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INTEGRATING RADIO-FREQUENCY IDENTIFICATION (RFID) AND SENSOR TECHNOLOGIES FOR A SMART PARKING MONITORING SYSTEM IN A HIGHER EDUCATION INSTITUTION

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ABSTRACT
This study presents the development and evaluation of a Smart Parking Monitoring System using Radio-Frequency Identification and Sensor Technologies for Christ the King College de Maranding, Inc. (CKCMi). To address traditional problems such as parking congestion, unauthorized vehicle access, and the lack of real-time monitoring within the campus. The system automates vehicle identification, entry and exit logging, and parking slot availability detection. By integrating RFID cards, an RFID reader, ultrasonic sensors, mini servos, and a Raspberry Pi 4 microcontroller. The Waterfall Model guided the development process to ensure an organized and reliable result. The ISO 9126-1 software quality standard was also used to evaluate system performance by its stakeholders, including school administrators, school guards, faculty, and staff. Resulting in high mean scores in functionality (4.21), reliability (4.06), usability (4.06), efficiency (4.08), maintainability (4.02), and portability (4.01). These findings demonstrate that restricting campus access to authorized vehicles only significantly increases parking flow and improves campus security. In summary, the study highlights how RFID and sensor technology can be useful to assist institutional operational demands in terms of modernized parking monitoring systems. The researchers recommend future integration with mobile applications, camera-based verification, and increased data analytics to improve accuracy, convenience, and scalability for broader institutional use in order to further strengthen system capability.

Keywords:
Parking Monitoring System, ISO 9126-1 Software Quality Standard, Radio-Frequency Identification, Sensor Technology, Raspberry Pi 4 Microcontroller, Waterfall Model, Smart Parking Monitoring

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INTRODUCTION

As academic institutions continue to expand their infrastructures, personnel, and students, they also face rising vehicle numbers. Parking management has become an increasingly visible problem in the campus transportation process. Many schools also struggle with congestion, unreliable monitoring, and inefficient traffic flow caused by traditional manual parking processes. These issues highlight the need for more organized and technology-supported mobility systems that can ensure safety, accuracy, and convenience within educational environments

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[9]. In this context, this study was conducted at Christ the King College de Maranding (CKCM), where administrators, faculty members, security personnel, and students served as stakeholders in evaluating the system using the ISO 9126-1 software quality standards.

In recent years, various technological innovations have been explored in relation to parking monitoring areas. To respond to the growing concerns in mobility and facility management. It includes IoT devices, image processing applications, QR systems, wireless sensor networks, and cloud-integrated platforms. Due to its ability to automate identification, streamline data capture, and integrate seamlessly with digital monitoring systems. Studies emphasize that RFID uses components such as tags, readers, microcontrollers, and database systems to facilitate real-time access control and vehicle verification while reducing human intervention [1].

International implementations demonstrate that RFID-based parking solutions can significantly enhance parking operations. For example, IoT-enabled RFID systems in universities abroad have improved real-time slot detection, automated gate management, and remote monitoring, resulting in smoother traffic flow and reduced human error [2], [4]. Similar advancements are also evident in smart city initiatives where RFID-cloud integrations optimize public parking management through real-time reservation and occupancy data [6]. While some Philippine institutions have begun transitioning to technology-assisted parking systems, many campuses, particularly in provincial areas, continue to rely on manual logging and visual inspection, leading to persistent issues in accuracy, security, and operational efficiency [8].

Although RFID-based parking systems have proven effective in reducing congestion and unauthorized access, institutions that continue to employ manual processes remain vulnerable to delays, inaccuracies, and inefficient traffic flow. These traditional methods hinder the ability of institutions to manage parking operations efficiently, resulting in compromised security and mobility. To address this gap, the present study develops an RFID-enabled parking monitoring system designed to automate vehicle entry, exit, and real-time monitoring at Christ the King College de Maranding, Inc.

LITERATURE

RFID-based and sensor-supported parking systems consistently demonstrate significant improvements in automation, real-time monitoring, and operational efficiency based on existing literature. Several studies highlight RFID as highly effective for rapid, contactless authentication and identity verification. RFID streamlines access control by reducing human error and speeding up vehicle entry in institutional settings [1], [8]. IoT- and microcontroller-driven designs also reinforce these strengths [2]. Raspberry Pi–based campus system and IoT-RFID framework both validated that low-cost embedded platforms can perform accurate slot detection and entry logging [10]. Other integrations, such as the MODM-RPCP RFID solution and cloud-enabled parking architectures, improve user convenience through reservation systems, remote monitoring, and real-time dashboard updates [3], [6]. Emerging technologies, including machine vision, ultrasonic sensors, and CNN-based detection, also demonstrate strong performance in closed-lot environments [11]. UHF solutions, such as the inkjet-printed RFID prototype, further show that RSSI-based detections can achieve high accuracy [4]. Meanwhile, RFID has also proven useful in applications other than parking, like IoT-based attendance systems [12]. As well as practical applications, including automated multi-level IoT parking systems with RFID-based billing [15], IoT–RFID billing systems integrated with GSM and GPS technologies [14], and ultrasonic-controlled parking systems [13], have continuously reported improvements in space utilization, user satisfaction, and traffic congestion. These innovations are also consistent with ISO 9126-1 software quality evaluation standards. Which means they received excellent ratings for functionality, reliability, efficiency, maintainability, and portability. Overall, these systems demonstrate the technology's usefulness for quick and automatic identification and apply to vehicle parking monitoring in institutions.

The reviewed studies also present common limitations across RFID, IoT, sensor-based, and machine-vision parking systems despite their advantages. Sensor inaccuracies are a recurring challenge: ultrasonic sensors, while popular, may be affected by distance, obstruction, or angle issues [2], [13]. RSSI-based UHF systems can struggle with interference, reducing detection precision under varying environmental conditions [4]. Smart parking sensor research identifies further concerns, particularly in open parking lots. Where magnetometers, ultrasound, and infrared sensors often fail to deliver reliable, real-time occupancy readings. Due to weather exposure and inconsistent ground conditions [11]. Operational issues also persist in several studies, such as WSN-RFID hybrids [7], which still experience congestion during peak hours, and QR-based parking systems [5], which lack mechanisms for dynamic slot reservation or multi-user conflict resolution. Furthermore, some studies highlight usability and adoption challenges with parking. Smart campus reviews show that insufficient user training and unclear documentation hinder effective utilization [9]. Cloud-linked solutions raise privacy and

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data-security concerns [6]. This is especially true when systems rely solely on tag authentication without additional verification. Even outside parking, RFID-based attendance research notes vulnerabilities such as tag misuse or proxy attempts [12]. Proving similar risks may occur in vehicle access contexts. Overall, these limitations mirror the operational gaps observed in many institutions, including Christ the King College de Maranding, Inc. Where manual logging, partial automation, and limited monitoring accuracy and parking efficiency are.

To address these issues, several studies strongly suggest a combination of technology reinforcement, system integration, and user-centered design. First, multiple studies recommend sensor fusion. Combining RFID with ultrasonic sensors, machine vision, CNN-based classification, or multi-agent systems. To improve detection accuracy and environmental resilience, especially in open parking lots [11], [4]. Second, optimization models from IoT–cloud solutions [6] and multi-objective reservation systems [3] support the integration of real-time dashboards, mobile applications, slot reservation, and automated queuing algorithms to reduce congestion and enhance traffic flow. Third, insights from smart-campus evaluations emphasize the importance of thorough documentation, user manuals, and structured training [9]. To improve usability and system acceptance among its stakeholders. Fourth, feasibility studies and IoT-attendance evaluations suggest that continuous monitoring, iterative testing, and ISO 9126-1–guided quality assessment standards strengthen long-term reliability and maintainability [8]. [12]. Therefore, for CKCM's RFID-based and sensor-supported parking monitoring system, the recommended solutions include adopting a hybrid sensor approach (RFID, ultrasonic, and optional machine vision). Developing a mobile-accessible monitoring and reservation dashboard, applying rigorous ISO 9126-1 evaluation for each development iteration, and implementing systematic training and user support to ensure accurate, efficient, and widely adopted parking operations.

OBJECTIVES

The main objective of this study is to design, develop, and evaluate an RFID-based and sensor-supported parking monitoring system performance for Christ the King College de Maranding, Inc. (CKCM). It includes the following:

1) To provide a system that can track vehicle entry, parking space occupancy, and total parking availability in real time using RFID readers, sensors, and a web-based application.
2) To automate the vehicle entry and exit process using RFID technology by enabling contactless identification and authorization of registered vehicles entering the CKCM parking area.
3) To design a centralized database capable of securely storing and managing user information, vehicle records, RFID logs, and system activity for reporting and decision-making.
4) To generate logs and reports on motor vehicle entries, exits, and parking usage to help with administrative tasks.
5) To assess the system's overall performance in terms of reliability, efficiency, usability, functionality, maintainability, and portability using the ISO 9126-1 Software Quality Standard.
6) To improve campus security by restricting parking access to registered and authorized RFID cardholders only.
7) To minimize blockages and manual labor by streamlining parking management processes through automation and real-time data processing.

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METHODOLOGY

The study's methods will be discussed in this chapter, including the research design, research environment and research respondents.

Research Design

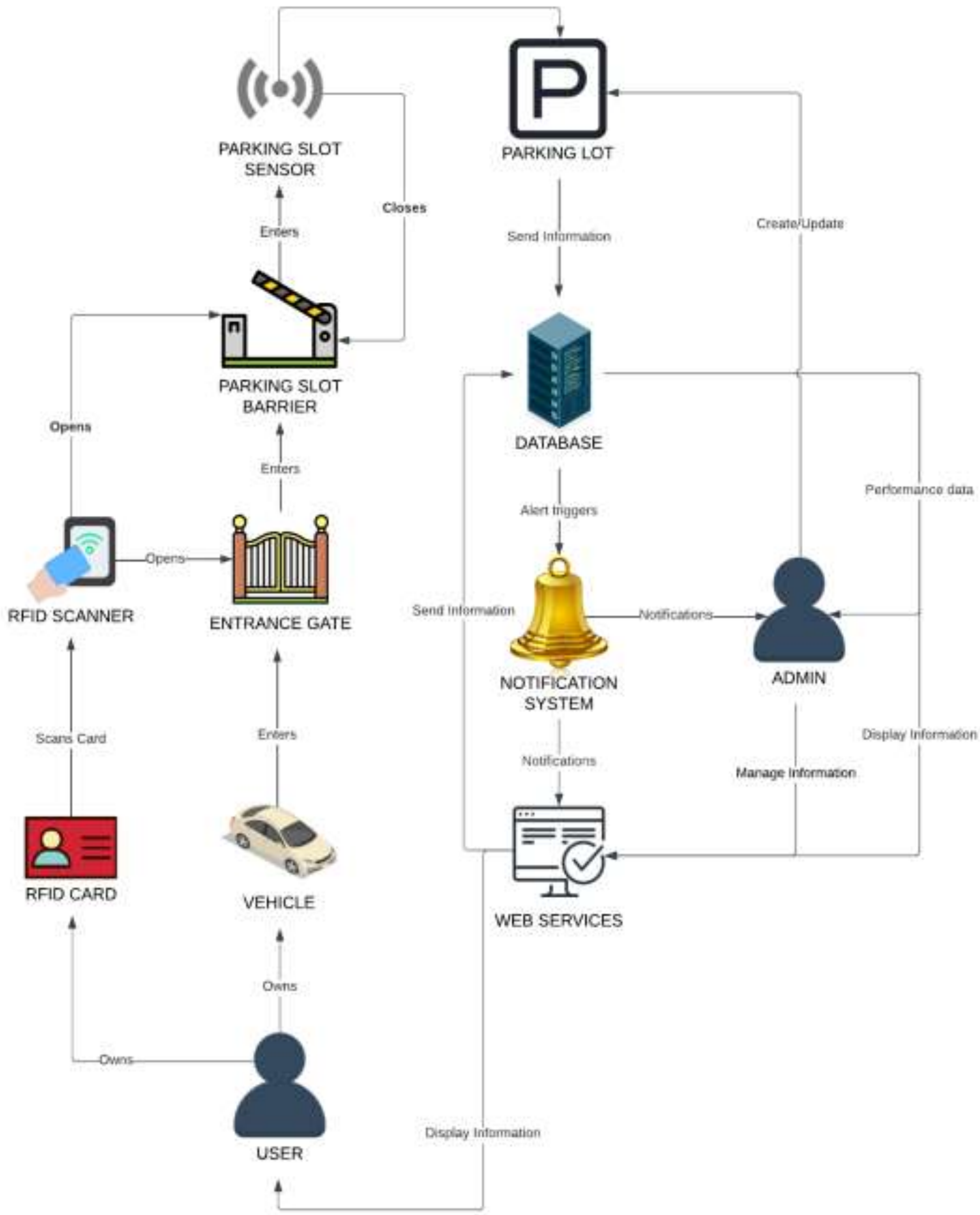

Figure 1. Project Detailed Design

Figure 1 highlights the Detailed Design of a parking monitoring system using Radio-Frequency Identification (RFID) Technology. It integrates several components to automate parking spot detection and improve information flow to ensure a seamless experience for users. Parking Spot Sensors with RFID readers can detect

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RFID cards that are assigned to authorized vehicles. A centralized database receives data from these sensors, and it is responsible for keeping track of current parking data and constantly checking conditions. The database triggers alerts based on predefined conditions, such as full occupancy or availability of spots. The Notification System then communicates updates to stakeholders, primarily Admins, who oversee the system and receive both availability alerts and performance data for analysis and decision-making. Furthermore, the system updates a Web Services platform, enabling users like students and faculty to access real-time parking availability, thereby improving the efficiency of their parking experiences. This integration of real-time data allows for efficient automated management of parking spaces. Reducing manual workload and enhancing overall parking processes in the institution.

Architectural Design (SDLC Waterfall Model)

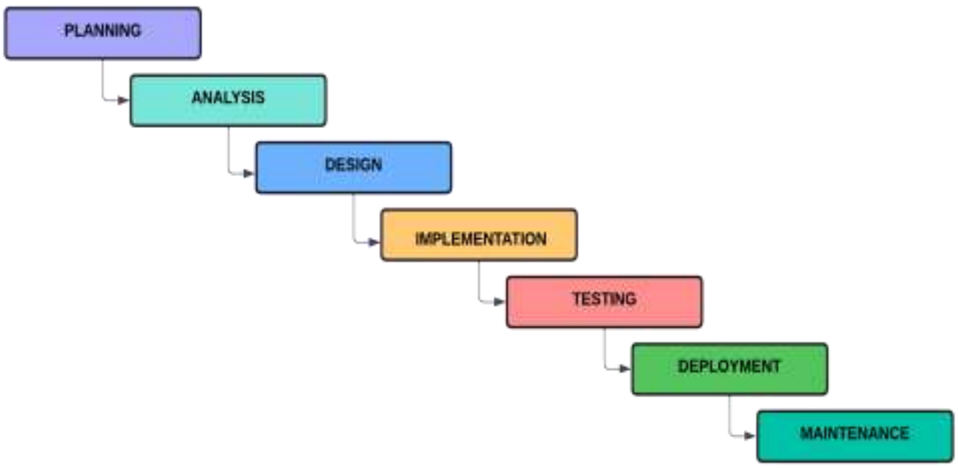

Figure 2. Waterfall Model

Figure 2 illustrates the researchers' development of the parking monitoring system, using the Waterfall Model. The process is visually represented by the waterfall diagram. How each step changes at each stage of the software development lifecycle. The method follows sequentially, with each step must be done accordingly. With careful planning, designing, and testing, this method ensured an organized and systematic development process. The system development research design, the Waterfall Model, includes:

Requirements Gathering. This phase is the initial and most useful stage in the development of the parking monitoring system. It serves as the foundation of the project's objectives, scope, feasibility, and required resources. To make sure that the system thoroughly addresses the present challenges in the institution's existing manual parking management process. Several Interviews, observations, and technical research must be done during this stage. The development team gathered essential information from key stakeholders, including the school administration, security personnel, faculty, and students. To determine the specific goals and operational needs of the project. The main objective was to create a secure, real-time, and automated parking system capable of efficiently monitoring vehicle entries and exits while minimizing unauthorized use of parking spaces

Requirement Analysis. This phase corresponds to the previous one, which is a very important phase in developing the parking monitoring system. Its primary goal was to thoroughly gather, analyze, and document the project's data requirements. The process involved engaging with the system's stakeholders through various methods, including interviews, surveys, observations, and document reviews. To fully determine their needs, expectations, and any constraints involved. The analysis also included both the system's functional requirements, such as vehicle registration, real-time tracking of parking availability, and notification updates. As well as non-functional requirements, including system security, user accessibility, and ease of use for the interface.

The parking monitoring system's software requirements use HTML and CSS for front-end development to create a responsive interface, while JavaScript adds interactivity. On the back-end, Python and PHP (with Laravel or Symfony frameworks) manage server-side operations, including user authentication and RFID data

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processing. Data is securely stored in a MySQL database, and Node.js facilitates real-time communication. The MFRC522 Library connects the software with the MFRC522 RFID module for accurate RFID reading. Additionally, Visual Studio Code is the main IDE, and the Raspberry Pi 4 serves as the central processing hardware for data transmission. These components work together to provide automated, secure, and real-time monitoring of vehicle movements on campus.

While its hardware requirements use RFID technology. The server requires a quad-core processor (2.5 GHz or higher), 8–16 GB RAM, and at least 250 GB of SSD storage for the main system, plus an additional 250 GB for backups. A 1 Gbps Ethernet connection is necessary for real-time data transfer, and the system is compatible with Linux or Windows Server. A backup server with a dual-core processor (2 GHz or higher), 4 GB RAM, and 500 GB HDD/SSD is recommended. RFID components include UHF RFID readers with a 1-meter detection range and durable passive RFID cards. An ultrasonic sensor improves vehicle detection with connections via GPIO, serial, or USB interfaces. Peripheral devices recommended are LCD/LED monitors, RFID printers, and UPS units for data protection. Networking equipment consists of managed Gigabit switches and high-quality Ethernet cables. Additionally, Python is compatible with the other components, ensuring web browser support, SSD storage for databases, and using IP65-rated outdoor devices to ensure system reliability and efficiency.

System Design. This phase is a critical step for the researchers' development of a parking monitoring system. To provide a comprehensive blueprint outlining the system's architecture and functionality, the requirements gathered from the previous phases are being analyzed. The primary goal of this phase is to ensure that the system meets all defined requirements and provides a seamless, efficient, and user-friendly experience for all stakeholders. This includes defining how the system will operate, including the user interface, database structure, system components, and the interactions among these components.

However, some minor clarifications were discovered during technical reviews and prototype testing. Therefore, the Waterfall Model needs requirements to be finalized before moving to the next phase. Instead of restarting the whole process, the researchers made small, controlled improvements within the approved project scope. These included fixing database relationships, improving RFID and database communication, and making the real-time dashboard faster and more responsive, these changes did not affect the main goals of the system but improved its performance and usability. The modular system design was used so parts could be updated without affecting the whole system by the team. As well as tracked all changes through proper documentation, and conducted validation checks before full implementation, to stay organized while allowing flexibility. This approach allowed improvements while still following the structured process of the Waterfall Model.

Hierarchy Input Process Output (HIPO)

The Hierarchy Input Process Output (HIPO) model serves as a structured framework for designing and analyzing the parking monitoring system. It delineates the system's data flow and module contributions to efficient parking management, centering on the main function of managing parking operations. Key modules include User Management, which oversees registration and access control. Vehicle and RFID Management, which records vehicle data and validates RFID scans. Hardware Device Control, which facilitates communication with devices like RFID readers and controls gate barriers; and Report Generation, which provides analytics on parking activities. The HIPO model ensures accurate data processing and real-time monitoring for effective RFID-enabled parking operations.

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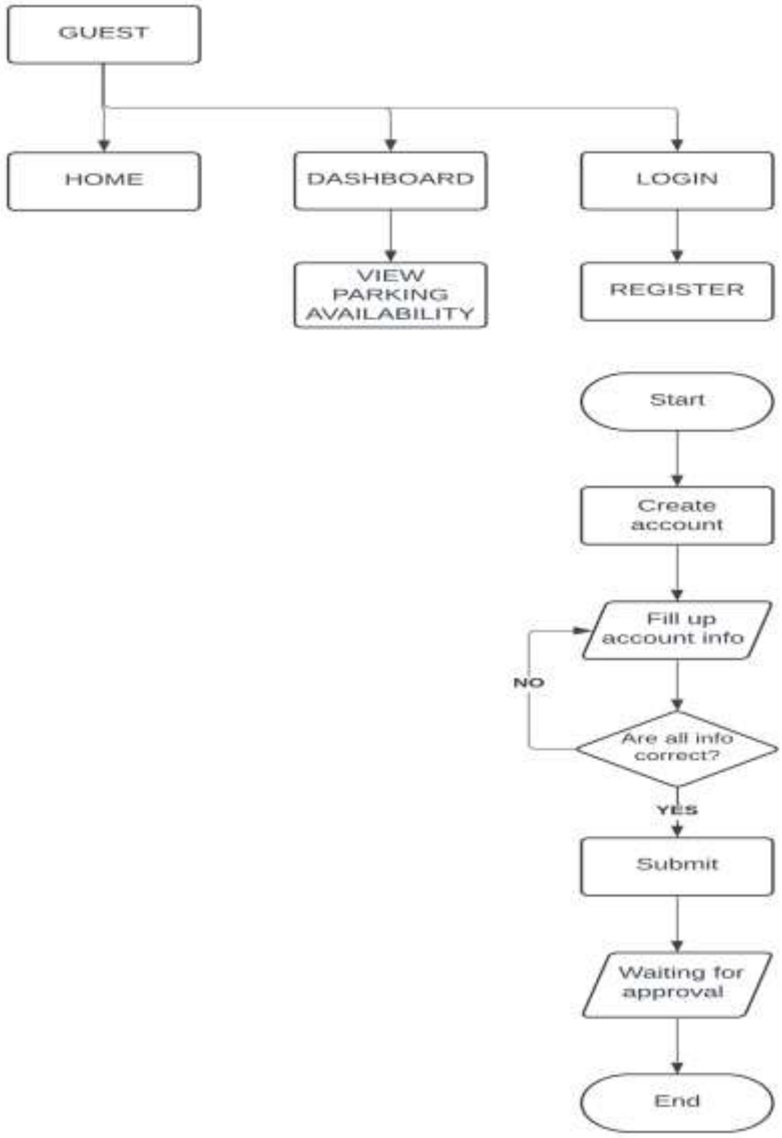

Figure 3. Hierarchical Input Process Output (GUEST)

Figure 3 shows the Hierarchical Input-Process-Output (HIPO) Diagram for the Guest Module of the system. This diagram illustrates user interaction through three main functions: Home, Dashboard, and Login. The Home module offers an overview and usage guidelines of the parking system. The Dashboard provides real-time data on available and occupied parking slots, aiding visitors in making informed decisions to improve traffic flow. The Login module allows user registration and account creation, pending approval for access to advanced functions like vehicle monitoring and record management. Overall, the HIPO diagram emphasizes accessibility, transparency, and coordination in the RFID-based parking system.

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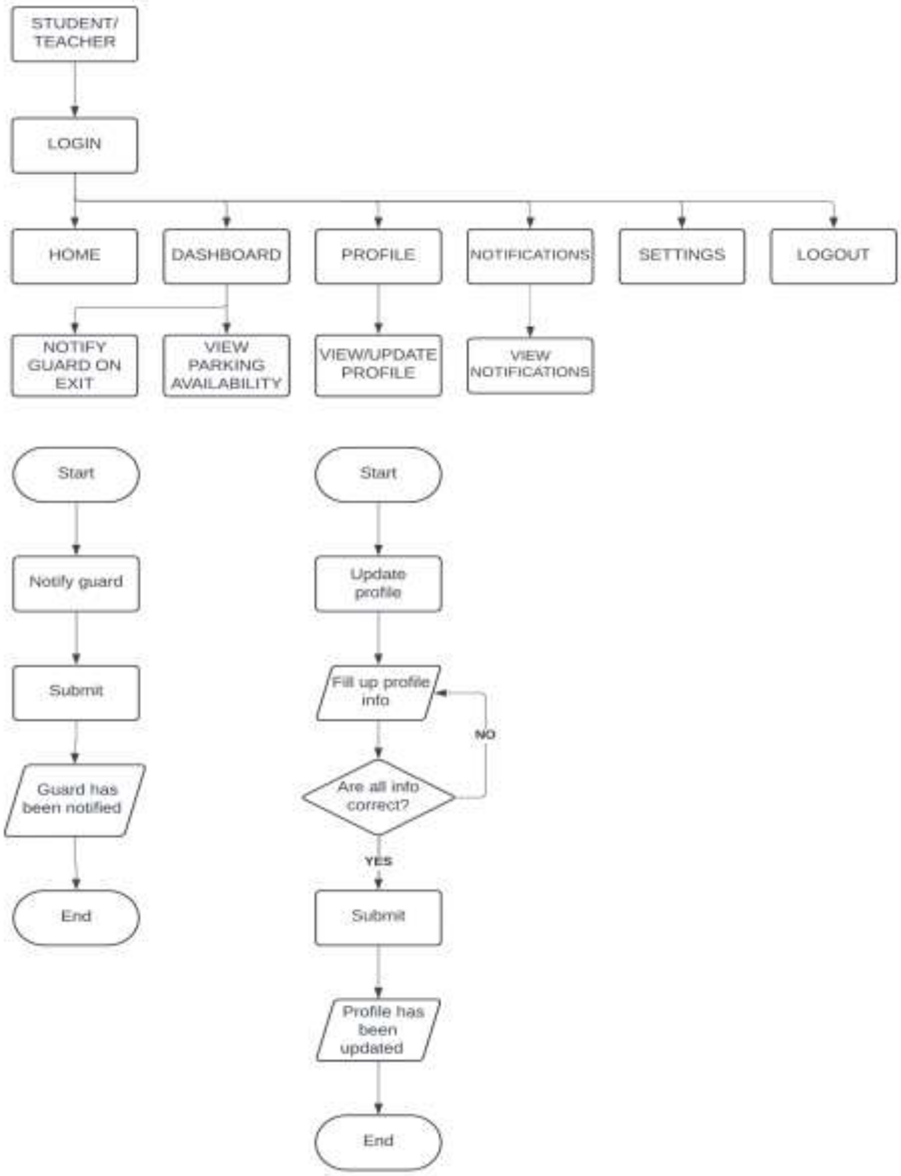

Figure 4. Hierarchical Input Process Output (STUDENT/TEACHER)

Figure 4 illustrates the HIPO Diagram of the parking monitoring system using RFID Technology for user interaction of teachers and students. Highlighting features such as "Home" that allow users to notify security during vehicle exit. Which ensures tracked movements for safety. A "Dashboard" that shows real-time parking availability. "Profile" section that enables updates to personal and vehicle information, with verification for data integrity. "Notification" keeps users informed about updates and reminders. "Settings" that allows personalization of preferences. Lastly, "Logout" that ensures secure session termination as part of system security.

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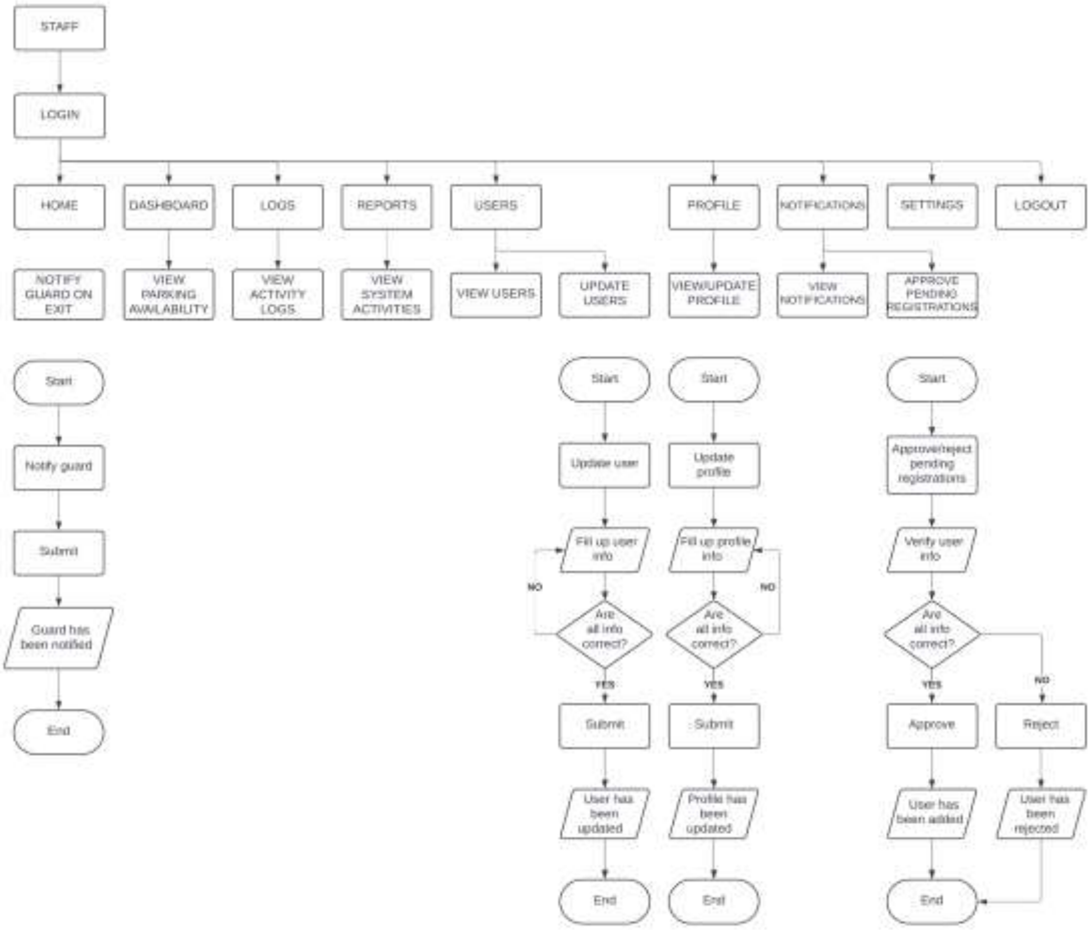

Figure 5. Hierarchical Input Process Output (STAFF)

Figure 5 illustrates the HIPO Diagram of the user interface in the Parking Monitoring System, using RFID technology for staff. It outlines the workflow for staff when managing parking operations and user information. Post-login, staff access modules like Home, Dashboard, Logs, Reports, Users, Profile, Notifications, Settings, and Logout. Staff notify guards of vehicle exits via the home module, while the Dashboard displays real-time parking data for decision-making. The Logs and Reports modules summarize activities for performance analysis. The Users module allows verification and updating of user information, and the Profile section lets users modify credentials. Notifications provide updates on system events, Settings allow for configuration changes, and Logout secures session termination.

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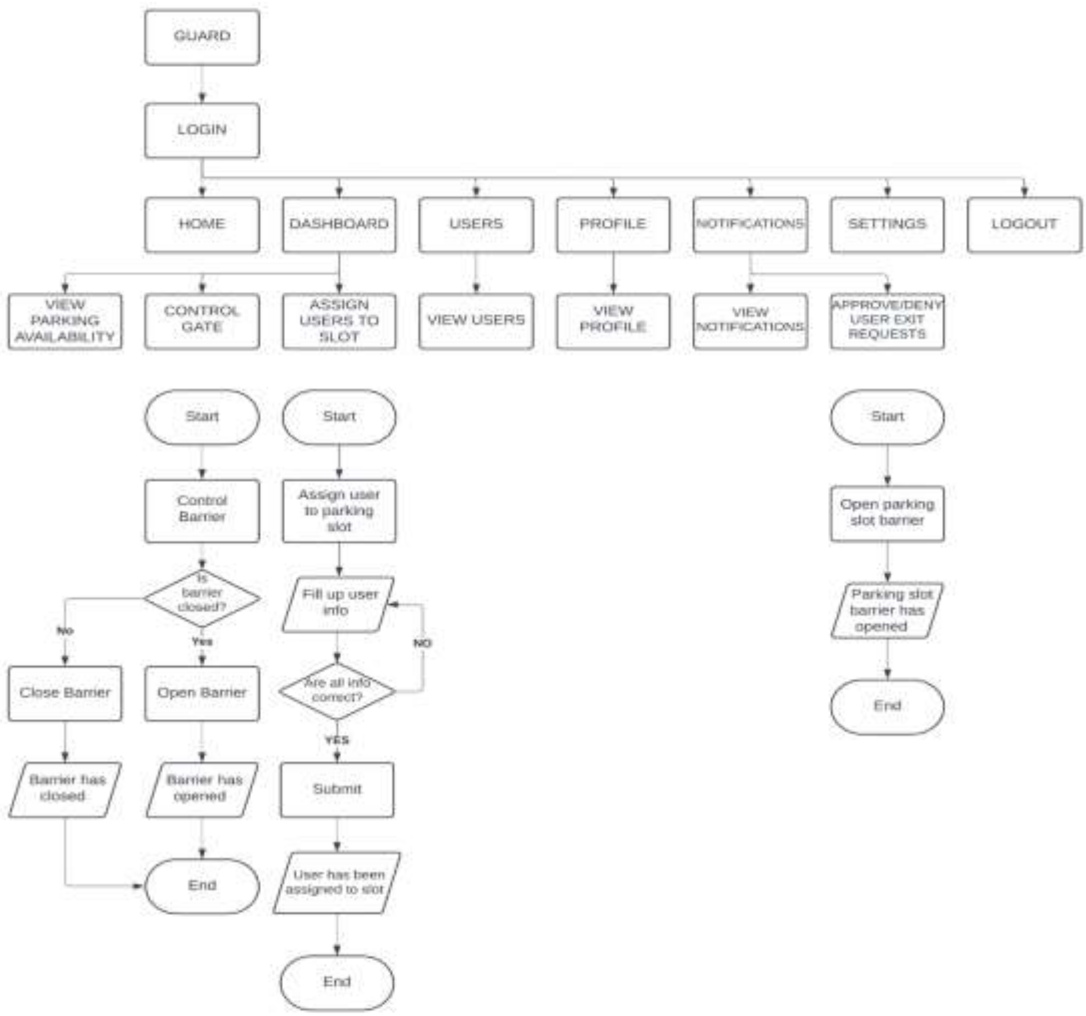

Figure 6. Hierarchical Input Process Output (GUARD)

Figure 6 illustrates the HIPO Diagram of the user interface in the Parking Monitoring System, using RFID Technology for Guard. It details the workflow of guards, enabling them to manage parking activities and maintain campus security. Guards log in to access modules like Home, Dashboard, Users, Profile, Notifications, Settings, and Logout. The Home section allows for real-time parking availability monitoring, and the Dashboard controls parking barriers based on vehicle movement. After confirming user information, the Users module then makes slot assignment easier. Additional modules help manage personal information and alerts, while the Logout option securely ends sessions. The HIPO flowchart emphasizes a streamlined workflow that enhances gate control and overall security at Christ the King College de Maranding, Inc.

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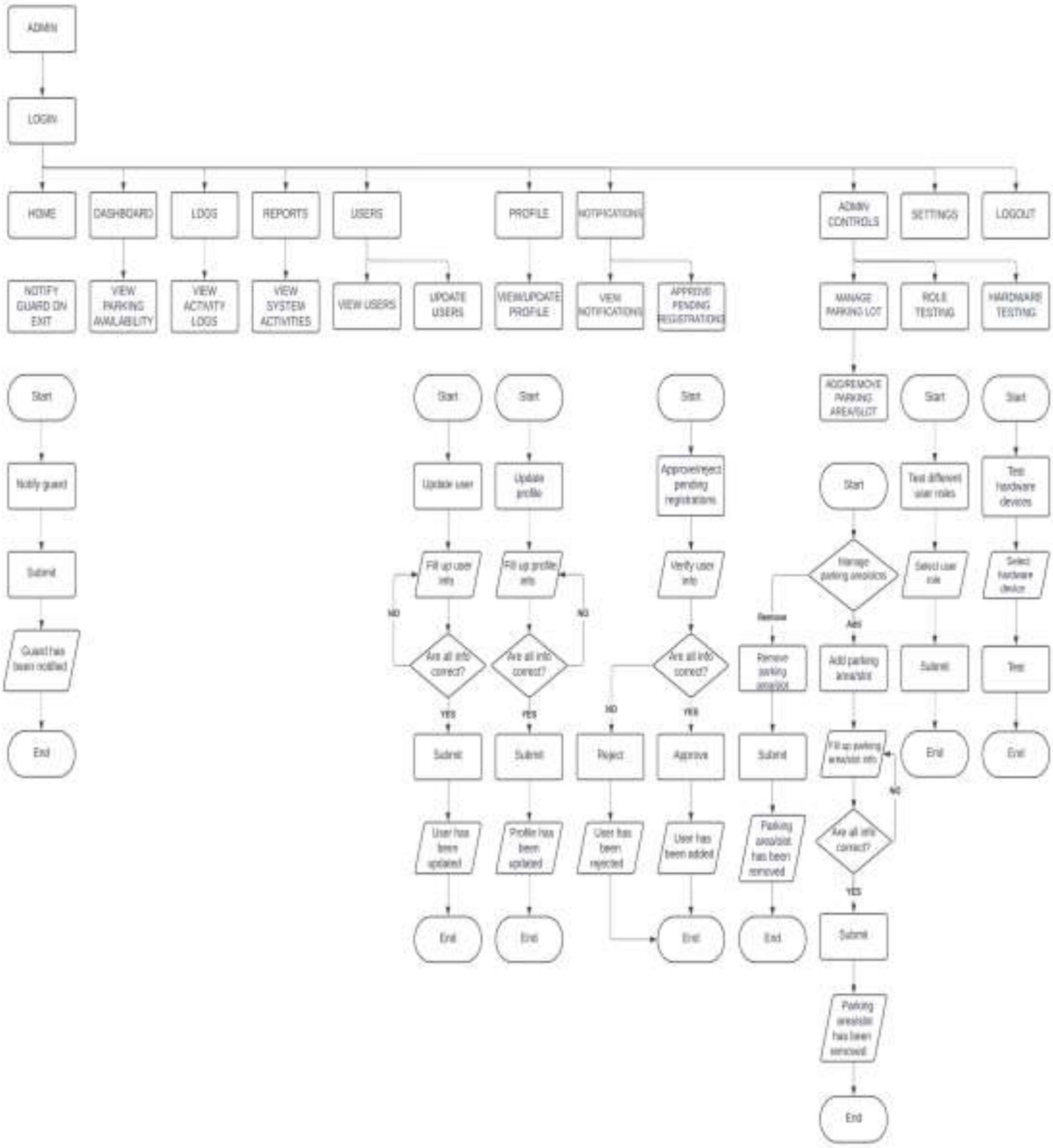

Figure 7. Hierarchical Input Process Output (ADMIN)

Figure 7 illustrates the HIPO Diagram of the user interface in the Parking Monitoring System, using RFID Technology for administrators. It shows the management of system operations, user data, and hardware functions by the administrator. After logging in, the administrator accesses key modules such as Home, Dashboard, Logs, Reports, Users, Profile, Notifications, Admin Controls, Settings, and Logout. The Home module facilitates communication with guards. The system also has a Dashboard; it provides real-time updates of parking spaces for monitoring. Logs and Reports document timely activities and performance evaluations. The Users module allows for the management of user information, and the Profile and Notifications modules handle personal updates and alerts.

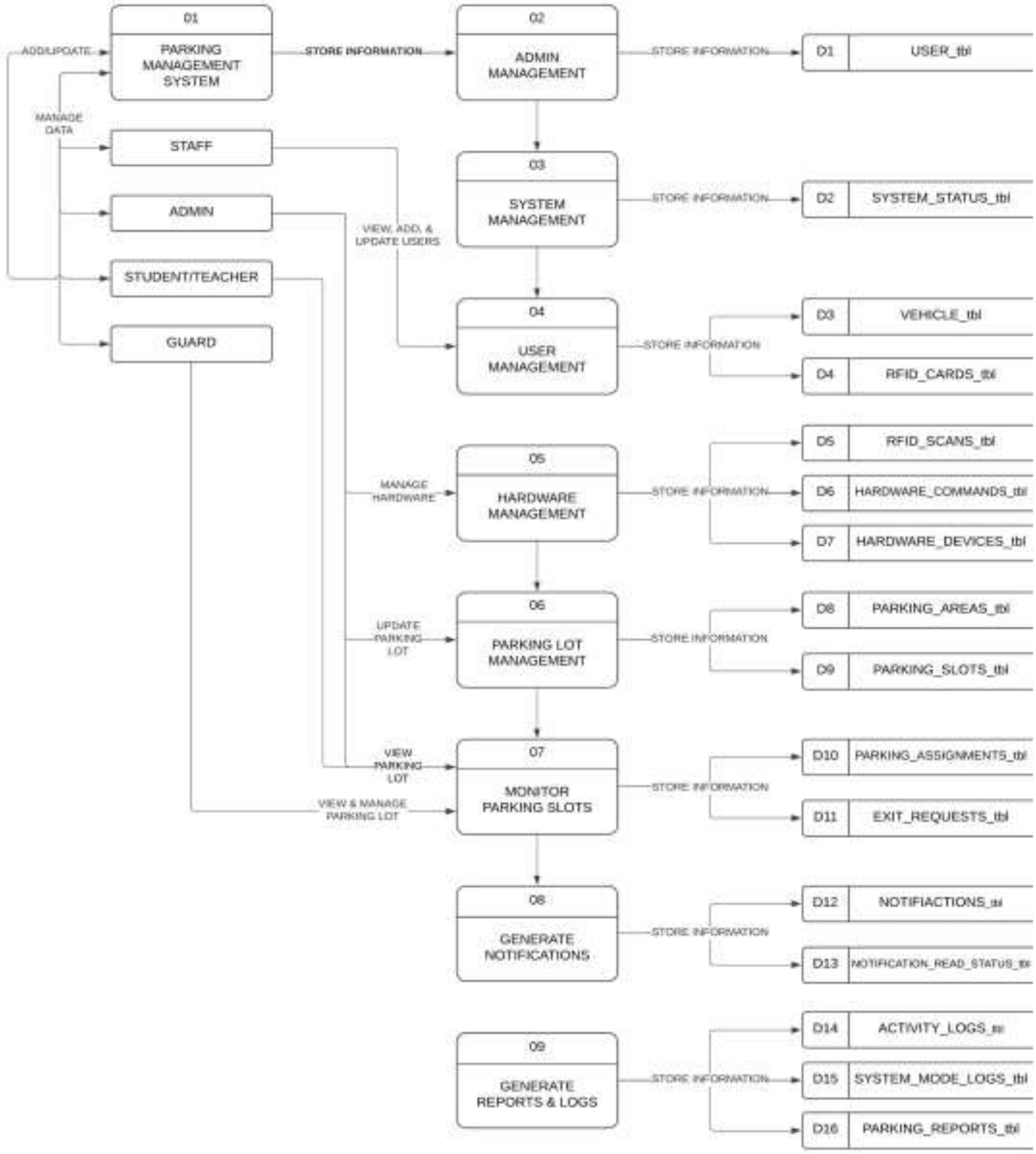

Figure 8. Data Flow Diagram of CKCM PMS Using RFID Technology

Figure 8 illustrates the Data Flow Diagram (DFD) of the parking monitoring system using RFID Technology. It details how databases, processes, and users interact with it. It is accessed by users for data management, including administrators, staff, students, instructors, and security personnel. The processes include system management for performance monitoring. Administration management for user access control, and hardware management for RFID device oversight. Parking lot management for slot updates, monitoring for real-time occupancy, and notification generation for alerts. Lastly, report generation for the archiving of information of activities and operational accountability. Several data tables, such as VEHICLE_TABLE for vehicle records, PARKING_SLOTS_TABLE and PARKING_AREAS_TABLE for parking configurations, RFID_SCANS_TABLE for scan logs, ACTIVITY_LOGS_TABLE for documentation of system actions, and USER_TABLE for user information

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Figure 9. Entity-Relationship Diagram of CKCM PMS Using RFID Technology

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Figure 9 illustrates the Entity-Relationship Diagram (ERD) for the Parking Monitoring System using RFID technology. This diagram outlines the system's entities and their relationships, highlighting data consistency, automation, and real-time monitoring for secure RFID-based parking management. It consists of data structures and connections, composing tables for users, RFID cards, vehicles, parking areas, and assignments, as well as tracking hardware components and commands.

Implementation. This phase focused on transforming the approved system designs into a fully functional RFID-based Parking Monitoring System. By integrating hardware and software components for vehicle identification, access control, and data management. Developers used tools and programming languages such as PHP, Python, HTML, CSS, JavaScript, SQL, and Bootstrap within Visual Studio Code to build the system. While also preparing technical specifications, data models, and workflows to ensure alignment with user requirements. During hardware-software integration and pilot testing, minor technical refinements were made to improve real-world performance. Which includes optimizing RFID scanning intervals, enhancing real-time data updates for multiple users, and adjusting notification triggers during peak hours. These adjustments were carefully documented, tested in controlled modules, and validated before full integration. This approach shows that although the Waterfall Model follows a structured sequence, it can still allow controlled technical flexibility through proper documentation, modular design, and systematic validation.

Testing. During this phase, the system undergoes initial evaluations. For researchers to assess if its fundamental operations are functioning correctly. Preliminary system and integration testing have provided valuable insights into system performance and potential areas for improvement. This is more technical than user-based, aimed at confirming that the system components are integrated properly and capable of handling real-time data communication. It includes checking the responsiveness of the RFID reader. As well as the performance of the Raspberry Pi 4. Also, the accuracy of vehicle data recorded in the database and displayed through the online platform. Once full-scale testing begins, the development team will focus on evaluating reliability, speed, and user interaction. Ensuring that the RFID-based system meets the expectations of its end users, including administrators and parking staff.

Deployment. This phase is the final installation and activation of the RFID-based Parking Monitoring System within the CKCM institution. System optimization is prioritized in this stage to ensure efficient data processing, immediate updating of parking logs, and a responsive user interface. User Acceptance Testing (UAT) is conducted to verify that all system functionalities perform as intended in a live environment. The process of this phase also includes deploying RFID scanners at designated entry and exit points. Configuring the Raspberry Pi 4 for data processing. As well as integrating the system with the online platform to enable real-time access and monitoring. In addition, administrators and security personnel undergo training sessions to familiarize themselves with system operation, troubleshooting procedures, and data management features. This phase ensures a smooth transition from manual parking procedures to an automated RFID-based system.

Maintenance. This phase plays an important role in making sure the deployed system remains efficient, secure, and reliable over time. Monitoring system performance, fixing detected bugs, and updating the software to enhance stability are part of maintenance activities. Regular inspections of the RFID sensors and Raspberry Pi hardware are also conducted to maintain accurate readings and uninterrupted operation. Database management ensures vehicle logs, time-stamps, and user information remain accessible and well-organized as well. Additionally, user feedback will be gathered after actual testing and usage, allowing the development team to implement improvements and optimize the user experience.

RESULTS

Assessment of the Developed System using ISO 9126-1 Software Quality Standard

The performance of the developed Christ the King College de Maranding, Inc. (CKCM) Parking Monitoring System Using Radio-Frequency Identification (RFID) Technology was assessed using the ISO 9126-1 software quality framework. Results from the survey conducted among school faculty, IT professionals, security staff, students, and administrative users showed that the system performed excellently in all six quality indicators: reliability, efficiency, functionality, usability, maintainability, and portability.

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Statement	Mean	Interpretation
1. The system accurately records vehicle entries and exits through RFID scanning.	4.78	Very Reliable
2. The system consistently identifies authorized users and their RFID cards.	4.60	Very Reliable
3. The system provides accurate and error-free data logs.	4.68	Very Reliable
4. The system ensures secure and stable data transmission between RFID devices and the database.	4.75	Very Reliable
5. The system operates continuously with minimal errors or downtime.	4.75	Very Reliable
Average	4.71	**Very Reliable**
Note: 5-4.2 Very Reliable; 4.19-3.5 Reliable; 3.40-2.7 Fairly Reliable; 2.6-1.9 Minimally Reliable; 1.8-1.0 Not Reliable		

Table 1. System Reliability Evaluation

Reliability: 4.06 (Effective)
Table 6 presents the evaluation of the Parking Monitoring System using RFID technology. The system demonstrated high performance in accurately recording vehicle entries and exits (mean: 4.78), identifying authorized RFID users (mean: 4.60), and maintaining precise data logs (mean: 4.68). Moreover, it exhibited secure data transmission (mean: 4.75) and uninterrupted system operation (mean: 4.75), indicating a high level of stability and dependability. The system achieved an overall mean rating of 4.71 in terms of reliability, which is "Very Reliable".

Statement	Mean	Interpretation
1. The system efficiently processes RFID scans and updates parking records in real time.	4.85	Very Efficient
2. The system operates smoothly with minimal loading time or response delay.	4.65	Very Efficient
3. The system effectively utilizes server and network resources to ensure optimal performance.	4.83	Very Efficient
4. The system can handle multiple users and simultaneous RFID transactions without performance issues.	4.68	Very Efficient
5. The system maintains stable performance even during peak usage or heavy data processing.	4.75	Very Efficient
Average	4.75	**Very Efficient**
Note: 5-4.2 Very Efficient; 4.19-3.5 Efficient; 3.40-2.7 Fairly Efficient; 2.6-1.9 Minimally Efficient; 1.8-1.0 Not Efficient		

Table 2. System Efficiency Evaluation

Efficiency: 4.75 (Very Efficient)
Table 2 presents the Parking Monitoring System evaluation. Key findings include very positive responses regarding real-time RFID scanning and record updates (4.85), smooth performance under multiple vehicle transactions (4.68), and stability during peak hours (4.75). The system effectively minimizes loading times (4.65) and utilizes resources efficiently (4.83), significantly speeding up vehicle processing and reducing congestion, thereby leading to shorter wait times and faster entry validation for users. The overall mean score of the system in terms of efficiency is 4.75, which is "Very Efficient".

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Statement	Mean	Interpretation
1. The system effectively detects vehicles entering and exiting the parking area.	4.68	Very Functional
2. The system accurately displays real-time parking availability.	4.68	Very Functional
3. The system records and stores user and vehicle information correctly.	4.80	Very Functional
4. The system generates reports and summaries accurately and promptly.	4.70	Very Functional
5. The system performs its intended functions efficiently without failure.	4.80	Very Functional
Average	4.73	**Very Functional**
Note: 5-4.2 Very Functional; 4.19-3.5 Functional; 3.40-2.7 Fairly Functional; 2.6-1.9 Minimally Functional; 1.8-1.0 Not Functional		

Table 3. System Functionality Evaluation

Functionality: 4.73 (Very Functional)
Table 3 presents the evaluation of the Parking Monitoring System using RFID technology. The results indicate that the system effectively performs its key functionalities when tested. Including accurate detection of vehicle entries and exits (4.68), real-time display of parking availability (4.68), and secure storage of user and vehicle information (4.80). It also generates fast and reliable activity reports (4.70) and operates without crashes or system failures (4.80). The system achieved an overall mean rating of 4.73 in terms of functionality, which is "Very Functional".

Statement	Mean	Interpretation
1. The system interface is intuitive and easy to navigate.	4.68	Very Usable
2. The system interface design is organized, clear, and visually appealing.	4.80	Very Usable
3. The system provides clear instructions that are understandable to all users.	4.83	Very Usable
4. The system responds promptly to user actions and displays real-time updates.	4.73	Very Usable
5. The system enhances user experience and convenience.	4.83	Very Usable
Average	4.77	**Very Usable**
Note: 5-4.2 Very Usable; 4.19-3.5 Usable; 3.40-2.7 Fairly Usable; 2.6-1.9 Minimally Usable; 1.8-1.0 Not Usable		

Table 4. System Usability Evaluation

Usability: 4.77 (Very Usable)
Table 4 presents the evaluation of the Parking Monitoring System using RFID technology for Usability. When it comes to user interface, it was proven easy to navigate (4.68) with clear buttons, and a visually organized layout (4.80). Also, Instructions and messages were found to be understandable (4.83), minimizing user confusion. The system's responsive updates (4.73) facilitate efficient parking activity monitoring, enhancing convenience for guards and students (4.83) as well. The system gained an overall mean usability rating of 4.77, which is "Very Usable."

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Statement	Mean	Interpretation
1. The system's structure and documentation allow for easy updates and improvements.	4.80	Very Maintainable
2. The system allows maintenance without affecting other functions.	4.63	Very Maintainable
3. The system is easy to troubleshoot when issues arise.	4.70	Very Maintainable
4. The system enables efficient deployment of updates and fixes.	4.70	Very Maintainable
5. The system maintains stability after updates or modifications.	4.83	Very Maintainable
Average	4.73	**Very Maintainable**
Note: 5-4.2 Very Maintainable; 4.19-3.5 Maintainable; 3.40-2.7 Fairly Maintainable; 2.6-1.9 Minimally Maintainable; 1.8-1.0 Not Maintainable		

Table 5. System Maintainability Evaluation

Maintainability: 4.73 (Very Maintainable)
Table 4 presents the evaluation of the Parking Monitoring System using RFID technology for Maintainability. Key features include the system's ability for updates without affecting other functions (4.83), ease of modifications due to well-structured documentation (4.80), efficient error tracing and fixing (4.70), and the capability to deploy updates without user interruption (4.70). These results demonstrate that the system is designed for long-term use, allowing for improvements and repairs while maintaining operational stability. Yielding an average rating of 4.73, classifying it as "Very Maintainable."

Statement	Mean	Interpretation
1. The system operates effectively across different devices (Computers, Tablets, Smartphones).	4.80	Very Portable
2. The system is compatible with multiple operating environments.	4.75	Very Portable
3. The system can be accessed both within and outside the campus.	4.75	Very Portable
4. The system data can be transferred or backed up securely.	4.65	Very Portable
5. The System updates do not disrupt overall functionality.	4.70	Very Portable
Average	4.73	**Very Portable**
Note: 5-4.2 Very Portable; 4.19-3.5 Portable; 3.40-2.7 Fairly Portable; 2.6-1.9 Minimally Portable; 1.8-1.0 Not Portable		

Table 6. System Portability Evaluation

Portability: 4.73 (Very Portable)
Table 4 presents the evaluation of the Parking Monitoring System using RFID technology in terms of its portability. The results show that the system is compatible with different devices (4.80). It operates across different platforms (4.75). Allows access beyond school premises (4.75). It ensures secure data transfer (4.65), maintains full functionality during system updates (4.70), and thereby enabling seamless expansion or migration to different servers. Overall, the system attained a mean score of 4.73, which is "Very Portable".

DISCUSSION

The results of this study indicate that the Christ the King College de Maranding, Inc. (CKCM) - Parking Monitoring System using Radio-Frequency Identification (RFID) Technology significantly enhanced parking operations. Through automation, real-time monitoring, and efficient vehicle access control. The system eliminated manual logging by enabling contactless RFID-based entry and exit, improving accuracy and reducing processing time. These results are consistent with prior studies which emphasized RFID's effectiveness in minimizing human error and accelerating access control in institutional environments [1], [8]. Furthermore, the integration of embedded platforms and sensors aligns with the findings from studies, confirming that Raspberry

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Pi– and IoT-based architectures can provide reliable, low-cost solutions for slot detection and real-time data logging [2], [10].

The centralized monitoring dashboard and secure database design of the parking monitoring system greatly reflect best practices reported in related literature, similar to the RFID–IoT frameworks [3], [6]. The system supports real-time tracking of parking occupancy, automated reporting, and improved administrative efficiency. Based on the system's functionality, reliability, usability, efficiency, maintainability, and portability. The system evaluation results in accordance with the ISO 9126-1 Software Quality Model, showed that respondents rated the system as "Effective" and "Very Effective". These outcomes demonstrate that the system not only meets technical requirements but also enhances user satisfaction and operational transparency within the campus.

Despite these improvements, minor challenges such as peak-hour system load and sensor dependency were observed, reflecting limitations noted in earlier studies. Prior research reported similar issues related to sensor accuracy, environmental interference, and congestion during high-traffic periods [2], [11], [7]. In response, the literature recommends hybrid sensor integration, continuous testing, and user-centered design supported by ISO 9126-1-guided evaluation. These recommendations were being addressed in the developed system through its combined use of RFID and sensors, an iterative development approach, and stakeholder involvement. Overall, the findings prove that the system effectively bridges the research gap identified in related literature by delivering a reliable, scalable, and sustainable parking monitoring solution designed to meet the needs of an academic institution.

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CONCLUSION

The development and implementation of the Parking Monitoring System using Radio-Frequency Identification (RFID) Technology has successfully improved vehicle access control, parking visibility, and overall traffic management within the campus. The system also streamlined parking operations by automating vehicle entry and exit. To provide real-time monitoring of parking slot availability and ensure accurate recording of vehicle movement data. Users, including administrators, security personnel, and authorized drivers, can effectively monitor parking activities through the integrated web-based platform, promoting a more organized, secure, and transparent parking environment. Despite these improvements, minor issues remain, such as occasional system slowdowns during peak entry and exit hours, limited technical documentation that may affect independent troubleshooting, and reliance on a small number of IT personnel for system maintenance. Addressing these concerns is necessary to further improve the system's reliability, usability, and long-term sustainability within the institution.

The researchers recommend that future improvements should focus on system maintainability, integration, functionality, and the user experience based on the findings and conclusion. Also, using a modular system architecture with version control would let the future researchers upgrade parts of the system without affecting the whole system. Integrating more with institutional systems like databases intended for students, personnel, and finances might make it easier to get permission in parking spaces, and reports. As well as adding features like real-time notifications, smartphone access, and optional parking reservations could make users more interested and help ease traffic at busy times. Finally, to make the system easier to use, more people should be able to use it, and it should be easier to manage the campus parking lots effectively and in a way that lasts.

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