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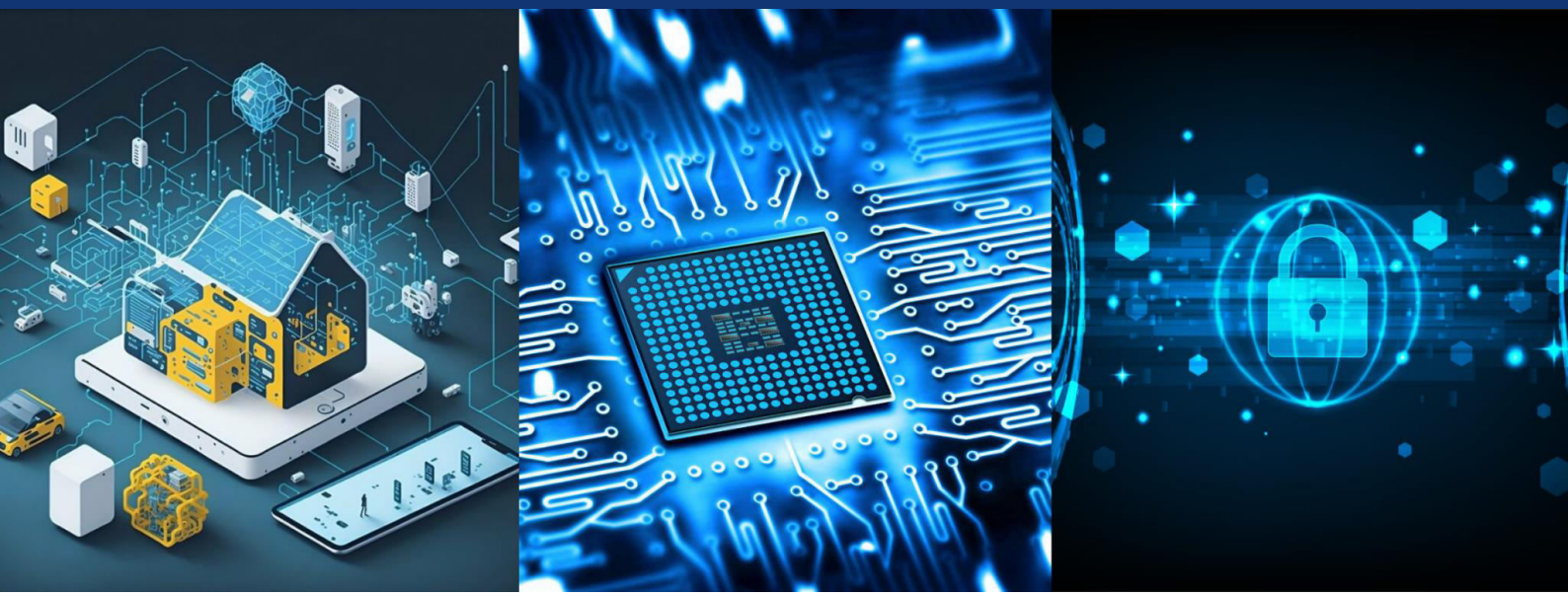

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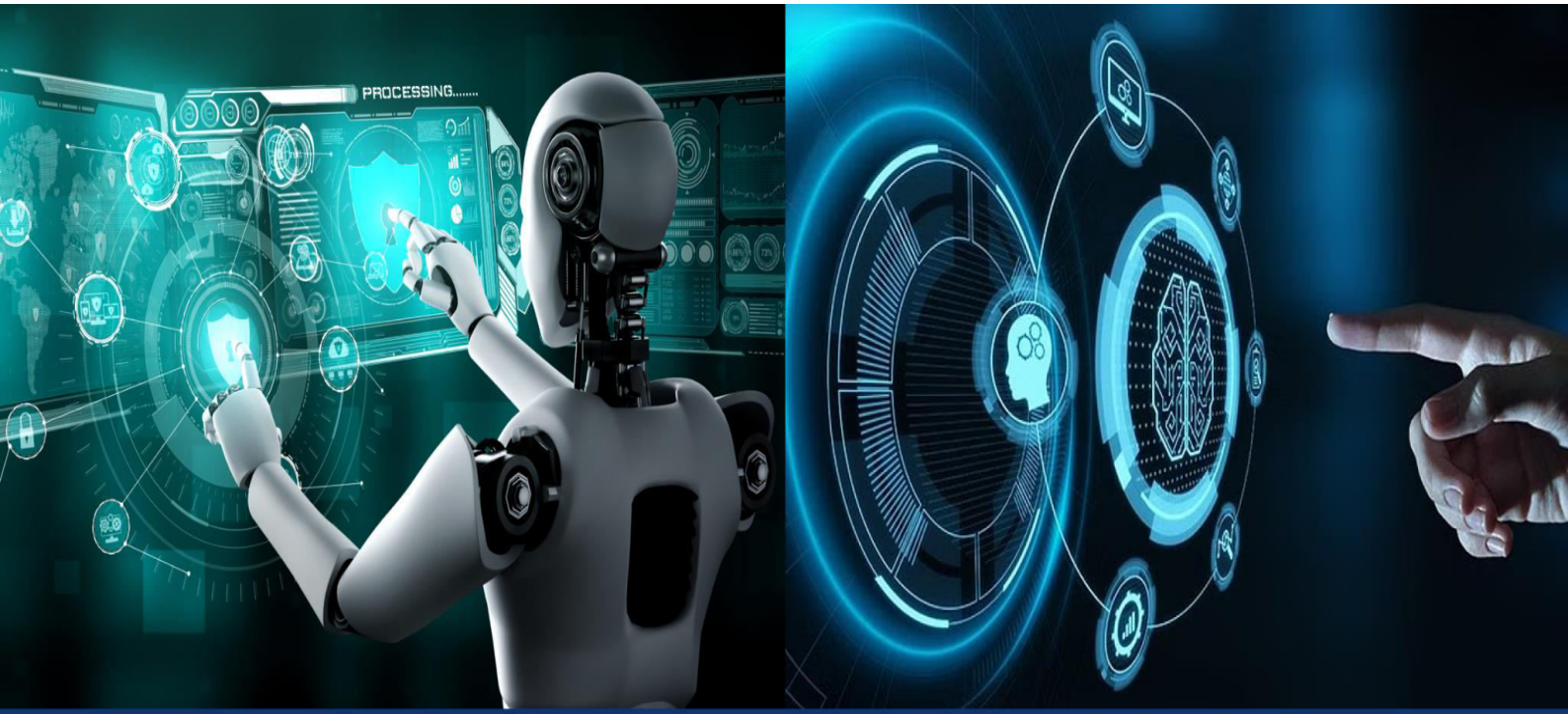

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IoT-Driven Intelligent Campus Transit with RFID-Based Credit Tracking System

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ABSTRACT: The increasing dependence on institutional transportation has created a need for smarter and more reliable monitoring systems. Conventional approaches used in schools and colleges for handling transport fees are mostly manual, making the process slow, less secure, and difficult to track in real time. To overcome these limitations, this project introduces an intelligent campus transport system that combines Internet of Things (IoT) technology with RFID-based identification and a credit-oriented payment mechanism. In the proposed system, every student is assigned a personalized RFID card embedded with a unique identification number. This ID is connected to a digital account where transport credits are maintained. When a student enters the bus, the RFID reader captures the card information and forwards it to the ESP32 controller. The controller processes the data and verifies whether sufficient credit is available in the student's account. If the balance meets the required condition, the system automatically deducts the travel cost and updates the remaining credit instantly. The updated balance is then presented on an LCD screen, allowing both the student and operator to view the current status without delay. If the system detects that the available credit is exhausted or below the required level, it immediately triggers an alert using a buzzer and displays a warning message. This ensures that unauthorized travel is minimized and proper monitoring is maintained at all times. In addition to this, an Android-based administrative interface is developed to simplify the process of updating payment details and recharging credits. The administrator can securely manage all student accounts through this application without relying on manual record keeping. By integrating IoT connectivity, the system ensures smooth communication between hardware components and the backend system, making the entire process efficient and scalable. The proposed solution not only reduces human effort but also improves accuracy, transparency, and operational control. This system can serve as a modern replacement for traditional transport management methods in educational institutions, offering a secure, automated, and user-friendly approach.

KEYWORD: IoT, RFID, Smart Transportation, Credit Tracking, ESP32, Automation

I. INTRODUCTION

The advancement of technology in educational institutions has created a strong need for smart and automated systems to manage daily operations efficiently. One such important area is campus transportation, where managing student travel and fee verification remains a challenging task. In many institutions, transport management still relies on manual processes, which often lead to inefficiency, lack of transparency, and difficulty in tracking real-time usage.

Students are typically required to carry identification cards or transport passes, which are checked manually during boarding. However, this method does not guarantee accurate verification of fee payment status. As a result, unauthorized usage of transport services may occur, and maintaining records becomes a time-consuming process for administrators.

To overcome these limitations, an intelligent transportation system using RFID and IoT technology is proposed. This system aims to automate student identification and transport fee monitoring using a credit-based mechanism. Each student is provided with an RFID card linked to a digital account, allowing seamless verification and tracking of transport usage.

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The integration of IoT enables real-time communication between hardware components and the database, ensuring accurate and instant updates. The use of an ESP32 microcontroller allows efficient data processing and system control, while an LCD display provides immediate feedback regarding the student's credit balance.

In addition, an Android-based application is developed to assist administrators in updating fee details and managing student accounts. This reduces manual effort and improves overall efficiency. The system also includes an alert mechanism to notify when the credit balance is insufficient, ensuring proper monitoring of transport usage.

Overall, the proposed system provides a smart, reliable, and automated solution for campus transportation management, improving efficiency, transparency, and user convenience.

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II. LITERATURE REVIEW

R. Kumar and S. Verma (2021) proposed an IoT-based transportation monitoring system that utilizes GPS technology to track vehicle movement and provide real-time location updates. Their system allows users to monitor transport status through mobile applications, improving accessibility and tracking efficiency. However, the system does not include any mechanism for verifying whether users have paid transport fees, which limits its application in fee-based systems.

P. Sharma and A. Gupta (2020) developed an RFID-based student identification system for educational institutions. Their work focuses on automating attendance and entry management using RFID cards. While the system ensures quick identification of students, it does not support a dynamic credit-based mechanism for managing transport fees, which reduces its functionality in transportation systems.

Uichin Lee et al. (2023) explored the role of smart sensing technologies in connected environments. Their research highlights how sensor data can be collected and analyzed to improve decision-making processes. The study emphasizes the importance of integrating IoT systems for efficient data monitoring. However, it primarily focuses on data collection and analysis rather than implementing access control based on user authorization.

I. WayanMustika et al. (2018) introduced a mobile-based monitoring system that integrates cloud storage and application interfaces for real-time data management. The system enables remote access and monitoring through mobile devices, improving convenience and accessibility. Despite its advantages, the system lacks an automated validation mechanism to control user access based on predefined conditions such as payment status.

Vilas Rathod et al. (2023) proposed a wireless sensor-based monitoring system for real-time applications. Their system collects data from sensors and transmits it to remote platforms for analysis. This approach improves system scalability and remote accessibility. However, it does not include any intelligent decision-making mechanism to control access or manage user activities automatically.

AdwaithSreedher et al. (2022) developed a multi-sensor IoT-based monitoring system that collects environmental data and displays it through cloud platforms. The system provides real-time monitoring and visualization, making it useful for various applications. However, it lacks integration with access control systems and does not provide automated decision-making based on user data.

M. Patel and K. Shah (2019) proposed a smart bus management system using IoT and GSM technology to improve communication between drivers, passengers, and administrators. The system provides real-time notifications regarding bus location and estimated arrival times through SMS services. This approach enhances user convenience and reduces waiting time. However, the system lacks integration with automated payment or verification mechanisms, making it less effective for managing transport fees.

S. Ramesh and P. Karthik (2021) developed a cloud-based transportation monitoring system that stores and processes data collected from IoT devices. Their system enables administrators to analyze transport usage patterns and optimize routes accordingly. Although the system improves data-driven decision-making, it does not include a user authentication or credit validation feature, which is essential for secure and efficient transport management.

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N. Ahmed et al. (2022) introduced an RFID and IoT-based smart card system for secure access control. The system allows users to gain entry into authorized areas by scanning RFID cards, ensuring enhanced security. While this system is effective in access control, it does not support dynamic credit deduction or financial transaction tracking, limiting its applicability in transportation systems requiring fee management.

J. Fernandez and L. Gomez (2020) proposed areal-time vehicle tracking and monitoring system using GPS and IoT technologies. The system collects vehicle data and displays it on a centralized platform, allowing administrators to monitor movement and performance. Although it provides accurate tracking, it does not include an integrated mechanism for user identification or payment validation.

K. Lakshmi and R. Priya (2023) developed an IoT-enabled smart ticketing system for public transportation. Their system uses QR codes and mobile applications to facilitate digital payments and ticket verification. This reduces the need for physical tickets and manual checking. However, the system relies heavily on smartphones and internet connectivity, which may not be accessible to all users, and it does not incorporate RFID-based automatic identification.

T. Nguyen et al. (2021) presented a smart transportation system that integrates IoT sensors with machine learning algorithms for predictive analysis. The system predicts traffic patterns and optimizes transport routes to reduce congestion. While this approach improves efficiency and planning, it does not address user-level access control or payment verification.

From the above studies, it is evident that most existing systems focus on monitoring, tracking, and data visualization. While these systems improve efficiency and provide real-time information, they do not offer a complete solution for automated transport fee verification and access control. To overcome these limitations, the proposed system introduces an RFID-based credit tracking mechanism integrated with IoT technology. This approach enables real-time identification, automatic credit deduction, and efficient transport management, providing a more comprehensive and intelligent solution.

III. PROPOSED SYSTEM

The proposed system presents an advanced solution for automating student transportation management by integrating RFID technology with IoT-based communication. The primary objective of this system is to replace traditional manual verification methods with an intelligent, real-time monitoring mechanism that ensures efficiency, accuracy, and transparency in transport usage.

In this system, every student is provided with a unique RFID card that contains a distinct identification number. This ID is securely linked to a centralized database where all student-related information, including transport routes and credit balance, is stored. When a student boards the bus, the RFID reader installed at the entrance scans the card and transmits the data to the ESP32 microcontroller for further processing.

The ESP32 acts as the core processing unit of the system, where it verifies the received card ID with the stored database records. Once verified, the system checks whether the student has sufficient credit balance available for the journey. If the balance is adequate, the system automatically deducts the required credit points and updates the remaining balance in real time. This updated information is immediately displayed on the LCD screen, providing instant feedback to both the student and the bus operator.

In cases where the student's credit balance is insufficient or reaches zero, the system activates a buzzer alert and displays a warning message such as "Insufficient Balance – Please Recharge." This feature helps in preventing unauthorized access to transport services and ensures strict monitoring of fee payment.

Furthermore, the system includes an Android-based administrative application that allows authorized personnel to manage student accounts efficiently. Through this application, administrators can add new students, update payment details, and recharge credit points. This eliminates the need for manual record maintenance and significantly reduces administrative workload.

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The integration of IoT technology enables seamless communication between hardware components and the backend system, ensuring real-time data synchronization. The proposed system is designed to be scalable, reliable, and user-friendly, making it suitable for implementation in schools and colleges. By automating the entire transport management process, the system enhances operational efficiency and provides a smart solution for modern educational institutions.

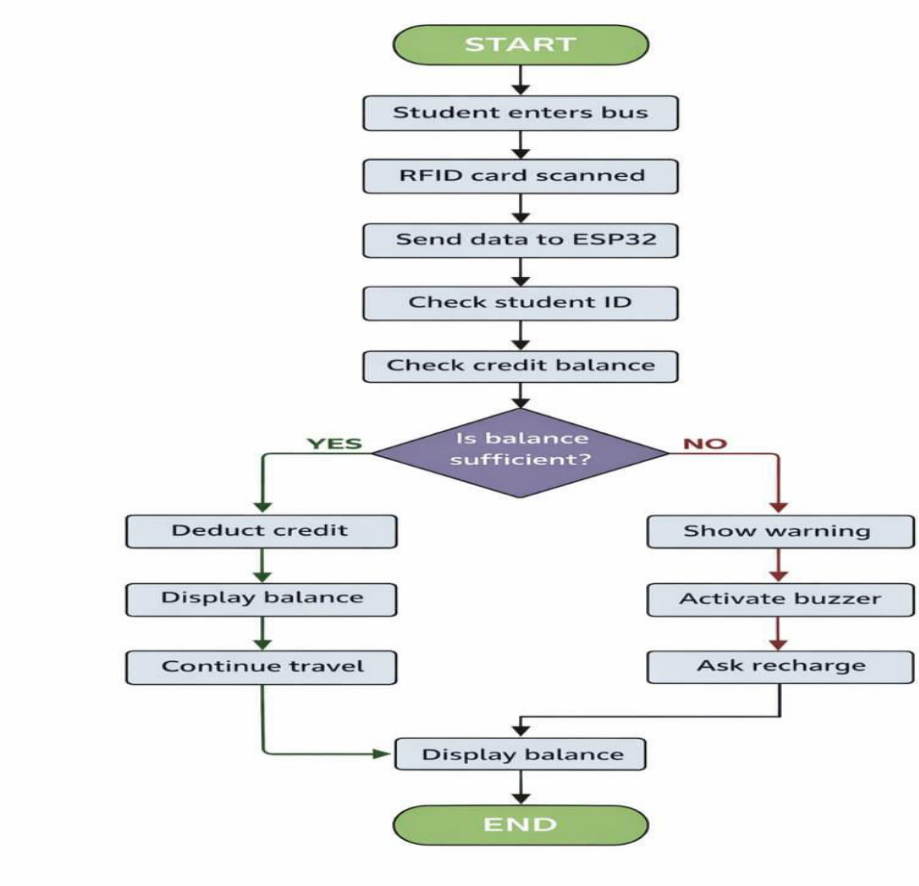

Figure 1. Flow chart of the system

IV. METHODOLOGY

The development of the proposed IoT-based smart transportation system follows a systematic and structured methodology to ensure efficient implementation and reliable performance. The process begins with requirement analysis, where the limitations of existing transport management systems are studied in detail and the need for automation is identified. Traditional systems often rely on manual attendance, lack proper monitoring, and are prone to errors in fare collection and record maintenance. These drawbacks highlight the importance of implementing a smart and automated solution. Based on this analysis, suitable hardware and software components are selected to design an effective and scalable system. The selection process focuses on cost-effectiveness, reliability, ease of integration, and performance efficiency, ensuring that the system can operate smoothly in real-time conditions.\

The first step in the implementation involves assigning a unique RFID card to each student. These RFID cards contain unique identification numbers, which are linked to the student's transport account in the system database. The process of issuing RFID cards is carefully managed to avoid duplication and ensure secure identification. The database stores essential details such as student name, identification number, transport route, boarding point, and available credit balance. In addition to these basic details, the system can also store transaction history and usage patterns for future analysis. Proper database design techniques are used to ensure efficient storage, quick retrieval of data, and data integrity. Security mechanisms such as authentication and restricted access are also considered to protect sensitive information from unauthorized use.

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Once the RFID cards are issued, the hardware setup is developed by integrating the RFID reader, ESP32 microcontroller, LCD display, and buzzer. Each component plays a crucial role in the functioning of the system. The RFID reader is responsible for detecting and reading the card information, while the ESP32 microcontroller acts as the central processing unit that controls all operations. The LCD display is used to provide real-time feedback to the users, and the buzzer serves as an alert mechanism for error conditions. The RFID reader is installed inside the bus near the entrance to ensure easy access for students while boarding. Proper wiring and power supply arrangements are made to ensure uninterrupted operation of the hardware components. The integration process is carried out carefully to ensure seamless communication between all components.

When a student boards the bus, the RFID reader captures the card ID and sends it to the ESP32 microcontroller for processing. The communication between the RFID reader and the microcontroller is established using appropriate communication protocols to ensure accurate data transfer. The microcontroller then processes the received data and interacts with the database to verify the student's identity. This verification process ensures that only valid and registered users are allowed to use the transportation system. The system is designed to perform these operations quickly, minimizing delays and ensuring a smooth boarding process for students.

The microcontroller then verifies the received data with the stored database and checks the available credit balance. If sufficient credit is present, the system deducts the required amount and updates the balance accordingly. The deduction process is automated and eliminates the need for manual fee collection, thereby reducing errors and saving time. The updated balance is displayed on the LCD screen in real time, providing immediate feedback to the student. This helps students stay informed about their account status and encourages timely recharges. If the balance is insufficient, the system activates a buzzer alert and displays a warning message. This alert mechanism ensures that both the student and the system operator are aware of the issue, allowing necessary actions to be taken.

In parallel, an Android-based application is developed to enable administrators to manage the system effectively. The application provides a user-friendly interface that simplifies system management tasks. Through this application, administrators can update payment details, recharge student accounts, and monitor transport usage. The application also allows administrators to view transaction records, track student boarding activities, and generate reports for analysis. This ensures that all data is maintained accurately and updated in real time. The integration between the mobile application and the database is achieved using secure communication protocols, ensuring data consistency and reliability. The use of a mobile application significantly reduces manual effort and improves overall system efficiency.
After completing the development phase, the system undergoes testing under different conditions to verify its accuracy and performance. Testing is an essential step to identify and eliminate errors before deployment. Various test cases are conducted to ensure that the system correctly identifies students, updates credit balance, and generates alerts when necessary. The system is tested for different scenarios, including valid card detection, invalid card usage, insufficient balance conditions, and hardware failures. Performance testing is also carried out to evaluate the system's response time and reliability under continuous operation. Based on the test results, necessary improvements are made to optimize system performance and enhance its stability.

Finally, the system is deployed for practical use in a real-time environment, where it operates continuously to monitor student transportation. During deployment, proper installation and configuration of hardware components are ensured. Training may also be provided to administrators and users to help them understand the system functionality. The system is designed to operate with minimal maintenance and provide consistent performance over time. This structured methodology ensures that the proposed system functions efficiently, providing a reliable and automated solution for transport management.

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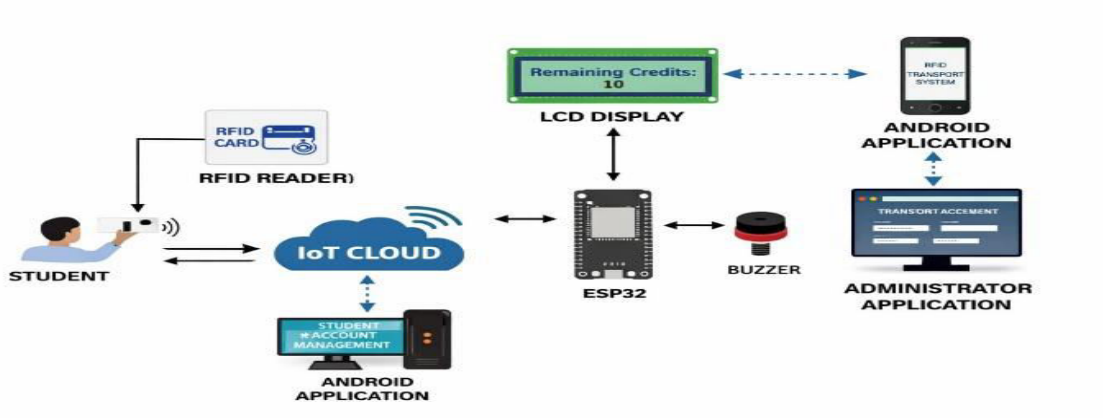

Figure 2. Block diagram of the system

V. RESULTS

The developed IoT-based RFID transportation management system was successfully implemented and tested under different operating conditions to evaluate its performance and reliability. The system effectively demonstrates the ability to automate student identification and transport fee monitoring using a credit-based mechanism. During testing, each student was able to access the transportation system using their assigned RFID card, and the system responded accurately by identifying the user and verifying their account details.

The RFID reader was able to detect the student card quickly and transmit the data to the ESP32 microcontroller without noticeable delay. The microcontroller processed the received data efficiently and verified the available credit balance in real time. When sufficient balance was available, the system successfully deducted the required credit points and updated the remaining balance instantly. The updated balance was clearly displayed on the LCD screen, providing immediate feedback to both students and bus operators.

In cases where the credit balance was low or insufficient, the system performed as expected by activating the buzzer alert and displaying a warning message on the LCD screen. This feature proved to be effective in preventing unauthorized access to the transport service. The alert mechanism ensured that students were notified about their balance status and encouraged timely recharge of credits.

The Android-based administrative application also functioned efficiently, allowing administrators to update student payment records and recharge credit points without difficulty. The data synchronization between the application and the hardware system was smooth, ensuring accurate and up-to-date information at all times. This reduced the dependency on manual record keeping and minimized the chances of errors.

Furthermore, the system showed stable performance during continuous operation, indicating its suitability for real-time deployment in educational institutions. The integration of IoT technology enabled seamless communication between system components, improving overall efficiency and reliability.

Overall, the results confirm that the proposed system provides a practical and effective solution for managing student transportation. It enhances transparency, reduces manual effort, and ensures proper monitoring of transport usage, making it a valuable improvement over traditionalsystem.

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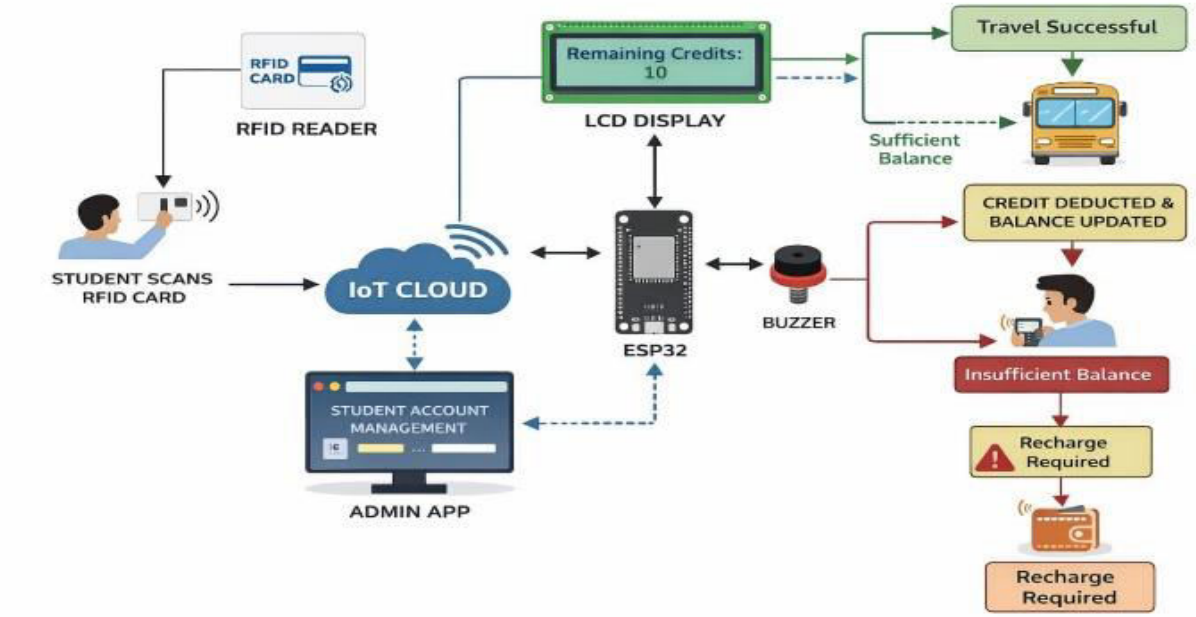

VI. CONCLUSION

The IoT-driven intelligent campus transit system using RFID-based credit tracking provides a modern and efficient solution for managing student transportation in educational institutions. The system successfully addresses the limitations of traditional manual methods by introducing automation, real-time monitoring, and secure access control.

By integrating RFID technology with a credit-based mechanism, the system ensures that only authorized students with sufficient balance can access the transport service. The use of the ESP32 microcontroller enables efficient data processing and system control, while the LCD display provides clear and immediate information regarding the student's credit status. The inclusion of a buzzer alert mechanism further enhances the system by providing instant notifications in case of insufficient balance.

The Android-based administrative application plays a crucial role in simplifying system management. It allows administrators to update payment details, manage student accounts, and monitor transport usage effectively. This reduces manual workload and ensures that all records are maintained accurately.

The implementation of IoT technology enables seamless communication between system components, ensuring real-time data updates and improved system performance. The system is designed to be scalable and adaptable, making it suitable for deployment in various educational institutions with different requirements.

In addition to improving efficiency and transparency, the proposed system also enhances user convenience by providing a simple and user-friendly interface. Students can easily monitor their balance, while administrators can manage operations with minimal effort.

For future enhancements, the system can be extended by integrating GPS tracking to monitor bus location in real time and cloud storage for maintaining large-scale data. Advanced features such as mobile notifications and online payment integration can further improve system functionality.

In conclusion, the proposed system provides a reliable, efficient, and intelligent solution for campus transportation management. It not only reduces manual effort but also improves accuracy, security, and overall system performance, making it a valuable contribution to smart campus development.

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