green	Read	Registered
6	Student 06	Read	Red	Not Read	Not Registered
7	Student 07	Read	Red	Not Read	Not Registered
8	Student 08	Read	Red	Not Read	Not Registered

Table 3. Experiment Results and Distance and Time Tests

No	Student Name	Distance (cm)	Time (second)		Status
			Tools	Website	
1	Student 01	Affixed	2.43	3.64	Read
2	Student 03	Affixed	2.77	3.44	Read
3	Student 05	Affixed	3.22	3.98	Read
4	Student 01	0.5	2.51	3.22	Read
5	Student 03	0.5	2.38	2.90	Read
6	Student 05	0.5	2.96	3.55	Read
7	Student 01	1	1.97	3.18	Read
8	Student 03	1	1.46	2.62	Read
9	Student 05	1	2.93	3.20	Read
10	Student 01	1.5	-	-	Not Read
11	Student 03	1.5	2.21	3.48	Read
12	Student 05	1.5	1.04	2.45	Read
13	Student 01	2	2.68	3.70	Read
14	Student 03	2	-	-	Not Read
15	Student 05	2	2.97	3.97	Read
16	Student 01	2.5	1.99	3.34	Read
17	Student 03	2.5	-	-	Not Read
18	Student 05	2.5	-	-	Not Read
19	Student 01	3	-	-	Not Read
20	Student 03	3	-	-	Not Read
21	Student 05	3	-	-	Not Read

In the experiment, the distance needed to read the RFID Tag was 0-2.5cm. While the time needed for the tool to read the RFID Tag had an average of 2.39 seconds and the time needed for the website was an average of 3.33 seconds. In addition, of all the experiments carried out, only 3 experiments could not read the RFID Tag and had a value of 85.71%.

3.2. Software System Testing

The procedure for testing the MySQL web application and Database is the same as testing the hardware when checking the RFID value on the serial monitor screen. The difference between checking the RFID value on the serial monitor and on the website is that the UID number is already stored in the database. After the data is returned from MySQL, the data will be displayed on the previously created website, and the data will be directly managed by the administrator for new users and registrants. The admin then enters the new user registration name, UID number, NIM, study program, faculty, and address. Specifically for the UID number column, it will automatically display the number when the RFID Tag is attached to the RFID Reader.

3.2.1. WiFi Configuration Testing (Access Point)

In it, the ESP32 manages the local network. This is used to search for registered networks to automatically transfer the data that has been read to the database system. The ESP32 processes the data that has been read and displays it according to the success status on the specified LCD. After entering the registered username and password, the network connection status will then be connected, as seen in (Fig. 9).

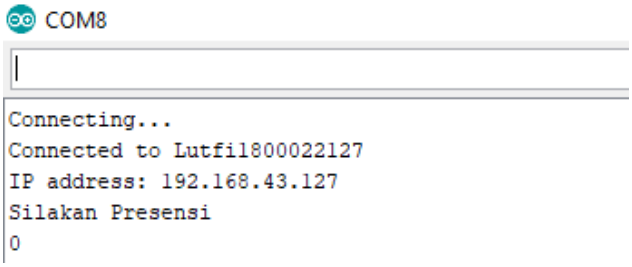

Fig. 9. Local Network Configuration Testing Display on the Serial Monitor

The indicator to find out whether Wifi is connected or not is on the 16x2 LCD module. On the LCD module, "Connecting" will be displayed when searching for a Wifi network, while when the Wifi is connected, "Connected" will be displayed. If the local network has not been found by the system, the search will continue to be repeated.

3.2.2. Student Data Reading System Testing

This test is intended to identify a functioning web program and a tool that has been designed to read RFID Tags. Student reading data is shown in (Fig. 10).

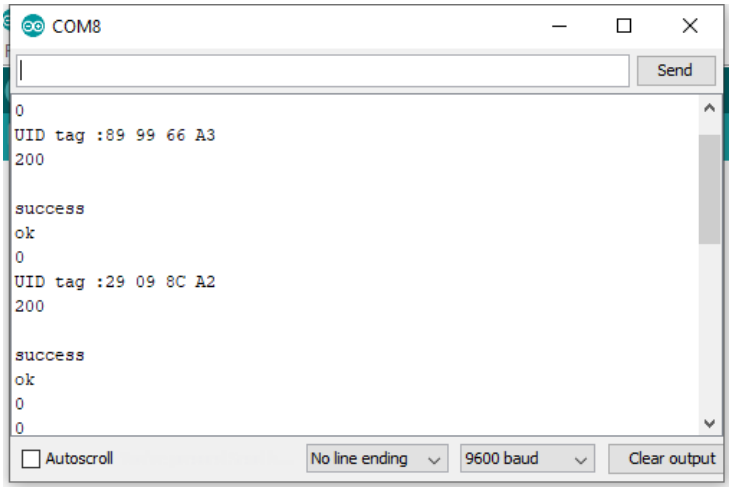

Fig. 10. Display of Test Success on Serial Monitor

3.2.3. Website Page Testing

A) Login Page

This page is the first thing that will be seen when accessing the web application. This page requires users to fill in two columns: username and password, can be seen in (Fig. 11).

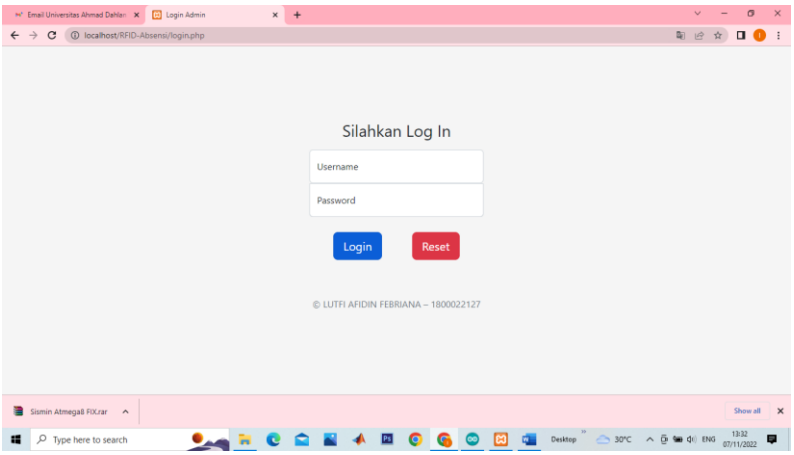

Fig. 11. Login Display

B) Menu Page

The display that appears after the login page is the menu page which includes Student Data, Master Data, Attendance Recapitulation, Attendance and Logout data, can be seen in (Fig. 12).

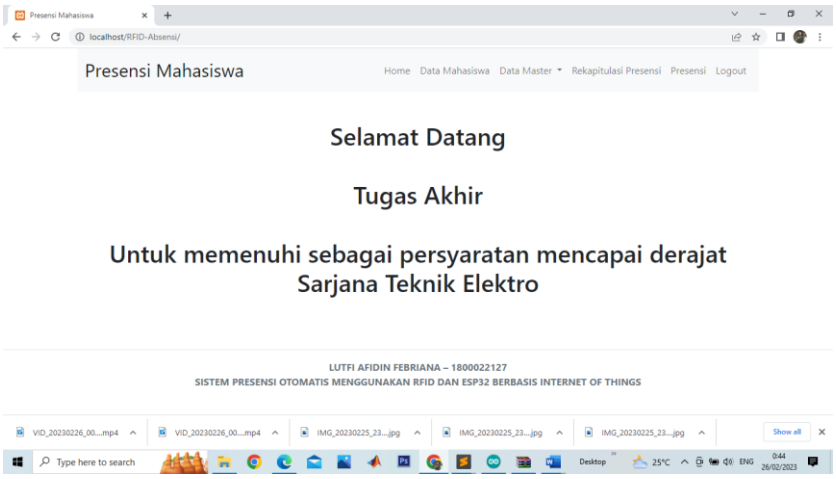

Fig. 12. Menu Display

C) Student Data Page

This page will display registered student data. On this page there is also an "Add Student Data" feature which aims to add students who are not yet registered to the website data. The student data page can be seen in (Fig. 13).

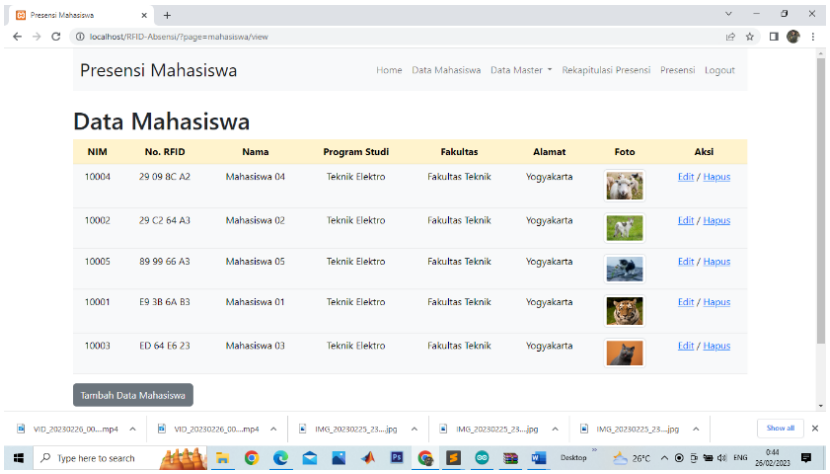

Fig. 13. Student Data Display

D) Master Data Page

This page has optional features, namely Study Program, Faculty, Course, and Administrator Data. This aims to add data according to these features, which can be seen in (Fig. 14).

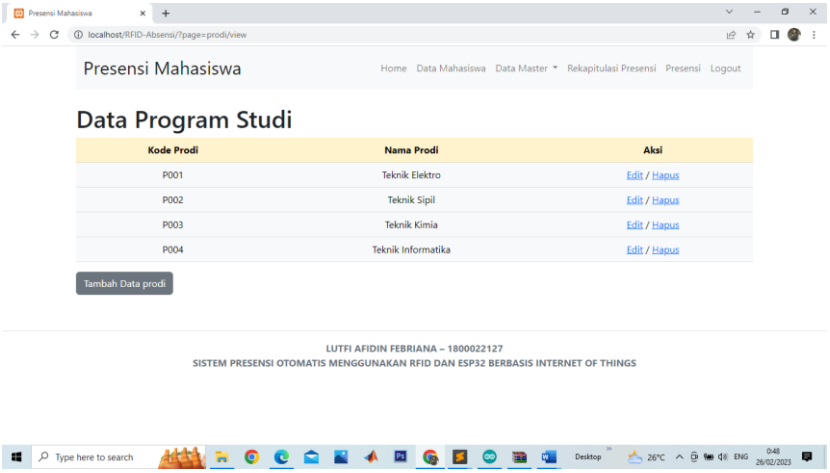

Fig. 14. Master Data Display

E) Attendance Recapitulation Page

On the attendance recapitulation page, the pages displayed are several choices of Courses to be selected. The attendance recapitulation page can be seen in (Fig. 15).

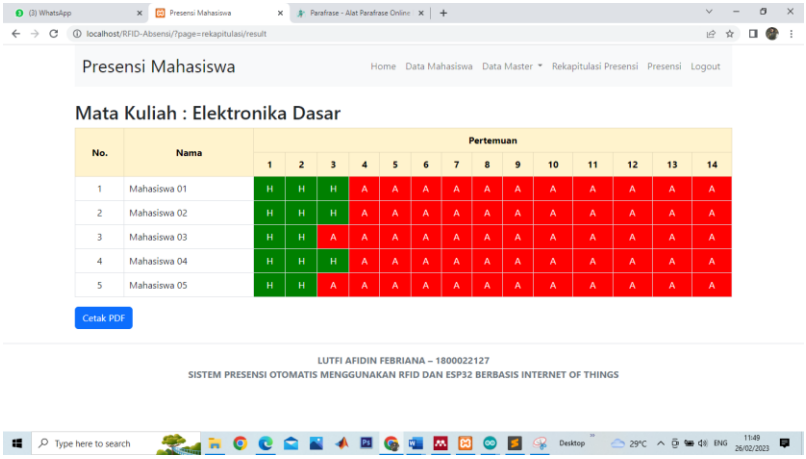

Fig. 15. Attendance Recapitulation Display

F) Attendance Page

Then on the attendance page, there is a feature to select courses and select meetings. This aims so that the attendance made by students can be saved according to the courses and meetings selected. The attendance page can be seen in (Fig. 16).

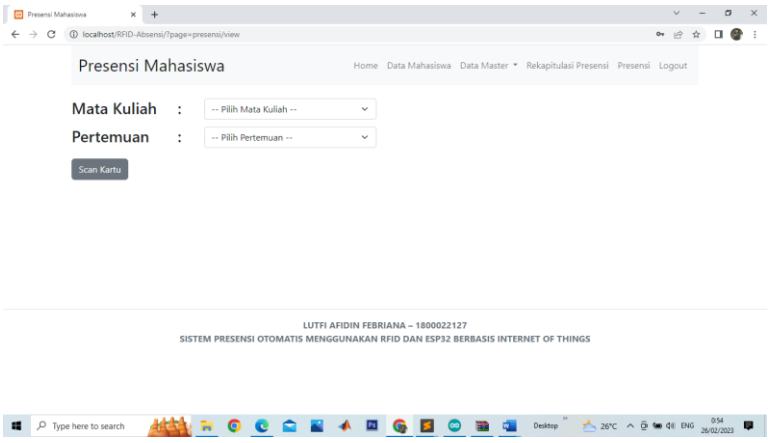

Fig. 16. Attendance Page View

3.2.4. REST API Method Testing

Testing is done as a way that the communication system between ESP32 and the local server is functioning properly. The tool sends a request to the local server and waits for a response from the server. The local server address used in this test is 192.168.43.219 and the PHP directory used is the RFID-Absensi/absensii/response.php directory on the local server, as seen in (Figure 17).

```
const char *host = "http://192.168.43.219/RFID-Absensi/getUID.php";
String url = "http://192.168.43.219/RFID-Absensi/presensi/response.php";
```

Fig. 17. REST API Address Program

4. Conclusion

The tool design that has been made can be used to create an attendance system and can be connected to a server with a local area network. Enter all the required data parameters into the database. After testing the card reading, this tool can distinguish between registered and unregistered cards. On the website system on the tool there is a feature to print the results of the attendance

recapitulation in pdf format. From several tests, the results obtained are that the distance needed to read the RFID Tag is 0-2.5cm. Meanwhile, the time needed by the device to read the RFID Tag has an average of 2.39 seconds and the time needed by the website with an average of 3.33 seconds. In addition, from all the experiments conducted, only 3 experiments were unable to read the RFID Tag and had an overall value of 85.71%.

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