

RESPONSIVE RADIO FREQUENCY IDENTIFICATION DOOR ACCESS CONTROL SYSTEM USING HASHING ALGORITHM

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Abstract

Quality and security are vital for institutional growth and stability. In today's interconnected world, technological integration drives progress enhances competitiveness, and improves operational efficiency. Radio Frequency Identification (RFID) is widely used in educational environments for access control but still faces challenges such as unauthorized access and data theft. This study introduces a responsive RFID door access control system with a hashing algorithm to generate unique serial numbers, preventing duplicate RFID cards and unauthorized entry into laboratory rooms at the University of Antique – Tario Lim Memorial Campus, College of Computer Studies. The system replaces outdated lock-and-key mechanisms with RFID and a secure hashing algorithm to ensure only authorized individuals can access restricted areas. It also automates management tasks, including course, instructor, student information, class scheduling, and real-time attendance monitoring. The system's effectiveness, efficiency, and reliability were rigorously evaluated against ISO 25010 standards and user acceptability assessments. Results demonstrate a significant improvement in security and resource protection. The study also provides insights into such systems' design, implementation, and application in academic settings. This research recommends campus-wide adoption of the system to strengthen security measures and operational efficiency, contributing to the safer management of resources in educational institutions.

Keywords: Class scheduling, ISO 25010 standards, Hashing algorithm, RFID (Radio Frequency Identification), Real-time attendance monitoring.

INTRODUCTION

In academic institutions, particularly in laboratory settings, safeguarding assets and ensuring the safety of faculty and students is of utmost importance (Purohit, S., 2018). Traditional lock-and-key systems, still widely used, present significant security risks, including the potential for keys to be lost, stolen, or duplicated. These vulnerabilities are especially critical in academic environments like the University of Antique – Tario Lim Memorial Campus, where unauthorized entry and scheduling conflicts create safety risks, disrupt activities, and jeopardize equipment. While RFID-based access control systems offer a more secure alternative, challenges remain in preventing unauthorized access and ensuring the system is reliable and efficient (EPS Security, 2024). This study addresses these issues by proposing a Responsive RFID Door Access Control System Using Hashing Algorithm to generate unique RFID serial numbers, preventing duplication and unauthorized entry (Mankar *et al.*, 2013).

In addition to enhancing security, the system automates the management of laboratory schedules, course, faculty, and student data, while generating real-time attendance reports (Mohandes, 2016; BuildOps. 2024). The main argument of this research is that integrating RFID technology with a secure hashing algorithm can significantly improve both security and operational efficiency in academic settings. The purpose of this article is to present this system as a solution to

the challenges faced by educational institutions, demonstrating how such an approach can enhance security, streamline scheduling, and improve attendance tracking.

LITERATURE REVIEW

This literature review examines current research on Responsive RFID Door Access Control System Using Hashing Algorithm. It looks at key theories, findings, and trends in the field, focusing on how combining RFID technology with a hashing algorithm improves security and functionality.

Radio Frequency Identification (RFID) Technology

Radio Frequency Identification (RFID) is a technology that uses radio waves to identify tagged objects without direct contact. It is widely applied across various industries, including supply chain management and inventory tracking. RFID systems consist of a microchip, an antenna, and a scanner. While RFID technology was first developed in the 1970s, advancements in data storage and scanning technology have made it more affordable and accessible in recent years. RFID technology is versatile and used for tracking products, animals, and currency, offering efficient and reliable real-time data capture and asset management across a range of applications. The RFID provides valuable insights into how RFID has been applied in similar access control systems. This information helps guide the selection of the right components, ensuring reliable communication between tags and readers. Studies on data management and encryption techniques also influence how access credentials are stored and protected, ensuring secure user authentication (Investopedia. n.d.).

Hashing Algorithm

A hashing algorithm converts data into a fixed-size string (hash value), ensuring data integrity and security. An algorithm like SHA generates unique hash values for each input, making even small data changes detectable. Hash functions are one-way processes, preventing retrieval of the original data, and minimizing collisions for uniqueness. In the Door Access Control System, the algorithm secures user data, like RFID credentials, by storing only hash values, protecting sensitive information. Advanced hashing techniques, such as unique serial number generation, further enhance security and data integrity (Shinder, 2008).

Microcontroller Systems

A microcontroller is an integrated system combining a microprocessor, memory, and I/O interfaces, often with additional features like timers or analog-to-digital converters. Used in applications from office equipment to household appliances, microcontrollers, especially the PIC series, are valued for their efficiency, versatility, and low cost. In an RFID-based Door Access Control System, microcontrollers like Arduino play a key role, in processing signals from RFID readers, verifying credentials, and controlling electronic locks. Their low cost, low power consumption, and scalability make them ideal for adaptable and cost-effective security systems. They ensure quick, reliable responses, enhancing security and user experience (Elsevier, 2010).

Electronic Access Control (EAC) Systems

Electronic Access Control (EAC) systems have become an essential technology in modern security solutions, offering significant advantages over traditional mechanical lock-and-key methods.

EAC systems use electronic locks and credential readers to manage access to private properties, providing enhanced flexibility and control. According to Motorola Solutions (2024), these systems allow stakeholders to remotely monitor and adjust access, ensuring that properties remain secure and protected. Unlike mechanical locks, EAC systems offer a range of credential types, such as key cards, mobile credentials, and biometric readers, enabling security teams to tailor access control based on specific needs and security levels. EAC systems also provide additional functionalities that mechanical solutions cannot, such as tracking access events, monitoring occupancy levels, and sending real-time alerts for suspicious activities. These features allow administrators to adjust permissions promptly, improving overall security and offering layered protection for high-risk areas. The flexibility of EAC systems allows for more robust and adaptable security measures, making them a preferred choice for organizations seeking enhanced physical security (Motorola Solutions n.d.).

Scheduling Systems

A scheduling system is a tool designed to allocate resources, plan tasks, and optimize time management by coordinating activities in various contexts. It is especially valuable in environments with multiple variables, such as workforce availability and deadlines, ensuring smooth operations and efficient resource use. Scheduling systems improve organizational efficiency by automating planning, reducing conflicts, and enhancing productivity. In a Door Access Control System, similar principles of resource allocation and task coordination can be applied to manage user access based on time slots, roles, and permissions, ensuring authorized entry, and enhancing security (BuildOps, 2024).

Software Quality Framework (ISO 25010)

ISO 25010, part of the SQuaRE series, defines a model for assessing software quality, outlining eight key characteristics such as functional suitability, performance efficiency, usability, reliability, security, maintainability, and portability. It also includes software quality in use characteristics like effectiveness and user satisfaction. This standard guides for improving software quality throughout development. Jill Britton (2021) notes that static analysis tools align with ISO 25010 by identifying quality issues early, particularly in performance, security, and maintainability. ISO 25010's framework will be applied in developing the Door Access Control System to ensure it meets functional requirements and user expectations. By focusing on characteristics like security, performance, maintainability, and usability, the system will be designed for efficiency, long-term use, and user satisfaction (Britton, 2021).

Study of Arduino Microcontroller Board

Ismailov and Jorayev (2022) highlight the versatility of the Arduino microcontroller, particularly its user-friendly programming environment, which is ideal for educational and research projects. The Arduino IDE, an open-source platform, simplifies coding and development by offering an extensive library repository that accelerates project creation. This versatility will be key in developing the Door Access Control System. The Arduino platform's ability to quickly integrate sensors and its accessible IDE will streamline the development of features like RFID integration, lock control, and user authentication, resulting in an efficient, scalable system.

C Implementation of Secure Hashing Algorithm-256 Algorithm

Mankar *et al.* (2013) highlights the importance of hash functions in cryptography, particularly in ensuring data integrity and authentication when combined with digital signature algorithms. Their study proposes a scheme to improve the SHA-256 algorithm by reducing the critical path of duplicate operations in each iteration, optimizing its performance. These insights will enhance the security of the Door Access Control System by using SHA-256 to securely store and verify access credentials. The proposed improvements to SHA-256 can optimize performance, ensuring faster, reliable authentication without compromising security.

Survey on various door lock access control mechanisms

R. S. Divya & M. Mathew, (2017) emphasize the growing importance of security in access control systems, noting the shift from traditional locks and passwords to advanced technologies like RFID, biometrics, and cryptography. Their study highlights the evolution of security measures to prevent unauthorized access, with ongoing research leading to even more secure systems in the future. This research informs the development of the Door Access Control System, emphasizing the need for modern technologies like RFID and cryptography to ensure robust security. By incorporating these features, the system will remain secure and resilient against future challenges, protecting sensitive areas from unauthorized entry.

Automated Class Scheduling System

Gamale *et al.* (2015) highlight the benefits of automated systems over traditional manual methods, particularly in educational institutions. Their study at Bohol Island State University found that an automated class scheduling system was more efficient, accurate, and reliable than manual systems, addressing issues like time-consuming revisions and human errors. These insights are applicable to the development of the Door Access Control System, where automation will streamline tasks such as user authentication, access logging, and time-based permissions. By reducing human error and ensuring real-time updates, the system will improve efficiency, speed, accuracy, and stability, offering a more practical and reliable solution for security.

RFID-Based Students Attendance Management System

Arulogun *et al.* (2013) highlight the growing importance of RFID technology in enhancing efficiency and accuracy, particularly in tracking and monitoring systems. They discuss how RFID, with its low cost and ability to deliver precise data, is becoming an essential tool in various applications, such as improving student attendance tracking. This concept applies directly to the Door Access Control System, where RFID technology will automate access control and provide real-time monitoring of user entry. By using RFID tags for accurate identification and data collection, the system will ensure secure, efficient, and reliable access for authorized personnel, offering a scalable solution for improved security.

Automatic Access Control System using Arduino and RFID

Orji, Cy, & Ujunwa (2018) emphasize the growing use of wireless security applications, particularly RFID, in access control systems. Their study presents an RFID-based access control system using Arduino, where the system grants or denies access based on matching a user's RFID tag UID with stored data. The system is cost-effective, reliable, and efficient in securing environments. This approach directly applies to the Door Access Control System, where integrating

RFID with Arduino allows for seamless, secure, and scalable contactless identification. The system ensures accurate access control while maintaining security, offering an affordable and practical solution for managing entry.

Synthesis

The **Responsive RFID Door Access Control System Using Hashing Algorithm** integrates key concepts across three fundamental dimensions: **Security**, **Efficiency**, and **Scalability**, forming a robust analytical framework. **Security** is reinforced through the combination of RFID technology and advanced hashing algorithms which secure user credentials and ensure data integrity by preventing unauthorized access. **Efficiency** is achieved by leveraging microcontroller systems, such as Arduino, alongside automated scheduling, to streamline system operations, reduce response times, and improve cost-effectiveness, all while maintaining high reliability. **Scalability** is guaranteed through the flexible nature of RFID and microcontroller-based designs, enabling the system to expand seamlessly to support additional users, access points, and enhanced security features. This integrated framework provides a comprehensive lens for evaluating the system's design, functionality, and performance, ensuring that the solution is not only secure but also adaptable, efficient, and scalable. Ultimately, the integration of RFID with a hashing algorithm enhances system security, simplifies implementation, and offers a reliable, cost-effective solution for modern, dynamic access control needs.

RESEARCH METHOD

This study adopts a developmental research design, utilizing the Rapid Application Development (RAD) model to evaluate the effectiveness of the Responsive RFID Door Access Control System Using Hashing Algorithm. Primary data were collected through system performance testing, user surveys on usability, interviews with faculty and students, and operational logs tracking access attempts. Secondary data were sourced from existing research on RFID technology and hashing algorithms. The system was tested using an Arduino Uno microcontroller, RFID readers, and hashing algorithms, with software tools like Visual Studio 2022 and XAMPP. The study involved 85 participants, including 5 IT experts, 20 instructors, and 60 students from the University of Antique – Tario Lim Memorial Campus, College of Computer Studies. Data analysis utilized statistical methods to evaluate system accuracy, security, and the effectiveness of the hashing algorithm in preventing unauthorized access. The hashing algorithm's performance was assessed by comparing unauthorized access attempts before and after implementation.

RESULTS AND DISCUSSION

The study's findings demonstrate that the Responsive RFID Door Access Control System Using Hashing Algorithm successfully meets its objectives, enhancing security, efficiency, and usability. Integrating a hashing algorithm to generate unique RFID tag serial numbers strengthened the system's security, ensuring reliable and encrypted identification. Real-time access control feedback, provided through LCD screens, LEDs, and buzzers, improved the user experience by immediately indicating the access status. The system automated key administrative tasks, such as conflict-free scheduling, course management, and attendance tracking, streamlining academic operations and increasing efficiency. The user interfaces for administrators and instructors were

intuitive, ensuring ease of use and smooth system operation. Additionally, customizable reporting tools enabled real-time data analysis, supporting better decision-making. The system also provides a user-friendly experience, featuring intuitive interfaces and requiring minimal user intervention. Although further optimization is recommended to handle larger-scale deployments, the system shows considerable scalability potential, laying the foundation for future expansion and integration into diverse environments.

Ultimately, these findings demonstrate the system's substantial potential to enhance security, efficiency, and user experience in door access control applications.

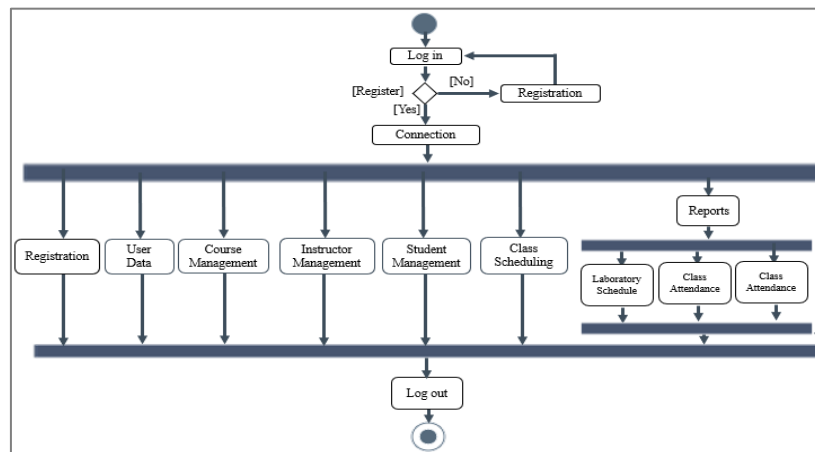


Figure 1: Activity diagram for admin

Figure 1 shows an activity diagram of the administrative workflows in the system. When the Admin logs in with their unique ID and password, they ensure secure access. The admin performs key tasks like managing instructor access cards, updating user data, managing courses, instructors, and students, scheduling laboratory classes for each room, and generating detailed reports that include class schedules and attendance records. These responsibilities are important for the admin to efficiently manage and enhance the system's performance, meeting user needs effectively.

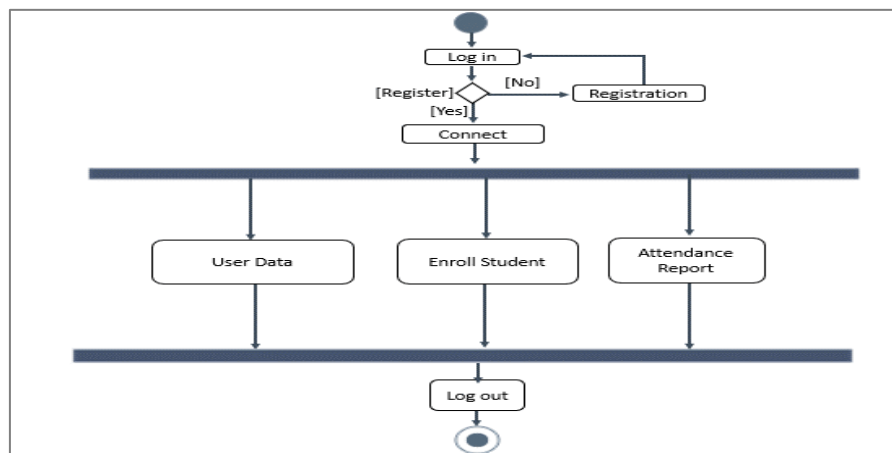


Figure 2: Activity diagram for instructor

Figure 2 illustrates the activity workflow for instructors in the system. Initially, instructors are required to be registered by the Admin. Once registered, they can manage student data, enroll them in courses, and efficiently generate attendance reports after each class session.

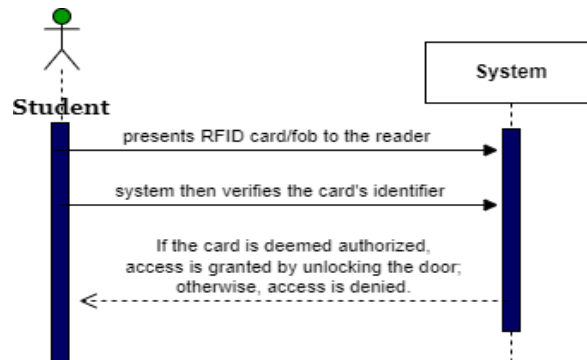


Figure 3: Sequence Diagram for Student

Figure 3 illustrates a student's limited access to the system, where they scan their RFID key card or fob at the reader during scheduled classes. If the card is registered, access is granted; if not, entry is denied. The system ensures that only authorized students can enter designated areas during their scheduled laboratory activities, enhancing both security and efficiency.

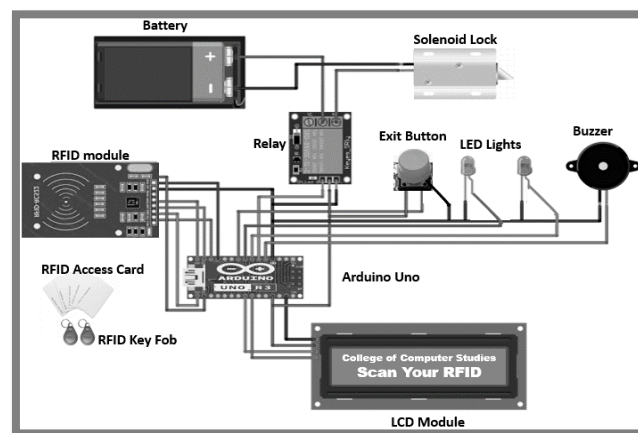


Figure 4: System Architecture of the System

Figure 4 shows how the Responsive RFID Door Access Control System Using Hashing Algorithm operates. To enter, users present their RFID card or fob to the RFID reader at the entry point. The reader captures the card's unique identifier and sends it to the Arduino Uno microcontroller. Using a hashing algorithm, the Arduino Uno securely checks the identifier against its database of authorized users and access permissions. This algorithm converts the identifier into a unique serial number, which is then compared with stored values in the database. If there's a match, indicating authorization, the Arduino Uno commands the electric door lock to unlock. A green LED light and a brief beep from the buzzer signal successful access. If access is unauthorized, the Arduino Uno denies entry, causing the LED to turn red and potentially emitting a different sound from the buzzer.

Furthermore, the Arduino Uno keeps a record of each access attempt, logging the time it occurred, the user's identification, and whether access was granted or denied. This information helps system administrators monitor who enters and when. Administrators can oversee access logs, modify permissions for users as required, and conduct maintenance tasks to ensure the system operates smoothly. This control allows them to maintain security and manage operations effectively.

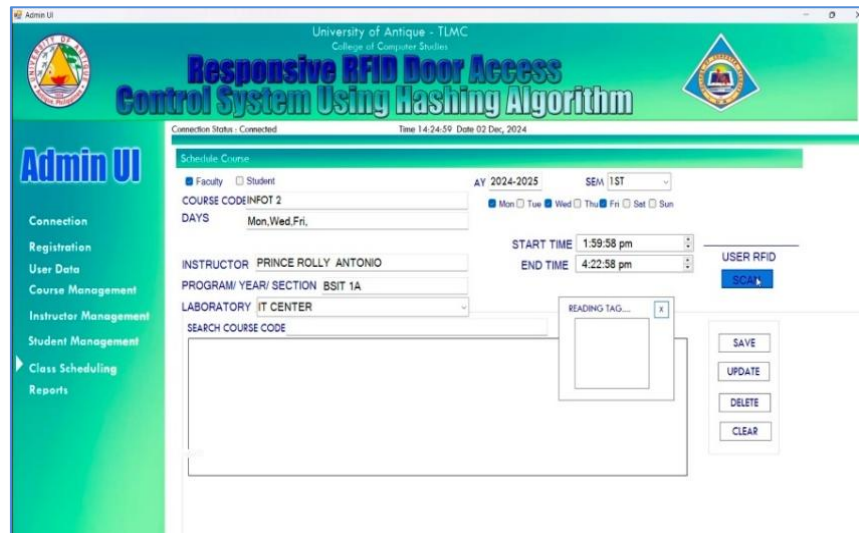


Figure 5: A screenshot of the Admin UI for Class Scheduling

Figure 5 illustrates the Admin User Interface, which includes the following features: Connection, Registration, User Data, Course Management, Instructor Management, Student Management, Class Scheduling, and Reports. The focus is on the class scheduling process, where the administrator creates the faculty laboratory schedule based on the approved class timetable for each instructor. Before proceeding, the administrator scans the instructor's RFID access card. Once the class schedule is confirmed, laboratory sessions are added, considering instructor availability, course requirements, and resources. The program head plays a key role in ensuring the schedule is conflict-free and optimizing the use of rooms, equipment, and lab assistants. Any changes in instructor availability or student enrollment are adjusted accordingly. The finalized schedule is then shared with faculty and students to ensure smooth course delivery, improving communication and coordination.

Table 1. The Overall Summary Evaluation by the IT Experts

ISO 25010 Quality Characteristics	Mean	Interpretation	SD
Functional Suitability	4.67	Excellent	0.51
Reliability	4.65	Excellent	0.52
Portability	4.68	Excellent	0.51
Usability	4.67	Excellent	0.51
Performance Efficiency	4.60	Excellent	0.55
Security	4.72	Excellent	0.49
Compatibility	4.80	Excellent	0.40
Grand Mean	4.68	Excellent	0.50

Table 1 presents a summary of the overall assessment by IT experts on the system using the ISO 25010 standard, focusing on key quality characteristics: Functional Suitability, Reliability, Portability, Usability, Performance Efficiency, Security, and Compatibility. The mean scores for these attributes were 4.67, 4.65, 4.68, 4.67, 4.60, 4.72, and 4.80, respectively, reflecting excellent performance across all evaluated dimensions. These high ratings suggest that the system demonstrates strong adaptability, allowing for modifications without compromising the quality of the existing product.

CONCLUSION

Based on the evaluation results using ISO 25010 standards and a thorough analysis of the data from the respondents, it is concluded that the development of the Responsive RFID Door Access Control System Using Hashing Algorithm successfully ensured secure access and prevented unauthorized entry, with excellent security and portability ratings from both IT experts and user acceptability tests. The integration of the hashing algorithm enhanced security by ensuring unique RFID tag data, further supported by high-security ratings. The system also streamlined administrative tasks by automating laboratory schedules and managing courses, instructor, and student data, improving coordination, and reducing scheduling conflicts, which was reflected in excellent ratings for functional suitability, performance efficiency, maintainability, and usability. Additionally, the system automated conflict-free scheduling and generated real-time attendance reports, boosting efficiency and reliability. The system's evaluation based on ISO 25010 confirmed its excellent performance across all key areas, including security, usability, and reliability.

Overall, these achievements highlight the system's effectiveness in improving security, efficiency, and data management, providing a strong foundation for future enhancements and real-world applications.

ACKNOWLEDGEMENT

The development of this research project, titled *Responsive RFID Door Access Control System Using Hashing Algorithm*, has been both challenging and rewarding. This achievement would not have been possible without the unwavering support, guidance, and contributions of numerous individuals. First and foremost, I would like to express my profound gratitude to my adviser, Dr. Ramil G. Lumauag, for his invaluable guidance throughout this research. His expert input, particularly in refining my documents and providing critical feedback, played a crucial role in the completion of this study. His patience, dedication, and extensive knowledge have been a constant source of inspiration and have significantly shaped the success of this project. I also extend my sincere thanks to the panel examiners—Professor Loreto Gabawa, Jr., Dr. Tracy Tacuban, Dr. May Florence Franco, Dr. John C. Amar, and Professor Ernest Andreigh Centina—for their expert advice and invaluable contributions in refining the system. Their input helped elevate the quality and precision of this work. I would like to express my heartfelt appreciation to my programming team—Ma'am Myra Samillano, Sir Patrick Torres, and Sir Robert But. Their ongoing support and technical expertise were fundamental to the development and optimization of the system. Their collaboration, hard work, and problem-solving skills were crucial to the success of this project, and I am deeply grateful for their dedication and efforts. Above all, I am eternally grateful to my family for their unwavering love, support, and encouragement. To my husband, Arnold B. Genove, thank you for your patience and

constant support throughout this journey, especially during trips for technical development meetings. Your love and understanding have been invaluable to me. Lastly, I thank the Lord Almighty for His grace, guidance, strength, and wisdom, which made this project possible. I am deeply thankful for His divine assistance, without which this achievement would not have been possible. My deepest gratitude goes to all who supported me—this project is a reality because of your collective efforts.

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