IMPLEMENTATION OF SMART ACCESS CONTROL IN HOTEL ROOMS INTEGRATING RFID AND IOT

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ABSTRACT: *In today's rapidly changing world where technology itself changes the way people prefer their things or services to be done most specifically in the hotel environment, the hospitality industry made several solutions to meet people's needs and preferences. Despite of these solutions, people still express their frustration with cumbersome check-in procedures, inadequate Wi-Fi access and slow management responses making it a critical problem to many hotels. Addressing these issues, this study developed an Integrated Smart Access Control System for hotel rooms that combines RFID-based room access, automated Wi-Fi connectivity, and real-time guest service requests into a cohesive platform. The system utilizes a Raspberry Pi 4 Model B microprocessor that incorporates RFID technology for secure room access and an automatic MAC-address-based Wi-Fi provisioning eliminating hassle manual processes for Wi-Fi connectivity. Additionally, the system provides a digital interface or an app for guest registration and for submitting real-time service requests. It's directly linked to the management dashboard of the app where the hotel management keeps track of all the requests, available rooms, and RFID Card used within the hotel. The developed system was tested based on its performance with an average processing time for unlocking the door of 178.25 ms and average processing time for Wi-Fi connectivity of 458.02 ms. As for the user experience, 30 respondents were tasked to test the system and result shows that 95% of the respondents found the system easy to use with mean± SD of 2.9± .109 reported that the system can be navigated easily.*

Key words: Smart Access Control, RFID, Internet of Things (IoT), Raspberry Pi, Automated Wi-Fi Connectivity, MAC Address Authentication, Hotel Management System

INTRODUCTION

The hospitality industry is undergoing a rapid digital transformation driven by advancements in automation and smart technologies. This evolution is essential as modern travelers increasingly demand seamless, contactless, and technology-enhanced experiences that prioritize convenience, security, and personalization [1]. Among these innovations, Radio Frequency Identification (RFID) technology has become a key enabler in improving hotel operations and enhancing guest satisfaction. RFID systems facilitate contactless room access, automate check-in processes, and strengthen security measures. As noted by Luo et al. [2], RFID integration in hotel environments significantly reduces waiting times during check-in and enhances the overall guest experience through efficient access management.

Despite these advancements, many hospitality establishments continue to operate disconnected systems—particularly for Wi-Fi access and guest service management—resulting in fragmented user experiences. Guests often face repetitive login procedures or inconsistent connectivity, which detract from the convenience and satisfaction expected in modern accommodations. Research indicates that stable and automatic Wi-Fi connectivity is now considered a basic necessity, with internet quality directly influencing overall guest satisfaction and hotel ratings [3]. Therefore, the integration of RFID-enabled room access with automated Wi-Fi authentication can provide a unified and frictionless guest experience.

In addition to connectivity, efficient communication between guests and hotel staff remains vital for service quality. Traditional channels such as phone calls or face-to-face interactions are prone to delays and miscommunication. Implementing digital interfaces linked to hotel management dashboards enables real-time service requests and faster response times [4]. This shift toward automation and integration supports a guest-centric model of hospitality service delivery.

However, current research and hotel technologies tend to focus on isolated systems—RFID access, smart room control, or online service requests—without offering a unified platform that combines all these elements. Zhang and Zhang [5] emphasize that the absence of an integrated framework limits the full potential of smart hospitality systems. Addressing this gap, the present study aims to develop an integrated solution that merges RFID-based access, automatic Wi-Fi connectivity, and digital service request functionality into a single system.

By bridging this technological gap, the study seeks to enhance operational efficiency and elevate the overall guest experience. The proposed integration aligns with the growing trend toward smart hotel ecosystems that leverage IoT and automation to deliver seamless, personalized, and efficient services—ultimately fostering customer loyalty and competitiveness in the hospitality industry.

CONCEPTUAL AND THEORETICAL FRAMEWORK

The implementation of an RFID-based hotel access system relies on both hardware and software parameters that ensure reliable performance. The mechanical locking mechanism requires determining the force F applied by the plunger, governed by the torque T of the electric strike lock and the radius r from the axis of rotation, as shown in Equation (1.1):

$$F = T / r$$

This equation ensures sufficient mechanical force for secure locking and unlocking operations. The corresponding power consumption P of the electric strike is calculated using the Power Law, relating voltage V and current I [6]:

$$P = V * I$$

Accurate power estimation prevents overload and ensures consistent operation during peak usage [6]. The RFID system's responsiveness is defined by its data transmission rate R, where N is the total number of bits transmitted over time T [7]:

$$R = N/T$$

Reliable communication also depends on minimizing the Bit Error Rate (BER), calculated as [8]:

$$BER = Ne/Nt$$

where Ne is the number of erroneous bits and Nt is the total bits transmitted, ensuring accurate tag recognition and secure guest access. For database operations, the total query time T*query* combines retrieval (T*retrieval*) and processing (T*processing*) times [9]: $Tquery = Tretrieval + Tprocessing$ Optimizing this reduces system delays and enhances real-time monitoring of guest access. To automate Wi-Fi connectivity, the system follows the IEEE 802.11 protocol. Devices broadcast their MAC addresses during connection via probe, authentication, and association frames, which are captured for secure session management [10]. The proposed system integrates QR code-based Wi-Fi access, DHCP lease monitoring, and backend validation. Upon scanning, the router logs the device's MAC and IP addresses, which are stored and verified in the Supabase database to ensure accurate, authenticated connectivity.

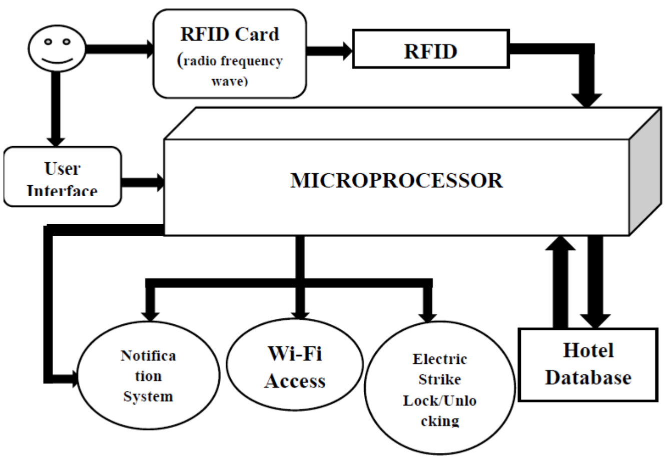

Figure 1. Conceptual Framework of the System

Figure 1 presents the architecture of the proposed RFID-based hotel access system, which integrates RFID authentication, Wi-Fi access, an electric strike lock, a notification system, and a hotel database—all managed by a central microprocessor.

When a guest taps the RFID card, the reader transmits its unique ID to the microprocessor, which verifies it through the hotel database. Upon successful authentication, the system triggers the electric strike lock to grant access and logs the event for monitoring. Simultaneously, the system enables automatic Wi-Fi connection, linking the guest's device credentials without manual input, thereby improving convenience and connectivity efficiency.

The notification system provides real-time alerts for room status and service requests, while the user interface allows guests to interact with hotel services digitally. Overall, this integrated design enhances security, operational efficiency, and guest experience by unifying access control, connectivity, and communication within a single smart hotel framework.

2 .MATERIALS AND METHODS

The system is powered by Raspberry Pi 4 Model B, which served as the central processing unit and controller of the entire system design. With built-in features such as Wi-Fi and usb port, it can function as a minicomputer to control all system components.

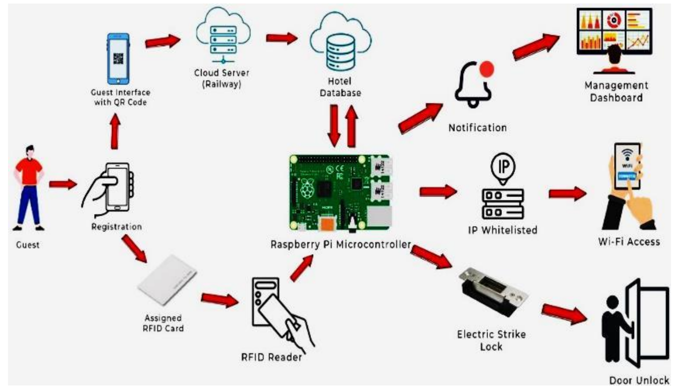

Figure 2. System Architecture

The system architecture shown in figure 2 represents the overall interaction between hotel guests, the RFID card, and the system's central microprocessor. It demonstrates the process in which a guest scans the RFID card at the door's reader, transmitting data to the microprocessor that verifies access authorization. Upon successful validation, the system simultaneously unlocks the door and connects the guest's device to the hotel's Wi-Fi network. Additionally, the user interface enables guests to perform various functions such as submitting service requests or communicating with hotel staff, all of which are processed through the same microprocessor. This integrated design enhances operational efficiency and delivers a seamless, user-centered experience by automating access, connectivity, and service management within a unified smart hotel framework.

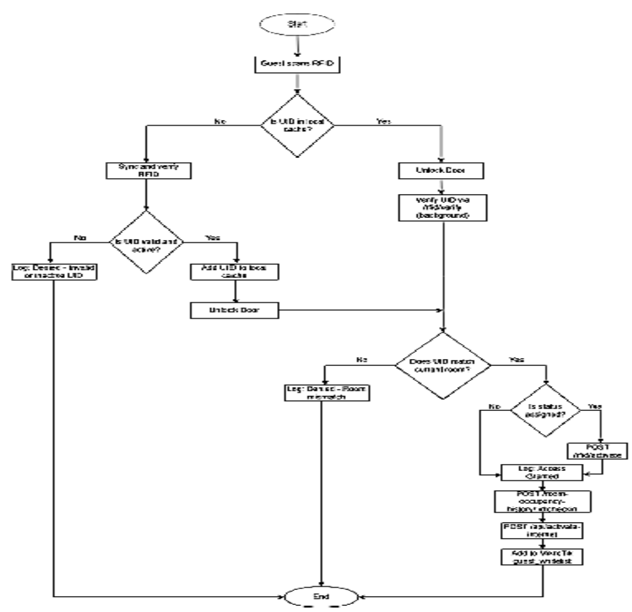

Figure 3 System Flowchart for Automated Door and Wifi Access

The RFID-based hotel access process shown in Figure 3 begins when a guest scans an RFID card at the door reader. The controller first checks whether the card's unique ID (UID) is present in the local cache; if so, the microprocessor authenticates the UID and unlocks the door immediately. If the UID is not cached, the controller synchronizes with the central database to validate the credential before granting access. Invalid or inactive UIDs are logged and denied for security and audit purposes. Once the UID is authenticated, the system verifies the guest's status and room assignment; authorized guests are admitted and the access event is recorded in the central database for monitoring and reporting. By combining local caching for rapid response with centralized verification for authoritative control, this flow ensures fast, secure, and reliable access while maintaining synchronization between door controllers and the hotel's server.

3. RESULTS AND DISCUSSION

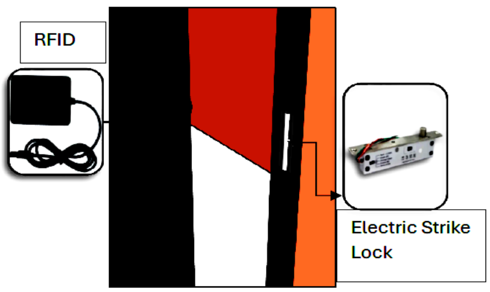

Figure 4 Design Prototype

Figure 4 shows the final design prototype of the Smart Access Control in Hotel Rooms integrating RFID and IoT. It is the implementation of the RFID reader and electric strike lock as part of the smart door system. When an authorized RFID tag is scanned, the system triggers the strike lock to grant entry, providing a secure and contactless method of access. This design aligns with the project's goal of developing a secure and automated access solution. The prototype serves as a functional model to evaluate performance in terms of operational efficiency, system reliability, and user accessibility. Experimental results indicate that the system consistently validates authorized entries and maintains lock stability, confirming its feasibility for real-world deployment.

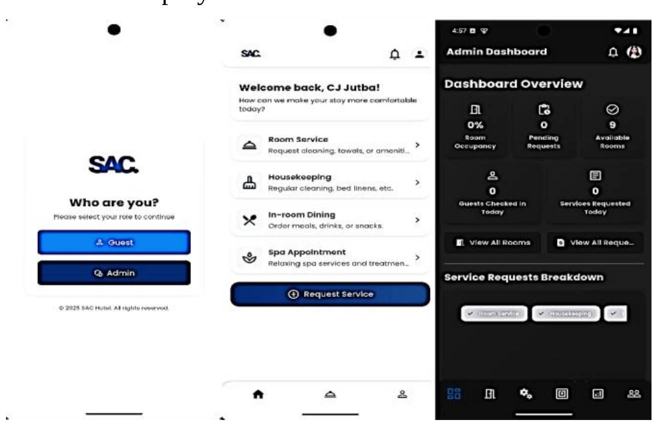

Figure 5. System Dashboard

The graphical interface of the Smart Access Control (SAC) system, illustrating two distinct views designed for guest and administrator users is presented in figure 5. The interface is accessible via both mobile devices and web applications, ensuring flexibility and ease of use across platforms. The Guest interface provides a centralized service request dashboard that allows users to easily access hotel amenities such as room service, housekeeping, in-room dining, and spa appointments through intuitive command buttons. Additionally, it includes options for submitting feedback and messages, enabling guests to directly communicate with hotel management for service-related concerns.

On the other hand, the Admin interface offers real-time monitoring of guest activities and service requests. As illustrated, the dashboard displays essential operational metrics, including guest occupancy rates, pending service requests, available rooms, and the total number of checked-in guests. This comprehensive overview enables administrators to manage operations efficiently and ensure prompt responses to guest needs. The integration of both interfaces enhances operational transparency, service efficiency, and guest satisfaction. By providing a unified digital platform for communication and monitoring, the system streamlines hotel service management, resulting in faster transaction processing and improved service delivery.

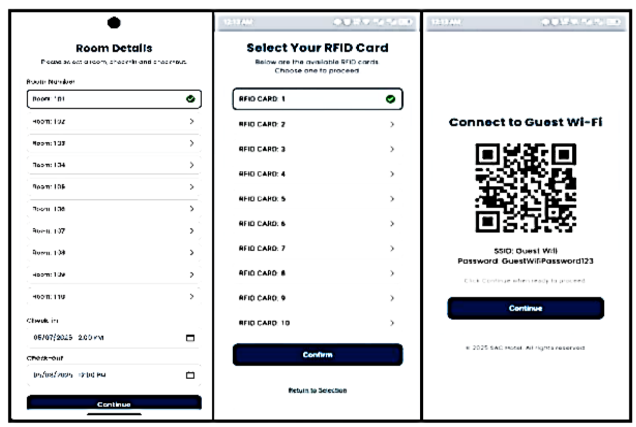

Figure 6. Automated Wi - fi Connectivity Feature

Figure 6 illustrates the registration process within the system mobile application, which automates both room access and Wi-Fi connectivity for guests. The process begins with the selection of the assigned room number, allowing guests to confirm the booking details directly through the apps. Afterwards, the guest registers an RFID card, which functions as a secure digital key for unlocking their assigned room. Once registered, the system generates a QR code that enables automated Wi-Fi connection. Scanning this code connects the guest's device to the hotel network and records the MAC address for secure authentication. The process concludes by pressing the Continue button, which finalizes both access and network registration. This digital workflow demonstrates how RFID and IoT integration can simplify hotel operations by minimizing manual check-in processes and physical key management. The automated connectivity also improves guest convenience while maintaining system security.

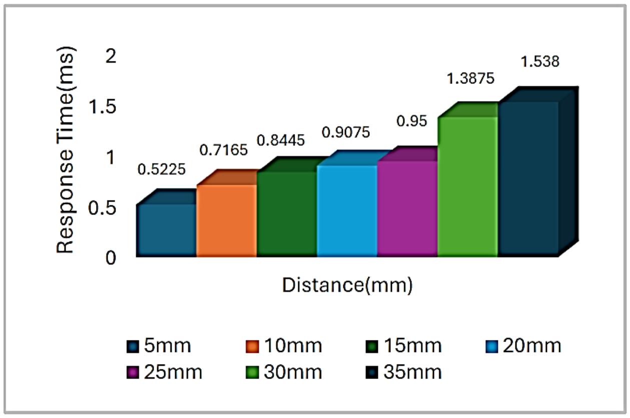

Figure 7. Summary of the RFID Read Range

The presented data in figure 7 summarizes the average response time of the RFID reader at different distances, showing a clear increase in response time as the distance between the RFID card and the Reader grows. At 5mm, the system recorded the fastest response time of 0.5225 milliseconds, while at the farthest distance of 35mm, the response time peaked at 1.538 milliseconds. This data indicates that the RFID reader performs most efficiently at closer ranges, with response time increasing significantly beyond 20mm. The results emphasize the importance of maintaining a minimal distance between the RFID tag and the reader to ensure optimal system performance and reliability. This finding aligns with similar research conducted at Udayana University, which reported that increased distance between the RFID tag and reader leads to longer response times in RFID-enabled mobile applications [11].

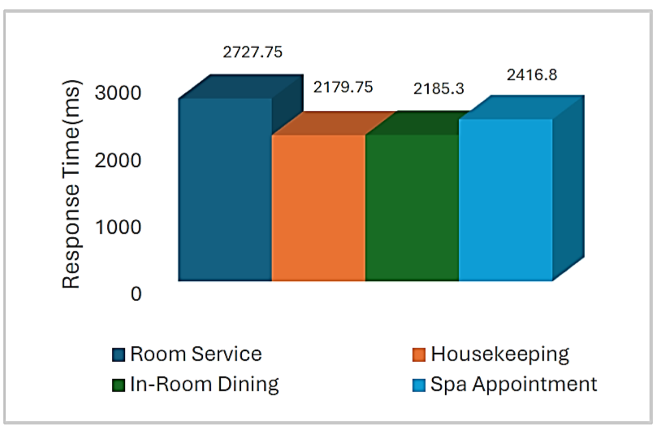

Figure 8. System Response Time for Service Requests

Figure 8 presents the average response time (in milliseconds) of various hotel service requests handled by the RFID-based access application. The data shows that Room Service recorded the highest average response time at 2727.75 ms, followed by Spa Appointment at 2416.8 ms, In-Room Dining at 2185.3 ms, and Housekeeping at 2179.75 ms. These results indicate that Room Service operations require slightly longer processing durations compared to other service categories, possibly due to higher data handling or network traffic involved in guest requests. The findings suggest that system response time may vary depending on the service type, highlighting the importance of optimizing system performance for high-demand hotel services. Maintaining a consistent and efficient response time across all service categories is essential to ensure user satisfaction and operational reliability. Similar research by Sudarma *et al.* [11] supports this result, reporting that system response time tends to fluctuate depending on the nature and complexity of

Table 1. User Experience Evaluation (n=30)

Criteria	**Objective Metric**	**Result (Mean ± SD)**	**(3-Point Scale)**	**Interpretation**
Ease of Use	Average Task Completion Time (s)	2.9 ± 0.109	The system is easy to use and understand.	Users completed tasks quickly and reported the system as easy to use, indicating good learnability.
System Stability	System Uptime (%)	97.8 ± 0.9	The system operates smoothly without errors or crashes.	It was perceived that the RFID–IoT integrated system is a highly reliable and efficient in terms of system uptime and operational stability.
Security	Authentication Success Rate (%)	96.2 ± 1.9	The data and access method are secure within the system.	The integrated access control system effectively maintains secure and dependable user verification, ensuring that only authorized individuals can access designated hotel rooms.
Response Speed	Average RFID Response Time (ms)	0.89 ± 0.31	The system responds quickly when performing tasks.	The system consistently responds quickly regardless of environmental or network conditions.
Accessibility	Read Range (mm)	25.4 ± 5.6	The system is accessible to all users regardless of technical background.	Indicates a stable and effective proximity detection suitable for hotel access applications
User Satisfaction	Task Success Rate (%)	97.3 ± 1.8	I am satisfied with the system's overall performance.	Users found the system highly functional, accessible, and dependable, supporting smooth interaction during hotel access activities.

RFID-enabled application tasks, emphasizing the need for efficient data handling protocols to reduce latency.

The RFID–IoT integrated system exhibited strong usability, reliability, and security, reflecting trends seen in smart access platforms. The low average task completion time (2.9 ± 0.109 s) suggests efficient user interaction, supporting earlier findings on rapid IoT-RFID operations and improved user experiences in related environments[12]. Reliability testing showed system stability at 97.8 ± 0.9%, matching industry standards for IoT uptime, which typically require at least 95% availability [13]. The authentication success rate of 96.2 ± 1.9% affirms secure and dependable access control, in line with advanced multi-factor protocols that strengthen system defenses [14]. Fast system response (0.89 ± 0.31 ms) ensures real-time interactions aligning to engineering advancements in minimizing latency for user-centric, real-time access applications. A read range of 25.4 ± 5.6 mm supports universal user accessibility, reflecting standards for RFID usability in hospitality and workplace environments. High task success rates (97.3 ± 1.8%) point to similarly positive outcomes for user satisfaction and functional dependability as reported in other security system studies [15]. Collectively, these metrics confirm that the system efficiently satisfies modern smart environment standards while prioritizing user needs, operational reliability, and scalable security, paving the way for broader IoT integration in hospitality and smart buildings [16].

4. CONCLUSION

The developed system addresses challenges in manual data collection and patient overcrowding by automating vital health data capture and management. Meticulous testing confirmed the system's accuracy and reliability, with a user-centric web interface and comprehensive compatibility testing showcasing its resilience and usability across platforms. Comparative analyses and t-tests validated the system's precision in healthcare settings, emphasizing the urgent need for efficient digitalized monitoring solutions. The IoT-integrated system promises to enhance patient care and streamline healthcare processes, suggesting future focus on refining features and fostering widespread adoption globally for improved healthcare delivery and outcomes.

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