Sfax University

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Smart Locker System

End-of-Year Project

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Summary

General introduction 1
Chapter I: Review of the existing infrastructure 2
I.1.Introduction 3
I.2. Traditional locking mechanisms 3
I.3. Electronic locking systems 4
I.4. Biometric locking systems 6
I.5. Conclusion 8
Chapter II: Solution Analysis and Design 9
II.1. Introduction 10
II.2. Proposed solution 10
II.3. Diagrams 10
II.4. Use cases 12
II.5. Benefits and limitations 13
II.6. Implementation 13
II.7. Conclusion 14
Chapter III: Hardware Design and Implementation 15
III.1. Introduction 16
III.2. Hardware components 16
III.3. Hardware integration 19
III.4. Design and implementation 20
III.5. Test and evaluation 22
III.6. Conclusion 22
Chapter IV: Software Design and Implementation 23
IV.1. Introduction 24
IV.2. Software components 24
IV.3. Software architecture 25
IV.4. Test and evaluation 28
IV.5. Conclusion 31
Economic study 32
General conclusion 33
Bibliography 34

List of figures

Figure 1 : Use case diagram 11
Figure 2 : Sequence diagram 11
Figure 3 : State machine diagram 12
Figure 4 : NodeMCU ESP8266 board 16
Figure 5 : ESP32-CAM module 17
Figure 6 : TTL to USB module 18
Figure 7 : Kit RFID RC522 reader 18
Figure 8 : OLED display module 18
Figure 9 : Other components 19
Figure 10 : First schematic 21
Figure 11 : Second schematic 21
Figure 12 : Fritzing logo icon 21
Figure 13 : Schematic of software architecture 28
Figure 14 : Attendance records interface 28
Figure 15 : Home interface 29
Figure 16 : System requirements interface 29
Figure 17 : phpMyAdmin database 30
Figure 18 : Client information interface 30

List of tables

Table 1 : Comparison of NodeMCU and different boards 17

General introduction

A smart locker system is a modern and efficient way of managing the storage and retrieval of items in a secure and automated manner. It employs advanced technologies such as sensors, RFID (Radio Frequency Identification), and biometric authentication to ensure that only authorized personnel can access the lockers and their contents.

Smart locker systems can be used in various settings such as offices, schools, airports, train stations, and banks. They provide a convenient and secure way for individuals to store and retrieve their personal belongings without the need for human intervention.

Smart locker systems offer several benefits such as increased security, reduced operational costs, and improved user experience. They also provide real-time monitoring and reporting capabilities, enabling administrators to track usage and manage the system more efficiently.

It can help reduce operational costs by eliminating the need for staff to manage the lockers manually. It also reduces the risk of lost or stolen items, which can be costly to replace. The system can also be used to track usage and generate reports, which can help identify areas for improvement and optimize the use of resources.

In summary, a smart locker system offers a secure, convenient, efficient, and customizable solution for managing the storage and retrieval of items in various settings. It can help reduce operational costs, improve user experience, and contribute to sustainability efforts.

This report is divided into four chapters, which are: **The review of existing infrastructure** where we explain the traditional methods used to record attendance, the second which named **solution analysis and design**, outlines the specific approach and methods used to carry out the project, including how the project was divided into different parts or sections. The third **Hardware design and implementation** describes the hardware part, and finlay the fourth chapter **Software design and implementation** is used to provide an overview of the software component**s** in the project. **[1]**

the Smart Locker System can be further enhanced with the integration of a door actuator and a sleek design block, facilitating easy installation on entry doors of target areas. This expansion opens new possibilities for the system's application in securing sensitive zones and providing controlled access.

Chapter I:
Review of the existing infrastructure

I.1.Introduction

The aim of this chapter is to examine the non-intelligent systems commonly used in our daily lives for securing personal belongings and valuables. We will discuss the limitations of traditional physical locking mechanisms, electronic locking systems, and biometric locking systems. This examination will provide a foundation for understanding the importance of intelligent locking systems, such as the Smart Locker System, and how it addresses the limitations and challenges of non-intelligent locking mechanisms. By the end of this chapter, the reader will have a comprehensive understanding of the different types of available locking systems as well as their advantages and disadvantages.

I.2. Traditional locking mechanisms

A. Introduction to traditional locking mechanisms

Traditional locking mechanisms refer to physical locks that have been used for centuries to secure personal belongings and valuables. They are an important aspect of security, providing a basic level of protection against theft and unauthorized access.

B. Types of traditional locking mechanisms

- Padlocks are portable locks that are not permanently attached to the object they are securing. They come in various sizes and are often used to secure storage units, bicycles, and gates. They operate by using a shackle that is inserted into a metal loop, which is then locked in place using a key. Advantages of padlocks include their portability and ease of use. However, they can be easily cut or broken, and keys or combinations can be lost or stolen.
- Combination locks are a type of padlock that use a series of numbers or letters to open the lock. They are often used to secure lockers, briefcases, and safes. Combination locks offer the advantage of not requiring a key, making them harder to pick. However, they can still be vulnerable to manipulation or guessing.
- Key-based locks are locks that require a physical key to open. They are the most common type of lock used for securing doors, cabinets, and other fixed objects. Key-based locks offer the advantage of being relatively inexpensive and easy to use. However, they are vulnerable to picking and key duplication.

C. Advantages of traditional locking mechanisms

- Traditional locking mechanisms offer several benefits, including their affordability, simplicity, and ease of use. They are also widely available and can be purchased at most hardware stores. In some cases, traditional locks may also be preferred due to their aesthetic design, especially in historic or traditional settings.

D. Limitations of traditional locking mechanisms

- Vulnerability to picking and bumping traditional locks are often vulnerable to picking and bumping, which are techniques used to manipulate the lock and gain unauthorized access. This vulnerability can compromise the security of the locked object and make it easier for thieves to break in.

- Key duplication and control issues traditional locks are also vulnerable to key duplication, which can compromise the security of the lock if keys fall into the wrong hands. Additionally, key control issues can arise when multiple keys are in circulation, making it difficult to track and manage access to the locked object.

- Limited access control traditional locks offer limited access control, as they do not provide a way to track or manage access to the locked object. This can be a major limitation in situations where security is of utmost importance, such as in businesses or government buildings.

Traditional locking mechanisms offer a basic level of security but have several limitations in terms of security and convenience. These limitations have led to the development of more sophisticated locking systems, such as electronic and biometric locks, which offer enhanced security and access control. However, traditional locks remain a widely used and affordable option for securing personal belongings and valuables. [2]

I.3. Electronic locking systems

A. Overview of electronic locking systems

Electronic locking systems are a type of locking mechanism that use electronic components to control access to a locked object. They are designed to provide enhanced security, access control, and convenience compared to traditional locking mechanisms. These systems are commonly used in hotels, apartment buildings, office complexes, and other commercial and residential settings.

Electronic locking systems include various types such as key card locks and pin code locks. Key card locks operate by using a key card with a magnetic strip that is swiped through a reader to unlock the door. Pin code locks require a user to enter a numeric code on a keypad to unlock the door. Electronic locking systems can also be controlled remotely through a network, allowing for centralized access control.

B. Comparison of different types of electronic locking systems

Cost comparison of electronic locking systems: Electronic locking systems can be more expensive than traditional locking mechanisms due to the use of electronic components and the need for professional installation. The cost can vary depending on the type of electronic locking system, the level of security required, and the size of the facility.

Security comparison of electronic locking systems: Electronic locking systems provide improved security compared to traditional locking mechanisms. They can offer features such as audit trails, access logs, and real-time monitoring, which can help prevent unauthorized access and improve security. However, the level of security offered by electronic locking systems can vary depending on the type of system and the level of encryption used.

Convenience comparison of electronic locking systems: Electronic locking systems offer more convenience than traditional locking mechanisms. Users can easily change access codes and restrict access as needed, which can be especially useful in a commercial setting. However, some electronic locking systems can be more complicated to use than traditional locks, and technical issues can arise, causing inconvenience.

Examples of situations where each type of electronic locking system is preferred: Key card locks are commonly used in hotels and office buildings, while pin code locks are often used in residential settings. The type of chosen electronic locking system will depend on the specific security and convenience needs of the facility.

C. Limitations of electronic locking systems

Vulnerability to hacking: Electronic locking systems are vulnerable to hacking, which can compromise the security of the locked object. Hackers can gain access to the system and override security measures, making it easier for them to break into the locked object.

Technical malfunctions: Electronic locking systems can also experience technical malfunctions, which can compromise the security of the locked object. Technical issues can cause the locking system to fail or malfunction, preventing access to the locked object.

D. Advantages of electronic locking systems

Improved security compared to traditional locking mechanisms: Electronic locking systems offer improved security compared to traditional locking mechanisms. They can provide real-time monitoring, audit trails, and access logs, making it easier to track and manage access to the locked object.

Better access control: Electronic locking systems offer better access control, allowing for the tracking and management of access to the locked object. This can be especially useful in commercial settings where access control is a major concern.

More convenience: Electronic locking systems offer more convenience compared to traditional locking mechanisms. Users can easily change access codes and restrict access as needed, which can be especially useful in a commercial setting.

Electronic locking systems offer improved security, better access control, and more convenience compared to traditional locking mechanisms. However, they are vulnerable to hacking and technical malfunctions, which can compromise the security of the locked object. The limitations of electronic locking systems have led to the development of more sophisticated locking systems, such as biometric locks. The outlook for electronic locking systems is likely to involve further advances in technology, such as improved encryption methods and enhanced remote monitoring capabilities.

I.4. Biometric locking systems

A. Description of biometric locking systems

Biometric locking systems are a type of locking mechanism that uses unique physical characteristics of an individual to grant access to a locked object. These physical characteristics include facial recognition, fingerprint recognition, and voice recognition. Biometric systems use algorithms to create a digital representation of these unique physical characteristics and match them with a pre-existing database for identification purposes.

B. Advantages and disadvantages of biometric locking systems

Advantages:

Enhanced security: Biometric locks provide a high level of security as they rely on unique physical characteristics that are difficult to replicate or forge.

Convenience: Biometric locks do not require any physical keys or cards, making it easy for individuals to access the locked object.

Accurate identification: Biometric locks provide accurate identification of individuals as they rely on unique physical characteristics.

Easy access management: Biometric locks provide easy access management as they can easily add or remove users from the system.

Disadvantages:

Cost: Biometric locks can be expensive to purchase and install compared to traditional locking mechanisms.

Technical limitations: Biometric locks can have technical limitations such as misidentification due to changes in physical characteristics, or difficulty in identifying individuals with certain physical conditions such as scars or injuries.

Privacy concerns: Biometric locks raise privacy concerns as they collect and store personal biometric data.

C. Current applications of biometric locking systems

Facial recognition locks: These locks use facial recognition technology to grant access to a locked area. Users typically need to stand in front of a camera for their face to be scanned.

Fingerprint recognition locks: These locks use a user's fingerprint to verify their identity and allow access. Users typically need to place their finger on a scanner for their fingerprint to be read.

Voice recognition locks: These locks use a user's voiceprint to verify their identity and allow access. Users typically need to speak a passphrase for their voiceprint to be analyzed.

QR code locks: These locks use a QR code that contains encrypted data to grant access. Users typically need to scan the QR code with their smartphone or other device.

RFID tag locks: These locks use radio-frequency identification (RFID) technology to allow access. Users typically need to wave an RFID tag or card in front of a sensor for the lock to be opened.

Overall, biometric locking systems provide a high level of security and convenience, but also come with certain limitations and technical challenges. As technology continues to evolve, it

is likely that we will see more advancements in biometric locking systems, addressing some of these limitations and making them more accessible for widespread use.

I.5. Conclusion

This chapter has covered common types of locking mechanisms, such as physical, electronic, and biometric locks. Advantages and limitations of each type have been discussed, along with examples of their use. While traditional locks have limitations in terms of security and convenience, electronic locks offer improved security and access control, but are susceptible to hacking and technical malfunctions. Biometric locks are the most advanced locking systems available but may not be suitable for all applications due to their high cost and limitations in terms of user privacy.

In summary, the Smart Locker System project will benefit greatly from this chapter by being able to evaluate and integrate the best locking mechanisms available, creating a secure, efficient, and user-friendly solution for customers.

Chapter II:
Solution Analysis and Design

II.1. Introduction

In this chapter, we will provide a comprehensive analysis of the Smart Locker System solution, which consists of three main components: facial recognition, QR code, and RFID tag. We will delve into the details of each component, including their design, functionality, and integration to create a cohesive and efficient system. Additionally, we will explore the benefits and limitations of each component and their suitability for different use cases.

To aid in our understanding of the system's design, we will also describe how we used SysML to model the various components of the smart locker system, including the hardware devices, software modules, and communication protocols.

II.2. Proposed solution

This chapter presents the proposed Smart Locker System solution, which addresses the issues identified in the previous chapter. The Smart Locker System solution is comprised of three main components: facial recognition, QR code, and RFID tag. These components work together to provide a secure, efficient, and user-friendly solution for locker access. By using a combination of facial recognition, QR code, and RFID tag technologies, the proposed Smart Locker System solution provides a range of options for users to access lockers quickly and easily. The system is also designed to address security concerns, as each access attempt is recorded and can be monitored by the system administrator.

The proposed Smart Locker System solution provides a secure, efficient, and user-friendly solution for locker access. By leveraging the strengths of different technologies, we have created a system that meets the needs of a variety of users and ensures the safety and security of their belongings.

II.3. Diagrams

This part provides an overview of the different types of diagrams used to illustrate the proposed Smart Locker System solution. The diagrams used include the use case diagram, sequence diagram, and state machine diagram. **[3]**

The use case diagram is used to describe the different user interactions with the system. It provides a high-level view of the system and its functionality. The main actors in the system are the user, the locker, and the administrator. The use case diagram shows the different

actions that each actor can perform, such as opening the locker, logging in to the system, and adding or removing lockers from the system. As shown in this figure:

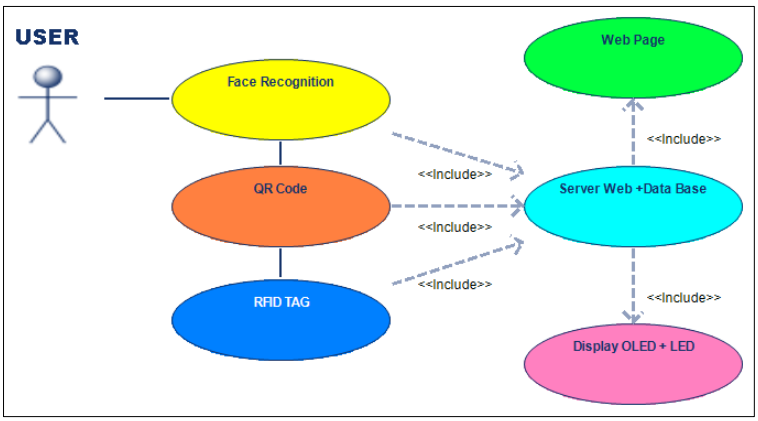

Figure 1 : Use case diagram

The sequence diagram is used to show the interaction between the different components of the system. It provides a detailed view of the system's behavior and how it responds to user inputs. The sequence diagram shows the different steps involved in accessing the locker, such as facial recognition, scanning the QR code, and scanning the RFID tag. It also shows the different responses from the system, such as granting or denying access as described in this diagram.

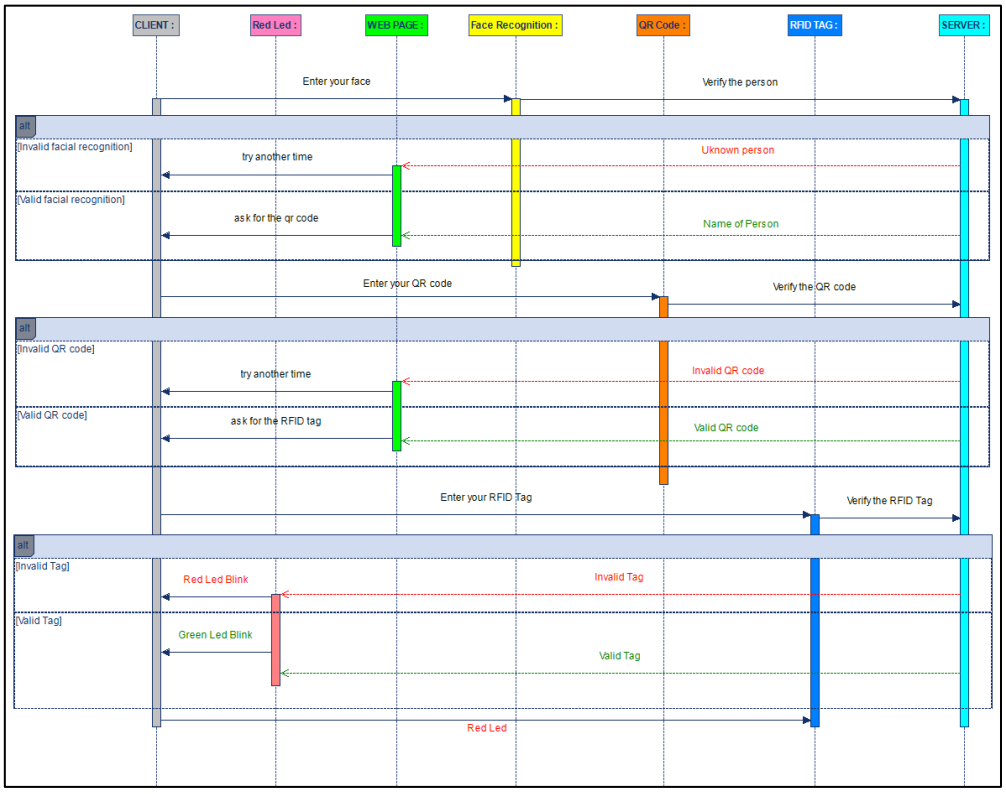

Figure 2 : Sequence diagram

The state machine diagram is used to show how the system behaves over time. It provides a detailed view of the different states of the system and the transitions between them. The state machine diagram shows the different states of the locker, such as locked, unlocked, and reserved. As shown in the figure, it also demonstrates the different triggers that initiate the system's transitions between these states, including user authentication, locker reservation, and locker release.

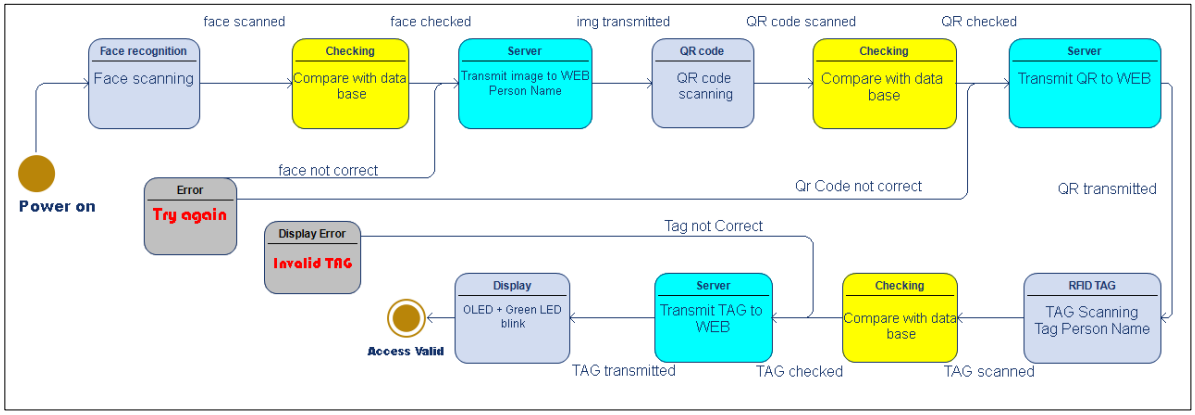

Figure 3 : State machine diagram

In general, the use of these three diagrams provides a comprehensive view of the Smart Locker System solution and how it works. They illustrate the different components of the system, the user interactions, and the system behavior over time. This information is essential for understanding the design and functionality of the proposed solution and its potential benefits and limitations.

II.4. Use cases

The Smart Locker System solution offers a wide range of use cases and can be applied in various settings where secure and convenient storage is needed. In this chapter, we will analyze the different use cases for the Smart Locker System solution and discuss how it meets the needs of each case.

In fact, the Smart Locker System can be used in public places, schools, universities, or workplaces where employees need a secure storage solution for their personal belongings. By implementing the facial recognition, QR code, or RFID tag access methods, employers can ensure that only authorized personnel can access the lockers. This can reduce the risk of theft and promote a safer working environment.

Overall, the Smart Locker System solution offers a wide range of use cases and can be customized to meet the specific needs of each setting. By providing a secure and convenient storage solution, the system can enhance safety and convenience for users.

II.5. Benefits and limitations

The benefits and limitations of the Smart Locker System solution were evaluated in this section. In terms of security, the system offers advanced features like facial recognition, QR codes, and RFID tags to ensure authorized access. It provides convenience through user-friendly access methods and remote management capabilities. Although the initial cost may be higher, the system offers long-term cost savings and reduces the need for maintenance. Compared to other locker systems, it provides enhanced security, convenience, and remote management. Overall, the Smart Locker System solution is a robust and efficient solution that meets various application requirements.

II.6. Implementation

The implementation of the proposed Smart Locker System solution involves a range of practical considerations, including technical requirements, logistics, and costs.

One of the first technical requirements to consider is the hardware needed for the system to function. This includes the physical lockers themselves, as well as any necessary components for the facial recognition, QR code, and RFID tag systems. In addition, the system will require a central computer or server to manage access control and user information.

Logistics is another key consideration for implementation. This includes determining the number and location of lockers, as well as the placement of the different components of the system. It is important to ensure that the system is accessible and user-friendly for customers, while also providing adequate security measures.

Cost is also a significant factor in implementing the Smart Locker System. The costs involved will depend on a range of factors, including the size and complexity of the system, the quality of the components used, and the necessary technical expertise. It is important to carefully consider the costs involved and to develop a realistic budget for the project.

Overall, the successful implementation of the Smart Locker System solution requires careful planning and consideration of a range of practical factors. By addressing these considerations and ensuring the system is designed to meet the needs of users and businesses, the Smart

Locker System can provide a secure, efficient, and convenient solution for a variety of use cases.

II.7. Conclusion

In addition to the proposed solution and its potential benefits and limitations, this report also discussed the different types of diagrams used to illustrate the Smart Locker System. These diagrams provided a visual representation of the system's components and their interactions, facilitating a better understanding of the proposed solution. By utilizing various types of diagrams, such as flowcharts, state diagrams, and activity diagrams, we were able to present a comprehensive view of the Smart Locker System's design and functionality.

Chapter III:
Hardware Design and Implementation

III.1. Introduction

The Smart Locker System is a complex solution that requires both hardware and software components to work together seamlessly. In this chapter, we will focus on the hardware component of the Smart Locker System. We will discuss the importance of hardware in the system and its role in ensuring the system's reliability and security. We will also describe the different hardware devices used in the system and their functions. We aim to highlight the importance of hardware in ensuring the system's functionality, reliability, and security. By the end of this chapter, readers will have a clear understanding of the different hardware devices used in the system and their functions, as well as their suitability for different use cases.

III.2. Hardware components

The Smart Locker System is comprised of several hardware components, each playing a crucial role in the system's functioning. In this section, we will discuss each component in detail, including its physical and technical specifications.

NodeMCU ESP-8266 board in accordance with the figure, is the brain of the system and is responsible for controlling all the other components. It is a microcontroller board that features built-in Wi-Fi connectivity, making it ideal for IoT applications.

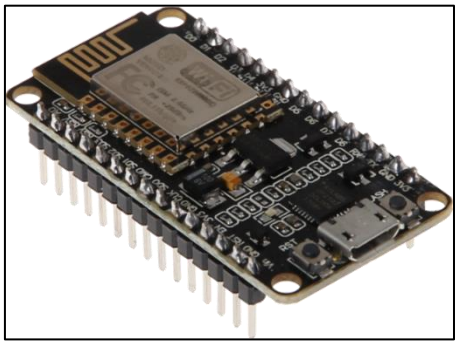

Figure 4 : NodeMCU ESP8266 board

Based on a study, the next table presents a comparison between the NodeMCU and the different boards:

Table 1 : Comparison of NodeMCU and different boards

Board	Wifi capability	Digital I/O Pins	Analog I/O Pins	Frequency	Other characteristics	Tunisian cost
NodeMcu ESP 8266 [4]	Built in Module Wifi	11	1	80MHZ	Suitable for low-power applications	40TND
STM32F407VGT6 [5]	Wifi module required	82	16	1.4GHZ to 1.5GHZ	Suitable for embedded systems and microcontroller-based projects	170TND
Raspberry-Pi 3 [6]	Built in Module Wifi	17	No one	72 MHZ to 120 MHZ	Full-fledged computer with rich features and capabilities	210TND
Arduino uno [7]	Wifi module required	14	6	16 MHZ to 48 MHZ	Popular platform for prototyping and DIY projects	26TND

Facial recognition and QR code scanner with a camera (ESP32-CAM) are used for user authentication. The facial recognition system uses a camera to capture an image of the user's face, which is then processed by an algorithm to verify the user's identity. The ESP32-CAM as illustrated in the figure, is a low-cost, compact, and high-performance camera module that is commonly used in IoT projects. [8]

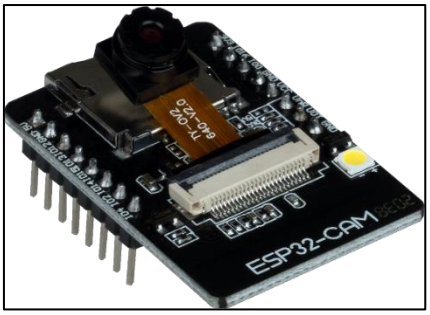

Figure 5 : ESP32-CAM module

TTL to USB module for ESP32-CAM in correspondence with the next figure, is a module that allows you to connect the ESP32-CAM to a computer through a USB interface. It is required for uploading code to the ESP32-CAM and for debugging purposes.

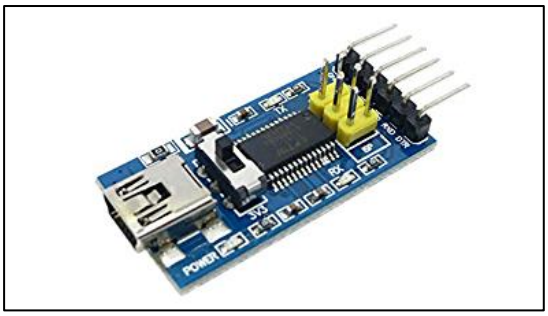

Figure 6 : TTL to USB module

The RFID tag reader (RC522) and tags as indicated in the figure, are used for locker identification. Each locker is equipped with an RFID tag, and the RFID tag reader can read the tag to identify the locker. The RC522 is a low-cost, highly integrated RFID reader that operates at 13.56 MHz. The tags are small, inexpensive, and durable, making them an ideal choice for identifying lockers in the Smart Locker System. **[9]**

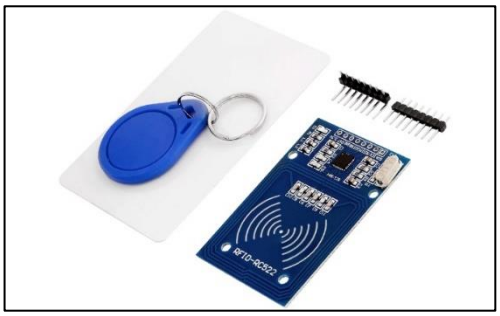

Figure 7 : Kit RFID RC522 reader

The display (OLED) in conformity with the figure is used to provide visual feedback to the user. It displays information such as locker availability and user instructions. The OLED is a compact and low-power display that can be easily integrated into IoT projects. **[10]**

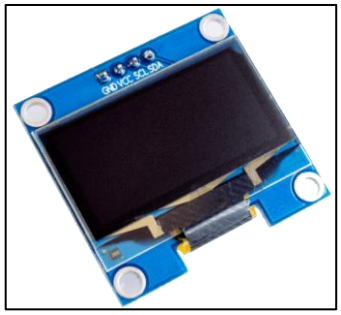

Figure 8 : OLED display module

The system is powered by a DC power supply, wires and a breadboard are also used to connect the various components of the system and provide power to each component. Green and red LED indicators with 220 Ohm resistors are also used to visually indicate the status of the system. This description is based on this figure.

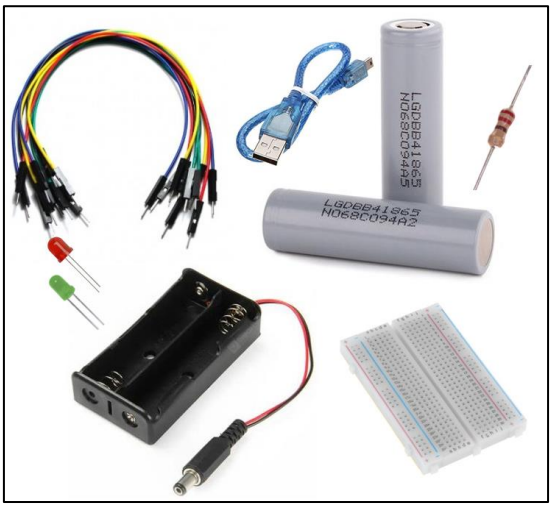

Figure 9 : Other components

In summary, each hardware component of the Smart Locker System has its own set of specifications and features, which contribute to the system's overall functionality and effectiveness. Understanding these hardware components and their characteristics is crucial to the successful design and implementation of the Smart Locker System.

III.3. Hardware integration

In the smart locker system, various hardware components are integrated and connected to create a cohesive system. The hardware integration process involves connecting the components to the NodeMCU8266 board through a breadboard. Hardware interfaces and communication protocols are crucial for seamless communication and operation among the components.

The system utilizes the UART and I2C interfaces for communication. These interfaces enable efficient data exchange between the NodeMCU8266 board and the different components. To facilitate different functionalities, the system employs specific communication protocols. The TCP/IP protocol is used for facial recognition, QR code detection, and RFID communication. It operates on port 80 for communication across these components. For facial recognition, a script runs on port 17 of ESP-32 cam device, utilizing the TCP/IP protocol. Similarly, a corresponding script executes on port 17 of the device for QR code

detection. The RFID system also employs the TCP/IP protocol on port 80, with a script running on port 17 of the RFID device.

The system's database is accessed through the MySQL protocol on port 3306. This protocol enables seamless connection and communication with the database, ensuring efficient data storage and retrieval. To support the system's operations, the XAMPP server is utilized. It starts the Apache server and MySQL server, providing essential functionalities. The server offers an interface for attendance records and a homepage (home.html), enhancing user interaction and system management. Furthermore, a dedicated HTML page for system requirements is accessible on port 5002. This page provides comprehensive information about the system's specifications and necessary resources.

In summary, the smart locker system leverages various hardware interfaces and communication protocols. The UART and I2C interfaces enable smooth data exchange, while the TCP/IP protocol facilitates communication for facial recognition, QR code detection, and RFID technology. The MySQL protocol ensures seamless database connectivity. The XAMPP server plays a vital role in starting the necessary servers and providing user interfaces, while the dedicated HTML page on port 5002 offers detailed system requirements.

III.4. Design and implementation

The design and implementation section of the Smart Locker System project focuses on the details of how the hardware components were designed and implemented to create a cohesive system. This section includes two schematics that demonstrate the system's connections and layout.

In the next page, the first schematic shows the connection between the ESP-32 cam and the TTL to USB module, which is essential for the system's facial recognition and QR code scanning capabilities. The second schematic illustrates how all the components are connected to the nodemcu8266, including the power supply, OLED, RC522, and two LED lights.

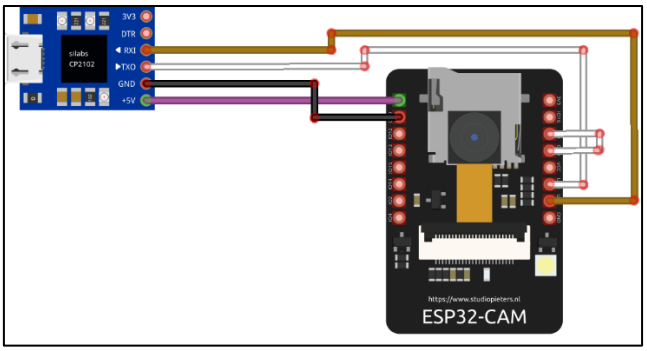

Figure 10 : First schematic

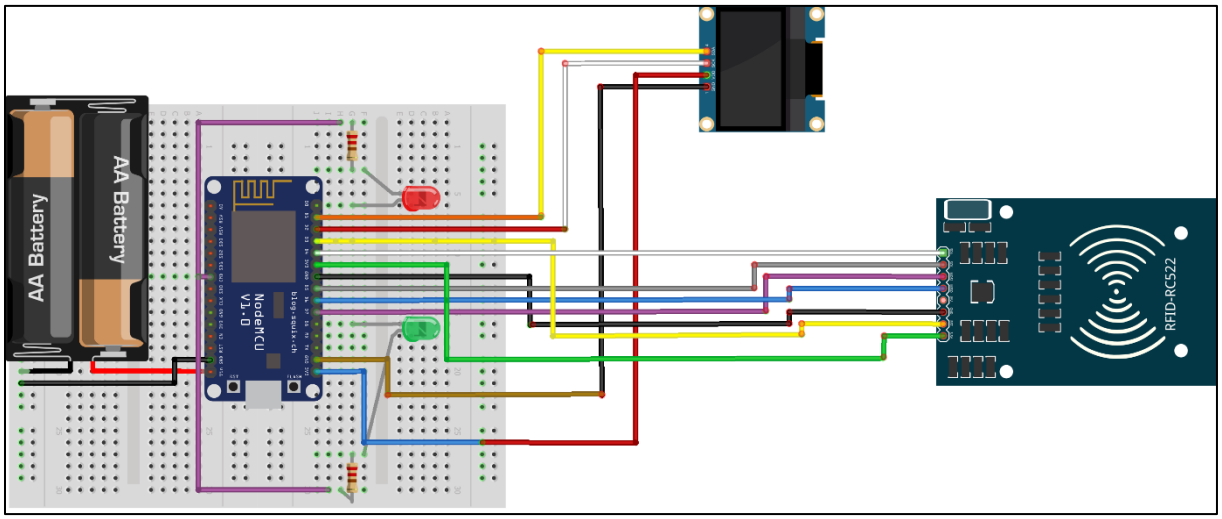

Figure 11 : Second schematic

To create these connections, we used a software tool called **Fritzing** which can be downloaded from the following website indicated in the bibliography. [11]

Fritzing is an open-source software designed to help users design and build electronics projects quickly and easily. We used Fritzing to create the schematic diagrams of the Smart Locker System, which helped us visualize the connections between the various components and ensure that everything was wired correctly.

Figure 12 : Fritzing logo icon

III.5. Test and evaluation

During the testing phase, the performance and functionality of the hardware components were evaluated to ensure the Smart Locker System was working properly. Several tests were conducted to evaluate the system's ability to recognize and respond to different inputs, such as QR codes, RFID tags, and facial recognition.

Additionally, the power supply and connections between components were tested to ensure stability and proper functioning. Any necessary adjustments were made, such as changing the voltage or amperage of the power supply or re-wiring connections, to improve the system's performance.

The results of the testing were analyzed to identify any areas of the system that required improvement. Based on these results, adjustments were made to the hardware components or system. These adjustments were aimed at improving the system's overall performance and functionality.

Overall, the testing and evaluation phase played a crucial role in ensuring the Smart Locker System was reliable, efficient, and user-friendly. By identifying and addressing any issues during this phase, the system was able to function effectively and meet the needs of its users.

III.6. Conclusion

This chapter presented the hardware components used in the Smart Locker System, their integration, and testing procedures. It also discussed the challenges faced and adjustments made to ensure optimal performance. The hardware components, such as facial recognition, QR codes, and RFID tags, played a crucial role in the system's functionality and security. Overall, the Smart Locker System provides secure and efficient storage solutions for users.

Chapter IV:
Software Design and Implementation

IV.1. Introduction

The Smart Locker System uses various programming languages, to implement the different software components. The user interface is web-based and is accessible through a web browser on any device with an internet connection. The software architecture follows a client-server model, with the client being the web interface and the server being the database management system. The chapter aims to provide a detailed description of the different software components and their technical characteristics, including how they were designed and implemented. Additionally, the chapter will discuss the testing procedures used to evaluate the performance and functionality of the software components, as well as the security and privacy measures implemented to protect user data and system integrity.

IV.2. Software components

The Smart Locker System is made up of several software components, including:

- Arduino IDE: This open-source software is used to program the NODEMCU ESP8266 microcontroller, which controls the system's hardware components, such as the OLED Display and RFID reader. Additionally, it is also used to program the ESPCAM module that is used to capture and stream video from the locker.
- VSCode: This is an integrated development environment (IDE) used to write the software code that runs on the Smart Locker System. The primary programming language used is Python, which is used to implement the system's logic. HTML, CSS, and JavaScript are also used to create the user interface, and JavaScript is used to add interactivity to the web application.
- Flask: Flask is a web framework for Python that is used to create the web application for the user interface. It provides a lightweight and flexible way to create web applications and is well suited for small to medium-sized projects.
- Socket.IO: This is a library used for real-time communication between the client and the server. It is used to enable communication between the Smart Locker System and the web application running on the user's device.
- MySQL: This is an open-source relational database management system used to store the data related to the Smart Locker System, including user information and locker availability.

- PhpMyAdmin: This is a web-based interface used to manage MySQL databases. It provides an easy-to-use interface for managing the data stored in the database and allows for the execution of SQL queries.
- XAMPP: This is a cross-platform web server solution used to manage the Smart Locker System. It includes the Apache web server, MySQL database, and PHP interpreter, making it a complete solution for developing and testing web applications.

These software components work together to provide a seamless user experience and efficient management of the Smart Locker System. The use of JavaScript also enhances the user experience by adding interactivity to the web application, allowing users to easily interact with the system and access their lockers.

IV.3. Software architecture

IV.3.1. Arduino scripts

In this section, we will discuss two Arduino scripts - Esp.ino and Nodemcu.ino - and their functionalities.

Esp.ino sets up a web server that allows users to control the ESP32 camera module. It defines different image resolutions to capture and serves the captured images over HTTP on different endpoints. Additionally, it connects to a WiFi network, prints the IP address, and starts the web server. The script continuously handles incoming client requests, making it a versatile tool for controlling the ESP32 camera module over a network.

On the other hand, Nodemcu.ino is an Arduino script for an RFID tag reader that sends the data read to a server over Wi-Fi. The script uses the MFRC522 library to interface with the RFID reader and the Adafruit SSD1306 library to display the tag ID on an OLED display. It also includes code to control two LEDs (red and green) based on the tag value read. The script connects to a Wi-Fi network using a username and password and then sends the tag data to a specified host and port using a TCP/IP client. If the server responds with data, the script parses it and sets the value of a global variable called tag1.

Overall, both Esp.ino and Nodemcu.ino scripts are excellent examples of how to use the Arduino platform for IoT projects.

IV.3.2. Python scripts

- Python Scripts for QR Code Generation and Database Manipulation

QRgen.py and base.py are two simple scripts with straightforward functionality. QRgen.py uses the qrcode module to generate QR codes from a given string and save them as PNG files with the specified file name. base.py uses the mysql.connector module to create a connection to the MySQL database and delete all rows from the "attendance" table using an SQL query. It then commits the changes to the database and prints the number of rows deleted. Both scripts provide examples that demonstrate their usage.**[12]**

The esp.py script sets up a TCP/IP socket server, receives a card number from a device, checks the MySQL database for authentication status, and returns a response. The script uses the mysql.connector library to connect to the database, creates a cursor object, and uses threading to handle multiple requests.**[13]**

The server.py script creates a basic web application with Flask and renders a template file named "sys.html" for requests made to the root URL. The script ensures that the app is only run when executed directly and not when imported as a module.**[14]**

The Face.py script uses OpenCV, face_recognition, and MySQL libraries to implement a face recognition system. The program captures an image, detects faces, and compares them with known faces in an image folder. If a known face is detected, the attendance is marked in a MySQL database.**[15]**

The QR.py script uses OpenCV, Pyzbar, and MySQL to read QR codes from a live video stream and mark attendance in a database. The script creates a connection to the MySQL database, checks if the data (QR code) is already present in the attendance table, and updates or adds a new record accordingly.

IV.3.3. PHP scripts

This PHP script uses HTML, CSS, JavaScript, and PHP to display attendance records in a table format and includes a live video feed from an ESP-32 CAM. The script connects to a MySQL database and retrieves data from the "attendance" table, generating a new table row for each record. The video feed is embedded in an iframe element with a white border and displayed in a size of 1000x1000 pixels. Overall, the script provides a user-friendly interface for displaying attendance records. **[16]**

IV.3.4. HTML scripts

In this section, we will describe three HTML scripts used in our project. These scripts include information.html, sys.html, and home.html. Each script has unique features and elements that are essential to their respective purposes.

Information.html: This HTML script displays a table of client information. The document contains a DOCTYPE declaration, HTML tag, head section with the title of the page and an external stylesheet, and a body section with the main content. The table has five columns, including the name of the client, the client's tag, a QR code image, a photo of the client, and the client's function. Additionally, the script defines a CSS class called "button" and applies it to the button element in the HTML.

Sys.html: This HTML script provides a table of hardware and software requirements for a final year project. The document contains an HTML header with a title and some metadata, CSS styles that affect the look and feel of the document, and a body section with a heading followed by a table. The hardware and software components required for the project are listed in the table, with each component having a brief description of its functionality.

Home.html: This HTML script describes the features and benefits of a high-secure locker system that incorporates artificial intelligence (AI) technology. The document contains a head section with metadata and links to external resources, a body section with the main content, and an iframe element that displays content from another webpage. The script also includes a setInterval function that reloads the webpage every 5 seconds.

These HTML scripts play an important role in our project, displaying essential information in a clear and concise manner. By using various HTML tags, CSS styles, and JavaScript functions, we have created functional and visually appealing scripts that serve their intended purposes.

To facilitate the liaison between the software architecture, a schematic in the next page can be used as a visual representation of the system components and their relations:

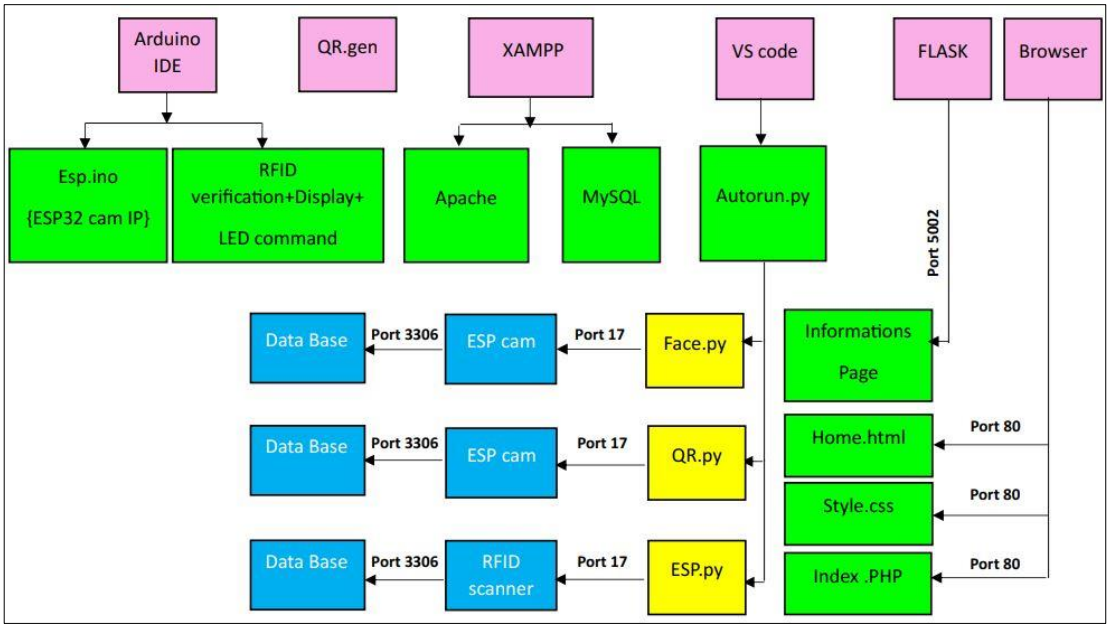

Figure 13 : Schematic of software architecture

IV.4. Test and evaluation

In this section, we will discuss the test and evaluation of the HTML interfaces and PHP database used in our project. We evaluated the performance and functionality of each interface and file using various testing procedures.

Firstly, we tested the Home.html interface in accordance with the next figure, which describes the features and benefits of a high-secure locker system that incorporates artificial intelligence (AI) technology. We verified that all links in the navigation bar were functional and that the iframe element displayed the content from the designated URL correctly. We also tested the setInterval function and confirmed that the webpage refreshed every 5 seconds.

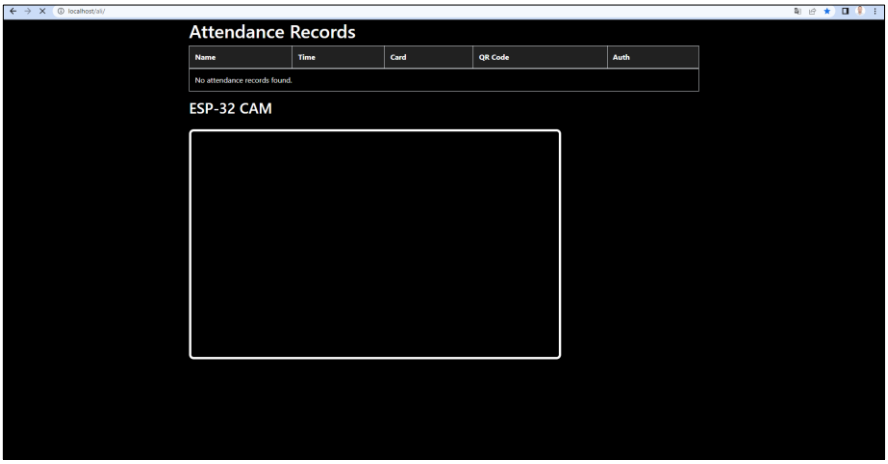

Figure 14 : Attendance records interface

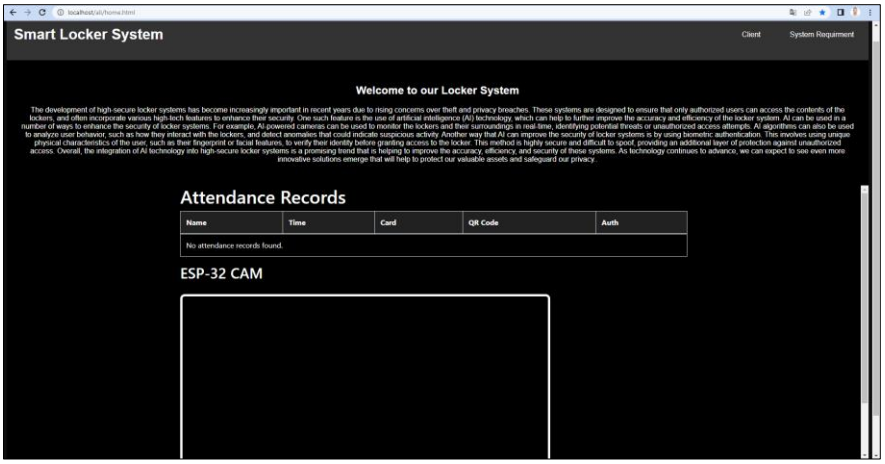

Figure 15 : Home interface

Next, we tested the Sys.html interface in conformity with this figure, which provides a table of hardware and software requirements for a final year project. We verified that the table displayed all components correctly, and that each hardware or software definition provided a brief description of the component's functionality. We also tested the button style defined in CSS and confirmed that the button had a hover effect that changed its background color to a darker shade of gray.

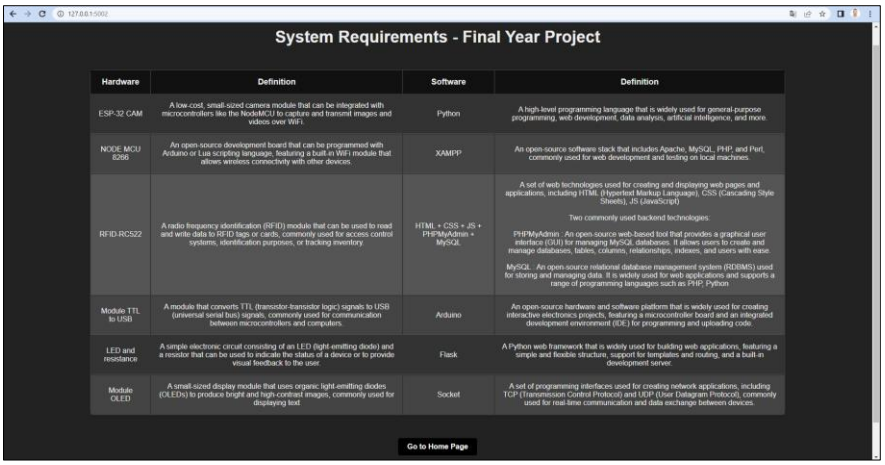

Figure 16 : System requirements interface

We also tested the phpMyAdmin server to monitor any modifications made to the database in real time. We confirmed that any changes made through the HTML interfaces were reflected immediately in the phpMyAdmin database in correspondence with the next figure.

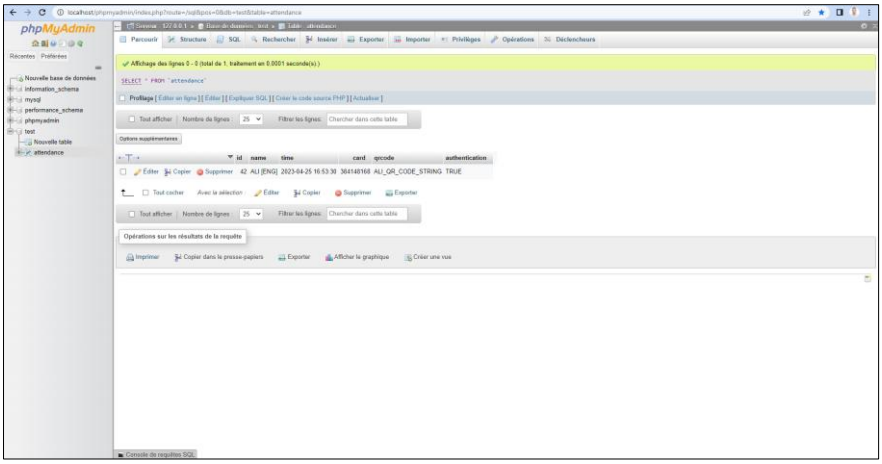

Figure 17 : phpMyAdmin database

Finally, we tested the Client.html interface in line with this figure, which displays a table of client attendance information. We verified that all information in the table was accurate and that the QR code and photo of each client were displayed correctly in separate cells of the table using the image tag. We also tested the CSS class called "button" and confirmed that the button had a black background, white text, and a border radius of 5 pixels, and that the background color changed to a darker shade of black when the user hovered over it.

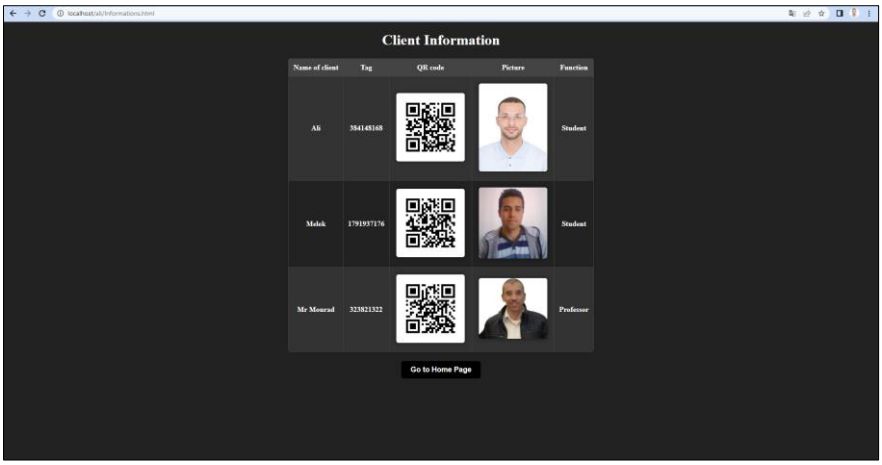

Figure 18 : Client information interface

Overall, the HTML interfaces and PHP database performed well and met our expectations. We made some adjustments to improve their functionality, such as correcting broken links and optimizing the display of certain components. The use of phpMyAdmin also proved to be effective in monitoring any modifications made to the database in real time.

IV.5. Conclusion

In conclusion, this chapter focused on the testing and evaluation of the software components used in the Smart Locker System. We discussed the various testing procedures used to evaluate the HTML interfaces and PHP scripts and highlighted the important features and benefits of each component. Additionally, we emphasized the security and privacy considerations that were considered during the development of the system.

Overall, the software components played a crucial role in the functionality of the Smart Locker System, enabling it to operate securely and efficiently. Through careful testing and evaluation, we were able to identify and correct any issues and make improvements to ensure optimal performance. The Smart Locker System is now better equipped to meet the needs of its users and provide a reliable and secure storage solution.

Economic study

To perform an economic study of the project, we need to analyze the costs of development and implementation. The total cost of the project, based on the components used, is 198.500 TND. This cost includes the following hardware components and their respective prices:

- ESP8266 Nodemcu - 30.000 TND
- ESP-32 cam - 60.000 TND
- OLED display - 23.500 TND
- RFID RC-522 and tags - 25.000 TND
- TTL to USB module - 10.000 TND
- Two power energy 12 V with support - 35.000 TND
- Two breadboards - 10.000 TND
- Other components like wires, LED, and resistors - 5.000 TND

By analyzing the costs, we can determine the feasibility of the project and make decisions regarding its implementation. The economic study can also provide insights into the project's return on investment and potential profitability. **[17]**

General conclusion

In conclusion, the Smart Locker System presented in this report is an innovative and sophisticated solution that offers high-security storage facilities with the latest technologies, such as AI and IoT. The system has been designed and developed to meet the needs of various industries, including retail, and logistics. The hardware and software components of the system have been carefully selected and integrated to ensure optimal performance and functionality.

The implementation of the system has been discussed in detail, including the programming languages like Python and C, libraries and frameworks used to develop the software components such as face_recognition and NumPy for machine learning, OpenCV for image processing, and Flask for web development. The report also provides a detailed analysis of the database management system, specifically focusing on the utilization of phpMyAdmin. This comprehensive discussion highlights the role of phpMyAdmin in storing and efficiently managing data for the Smart Locker System. By leveraging it, the system can store and organize data in a structured manner, facilitating seamless data retrieval and management processes. Test and evaluation of the system have also been thoroughly discussed, including the various methods and tools used to ensure the system's performance and functionality. Security and privacy considerations have also been implemented to protect user data and system integrity.

In terms of economic perspective, the total cost of the project, including hardware and other components, has been analyzed, which can help organizations to evaluate the feasibility of implementing the system.

In summary, the Smart Locker System offers a promising perspective for the future. By integrating with existing infrastructure and incorporating a door actuator solution, it has the potential to enhance security and convenience across various industries.

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Enhancing Security with the Smart Locker System
- Development and Implementation -

This report presents the development and implementation of the Smart Locker System, an innovative and sophisticated solution that provides high security for doors and sensitive areas by prohibiting entry to all individuals. By using a carefully selected and integrated combination of hardware and software, the Smart Locker System offers a secure and convenient experience for users. Security and privacy considerations have been implemented to protect user data and system integrity. The report also includes an analysis of the costs of system development and implementation, as well as the entire section related to the study and development of software and hardware. We are confident that this solution can have a significant impact in various sectors and pave the way for new advances in the field of door and sensitive area security.

Ce rapport présente le développement et l'implémentation du Smart Locker System, une solution innovante et sophistiquée qui offre une haute sécurité pour les portes et les zones sensibles en interdisant l'entrée à toutes les personnes. En utilisant une combinaison de matériel et de logiciel soigneusement sélectionnés et intégrés, le Smart Locker System offre une expérience sécurisée et pratique pour les utilisateurs. Des considérations de sécurité et de confidentialité ont été mises en œuvre pour protéger les données des utilisateurs et l'intégrité du système. Le rapport comprend également une analyse des coûts de développement et d'implémentation du système, ainsi que toute la partie relative à l'étude et au développement du logiciel et du matériel. Nous sommes convaincus que cette solution peut avoir un impact significatif dans divers secteurs et ouvrir la voie à de nouvelles avancées dans le domaine de la sécurité des portes et des zones sensibles.