A PROJECT REPORT

on

"SMART LOCKING SYSTEM"

Submitted to

KIIT Deemed to be University

In Partial Fulfillment of the Requirement for the Award of

BACHELOR'S DEGREE IN

COMPUTER SCIENCE AND ENGINEERING

BY

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UNDER THE GUIDANCE OF
PINAKI SANKAR CHATTERJEE

SCHOOL OF COMPUTER ENGINEERING

KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY

BHUBANESWAR, ODISHA -751024

April 2024

KIIT Deemed to be University

School of Computer Engineering
Bhubaneswar, ODISHA 751024

CERTIFICATE

This is certify that the project entitled

"SMART LOCKING SYSTEM"

submitted by

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This document serves as a testament to the genuine efforts exerted by the undersigned individuals, contributing to the fulfillment of the prerequisites for the conferment of the Bachelor of Engineering (Computer Science & Engineering) degree at KIIT Deemed to be University, Bhubaneswar. Undertaken during the academic year 2023-2024, this endeavor has been conducted under our diligent supervision.

Date: 06 /04 /2024

PINAKI SANKAR CHATTERJEE
(Project Guide)

School of Computer Engineering, KIIT, BBSR

Acknowledgement

We extend our heartfelt gratitude to **PINAKI SANKAR CHATTERJEE** from **KIIT DEEMED TO BE UNIVERSITY** for his invaluable guidance and unwavering support throughout every stage of this project. From its inception to its fruition, his expertise and encouragement have been instrumental in steering us towards our goals. His insightful feedback and mentorship have not only enriched the project but also instilled in us a sense of confidence and purpose. We are deeply appreciative of his dedication and commitment to ensuring that our project aligns with its intended objectives.

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ABSTRACT

In the realm of security and access control, traditional key-based locking systems are gradually being replaced by more efficient and technologically advanced solutions. This paper presents the design and implementation of a Smart Locking System employing RFID (Radio Frequency Identification) card authentication, Arduino Uno microcontroller, solenoid lock, and relay module. The system aims to provide a secure and convenient access control mechanism suitable for various applications such as homes, offices, and industrial environments.

The proposed Smart Locking System operates by authenticating users through RFID cards. Each authorized user is issued a unique RFID card encoded with specific identification data. When a user presents their RFID card to the system, the Arduino Uno microcontroller processes the card's information and verifies it against the authorized user database. Upon successful authentication, the system triggers the relay module, which activates the solenoid lock mechanism to unlock the door or access point.

Key features of the Smart Locking System include its ability to store and manage multiple user credentials, providing flexibility and scalability for accommodating varying access requirements. Additionally, the system offers real-time monitoring capabilities, enabling administrators to track access events and manage user permissions efficiently.

The utilization of Arduino Uno microcontroller ensures the system's affordability, ease of customization, and compatibility with a wide range of sensors and peripherals. The solenoid lock offers robust physical security, while the relay module facilitates seamless integration with the locking mechanism.

In conclusion, the Smart Locking System presented in this paper represents a cost-effective and reliable solution for implementing access control with RFID card authentication. Its versatility, scalability, and user-friendly operation make it an ideal choice for enhancing security and convenience in diverse environments.

Contents

Introduction

In today's rapidly evolving technological landscape, the need for efficient and secure access control systems is paramount. Traditional lock-and-key mechanisms are increasingly becoming outdated, giving way to more advanced solutions like RFID-based smart locking systems. This project focuses on the implementation of a smart locking system utilizing RFID card technology, Arduino Uno microcontroller, solenoid lock, and relay module. The integration of these components promises not only enhanced security but also convenience and flexibility in access management.

The current need for such a project arises from the limitations and shortcomings of conventional locking systems. Traditional locks are susceptible to various vulnerabilities, such as unauthorized duplication of keys, the risk of keys being lost or stolen, and the inconvenience of physical key management. Moreover, in environments where multiple individuals require access, managing and distributing keys becomes a logistical challenge. These gaps in the existing solutions emphasize the necessity for a more sophisticated and robust access control system.

By leveraging RFID technology, this project aims to address these shortcomings effectively. RFID cards serve as secure credentials for accessing the locked premises, offering a convenient and reliable means of authentication. The Arduino Uno microcontroller acts as the central processing unit, facilitating communication between the RFID reader, solenoid lock, and relay module. This centralized control allows for seamless integration and intelligent management of access permissions.

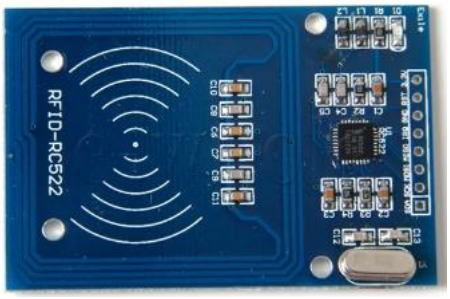
The significance of this project lies not only in its ability to enhance security but also in its potential to streamline access control processes. With the implementation of a smart locking system, organizations and individuals can enjoy greater peace of mind knowing that their premises are effectively protected against unauthorized entry. Furthermore, the convenience afforded by RFID technology simplifies access management, reducing the administrative burden associated with traditional key-based systems.

In this report, we will delve into the design and implementation of the smart locking system using RFID card technology. We will discuss the components involved, their functionalities, and the integration process. Additionally, we will explore the advantages of this system over conventional locking mechanisms and analyze its potential impact on security and access control practices. Through this comprehensive examination, we aim to highlight the significance and relevance of adopting smart locking solutions in modern environments.

Basic Concepts/ Literature Review

2.1 RFID Technology:

Radio Frequency Identification (RFID) technology is a widely used method for tracking and identifying objects. It operates by utilizing radio waves to communicate between an RFID reader and an RFID tag. RFID tags can be either passive, which rely on the reader's electromagnetic field for power, or active, which have their own power source and can transmit data over longer distances. In the context of a smart locking system, RFID cards act as the credentials for granting access. These cards contain embedded RFID tags that transmit unique identification information when in proximity to an RFID reader. The reader then captures this information and sends it to the Arduino Uno microcontroller for authentication and access control purposes.

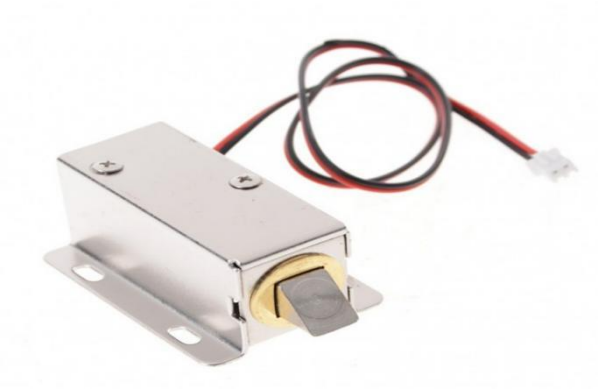


2.2 Arduino Uno Microcontroller:

Arduino Uno is an open-source microcontroller board based on the ATmega328P chip. It provides an easy-to-use platform for prototyping and developing various electronic projects. Arduino Uno features digital and analog input/output pins that can be programmed to interact with sensors, actuators, and other peripheral devices. In the context of a smart locking system, the Arduino Uno serves as the central processing unit responsible for controlling the operation of the RFID reader, solenoid lock, and relay module. It receives input from the RFID reader, processes the authentication data, and triggers the appropriate actions to either unlock or lock the door mechanism.

2.3 Solenoid Lock:

A solenoid lock is an electromechanical device that utilizes a solenoid to control the locking mechanism. When an electrical current is applied to the solenoid, it generates a magnetic field that moves a plunger or bolt, either engaging or disengaging the lock. Solenoid locks are commonly used in electronic locking systems due to their reliability, efficiency, and ease of integration with electronic control systems. In the context of a smart locking system, the solenoid lock is actuated by the Arduino Uno microcontroller upon successful authentication of an RFID card. This allows for secure and automated locking and unlocking of the door.



2.4 Relay Module:

A relay module is an electronic switch that allows low-power microcontrollers like the Arduino Uno to control high-power devices such as motors, lights, and locks. It consists of an electromagnet that, when energized, mechanically switches the connections of the relay, thereby turning the connected device on or off. In the context of a smart locking system, the relay module serves as an interface between the Arduino Uno and the solenoid lock. The Arduino Uno sends a signal to the relay module to activate or deactivate the solenoid lock based on the authentication status received from the RFID reader.

Through the utilization of these tools and techniques, the smart locking system provides a robust and efficient solution for access control, enhancing security and convenience in various environments.

Problem Statement / Requirement Specifications

3.1 Project Planning:

To effectively execute the development of the smart locking system using RFID card, Arduino Uno, solenoid lock, and relay module, the following requirements and features need to be considered:

- **RFID Card Authentication:** Implement a system capable of authenticating users based on RFID card credentials.
- **Arduino Uno Integration:** Integrate Arduino Uno microcontroller for processing authentication data and controlling the locking mechanism.
- **Solenoid Lock Activation:** Develop functionality to actuate the solenoid lock upon successful RFID card authentication.
- **Relay Module Interface:** Establish communication between the Arduino Uno and the solenoid lock using a relay module for switching high-power devices.
- **Access Control:** Implement mechanisms for granting or denying access based on the validity of the RFID card credentials.
- **Security:** Ensure the system's robustness against unauthorized access attempts and security breaches.
- **User Management:** Provide functionality for managing user access rights and permissions.
- **Compatibility:** Ensure compatibility with various RFID card formats and standards for broader usability.
- **User Interface:** Develop a user-friendly interface for configuring system settings and monitoring access logs.

3.2 Project Analysis:

Before proceeding with the development, the requirements and problem statement need to be thoroughly analyzed to identify any ambiguities, inconsistencies, or potential challenges. This analysis helps in refining the project scope and ensuring that the proposed solution aligns with the identified problem.

3.3 System Design:

3.3.1 Design Constraints:

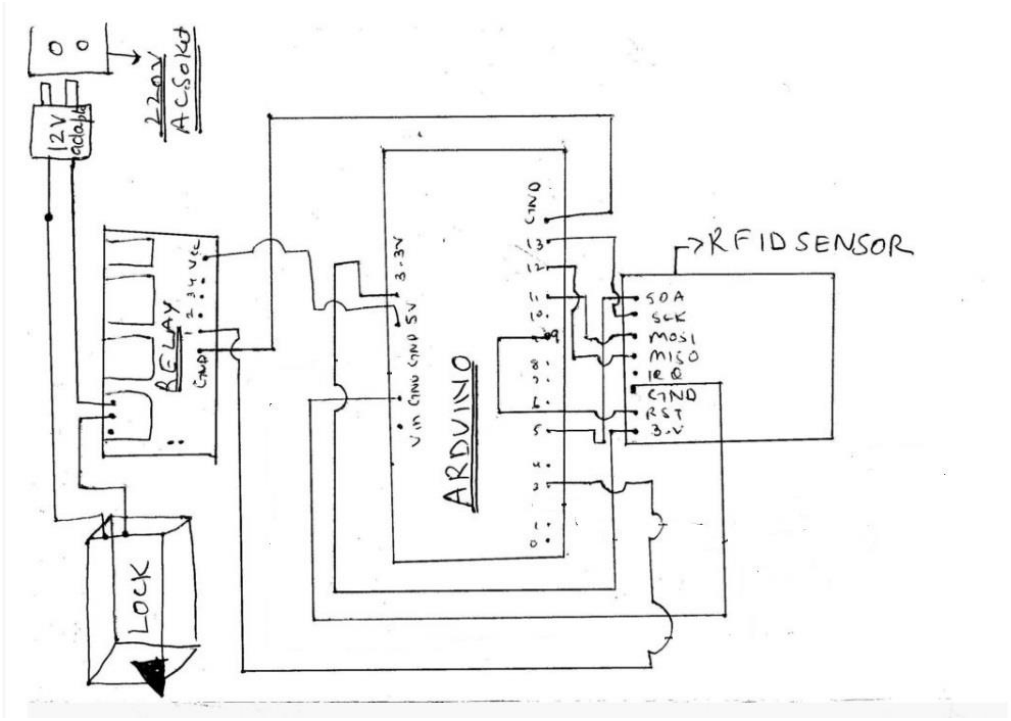
The smart locking system will operate in various environments, including residential, commercial, and industrial settings. The following design constraints need to be considered:

- **Hardware:** Utilize readily available and cost-effective components such as Arduino Uno, RFID reader, solenoid lock, and relay module.
- **Software:** Develop the system software using Arduino IDE for programming the Arduino Uno microcontroller.
- **Power Supply:** Ensure stable power supply for continuous operation of the system.
- **Environmental Conditions:** Design components to withstand varying environmental conditions, including temperature and humidity fluctuations.

3.3.2 System Architecture / Block Diagram:

The system architecture of the smart locking system can be represented using the following block diagram:

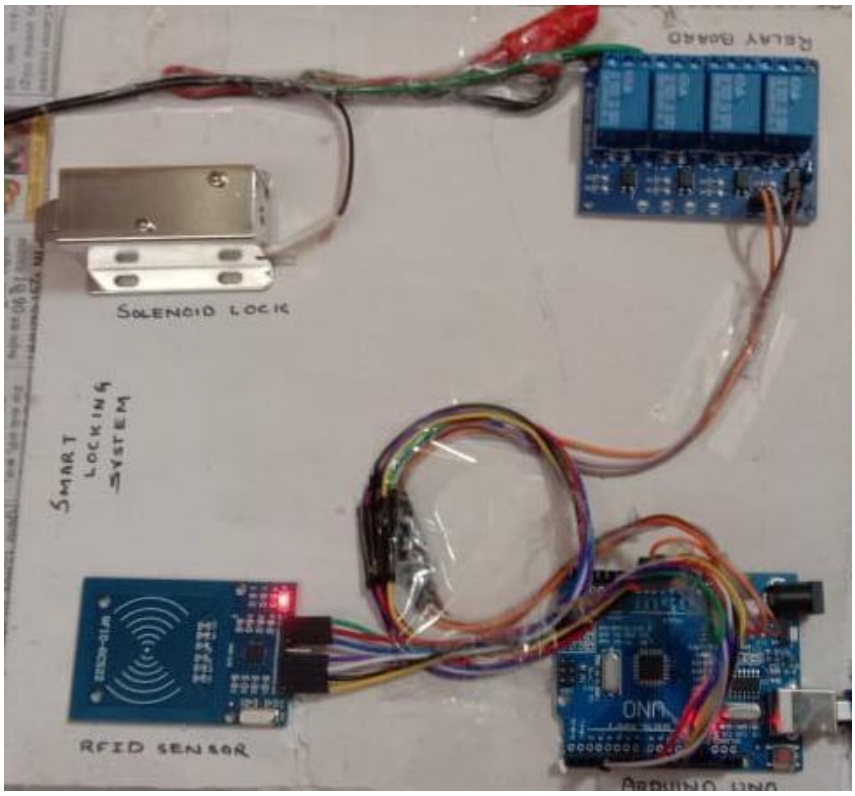
[Diagram]



The system consists of the following components:

- **RFID Reader:** Reads RFID card credentials and sends the data to the Arduino Uno.
- **Arduino Uno:** Processes the authentication data and controls the operation of the solenoid lock and relay module.
- **Solenoid Lock:** Actuates the locking mechanism based on the commands received from the Arduino Uno.
- **Relay Module:** Interfaces between the Arduino Uno and the solenoid lock for switching high-power devices.

This architecture provides a clear understanding of how the different components of the system interact with each other to achieve the desired functionality.



Implementation

In this section, present the implementation done by you during the project development.

4.1 Methodology OR Proposal:

The implementation of the Smart Locking System using RFID card authentication, Arduino Uno, solenoid lock, and relay module followed the following steps:

- **System Design:** Designing the overall system architecture, including the physical components (Arduino Uno, RFID module, solenoid lock, relay module) and their interconnections.
- **Arduino Programming:** Developing the Arduino sketch to handle RFID card authentication, communicate with the RFID module, and control the relay module to operate the solenoid lock.
- **RFID Card Management:** Implementing functionality to manage RFID card data, including adding new cards, removing revoked cards, and storing authorized card IDs securely.
- **User Interface (Optional):** Designing and implementing a user interface for system configuration, such as adding or removing RFID cards and viewing access logs.
- **Testing and Debugging:** Testing the system thoroughly to ensure proper functionality, including RFID card authentication, relay operation, and solenoid lock control. Debugging any issues encountered during testing.

4.2 Testing OR Verification Plan:

- **Test Case Title:** RFID Card Authentication
- **Test Condition:** Present a valid RFID card to the system.
- **System Behavior:** The system should authenticate the RFID card and grant access if the card is authorized.
- **Expected Result:** The solenoid lock should be unlocked, indicating successful authentication.

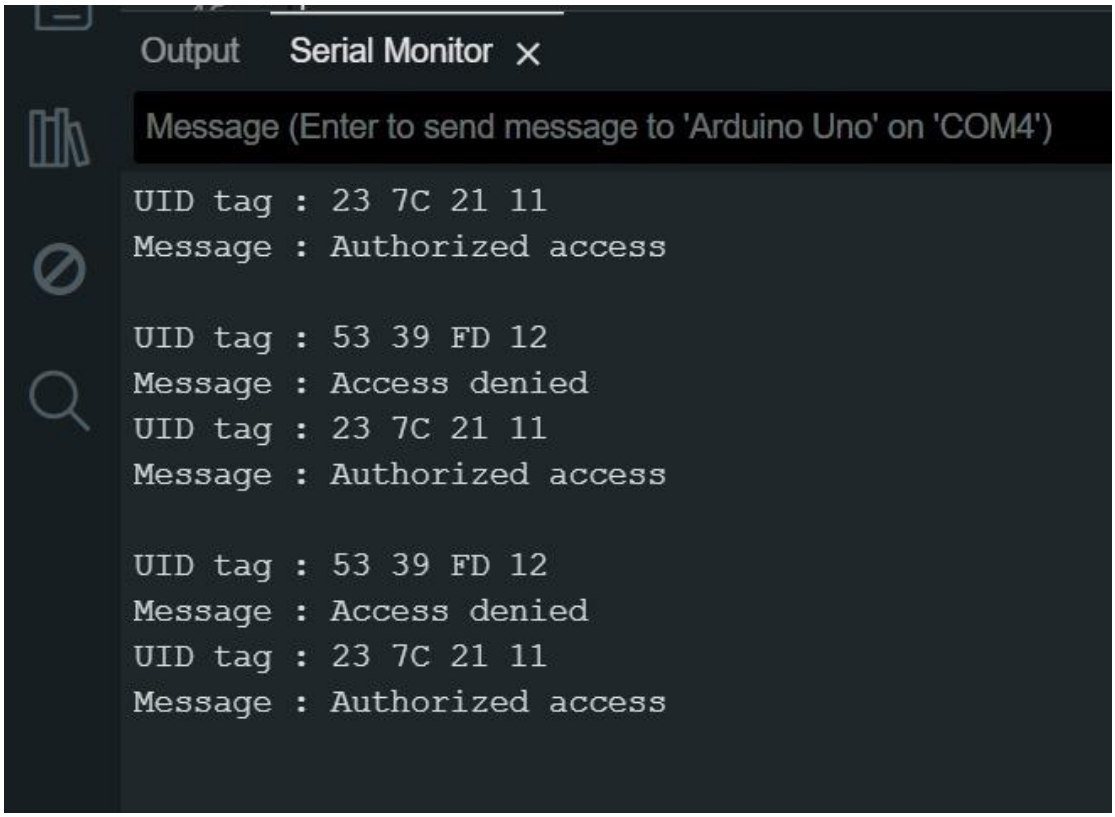
ID Test Case Title Test Condition System Behavior Expected Result:

T01 RFID Authentication Valid RFID card Authenticate card Unlock solenoid lock

T02 RFID Authentication Invalid RFID card Reject card Keep solenoid lock locked

4.3 Result Analysis OR Screenshots :

Screenshot of the implemented system interface:



4.4 Quality Assurance:

The quality of the implemented Smart Locking System was verified through thorough testing, ensuring that it meets the specified requirements and operates reliably under different conditions. Additionally, the system underwent peer review and feedback from stakeholders to address any potential issues and improve overall quality.

Standards Adopted

5.1 Design Standards:

For the design phase of the smart locking system project, the following recommended practices and standards are adopted:

- **IEEE Standards:** Adherence to relevant IEEE standards for system design and architecture.
- **UML Diagrams:** Utilization of Unified Modeling Language (UML) diagrams, including use case diagrams, sequence diagrams, and class diagrams, for visualizing and documenting system requirements, design, and interactions.
- **Hardware Design Guidelines:** Following industry-standard guidelines and best practices for hardware design, including component selection, layout, and wiring.

5.2 Coding Standards:

During the coding phase of the project, the following coding standards and best practices are adhered to:

- **Code Readability:** Ensuring code readability through consistent indentation, appropriate spacing, and meaningful variable names.
- **Modularity:** Writing modular and reusable code to enhance maintainability and scalability.
- **Commenting:** Providing clear and concise comments to explain the purpose and functionality of each code segment.
- **Avoiding Lengthy Functions:** Breaking down complex functionalities into smaller, manageable functions to improve code readability and maintainability.
- **Naming Conventions:** Following consistent naming conventions for variables, functions, and classes to enhance code clarity and understanding.
- **Code Optimization:** Writing efficient and optimized code to minimize resource usage and improve performance.

5.3 Testing Standards:

For the testing and verification phase of the project, the following standards and practices are followed:

- **ISO/IEC 25010:** Utilizing the ISO/IEC 25010 standard for software quality requirements and evaluation to define the quality characteristics and criteria for the smart locking system.
- **Unit Testing:** Conducting unit tests to verify the functionality of individual software components, including the Arduino Uno microcontroller code and RFID authentication logic.
- **Integration Testing:** Performing integration tests to ensure seamless communication and interaction between different system components, such as the RFID reader, Arduino Uno, solenoid lock, and relay module.
- **System Testing:** Conducting comprehensive system tests to validate the overall functionality, reliability, and security of the smart locking system in real-world scenarios.
- **Acceptance Testing:** Involving end-users or stakeholders in acceptance testing to ensure that the system meets their requirements and expectations.

By adhering to these standards and practices throughout the project lifecycle, the smart locking system is developed and validated to meet high-quality and reliability standards.

Conclusion and Future Scope

6.1 Conclusion:

In conclusion, the implementation of a Smart Locking System utilizing RFID card authentication, Arduino Uno microcontroller, solenoid lock, and relay module offers a promising solution for modern access control needs. Through the integration of these technologies, a secure, efficient, and user-friendly access control mechanism has been realized.

The use of RFID cards allows for seamless and reliable user authentication, enhancing security while eliminating the need for traditional keys. The Arduino Uno microcontroller serves as the brain of the system, processing authentication requests swiftly and effectively. Its flexibility and programmability enable easy customization to suit specific requirements, ensuring adaptability across various applications.

The inclusion of a solenoid lock ensures robust physical security, providing a reliable means of controlling access to designated areas. The relay module acts as a bridge between the Arduino Uno and the locking mechanism, facilitating the seamless operation of the system.

Overall, the Smart Locking System offers several advantages, including scalability, real-time monitoring capabilities, and ease of integration with existing infrastructure. Its cost-effectiveness and user-friendly interface make it a viable choice for enhancing security in homes, offices, and industrial settings alike.

As technology continues to evolve, the Smart Locking System can further be enhanced with additional features and functionalities, ensuring it remains at the forefront of access control solutions. With its combination of security, convenience, and adaptability, the Smart Locking System stands as a testament to the power of innovation in addressing modern security challenges.

6.2 Future Scope:

The Smart Locking System utilizing RFID card authentication, Arduino Uno microcontroller, solenoid lock, and relay module presents significant potential for future enhancements and expansions. Some of the potential future scope areas include:

- **Enhanced Security Features:** Integration of advanced encryption algorithms and multi-factor authentication methods to further enhance the security of the system. This could involve biometric authentication such as fingerprint or facial recognition in addition to RFID card authentication.

- **Remote Access and Monitoring:** Implementing IoT (Internet of Things) capabilities to enable remote access control and monitoring of the locking system through mobile applications or web interfaces. This would allow users to manage access permissions and receive real-time notifications of access events remotely.

- **Integration with Smart Home Systems:** Seamless integration with smart home automation systems for enhanced convenience and interoperability. This could involve integrating the smart locking system with voice assistants like Amazon Alexa or Google Assistant, allowing users to control access using voice commands.

- **Access Analytics and Reporting:** Incorporating data analytics capabilities to generate insights into access patterns, user behavior, and security incidents. This would enable administrators to identify potential security vulnerabilities, optimize access control policies, and generate detailed access reports.

- **Scalability and Expansion:** Designing the system architecture to support scalability and easy expansion to accommodate larger facilities or additional access points. This includes modular design principles and interoperability with a wide range of hardware components and peripherals.

- **Energy Efficiency:** Implementing power-saving features and energy-efficient operation modes to reduce energy consumption and environmental impact. This could involve optimizing the power management of components such as the solenoid lock and relay module.

- **Integration with Cloud Services:** Leveraging cloud-based services for data storage, authentication, and remote management, offering enhanced scalability, reliability, and accessibility. Cloud integration could also enable seamless synchronization of access data across multiple locations.

- **Customization and Personalization:** Providing users with the ability to customize and personalize their access control settings according to their preferences and requirements. This could include customizable access schedules, user profiles, and access permissions.

- **Integration with Access Control Standards:** Ensuring compatibility with industry-standard access control protocols and standards to facilitate interoperability with third-party systems and devices.

Overall, the future scope for the Smart Locking System is vast and encompasses various avenues for innovation and improvement, driven by advancements in technology and evolving user needs and preferences. By embracing these future opportunities, the Smart Locking System can continue to evolve as a cutting-edge solution for secure and convenient access control.

References

1. **Arduino Official Website:** The official Arduino website provides documentation, tutorials, and examples for Arduino Uno microcontroller programming and interfacing with various components. (https://www.arduino.cc/)

2. **RFID Module Documentation:** Manufacturers of RFID modules often provide datasheets, technical documentation, and example code for interfacing with their RFID modules. For example, if you're using an MFRC522 RFID module, you can refer to its documentation provided by the manufacturer.

3. **Solenoid Lock and Relay Module Documentation:** Similarly, manufacturers of solenoid locks and relay modules offer documentation and technical specifications for their products. This information can help understand the wiring, operation, and compatibility of these components with Arduino Uno.

4. **Books on Arduino Projects:** There are numerous books available on Arduino projects, including those focused on security systems and access control. These books often provide detailed instructions, code examples, and circuit diagrams that can be helpful for implementing a Smart Locking System. One example is "Arduino Projects For Dummies" by Brock Craft.

5. **Online Tutorials and Guides:** Websites like Instructables, Adafruit, and Hackster.io host a plethora of tutorials, guides, and project documentation related to Arduino-based projects, including smart locking systems. These resources often include step-by-step instructions, wiring diagrams, and code samples.

6. **Academic Journals and Conference Papers:** Academic literature may contain research papers, case studies, or articles related to smart locking systems, RFID technology, and access control. IEEE Xplore, ACM Digital Library, and Google Scholar are good platforms to search for relevant academic publications.

7. **Technical Forums and Communities:** Online forums and communities such as Arduino Forum, Stack Exchange (Arduino and Electrical Engineering), and Reddit's r/arduino can be valuable sources of information and support. You can find discussions, troubleshooting tips, and project ideas related to Arduino-based smart locking systems.

8. **Vendor Documentation and Support:** If you're using specific components or modules from vendors (e.g., Adafruit, SparkFun), their websites often provide detailed documentation, tutorials, and customer support resources that can be useful for your project.

SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

SMART LOCKING SYSTEM:

Abstract: The aim of the project is to develop a Smart Locking System utilizing RFID card authentication, Arduino Uno microcontroller, solenoid lock, and relay module. The objective is to create a secure and efficient access control mechanism that replaces traditional key-based systems, providing convenience and flexibility while ensuring robust physical security. The system aims to offer seamless integration, scalability, and real-time monitoring capabilities for various applications, such as homes, offices, and industrial environments.

Student Name : SUPRASAD SARANGI

Student Roll number : 2105838

- **Individual findings:** Compiled a comprehensive overview of the Arduino platform and its role in controlling the smart locking system. Identified key programming challenges and solutions for integrating different hardware components.
- **Contribution to project report preparation:** Investigated the programming aspects of the Arduino Uno, developing the code for RFID card authentication, solenoid lock control, and relay module interfacing. Contributed to the methodology, results, and conclusion sections of the report.
- **Contribution for project presentation and demonstration:** Presented the Arduino code structure and explained the logic behind the system's operation during the presentation. Conducted a live demonstration of the system's functionality.
-

Full signature of supervisor: Full signature of the student:

……. ……..

SMART LOCKING SYSTEM

Student Name : MISHAN MAURYA

Student Roll number : 21052229

- **Individual findings:** Provided detailed information on the selection and installation of solenoid locks for the smart locking system. Evaluated the performance and reliability of solenoid locks under various conditions.
- **Contribution to Project Report Preparation:** Conducted market research on available solenoid locks and relay modules, comparing their features, prices, and compatibility with the Arduino Uno. Contributed to the literature review and discussion sections of the report.
- **Contribution for Project Presentation and Demonstration:** Demonstrated the integration of the solenoid lock and relay module with the Arduino Uno during the presentation. Explained the wiring connections and functionality.

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Student Name : SUYASH DUTTA

Roll number : 2105843

- **Individual findings:** Identified the importance of relay modules in controlling the power supply to solenoid locks, ensuring safe and reliable operation. Discussed potential issues such as electromagnetic interference and voltage spikes and proposed mitigation strategies.
- **Contribution to Project Report Preparation:** Experimented with different RFID card reader modules compatible with the Arduino Uno, analyzing their read range, reliability, and compatibility. Contributed to the methodology, results, and discussion sections of the report.
- **Contribution for Project Presentation and Demonstration:** Demonstrated the RFID card reading process during the presentation. Showcased the system's ability to recognize authorized cards and trigger the locking mechanism.Prepared slides outlining the technical specifications of the Arduino Uno, solenoid lock, and relay module.

Full signature of supervisor: Full signature of the student:

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Student Name : ARYAN KUMAR JHA

Roll number : 2105778

- **Individual findings:** Provided insights into the advantages and limitations of RFID technology for implementing a smart locking system. Identified potential security vulnerabilities and proposed countermeasures.
- **Contribution to Project Report Preparation:** Researched and documented the theoretical framework behind RFID technology and its application in smart locking systems. Contributed to the introduction, literature review, and methodology sections of the report.
- **Contribution for Project Presentation and Demonstration:** Demonstrated the hardware setup during the presentation.

Full signature of supervisor: Full signature of the student:

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Student Name : DEEPANSHU PADHY

Roll number : 21052494

- **Individual findings:** Presented a comprehensive overview of the current state of smart locking technology, highlighting trends, innovations, and areas for improvement. Identified user preferences and pain points to inform the design and implementation of the team's smart locking system.
- **Contribution to Project Report Preparation:** Compiled and organized the project documentation, ensuring coherence and consistency in formatting and referencing. Edited and proofread the entire report for clarity, grammar, and spelling.
- **Contribution for Project Presentation and Demonstration:** Orchestrated the overall presentation flow, introducing each segment and facilitating transitions between speakers. Ensured that the presentation adhered to the allotted time frame and addressed any questions from the audience.

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SMART LOCKING SYSTEM

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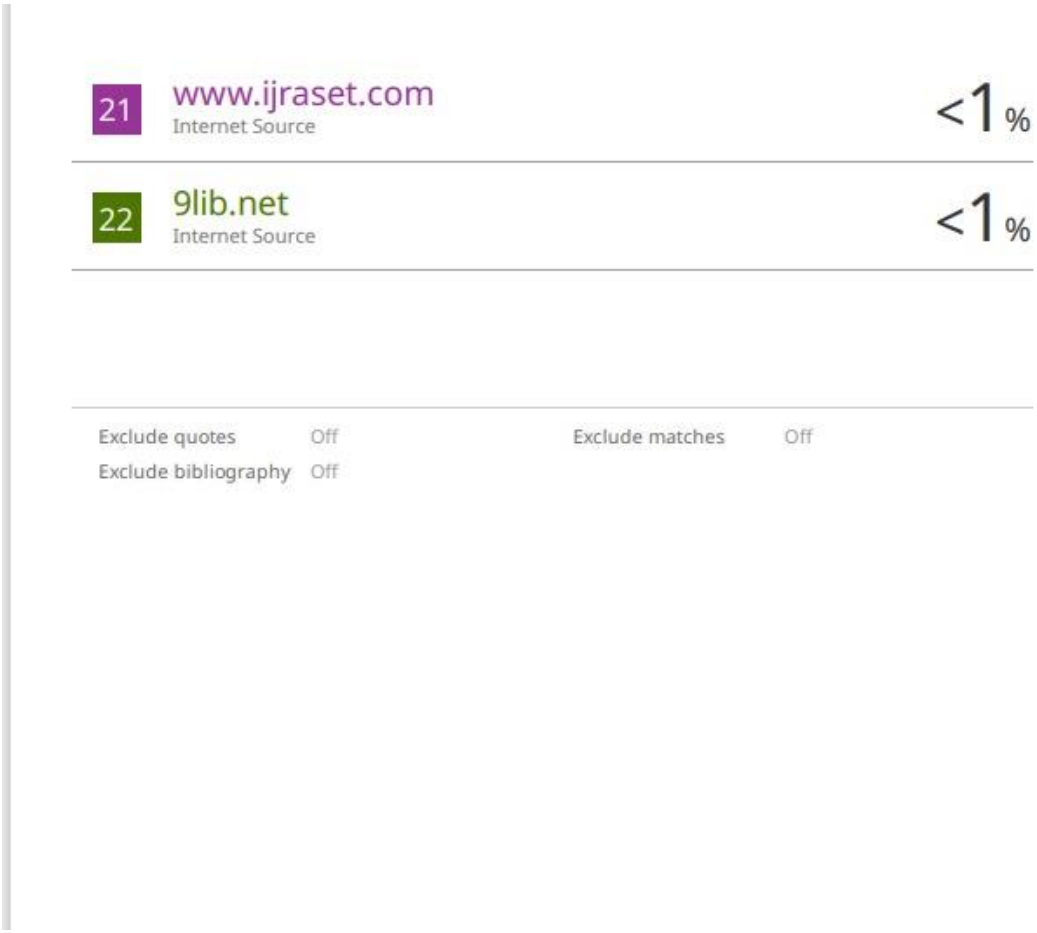
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