بسم الله الرحمن الرحيم

Palestine Polytechnic University

College of IT and Computer Engineering

Graduation Project

Title: IoT-Based Attendance System Using RFID and Fingerprint

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إهداء

** الْحَمْدُ لِلَّهِ الَّذِي هَدَانَا لِهَٰذَا وَمَا كُنَّا لِنَهْتَدِيَ لَوْلَا أَنْ هَدَانَا اللَّهُ ** صدق الله العظيم

الحمد الله حباً وشكراً وامتناناً ، ما كنا لنفعل هذا لو لا فضل الله فالحمد الله على البدء وعلى الختام

وسط أحداث أليمة وقعت منذ قرابة الخمسة أشهر ومجازر بشعة وقعت بأبناء شعبنا و غزتنا الحبيبة، ووسط

اقتحامات امتدت اياماً وايام نصل اليوم الى مبتغانا وقلبنا يعتصر ألماً وثاراً لأبناء جلدتنا، و نقف شامخين رافعين

الرأس تحية رحمة واجلال لشهدائنا الأبرار رحمهم الله، وما نحن مكملين اليوم إلا رغبة في إحياء بلادنا ،

ورغبة لقهر الكيان الذي يمحي وجود فلسطين ونفوذها في العالم ومتعلميها وعلمائها ويعمم الجهل ولكن هيهات له ذلك

إلى من لا توفيهم الكلمات والحروف حقهم في البر والإحسان ، إلى من رضا الله في رضاهم وما توفيقنا وسر نجاحنا إلا بهم،
إلى من كللهم الله بالهيبة والوقار، إلى من علّمونا العطاء بدون انتظار، إلى من كان دعاؤهم سر نجاحنا وحنانهم سر تقدمنا، إلى من نحمل اسماءهم بكل افتخار، نرجو من الله ان يمد بأعماركم لتروا ثمارا قد حان قطافها بعد طول انتظار، وستبقى كلماتكم نجوما نهتدي بها اليوم وفي الغد والى الابد

والدينا العزيزين

إلى من هم أقرب إلينا من روحنا إلى من شاركونا حضن الأم وبهم نستمد عزتنا واصرارنا

إخوتنا الأعزاء

إلى من آنسنا في دراستنا وشاركنا همومنا تذكاراً و تقديراً

أصدقاؤنا
جميعا نهدي ثمرة هذا الجهد المتواضع وفاءا الى حاملي لواء النور والسائرين في دربهم بإخلاص كل أساتذتي وجميع طلاب العلم
وقبل أن نمضي نقدم أسمى آيات الشكر والامتنان والتقدير والمحبة إلى مشرفنا الدكتور عليان أبو غربية الذي تفضل بالإشراف على هذا المشروع فجزاه الله كل خير وله منا كل التقدير والاحترام على جهوده الطيبة ومتابعته التي بذلها في سبيل تعليمنا ونجاحنا

وآخر دعواهم أن الحمد لله رب العالمين

صدق الله العظيم

Abstract

The "IoT-Based Attendance System Using RFID and Fingerprint" project is an innovative solution aimed at automating attendance tracking within educational institutions or businesses using IoT, with clear motivation and scope. The system uses Radio Frequency Identification (RFID) technology and fingerprinting to identify and authenticate individuals without requiring direct contact and then logs the data to the database of the website with the help of Wi-Fi modules.

The proposed methodology includes an RFID reader, RFID tags, Fingerprint Sensor, and a central database that stores all attendance records using a website. Each individual is assigned his fingerprint and a unique RFID tag that they carry with them, and the device is located at the entrance of the classroom or workplace, scans the tags, and records attendance in the database.

The system's main objectives are to be user-friendly, efficient, and accurate, and it eliminates manual attendance tracking, which can be time-consuming and error-prone. Real-time attendance data is also available, which enables educators and managers to monitor attendance and take appropriate action when absenteeism or lateness is detected.

The innovative IoT-based Attendance System we designed automates attendance tracking in educational institutions using RFID and fingerprint technology. Findings show improved accuracy, efficiency, and security, leading to streamline administrative processes and cost savings. Real-time monitoring and data analytics capabilities further empower decision-making via a web application connected to a centralized database. Overall, Our system achieved all of these aims.

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Chapter 1: Introduction

1.1 Overview:

The tracking of attendance is an important process in educational institutions and businesses since it provides valuable data regarding the attendance and punctuality of students and employees. However, traditional methods of tracking attendance such as handwritten sign-in sheets and barcode scanners can be time-consuming, labor-intensive, and prone to errors. In recent years, Radio Frequency Identification (RFID) and Fingerprint technology have emerged as a promising solution to automate attendance tracking.

The IoT-based Attendance System is a groundbreaking concept that uses RFID and fingerprint technology to automate attendance tracking in educational institutions and companies. This approach is intended to be efficient, accurate, and simple to use.

1.2 Problem Statement:

Manual attendance systems in educational institutions and workplaces are often time-consuming and prone to errors. This can lead to inaccurate attendance records, which can result in confusion and disputes between students/employees and administration. To address this problem, we propose the development of an IoT-based Attendance System using RFID and Fingerprint technology. This will automate the attendance process and make it more efficient, accurate, and convenient.

1.3 Aims:

The project aims to address the limitations of traditional attendance tracking methods by providing a modern and reliable IoT system with two-factor authentication that eliminates the need for manual attendance tracking. The system allows individuals to be identified and authenticated in a contactless manner, reducing the risk of errors and ensuring accurate attendance records.

1.4 Objectives:

1. To design and implement an IoT-based Attendance System using two-factor authentication that can accurately record and store real-time attendance data.
2. To streamline the attendance tracking process by reducing the time and effort required to collect attendance data, especially in large institutions like Universities.

3. To improve the efficiency of educational institutions or businesses by providing an automated attendance tracking system.
4. To develop a system that can quickly and accurately track student attendance, reducing errors and ensuring accountability.
5. To replace manual attendance tracking methods with a more reliable and efficient system that eliminates the risk of human error.

1.5 System requirements:

1.5.1 Functional Requirements:

1. RFID Card Creation: The system should allow administrators to create RFID cards for students/employees.
2. Fingerprint Creation: The system should identify the student's fingerprints and store them in database
3. RFID Reader: The system should have RFID readers to scan RFID cards.
4. Fingerprint sensor: The system should have a Fingerprint sensor to scan users' Fingerprints.
5. Attendance Tracking: The system should track attendance data automatically using a database of a website when students/employees scan their RFID cards with fingerprints.
6. Attendance Record Storage: The system should store attendance records in a centralized database connected to a web application.
7. Attendance Reporting: The system should generate daily, weekly, and monthly attendance reports that can be accessed by teachers/employers.
8. System Administration: The system should have an administrator dashboard that allows administrators to manage user accounts, view attendance data, and configure system settings.
9. Error monitoring: The system should show errors that occur in the attendance sign stage.
10. The student must record his attendance with the RFID card and the fingerprint using one of them or together depending on the determined way.
11. Enrollment: The student may proceed with registration in the system by generating RFID card. Upon the initial attempt to record attendance within the classroom, the student is required to scan their RFID card. Subsequently, the system will prompt the student to scan their fingerprint,

facilitating the storage of this information within a database connected with the website, for the first time for enrollment and then verification at other times.

12. Directing: The system should direct the student who tried to register in the wrong classroom to the right one where his lecture is.

1.5.2 Non-Functional Requirements:

1. Use secure transmission protocols: The communication between the system and the centralized database should be encrypted using secure transmission protocols to prevent interception and data theft.
2. Use a reliable database management system: The attendance data needs to be stored in a reliable database management system to ensure that it is easily accessible and secure. The database should be designed to handle large volumes of data and should have a backup system in case of system failure.
3. Scalability: Choose a scalable system. The system should be scalable to accommodate a large number of students/employees.
4. User-Friendly: The system should be user-friendly and easy to use for both administrators and students/employees by designing a simple and intuitive user interface.
5. Performance: The system should be able to process attendance data quickly and efficiently.
6. Compatibility: The system should be compatible with existing hardware and software in the institution or workplace.
7. Maintainability: The system should be easy to maintain and update.

1.5.3 Specific Security Requirements:

- Confidentiality: The system should use encryption techniques to secure attendance data during transmission and storage using SSL/TLS.
- Integrity: Ensure that the data within the transmission isn't modified. Connect all nodes to a different special network from a public one. Apply a secure hash algorithm before storing credentials.
- Availability: Ensure that the system (using a power bank) and internet connection are always available.
- Authentication: The system should require authentication to access attendance data to view and analyze attendance over the Internet from anywhere at any time, and only authorized users should be able to view the data.

- Authorization: Every user in the system has privileges to access the data.
- Accountability: The system should have a log file for tracking actions on a system.
- Physical Security: The RFID readers and other components of the system should be physically secured to prevent tampering or unauthorized access.

1.5.4 Derived Requirements:

- Network Security: The system should be designed to prevent network attacks, such as denial-of-service attacks, and ensure that network traffic is encrypted.
- Vulnerability Management: The system should have a vulnerability management process in place to identify and mitigate security vulnerabilities in the system.
- Incident Response: The system should have an incident response plan to handle security incidents and minimize the impact of security breaches.
- User Awareness: The system should promote user awareness about security risks and best practices for handling sensitive attendance data, such as using strong passwords and avoiding phishing scams.
- The system should send an email to the student/employee as a notification to show that he is attending that class.
- The RFID card should be embedded in the Student ID card.
- There is another design option for biometrics in this system like face recognition. Face recognition is a technology capable of matching a human face from a digital image or a video frame against a database of faces.
- In the future, we hope that our project will be able to record attendance during exam periods.
- Data Backup: The system should have a backup mechanism to ensure that attendance data is not lost due to system failure or data corruption.

1.6 Technologies used:

1. RFID Readers.
2. Fingerprint sensor.
3. RFID Tags.
4. HTML, CSS
5. PHP and MYSQL using PHPMyAdmin
6. Programming Languages: C++, JS

7. SSL/TLS encryption.
8. SHA-256
9. MySQL database.
10. Xampp
11. Vscode
12. Postman

In this chapter, we talked about an overview of the system, defining problem statements, general objectives, and system and security requirements.

Chapter 2: Background and Review of Literature

2.1 Literature review:

Several projects have been conducted to create an attendance and absence system for students to replace the traditional paper method. One such project is the "Attendance system with the combination of RFID and web-based system," which utilizes RFID tags and readers to obtain attendance data that is passed on to a web server via an Arduino microcontroller and stored in a database using PHP and MySQL.The admin of this system can view all students, and documents by logging in to this particular Web-based application and also can view the student's details using LCD displays **[1]**.

Another project is the "RFID and Pose Invariant Face Verification for Automatic Classroom Attendance System," which incorporates two-factor verifications, including RFID tags and face recognition, to prevent identity theft for attendance purposes **[2]**.

A third project is the "Attendance generating system using RFID and GSM (Global System for Mobile communication)," which uses a microcontroller as an intermediate GSM module and RFID to send attendance data to a GSM module and notify parents and administration of student attendance **[3]**.

The "Attendance Management system" project uses RFID readers to obtain attendance data, with multiple readers placed in each room to increase efficiency and there is a server application maintained via a laptop. The reader and laptop or PC are connected with the help of a wireless router or LAN connection **[4]**.

Finally, the "Student Presence Using RFID and Telegram Messenger Application" project involves RFID tags being tapped by students and then matched with stored data, which is then sent to the principal in the form of Excel and to parents via Telegram messenger **[5]**.

While all these projects aim to replace the paper attendance method, they differ in their use of technology and implementation methods, such as web-based biometric systems, GSM technology, and face recognition. Our project focuses on using RFID technology and fingerprints to obtain attendance data over the internet in a web application by two nodes or more.

2.2 Background:

The theoretical background for an IoT-based Attendance System using RFID (Radio Frequency Identification) and Fingerprint technology involves a few key concepts:

RFID Technology:

RFID technology uses radio waves to identify and track objects. An RFID system consists of a reader and a tag, which contains a small chip and antenna. The reader sends out a signal that activates the tag, allowing it to send back information such as an ID number.

Fingerprint Technology:

Fingerprint recognition is the process of verification of a person's identity by comparing their fingerprints with previously recorded samples. Human fingerprints consist of ridges and grooves created by the fingers. Fingerprints captured in the system are located at minute points – points at which scars begin or terminate. In addition, lines are drawn between them to generate a minutiae template. This process is called Minutiae based fingerprint matching, which is widely used for feature extraction.

Attendance System:

Attendance systems track when employees or students arrive at and leave a specific location, such as a school or workplace. These systems record attendance data and store it in a database that can be used for payroll and scheduling.

IoT-based Attendance System using RFID and fingerprint:

An IoT-based Attendance System uses RFID and fingerprint technologies to track when individuals enter or exit a building or room. The system records the time and date of each entry or exit and stores this information over the Internet for later analysis.

Benefits of Attendance System:

The Attendance System offers several advantages over traditional attendance systems, including increased accuracy, efficiency, and security. It eliminates the need for manual data entry, which can be time-consuming and error-prone. It also reduces the risk of fraud, as it is difficult to fake an RFID tag and a fingerprint.

Consequences of Attendance System:

- Privacy concerns: The use of this system raises concerns about privacy, as it can be used to track individuals' movements and activities. Some people may be uncomfortable with the idea of being monitored in this way, which could lead to resistance or even legal challenges.
- Cost: Smaller organizations and those with limited budgets may find it difficult to adopt RFID and fingerprint-based Attendance Systems based on the Internet of Things due to the high cost of implementation.
- Technical issues: RFID and fingerprint systems can be subject to technical issues, such as problems with tag or reader placement. These issues can cause the system to malfunction or produce inaccurate data, which could impact attendance records and cause confusion or frustration for users.
- Maintenance: Like any technology, systems require regular maintenance to ensure they are functioning properly. This can involve replacing batteries in tags, repairing or replacing readers, and performing software updates.

2.3 Summary:

In this chapter, we reviewed various previous projects, each employing different combinations of technologies such as RFID, GSM, face recognition, and web applications. The theoretical background covers key concepts including RFID and fingerprint technologies, as well as the benefits and consequences of implementing IoT-based attendance systems. Privacy concerns, cost implications, technical challenges, and maintenance requirements are highlighted as important considerations in the adoption of such systems. Overall, the chapter sets the stage for the development of an IoT-based attendance system utilizing RFID and fingerprint technologies for Internet-based data storage and analysis. What distinguishes our project is aiming to utilize both RFID technology and fingerprint scanning to gather attendance information via the internet within a web application offering administration and monitoring effectively, involving the interaction of two or more nodes.

Chapter 3: System Design

3.1 Overview:

In this chapter, we will cover the overall design of the system and the integration of its components, showing the block diagram, as well as details about the algorithms we will use.

Here's a high-level system design for an IoT-based Attendance System using RFID and Fingerprint Project. It provides a high-level overview and can be further expanded and customized based on specific requirements as shown in Figure (3.1) and Figure (3.2) below:

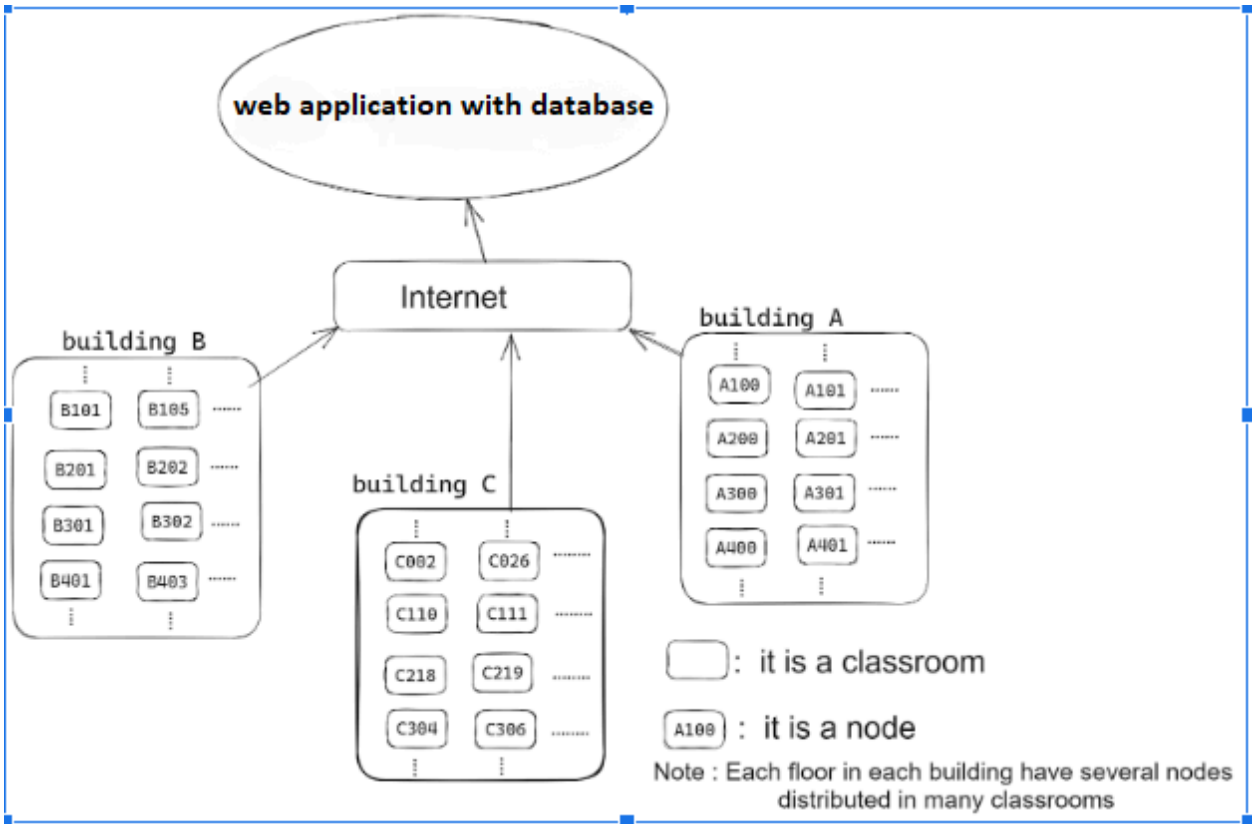

Figure 3.1: General system design for PPU buildings

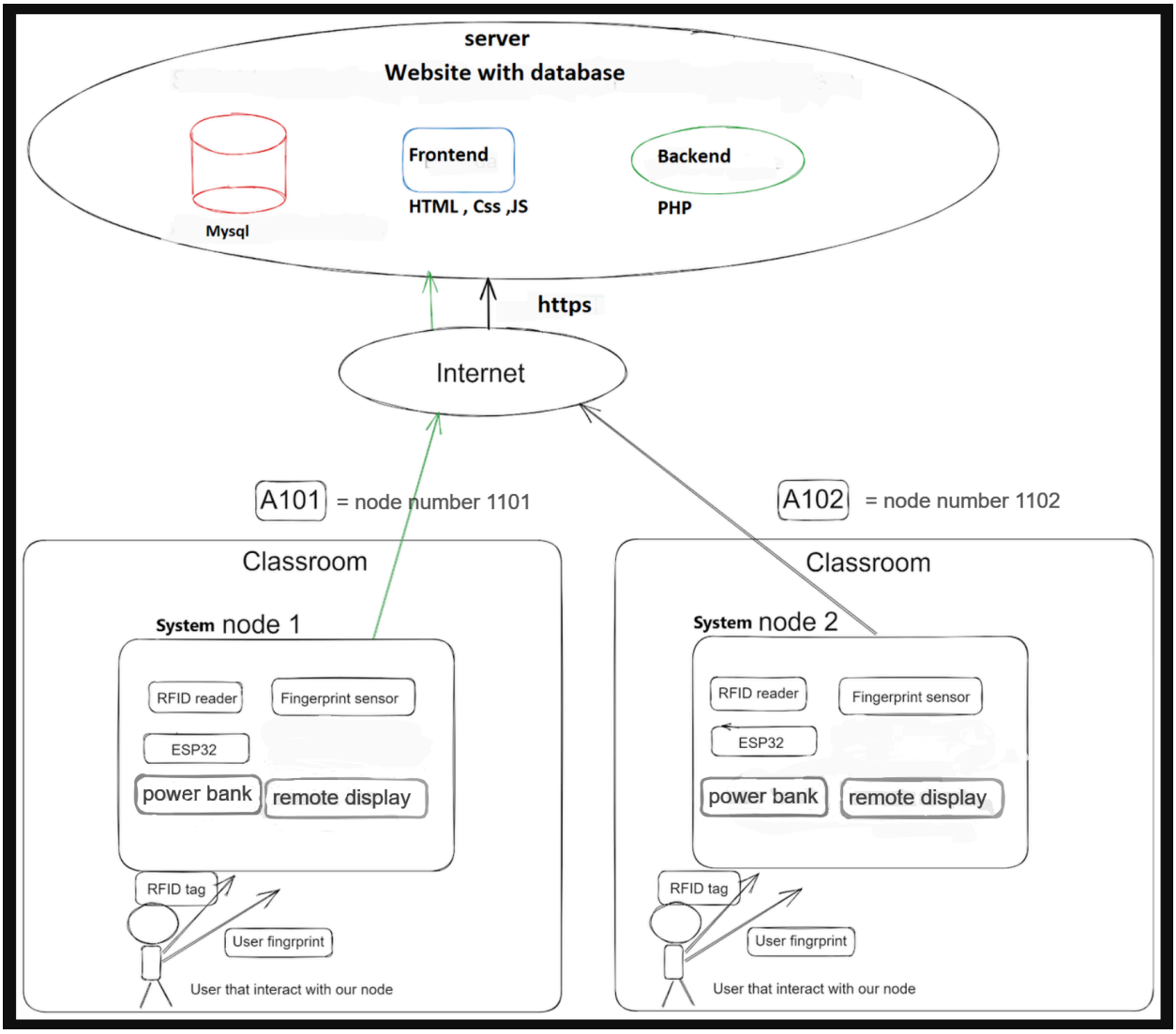

Figure 3.2: The structure of two nodes connected in parallel to web application with database

As shown in the previous figure 3.2 for each class there is an attendance system that contains different components and is connected with the internet and web application to store the data in the database. Note that (node 1 and node 2 are the attendance systems in the classes) that the user will interact with.

3.2 Hardware components:

1. **RFID Reader**: This is a device that reads the unique identification information contained in RFID tags. The reader can be stationary or portable, and it can be linked to a computer or network.

   The RC522 RFID module is a compact and versatile instrument for reading and writing RFID tags. It supports a variety of communication interfaces, including SPI and I2C, and operates at a frequency of

13.56 MHz. Due to its ease of integration and broad compatibility, it is frequently used in applications such as access control, inventory management, and electronic payment systems see figure(3.3) below:

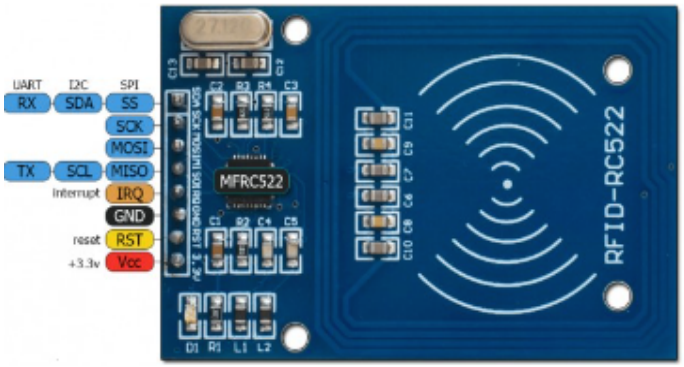

Figure 3.3: The RC522 RFID module

2. **RFID Tag**: A tiny device with a unique identifying number that is affixed to an object or person. In the case of an RFID Attendance System, each student or employee would be given an RFID tag to take around with them.

The ISO 14443A-compliant RFID Smart Intelligent Card operates at 13.56MHz and is a contactless card. Because it uses radio frequency technology to securely convey and maintain data see figure(3.4) below:

Figure 3.4: RFID Smart Intelligent Card, ISO 14443A 13.56MHZ

3. Fingerprint Sensor:

is a fingerprint module that works on an algorithm that extracts features from the acquired fingerprint image and represents the fingerprint information. The storage, comparison, and search of fingerprints are all done by operating fingerprint features see figure(3.5) below:

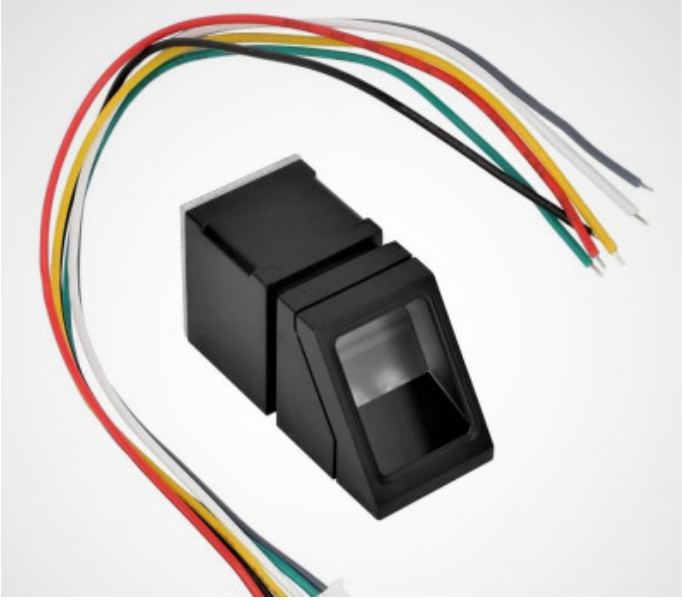

Figure 3.5: Optical Fingerprint Identification Module (Fingerprint Scanner)

4. **Computer**: A computer is required to view the website and analyze the attendance data collected by the RFID reader and fingerprint sensor in the database of the website.

5. **ESP32 Microcontroller**: The ESP32 microcontroller is a good choice for our attendance tracking system. The ESP32 microcontroller comes with built-in Bluetooth and Wi-Fi connectivity, thus no external Wi-Fi module is required. IoT applications that need wireless communication and database access benefit from this functionality.

In comparison to conventional Arduino boards, the ESP32 has more potent processing capabilities thanks to a dual-core processor and faster clock speeds. It has the computing power and memory to handle operations like fingerprint recognition, data storage, and RFID data processing.

The ESP32 may connect to your Wi-Fi network immediately thanks to built-in Wi-Fi capabilities and communicate with other devices. This qualifies it for use with our attendance monitoring system, which needs database storage see figure(3.6) below:

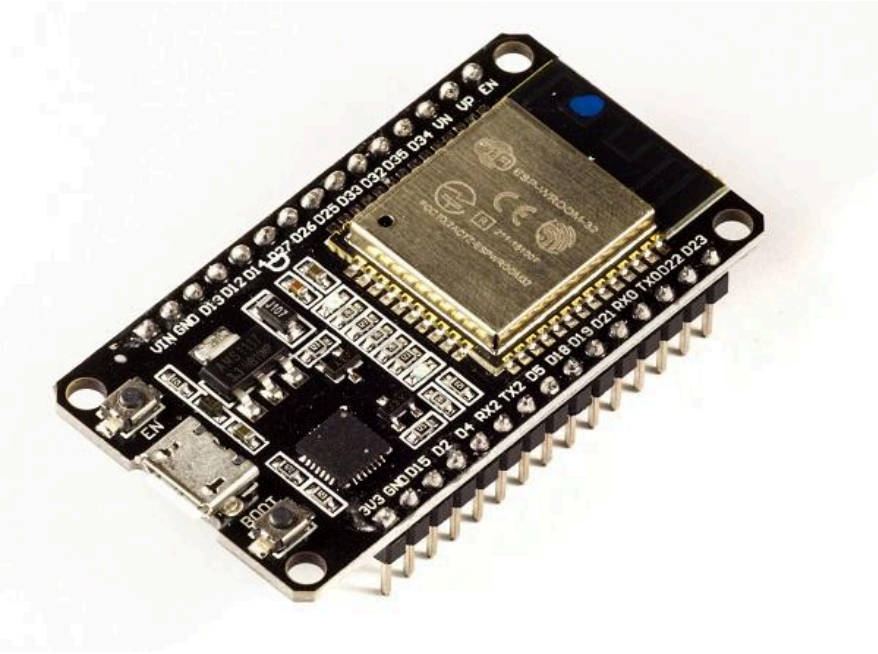

Figure 3.6: ESP32 Microcontroller

6. Power bank:

A Power Bank is a portable charger that allows you to recharge your electronic devices while on the go. They can charge smartphones, tablets, earbuds, smartwatches, and other mobile devices and range in size from tiny, pocket-sized devices to bigger, higher-capacity Power Banks.

Utilizing an external rechargeable power bank stands out as a secure and dependable method for supplying power to Arduino. These power banks are readily accessible, and many of them come equipped with 5V USB ports. This not only ensures the safety of the ESP32 but also extends its operational duration.**[7]**

Another advantageous aspect of power banks is their full rechargeability. With thousands of recharge cycles available, we can sustain power for the ESP32 over an extended period, contributing to prolonged usage.

Connecting the Power Bank with ESP32 will achieve the availability of our project. See figure(3.7) below

Figure 3.7: Power Bank module

7. Portable Monitor:

A mini portable monitor is a small, lightweight display that is convenient to transport. These small monitors are especially beneficial for professionals, gamers, and projects that require an additional display on the go. In our project, this monitor may be remotely connected to the APIs and provides flexibility in data display**[8]** see figure(3.8)below. **For cost purposes, we used the mobile screen to display data.**

Figure 3.8: portable monitor module

3.3 System Software components:

Embedded C++: All the hardware interface coding has been done in embedded C++ Language to program an ESP32 microcontroller to be able to deal with data and interact with other hardware components.

Attendance Tracking Software using Web Application Platform: The central component of the Attendance System, leveraging RFID and fingerprint technologies, is the web application platform software. Functioning online, this software is pivotal in gathering and preserving attendance data obtained through RFID readers and fingerprints. The collected data is stored in MySQL via internet connectivity. Additionally, this platform may offer supplementary features, including the generation of attendance reports.

Database Management Software PHPMyAdmin (MYSQL): Database management software is required to manage RFID and fingerprint attendance data. This software creates and maintains the database that stores attendance data.

Database Design:

The database design for the IoT-based Attendance System using RFID and Fingerprint templates. This database design enables seamless tracking and retrieval of attendance records, ensuring accuracy and reliability in the attendance management process. As shown in figure(3.9) below:

A database design for IoT- based Attendance system using RFID and fingerprint as shown in figure 3.9, typically includes several components such as:

Admin: This table in a database stores information related to the administrator such as id, name, and user_id.

Students: This table in a database stores information related to students such as ID, name and age, card, and fingerprint data.

Faculties: This table in a database stores information related to the college such as college ID, college name, and address.

Specializations: This table in a database stores information related to the Specializations in each college.

Course: This table in a database stores information related to courses such as course id, course name, start time, and end time.

Lecturers: This table in a database stores information related to the Lecturer such as id, name, and courses he teaches.

Classrooms: This table in a database stores information related to the classroom such as hall ID, and college ID.

Class_course_names: This table in a database stores information related to sections of the same course.

Api_settings: This table in a database stores information related to settings of the api such as student ID, classroom ID, and enrollment type (RFID or fingerprint)

Login_information: This table in a database stores information related to login operations of the website, such as person id, browser, and platform.

Distribution_students_in_class: This table stores information about how the students are distributed in a section.

Daily_schedule: This table stores information about the daily schedule of a classroom, showing the sections and times of every section.

Attendance_records: This table stores the attendance records of students in a section.

3.4 Database:

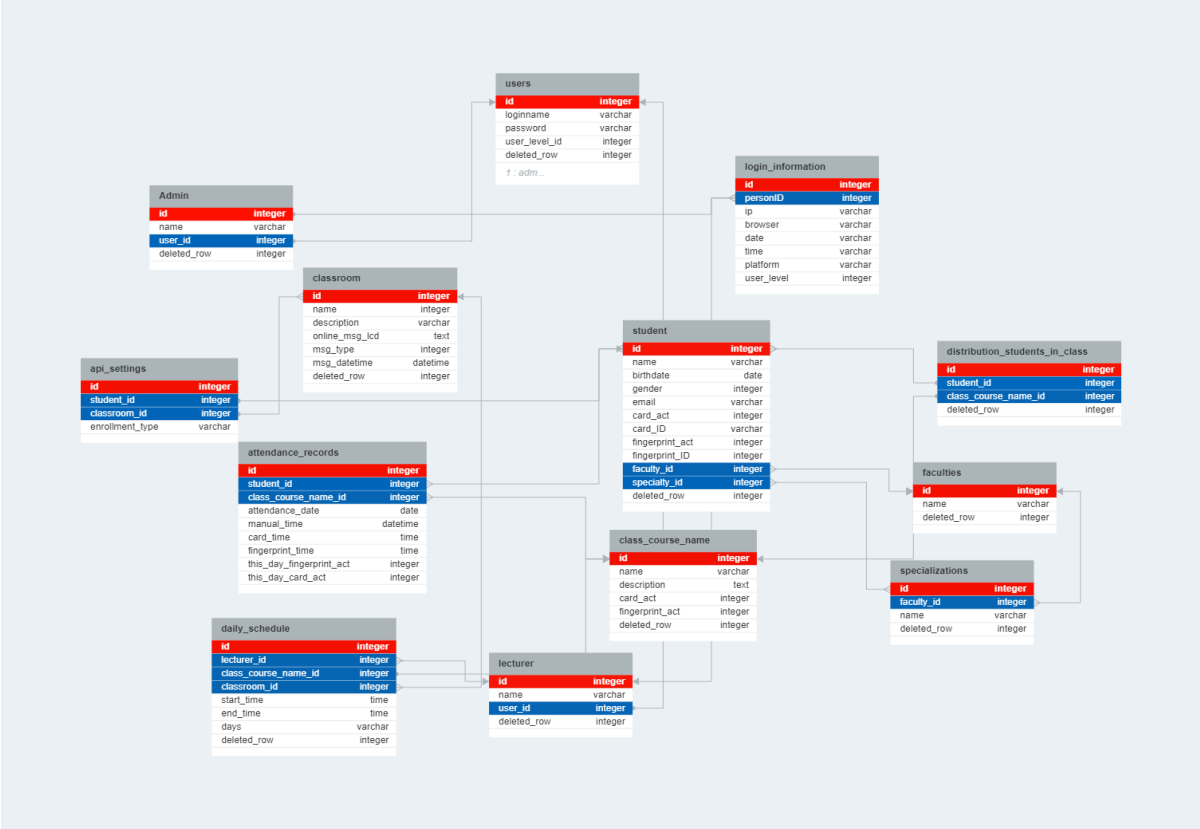

Figure 3.9: Database design for IoT-based Attendance System Using RFID and Fingerprint

3.5 Schematic diagram:

A schematic diagram is a representation of the elements of a system using abstract, graphic symbols rather than realistic pictures. It's a simplified and structured visual representation of an electrical or electronic circuit, among other systems. As shown in figure(3.10) below:

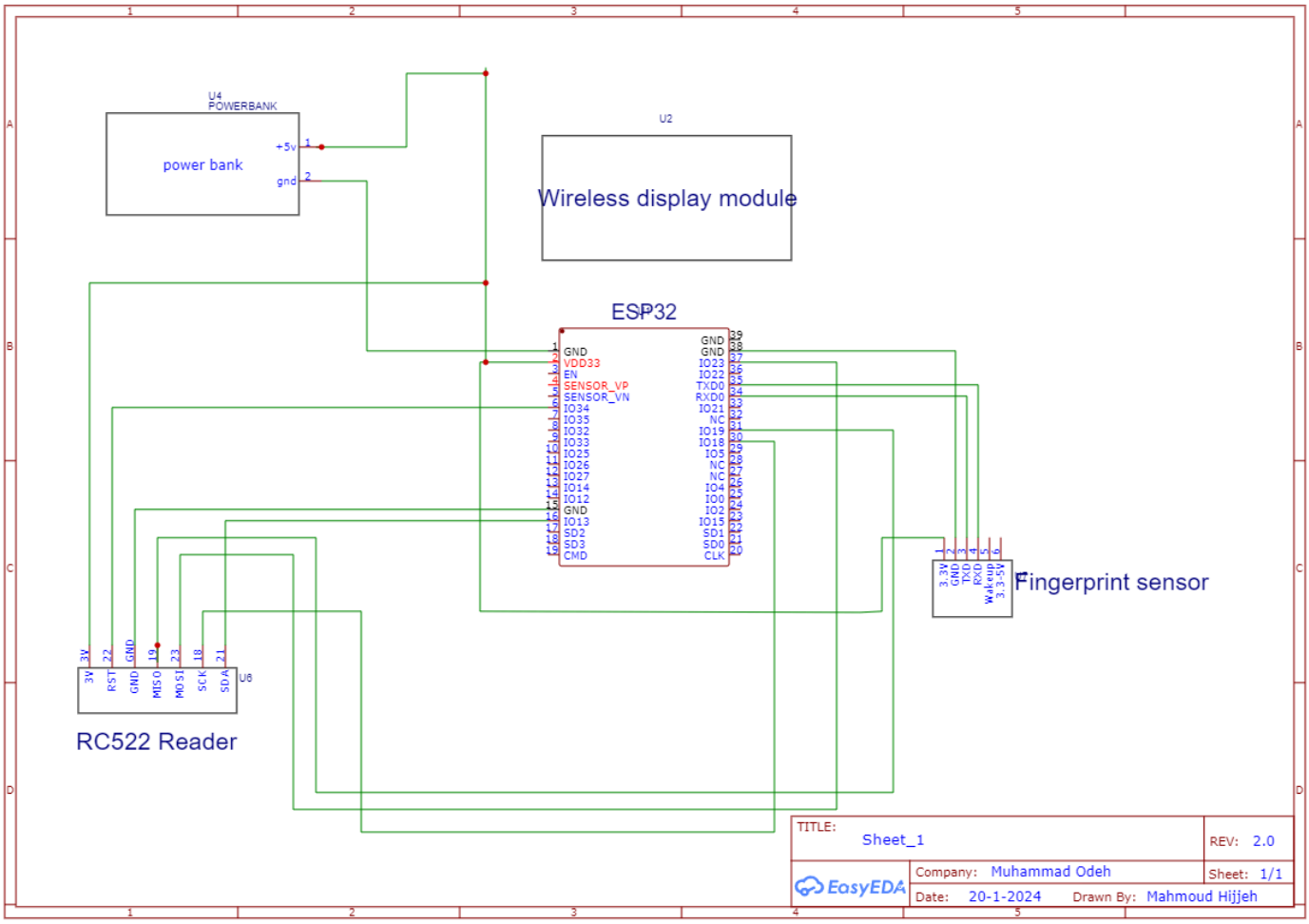

Figure 3.10: Schematic diagram for IoT-based Attendance System Using RFID and Fingerprint

3.6 Block diagram:

The block diagram shows how the system works its functions as a unit, and the connections between its components as shown in figure (3.11) below:

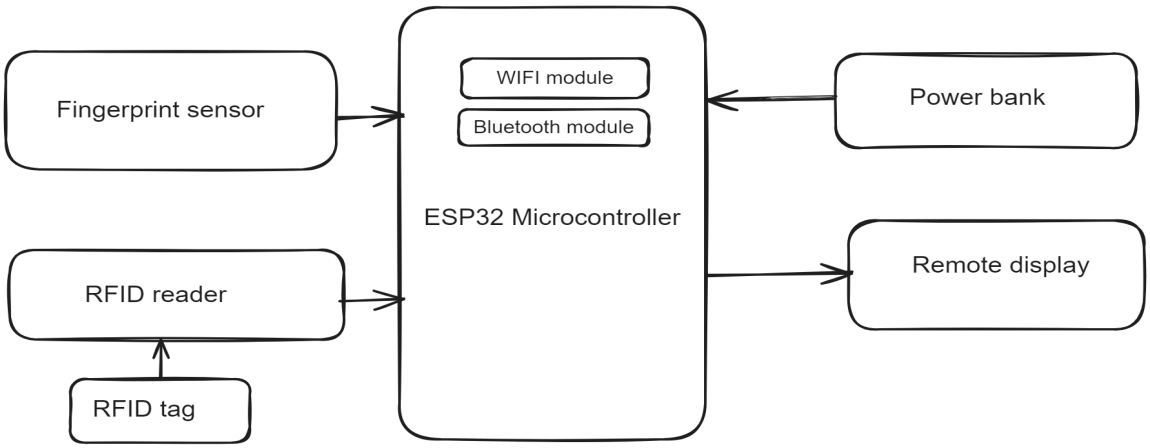

Figure 3.11: Block diagram of IoT-based Attendance System Using RFID and Fingerprint

3.7 Flow Charts:

The flow chart shows the steps or actions involved. Flow charts help stakeholders understand processes and systems by breaking them down into their component parts and showing how they are connected as shown in figure (3.12 a+b) below:

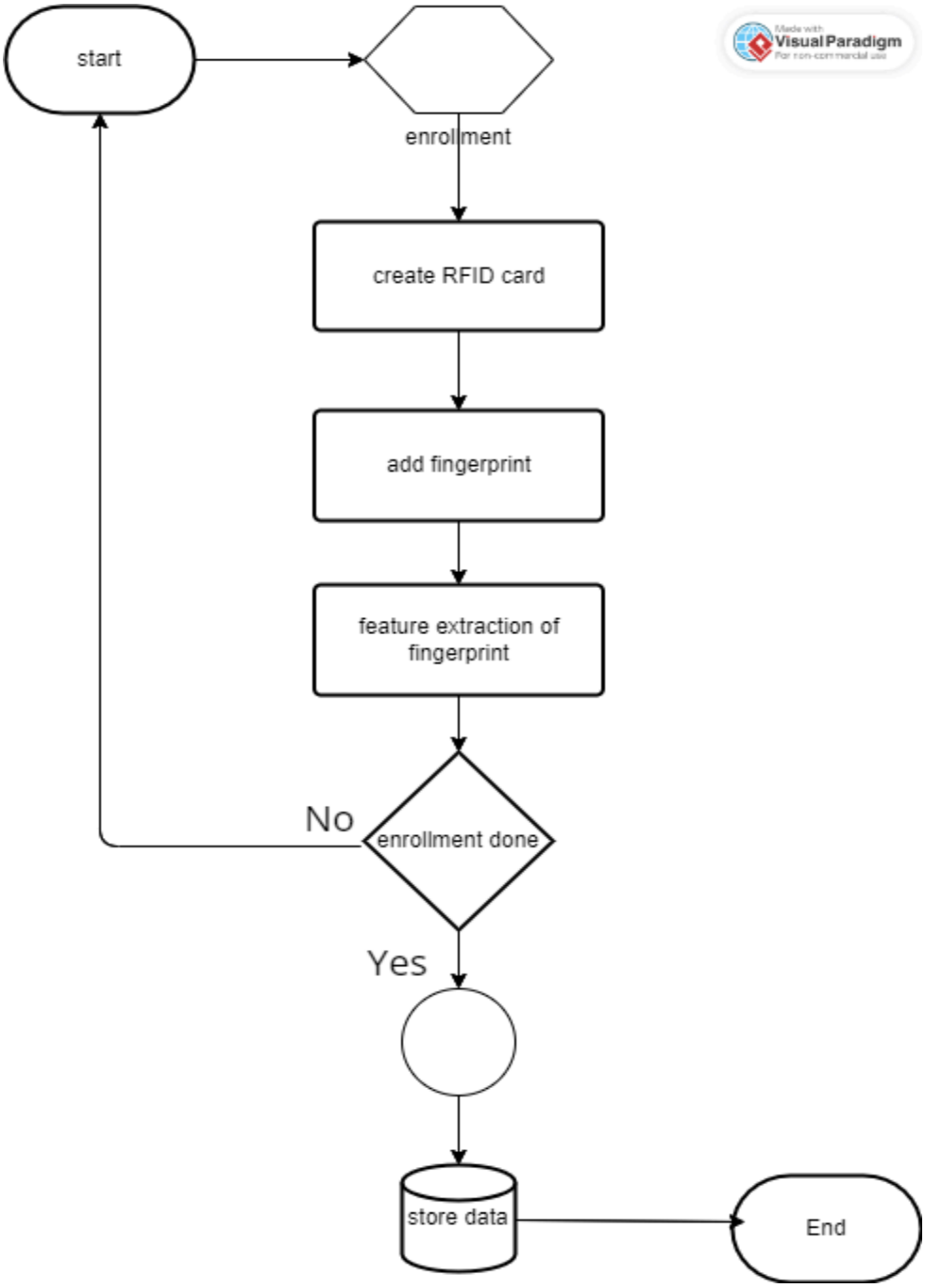

Figure 3.12(a): Enrollment Flow Chart of IoT-based Attendance System Using RFID and Fingerprint

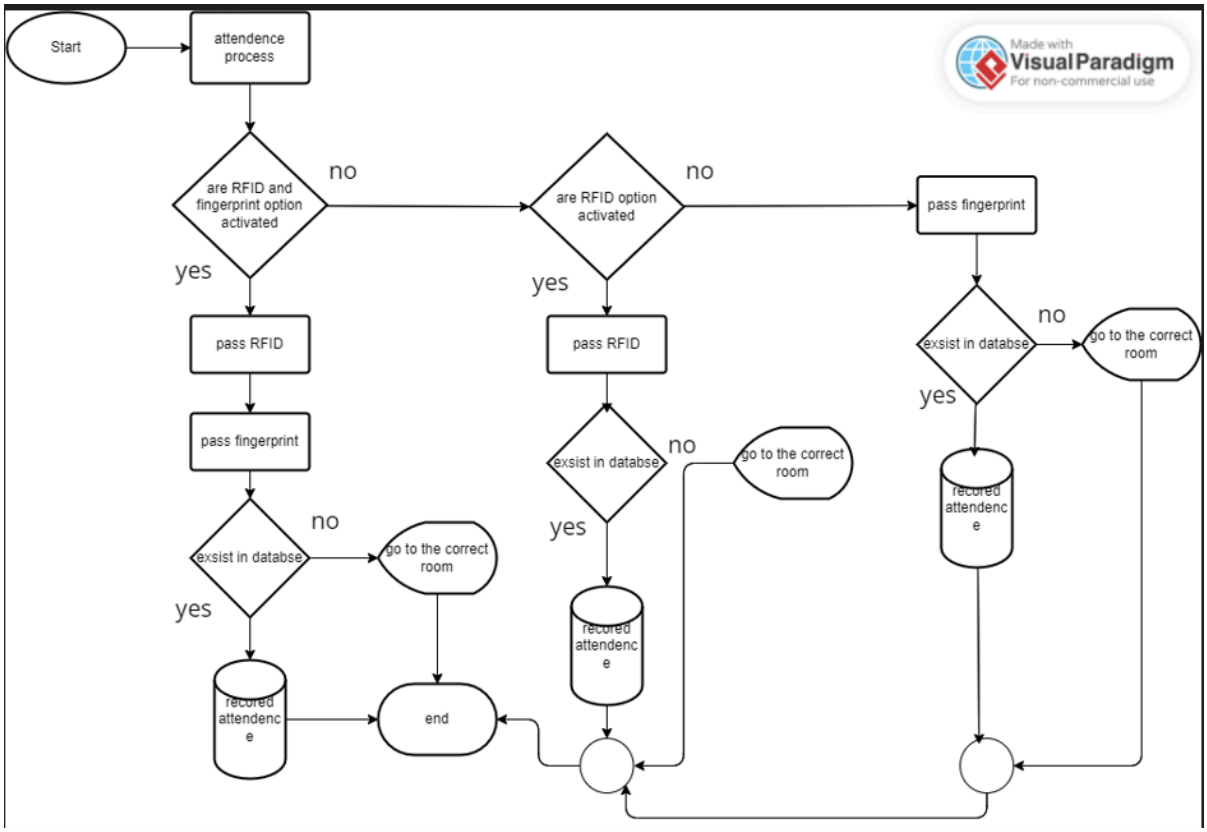

Figure 3.12(b): Attendance record Flow Chart of IoT-based Attendance System Using RFID and Fingerprint

3.8 Use Cases Diagrams:

A use case diagram for an IoT based Attendance System Using RFID and Fingerprint would typically depict the various actors (e.g.student, administrators) interacting with the system, and the specific tasks or functions they are able to perform. The use cases may include things like monitoring systems, entering RFID tags, and monitoring database as shown in figure (3.13) below:

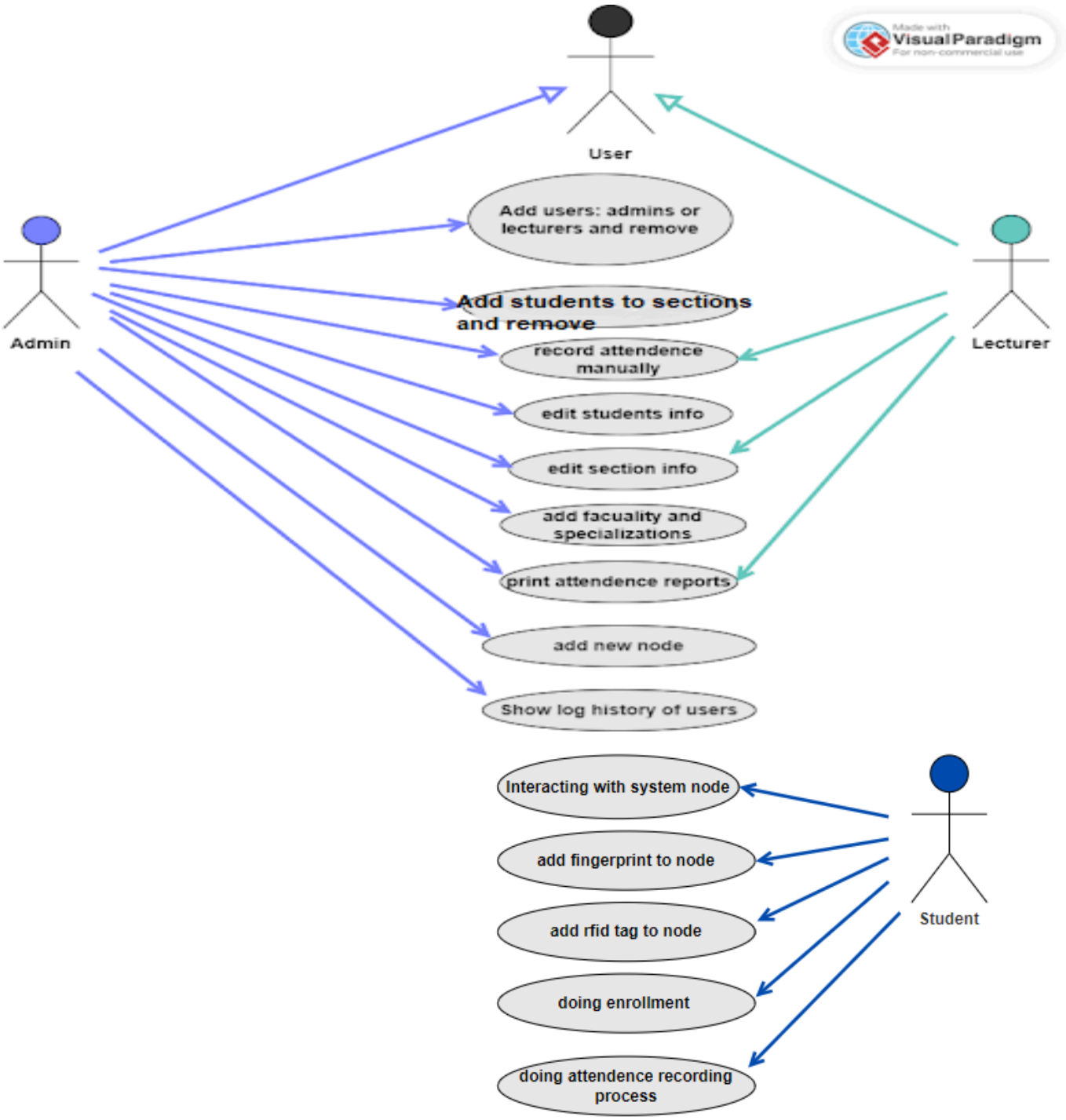

Figure 3.13: Use Case diagram of IoT-based Attendance System Using RFID and Fingerprint

3.9 Sequence Diagram:

A sequence diagram for an IoT-based Attendance System Using RFID and Fingerprint is a visual representation of the interactions between the different objects or components of the system, and the order in

which those interactions occur. It typically shows the different objects, such as the user, and the database, and how they communicate with each other to accomplish a specific task as shown in Figure (3.15) below:

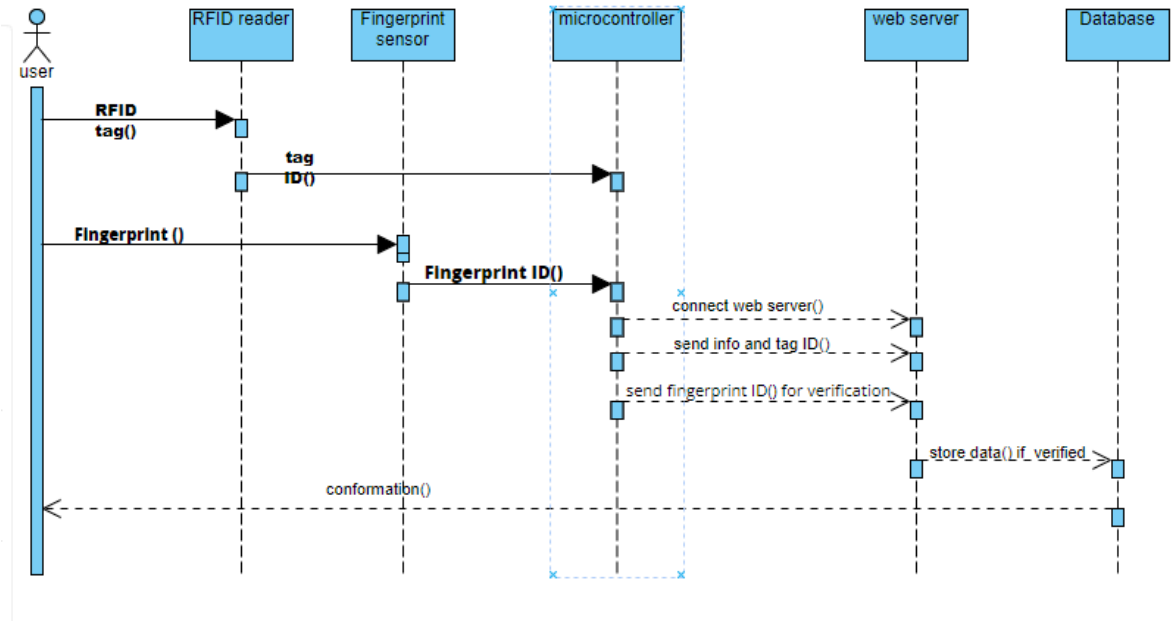

Figure 3.14: Sequence diagram of IoT-based Attendance System Using RFID and Fingerprint

3.10 Summary:

The idea for this project came from a need for organizations to streamline attendance tracking processes with IoT, RFID, and fingerprint. The goal was to develop an IoT-based attendance system that integrated RFID and fingerprints seamlessly. As a result of extensive planning and detailed design, we successfully designed the system, addressing the complexities of its components and programming. In this project, we researched various RFID-based attendance systems, allowing us to make informed decisions about component selection.

Chapter 4: Implementation

4.1 Overview

The implementation phase for the software and hardware components is explained in this chapter. We will demonstrate the construction of the system in this chapter. One of the most crucial phases is the system implementation stage, which is when the theoretical stage transitions into the practical stage, where the system is really built and programmed. The project's various hardware and software parts are covered in more detail overall.

4.2 Hardware Implementation

The hardware components used in our project will be described in this section.

We have gathered all the necessary components, including the ESP32 microcontroller – for its optimality and balance between performance and price, RFID reader, Fingerprint sensor, and wireless screen – for more flexibility in displaying data.

After referring to the diagram provided in the picture [3.12], we successfully established the necessary connections between the ESP32 microcontroller, RFID reader, and Fingerprint sensor as shown in Figure [4.1].

In addition, we used a Wi-Fi connection to connect the wireless screen to our project.

After ensuring the power supply was turned on, we verified the proper functioning of the ESP32 microcontroller, RFID reader, and Fingerprint sensor.

Repeat the same steps for the second Node.

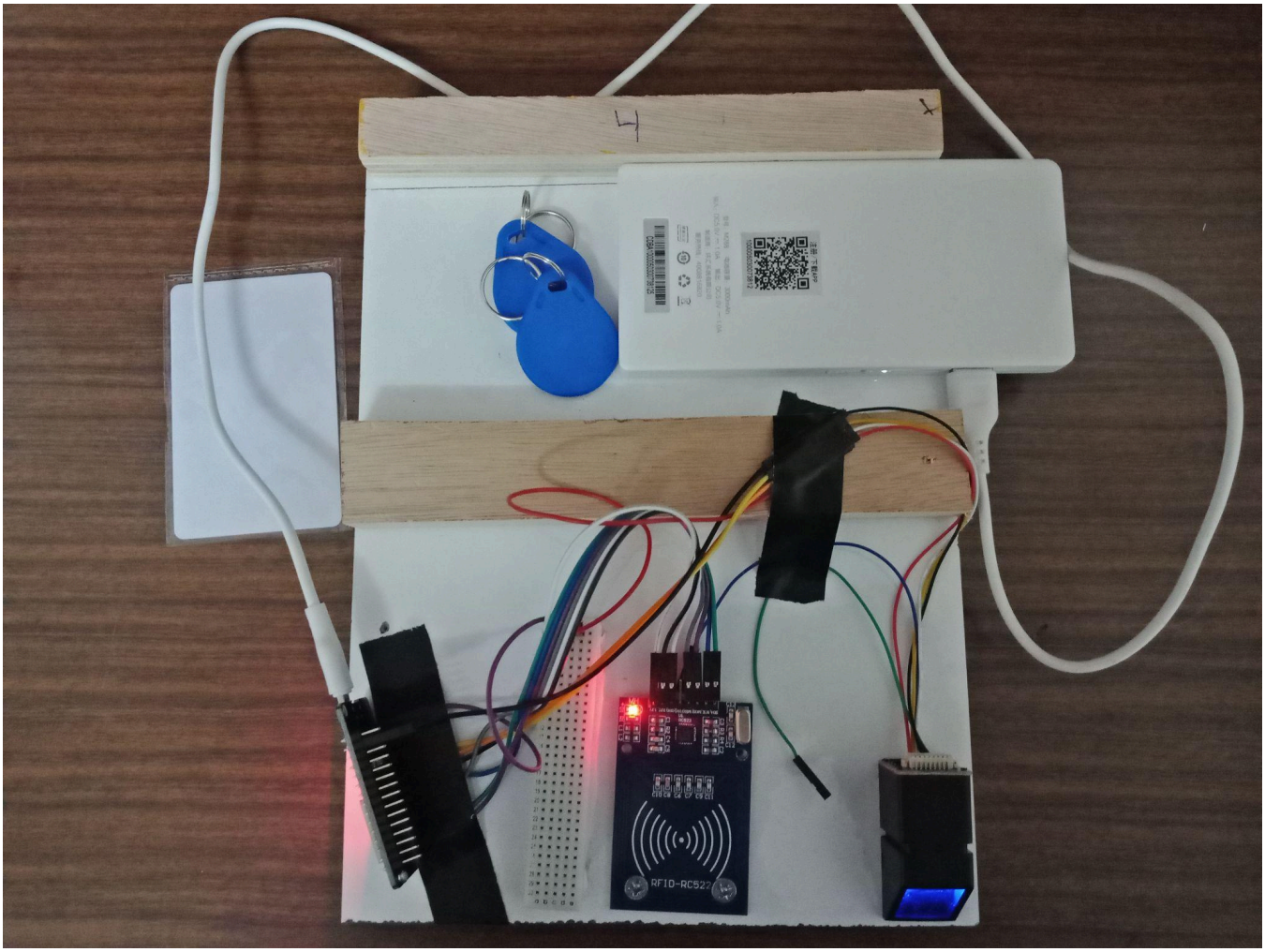

Figure 4.1: The system Hardware after implementation

4.3 Software Implementation

The project contains two parts as follows:

1. ESP32 code: which is built and uploaded to ESP 32 microcontroller to allow all the hardware components to work efficiently.

2. Web application: which is used by the universities' employees for adding, deleting, and updating students' information. Also to use other features.

This section explains how to integrate a webpage with an ESP32 code and establish communication between them.

4.3.1 ESP32 Implementation:

Steps:

- The start point was using Arduino IDE software for building the ESP32 code because it has a large community and makes it easy to write code and upload it to the board offline.
- Install ESP32 board manager to establish the environment.
- After selecting the board, you can start your own programming projects.
- Install the necessary libraries:
  - "WiFi.h": ESP32 WiFi library
  - "HTTPClient.h": for sending and receiving data over the internet using the HTTP protocol.
  - " ArduinoJson.h ": for handling JSON responses from the API
  - "OneWire.h": allows the Arduino to communicate with devices on a OneWire bus
  - "SPI.h": SPI is a common communication protocol used by many different devices like RFID card reader modules to communicate with microcontrollers.
  - MFRC522.h: Arduino RFID library
  - "Adafruit_Fingerprint.h": Arduino Fingerprint library
  - "HardwareSerial.h": Configures a hardware serial port (mySerial) for communication with the Fingerprint sensor
- After that, set up pins and WiFi information, Identify the APIs' URLs and start building the code.

4.3.2 Website Implementation

Using VS Code,

- Front end: Use HTML, CSS, and JS to build the front end or the interface of the project
- Back end: Use PHP to connect to the database and fetch the data to be displayed on the website and Screen.
- Database: PhpMyAdmin: It is an open-source tool to enable system administrators to manage MySQL databases on the Internet. it creates/drops/modifies /deletes tables and fields.
- Implement attendance routing using PHP to handle every attendance scenario and ensure the interaction between different pages of the website.

❖ Implementing User authentication and authorization: This includes creating a system for user registration, login, and managing user access to different parts of the website by using tools such as PHP's built-in password hashing functions and sessions. As shown in Figures **(4.2 - 4.14)** below:

Figure 4.2: User login interface

Figure 4.3: Management accounts

Figure 4.4: Classroom management

Figure 4.5: Management of colleges and specializations

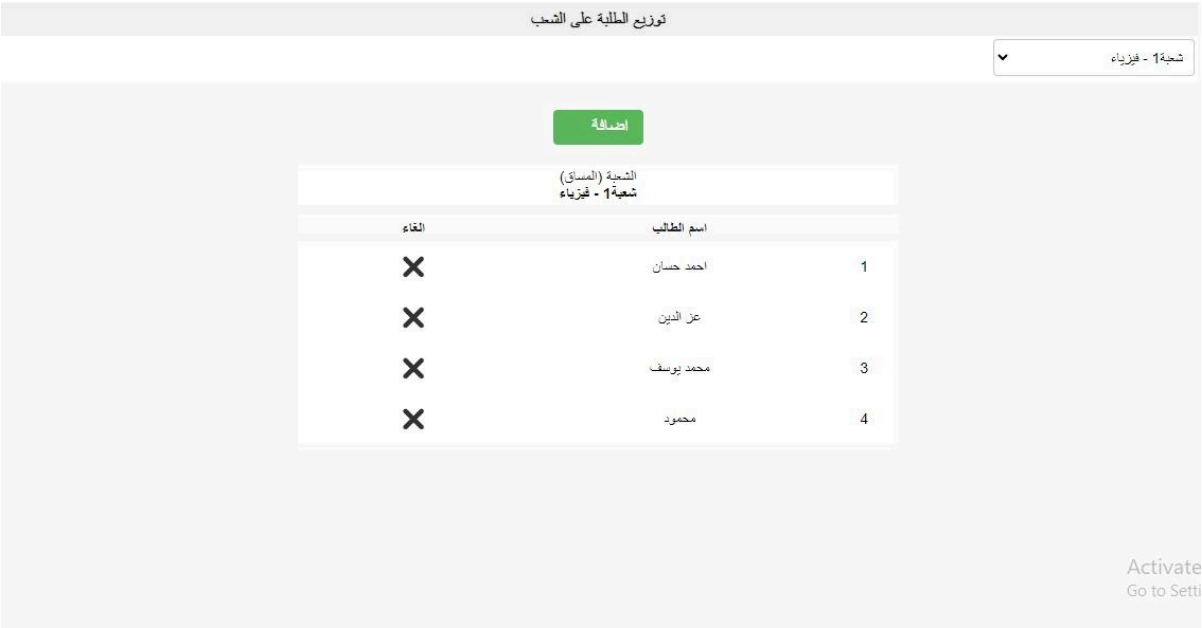

Figure 4.6: Distribution of students among sections

Figure 4.7: Sections (courses) management

Figure 4.8: Academic program

Figure 4.9: Record attendance

Figure 4.10: Classroom 3304 node -> The node is ready to record attendance

Figure 4.11: Students management

Figure 4.12: Enrollment API Status

Figure 4.13: Node status (RFID Enrollment)

Figure 4.14: Node status (Fingerprint Enrollment)

4.4 Implementation Issues:

We encountered several problems when starting the practical part of the project, and we did our best to overcome these problems. Some of these problems include:

1- Hardware Serial connecting: trying to use Hardware Serial to communicate with LCD, did not work, and the LCD screen did not work properly. Also, all hardware serial pins were used so we used a wireless screen (mobile screen) instead to display data.

2- The LCD screen displays a limited number of characters. Using a wireless screen offers flexibility in displaying data

3- JSON encoding/decoding: The state of JSON decoding/encoding has been a problem for a while.

4- Lectures Table: Designing the Lectures Table and connecting it to sections and students is a big issue. It is really the core of the project. Failure to design will lead to errors.

5- Data Monitoring: Due to many scenarios or cases, displaying the correct result or the errors on the screen is not easy.

4.5 Summary:

In this chapter, we illustrated the practical execution of the project's hardware and software components, Which emphasizes the transition from theory to practice and presents the construction process. Hardware implementation outlines the components used, their connections, and functionality verification. Software implementation covers ESP32 code and website development, detailing steps and tools employed. Challenges encountered, like hardware serial connection and JSON encoding, are addressed alongside solutions. Overall, the chapter provides a concise overview of the implementation journey, encompassing hardware setup, software development, and issue resolution.

Chapter 5: Testing

5.1 Introduction:

In the stage of testing the system, we make sure that the system (Hardware and Software) works correctly without any problems, and we also make sure that the functional and non-functional requirements of the project are completed, and that the system works with accuracy and high speed in completing tasks and displaying information. The stage of testing comes after the design and implementation of the system.

5.2 Hardware Testing:

Hardware testing verifies that hardware components meet the specified requirements and function as expected.

>> Figure (5.1) below shows that Testing succeeded (The Arduino language code is compiled into machine code for the ESP32 microcontroller by the IDE. If the code is free of syntax errors or other issues, the IDE creates a binary file and uploads it to the ESP32 via the correct COM port. After that, the uploaded code is executed by the ESP32, enabling the microcontroller to perform the functions we had programmed. Thus, it is clear from the serial monitor that the connection has been established successfully).

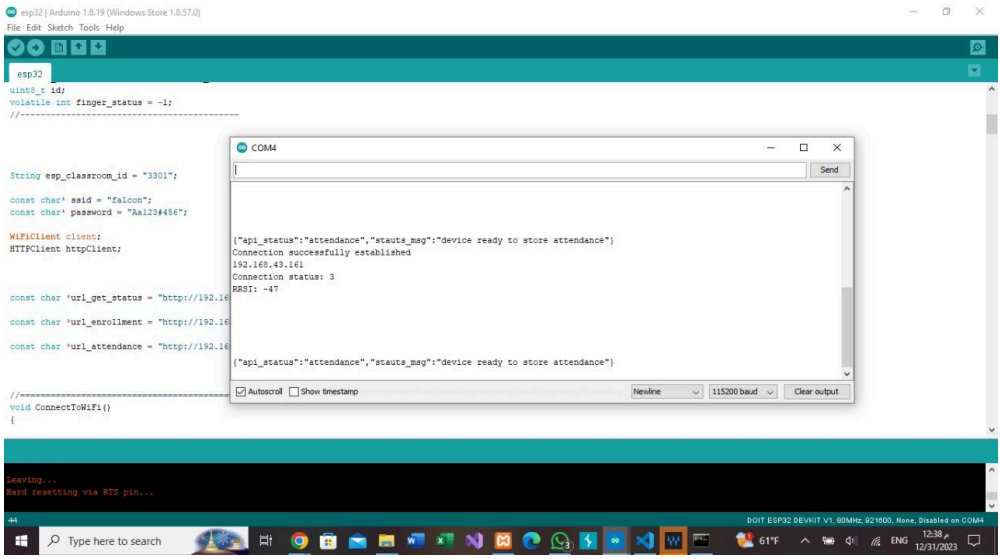

Figure 5.1: Hardware Testing

5.3 Software Testing:

Software testing is an essential stage in the software development life cycle that guarantees end users receive dependable, high-quality software. Testers seek to find and fix bugs by methodically assessing a program's functionality and performance to make sure the software satisfies its requirements.

5.3.1 Validation:

All information entered in all fields in the application is tested to ensure that the data entered by the user matches all conditions as follows:

• Customize the field in proportion to the entry.

• The process will not be executed if wrong data is entered.

• The process will not be executed if the user's entered number of characters exceeds the permissible limit.

• Ensure that there are actual users in the database.

5.3.2 API request testing:

API testing is a type of software testing that analyzes an application program interface (API) to verify that it fulfills its expected functionality, security, performance, and reliability. The result of the examination was successful. The following table (5.1) below reviews the testing we have done:

#	API	Input	Expected output	Obtained output	pass/fail
1	Enrollment API	*Student = "محمود ماجد حجه" *Classroom number = 3301 *Registration type = "بطاقه"	هذا الجهاز الآن قيد الانتظار لضبط إعدادات بطاقة للطالب (محمود ماجد حجه)	Okey	Pass
2		*Student = "محمود ماجد حجه" *Classroom number = 3301 *Registration type = "بصمه"	هذا الجهاز الآن قيد الانتظار لضبط اعدادت بصمة للطالب (محمود ماجد حجه)	Okey	Pass

3	Getting_status API	RFID or Fingerprint or all	الجهاز الآن قيد الانتظار لتسجيل الحضور	Okey	Pass

Table 5.1: API's request testing result

5.3.3: Log-in validations:

As shown in figure **(5.2 a, 5.2 b)** below:

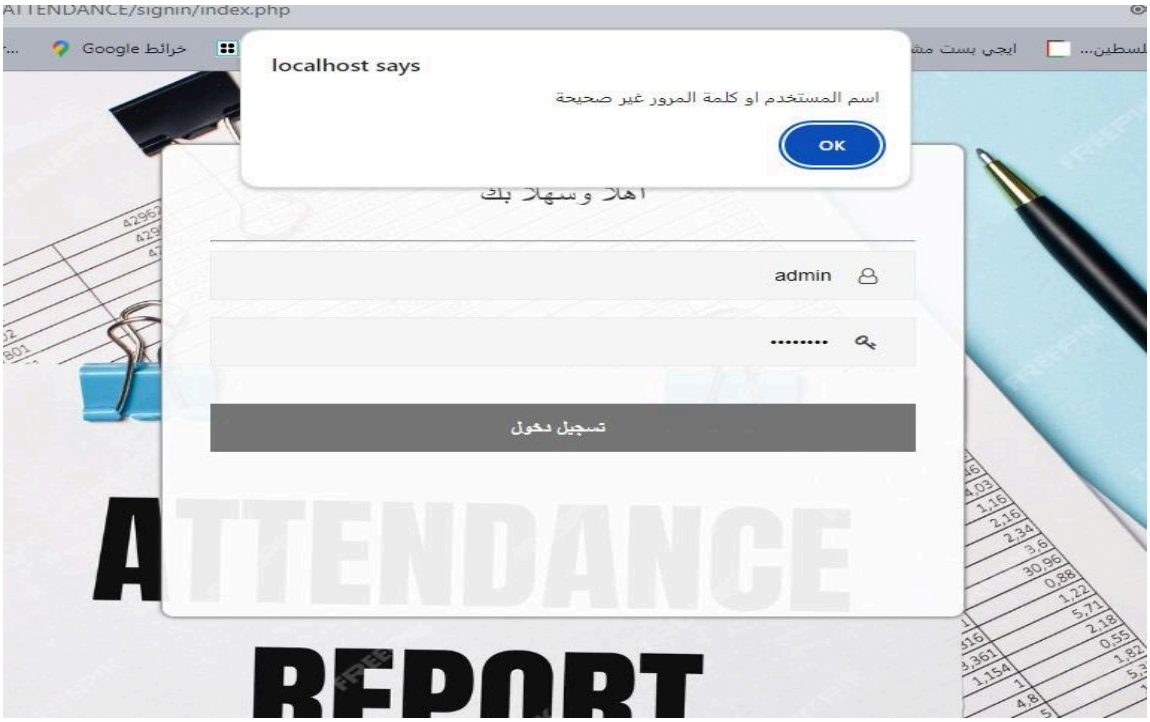

Figure 5.2 (a): Login validations(invalid data)

Figure 5.2 (b): Login validations(invalid password)

5.3.4: RFID attendance recording validation:

As shown in figure **(5.3 (a), 5.3 (b), 5.3(c))** below:

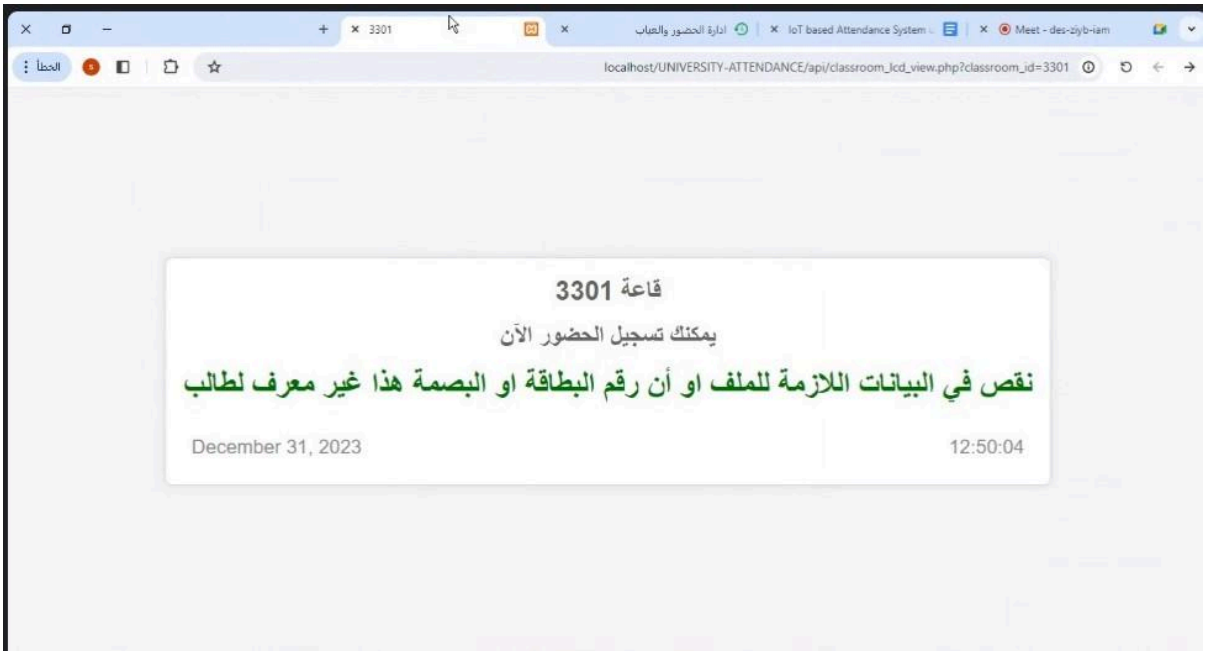

Figure 5.3 (a): RFID validation (RFID is not identified for a student)

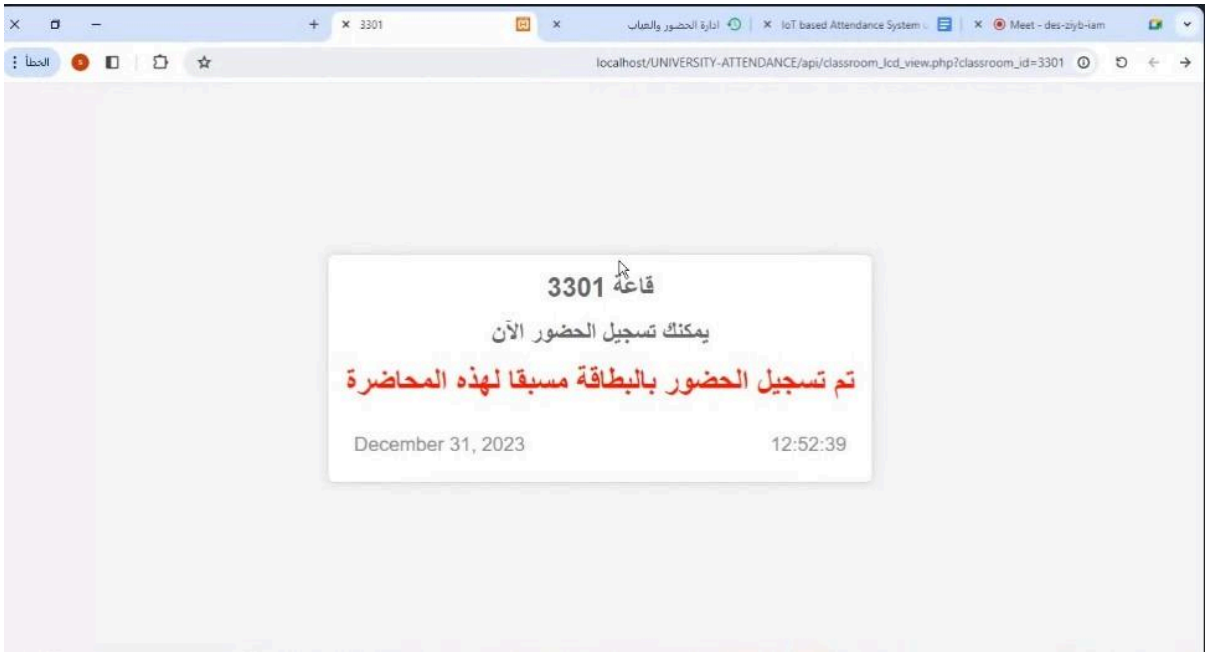

Figure 5.3 (b): RFID validation (attendance record repeating attempt)

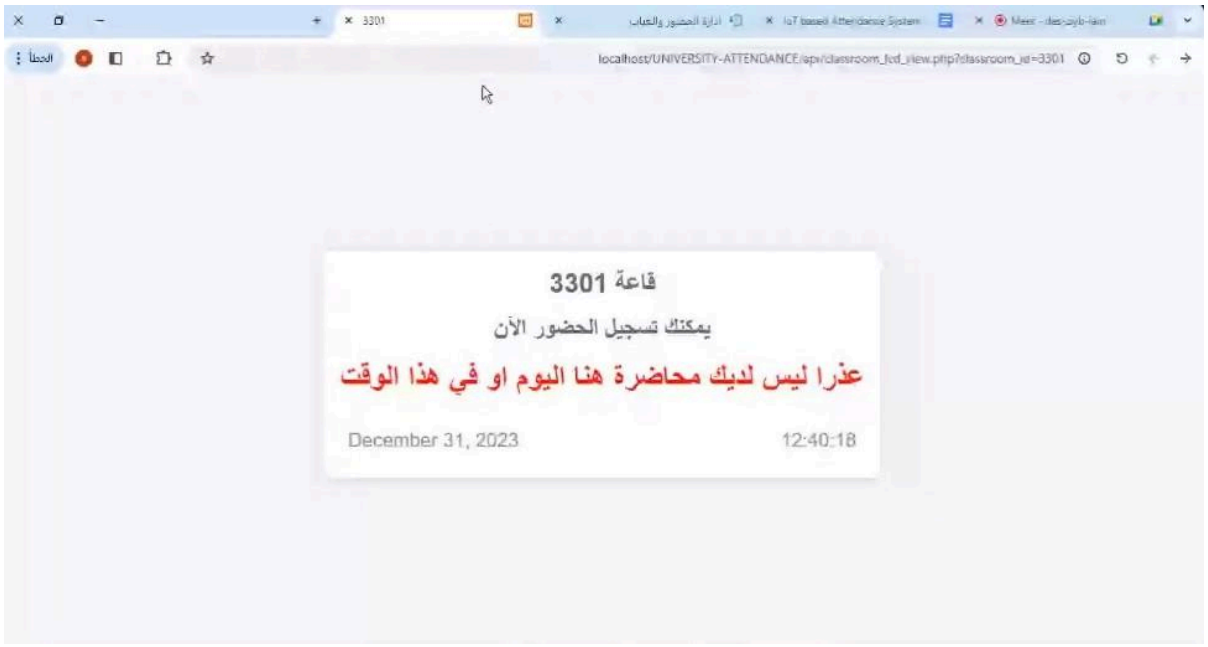

Figure 5.3 (c): RFID validation (wrong-time recording)

5.3.5: Fingerprint attendance recording validation:

as shown in figure **(5.4(a), 5.4(b), 5.4(c))** below:

Figure 5.4 (a): Fingerprint validation (wrong-time recording)

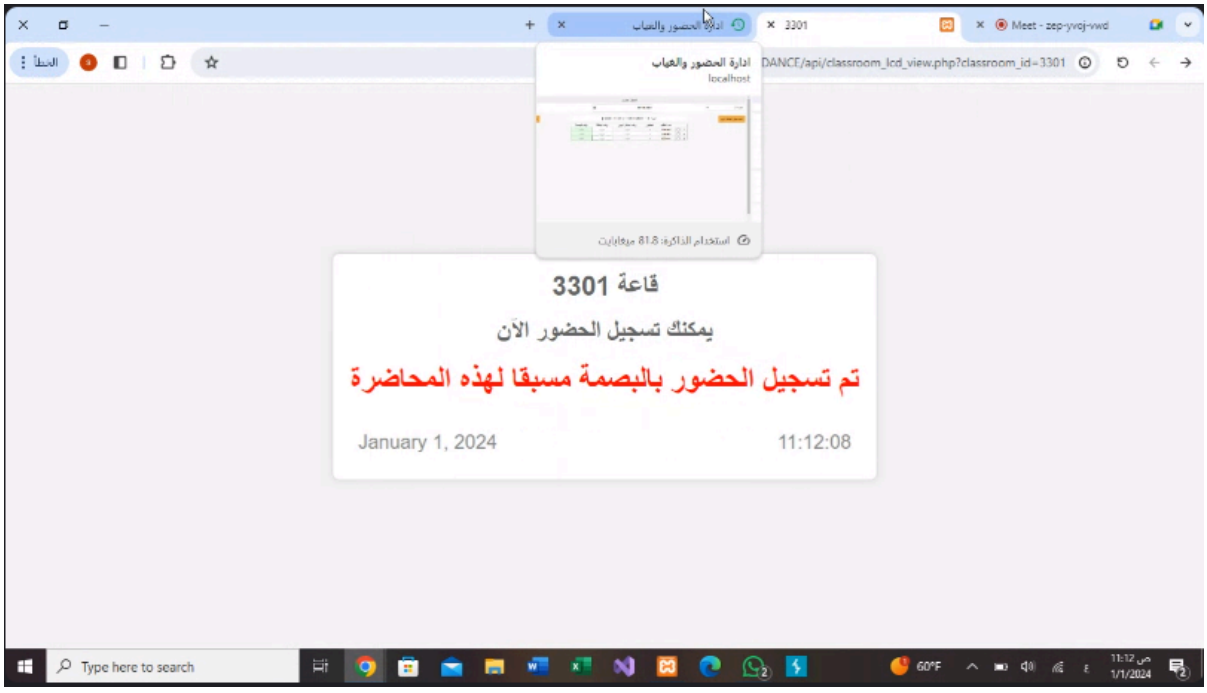

Figure 5.4 (b): Fingerprint validation (attendance record repeating attempt)

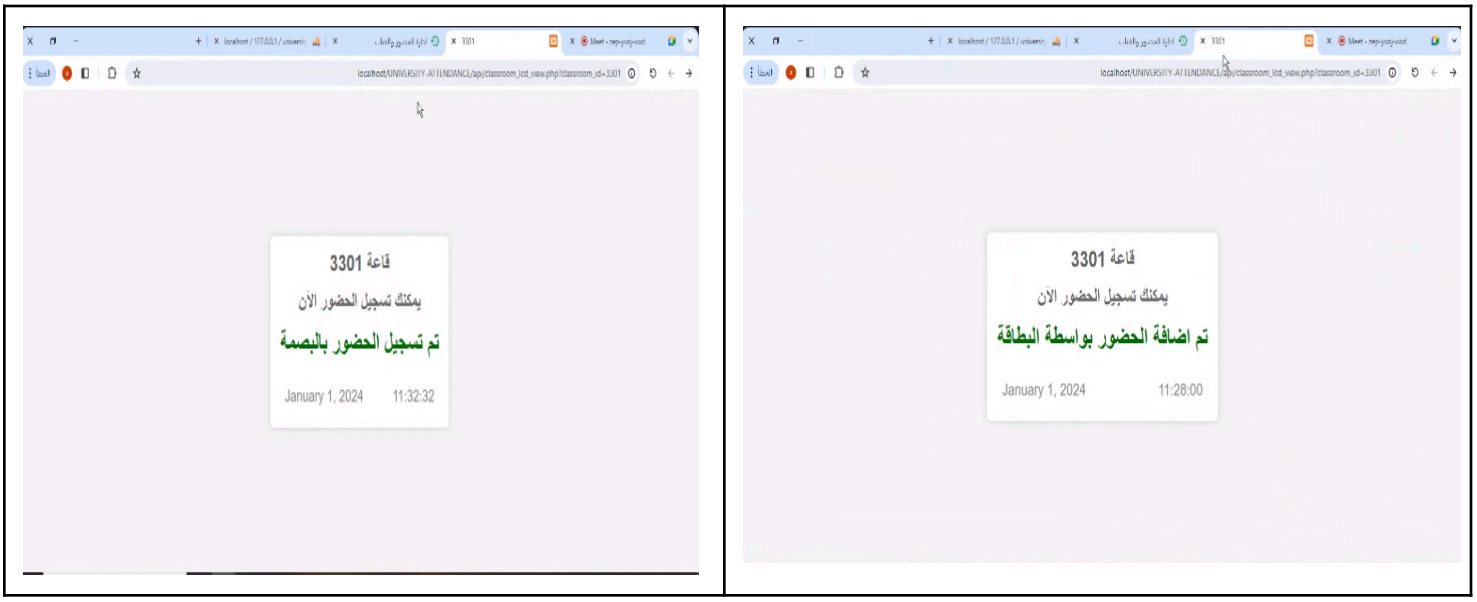

Figure 5.4 (c): Fingerprint validation (attendance record with both RFID and fingerprint)

5.3.6: attendance recording in wrong classroom validation:

as shown in figure (5.5) below:

Figure 5.5: Attendance recording in wrong classroom validation

5.3.7: register section in the same time as another section in same classroom validation:

as shown in figure (5.6) below:

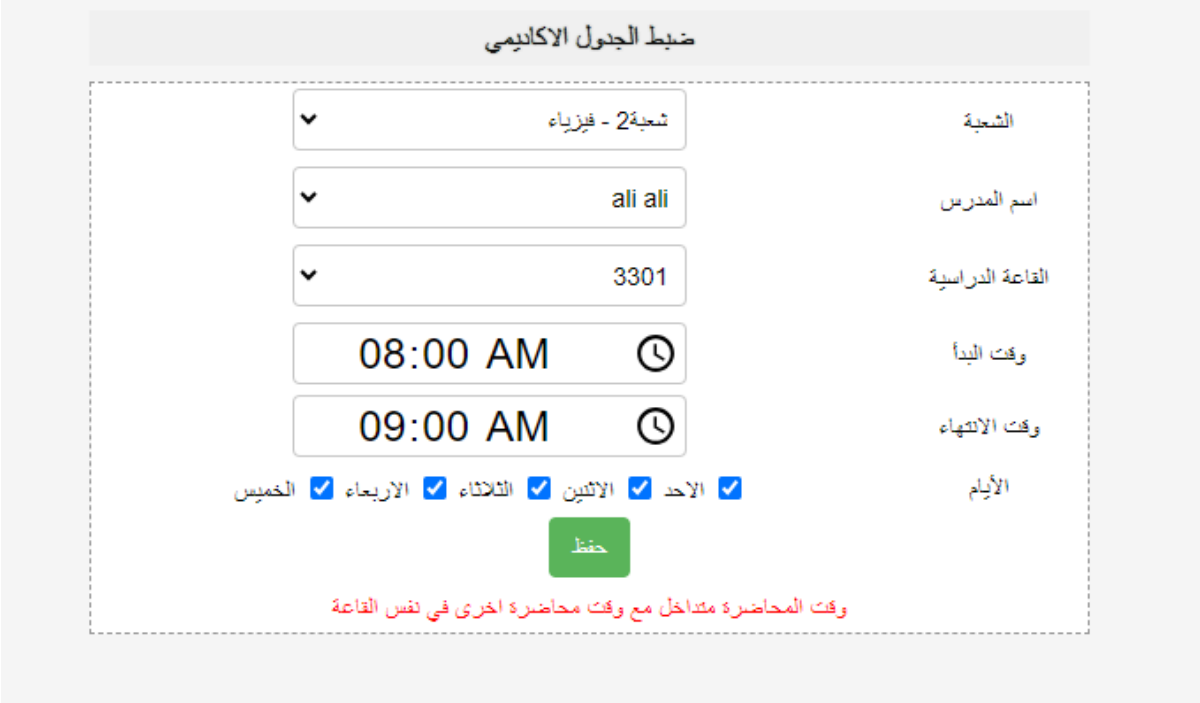

Figure 5.6: register section in the same time as another section in same classroom validation

5.4 Summary:

In this chapter, we covered the practical implementation and evaluation of the developed system. It details the setup process for both hardware and software components, emphasizing system architecture and integration. The chapter also discusses the testing phase, which includes assessing accuracy, efficiency, and scalability. Results are analyzed. Overall, this Chapter offers a thorough evaluation of the system's performance, showcasing its ability to streamline attendance management through RFID and fingerprint technologies. The performance testing was applied, but we did not evaluate all security subtests.

Chapter 6: Conclusion

The IOT-based Attendance System using RFID and Fingerprint is a pioneering project designed to revolutionize attendance management in educational and professional settings. Integrating RFID tags, fingerprint sensors, ESP32 modules, and a web application, the system employs a multi-layered approach to identify and record individual presence. Utilizing Wi-Fi connectivity, the attendance data is seamlessly transmitted to a website for authorized user access and analysis.

In this project, we have designed and implemented an IoT-based Attendance System using RFID and Fingerprint. The system can enroll and validate numerous students' biometric and RFID data before sending it to a website via the Internet. The PHP-coded website includes a database and attendance records. Lecturers can see the attendance records of each student enrolled in their sections, as well as their personal information and timestamps, by logging into the website. In addition, the website displays an attendance report for a specific segment. Lecturers have the option of tracking attendance in a variety of ways. This technology provides a safe and convenient method of marking attendance at universities where attendance is required.

We recommend implementing the system at the university for at least one semester, observing and solving problems that arise.

6.1 Future work:

The current system will be enhanced with many features in the future, including:

1. **Integration of Multiple Biometrics:** Incorporating multiple biometric features such as face recognition along with fingerprint recognition can enhance the system's accuracy and reliability.
2. **Message-Notification System:** A notification system could be implemented to inform students about their attendance via GSM3 or Gmail service.
3. **Contactless Attendance:** In light of the COVID-19 pandemic, a contactless and non-invasive process of face recognition using an ESP-32 cam could be critical.
4. **record attendance during exam periods.**
5. **Embedding RFID in student ID cards.**

6.2: References

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Sites helped to develop the system:

https://www.arduinolibraries.info/libraries/mfrc522
https://www.php.net/manual/en/
https://www.phpmyadmin.net/docs/