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DIGITAL BUS FARE MANAGEMENT SYSTEM

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Abstract: Efficient fare collection is crucial for the smooth operation of public transportation. Traditional cash-based methods often lead to delays, fraud, and inconvenience for both passengers and conductors. To overcome these challenges, this paper presents a Digital Bus Fare Management System that leverages RFID technology, IoT, and cloud integration to streamline fare collection. The system comprises three key components: a fare collection machine, a passenger mobile application, and an admin web platform. The fare collection machine, operated by the conductor, is built using ESP32, an RFID reader, a 16x6 LCD with an I2C module, and a 4x4 keypad. When passengers tap their RFID card, the fare is automatically deducted, reducing reliance on cash transactions. A Flutter-based mobile application enhances user convenience by allowing passengers to check balances, view transaction history, top up their cards, manage multiple cards, and apply for new cards. Additionally, a web-based admin platform facilitates card issuance, fare tracking, top-up processing, and application management. The system integrates Firebase Realtime Database for real-time data synchronization across all components. This system enhances security, accuracy, and efficiency for both passengers and transport authorities by automating fare collection and eliminating cash handling. The integration of IoT and cloud-based technologies ensures a seamless, reliable, and user-friendly approach to fare management, making public transportation more efficient and accessible.

Keywords: **(**Contactless Payment, Flutter App, Fare Collecting Machine, Firebase Realtime Database, web application.)

I. INTRODUCTION

Public transportation is an essential part of urban mobility, yet traditional cash-based fare collection methods often lead to inefficiencies such as delays, fraud, and inconvenience for both passengers and conductors. Managing cash transactions, issuing tickets, and keeping track of records can be cumbersome and prone to errors. To overcome these challenges, a modernized, automated fare collection system is necessary to improve efficiency, security, and user convenience. This paper introduces a Digital Bus Fare Management System that incorporates RFID technology, IoT, and cloud-based integration to streamline fare collection. The system enables passengers to use RFID-enabled travel cards, which can be recharged and managed through a Flutter-based mobile application. Conductors operate a fare collection machine that includes an ESP32 microcontroller, RFID reader, LCD, and keypad, ensuring quick and automated transactions. Additionally, a Firebase Realtime Database is used for real-time synchronization between the fare collection machine, mobile app, and a web-based admin platform, which facilitates fare tracking, top-up processing, and card management. By replacing cash handling with automated transactions, this system enhances accuracy, security, and convenience for both passengers and transport authorities, contributing to a more efficient and reliable public transportation experience.

II. LITERATURE REVIEW

Public transportation fare collection has evolved from manual cash-based methods to digital payment systems to enhance efficiency, security, and passenger convenience. Traditional methods, such as cash payments, token-based systems, and paper tickets, often led to long queues, transaction delays, and revenue leakage. While these methods were simple, they were prone to errors, fraud, and operational inefficiencies. To overcome these challenges, digital fare collection systems have been introduced, incorporating RFID smart cards, QR code payments, and NFC technology. RFID cards enable passengers to simply tap and pay, reducing transaction time, while QR codes and NFC allow smartphone-based payments, minimizing cash dependency. However, these digital solutions also have limitations, such as the need for smartphone access, internet connectivity, and periodic card recharges. An RFID-based digital fare management system provides a contactless, secure, and efficient alternative, improving transaction speed and accuracy. By integrating a mobile application and a centralized web portal, the system enhances passenger convenience, enables real-time balance checks and top-ups, and allows operators to monitor fare collection and passenger data more effectively, making public transportation more reliable and seamless.

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III. METHODOLOGY

The Digital Bus Fare Management System follows a structured approach to enhance fare collection efficiency and provide a seamless experience for passengers and transport operators. The system is composed of four primary components: RFID card issuance, fare collection machine, passenger mobile application, and a web-based operator portal.

A. RFID Card Issuance & Data Registration

Passengers are issued RFID-enabled smart cards, which store their unique ID and fare balance. The registration process is managed through a secure database that links each card to the passenger's account.

B. Fare Collection Machine & Transaction Processing

A fare collection machine, equipped with an RFID reader, is used by the conductor to process payments. When passengers tap their RFID card, the machine:

- Reads the card details and verifies balance.
- Deducts the appropriate fare based on the trip distance or fixed fare system.
- Updates the card balance and logs the transaction in the central database.

C. Mobile Application for Passengers

A Flutter-based mobile application allows passengers to manage their RFID cards conveniently. The app provides the following features:

- **Balance inquiry** to check remaining fare.
- **Transaction history** to view past payments.
- **Top-up options** for the cards.
- **Request submission** for applying new card.

D. Web Portal for Operators

A web-based admin portal helps transport authorities efficiently monitor and manage fare collection. The portal includes functionalities for:

- **Fare amount tracking:** Monitor total fare collected from passengers.
- **Card registration management:** Issue and manage RFID cards.
- **Top-up processing:** Top-up the cards.
- **Request handling**: Manage card-related requests received from the mobile app.

E. Cloud-Based Database Integration

The system is integrated with Firebase Realtime Database, ensuring:

- Real-time data synchronization between the fare collection machine, mobile application, and web portal.
- Secure data storage for passenger profiles, card balances, and transaction history.
- Instant updates to reflect fare deductions, top-ups, and new card registrations.

IV. ARCHITECTURE

The Digital Bus Fare Management System comprises three layers: hardware, application, and cloud, ensuring efficient and automated fare processing. The hardware layer includes an RFID-based fare collection machine operated by conductors. This machine, equipped with an ESP32 microcontroller, RFID reader, LCD display, and keypad, allows passengers to tap their RFID cards for fare payment. The system verifies the balance, deducts the fare, and records the transaction. The application layer features a Flutter-based mobile app for passengers and a web portal for administrators. The mobile app enables users to check balances, view transaction history, recharge cards, and request new ones. The web portal allows transport authorities to monitor transactions, manage card issuance, and process top-ups. The cloud layer, powered by Firebase Realtime Database, ensures real-time synchronization. Transactions, top-ups, and card updates are instantly recorded, providing accurate, up-to-date information for passengers and administrators. This structured approach enhances security, efficiency, and transparency by eliminating cash handling, reducing transaction errors, and streamlining fare management.

V. IMPLEMENTATION

A. Hardware Implementation

The fare collection system utilizes an ESP32 microcontroller integrated with an RFID reader to process passenger transactions. When a passenger taps their RFID card, the system reads the card's information and verifies the balance. A 16x6 LCD with an I2C module displays transaction details, while a 4x4 keypad allows conductors to perform manual inputs. The ESP32 is programmed via Arduino IDE, enabling seamless data transfer to the cloud database for real-time updates.

B. Mobile Application Development

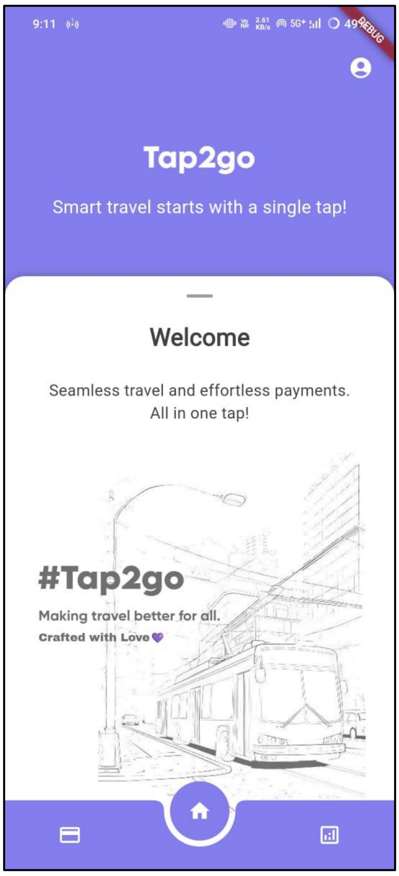
A Flutter-based mobile application is designed to provide passengers with an efficient way to manage their fare payments. The app allows users to check balances, review transaction history, top up cards, and request new card. By integrating with Firebase Realtime Database, the app ensures that all transactions and updates occur in real-time.

C. Web Portal Implementation

A web-based administrative platform, developed with HTML, CSS, and JavaScript. The portal enables functionalities such as monitoring fare amount, issuing and managing RFID cards, processing top-ups, and handling passenger requests. The portal ensures the efficiency and transparency.

D. Cloud Database Integration

The system leverages the Firebase Realtime Database to store and synchronize user information, fare balances, and transaction logs in real time. This cloud infrastructure ensures that all data remains accessible across the fare collection machine, mobile app, and web portal. This cloud platform improves the secure fare collection system.



Tap2go

Smart travel starts with a single tap!

Welcome

Seamless travel and effortless payments.
All in one tap!

#Tap2go

Making travel better for all.

Crafted with Love💜

Figure 1: Home Page

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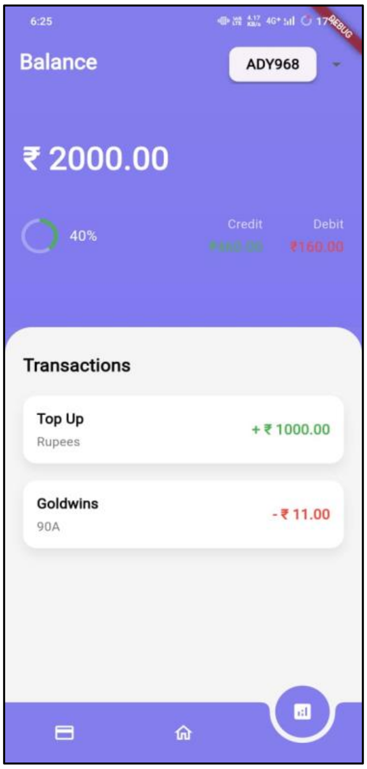
The Home Page of the "Tap2Go" app has a clean design with a welcome message highlighting seamless travel and payments. A bottom navbar ensures easy navigation.



6:25

Balance ADY968

₹ 2000.00

40%

Credit ₹460.00

Debit ₹160.00

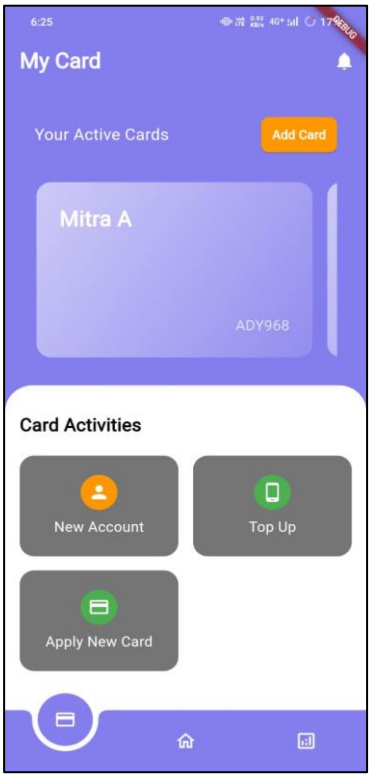
Transactions

Top Up
Rupees
+ ₹ 1000.00

Goldwins
90A
- ₹ 11.00

Figure 2: Balance Page

The Balance Page of the "Tap2Go" app displays the user's current balance. And a transaction history section lists details of past payments, with credits in green and debits in red.



6:25

My Card

Your Active Cards

Add Card

Mitra A
ADY968

Card Activities

New Account

Top Up

Apply New Card

Figure 3: Card Page

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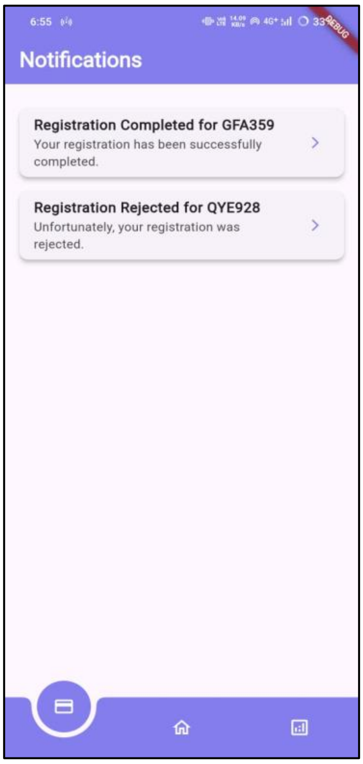
The My Card Page displays the user's active travel card with an option to add a new card. It includes card activities such as creating a new account, topping up, and applying for a new card.



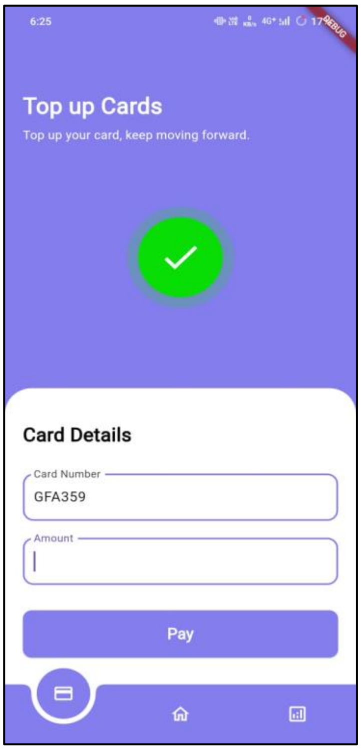
Notifications

Registration Completed for GFA359
Your registration has been successfully completed.

Registration Rejected for QYE928
Unfortunately, your registration was rejected.

Figure 4: Notification Page

The Notifications Page displays important updates regarding registration status, such as approval or rejection. Each notification provides details about the action taken.



Top up Cards

Top up your card, keep moving forward.

Card Details

Card Number: GFA359

Amount:

Figure 5: Top Up Page

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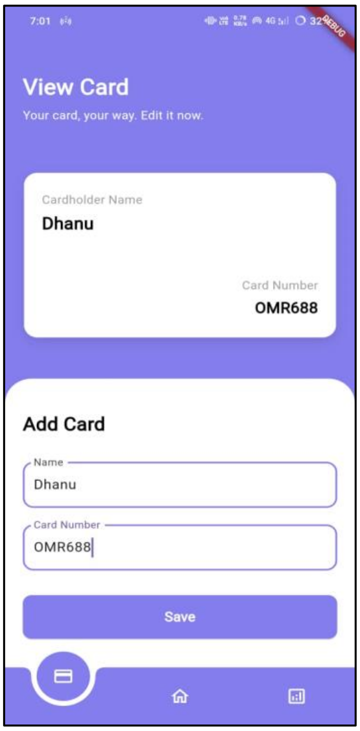
The Top-Up Page allows users to recharge their cards by entering the card number and amount. A confirmation icon indicates a successful transaction.



View Card

Your card, your way. Edit it now.

Cardholder Name: Dhanu

Card Number: OMR688

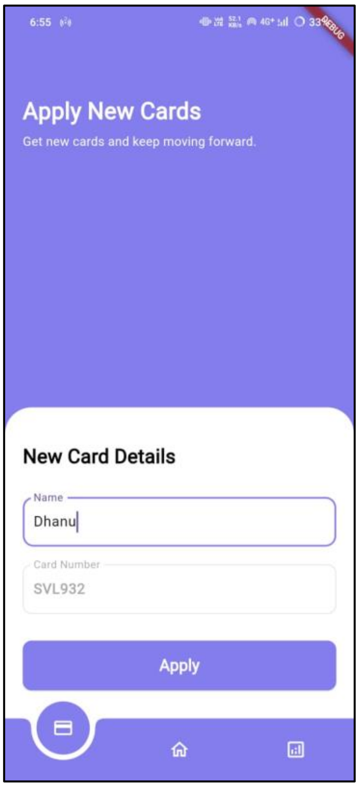
Add Card

Name: Dhanu

Card Number: OMR688

Figure 6: Add Card Page

The Add Card Page allows users to register a new fare card by entering their name and card number. A preview of the added card is displayed at the top. The "Save" button adds the card to the app.



Apply New Cards

Get new cards and keep moving forward.

New Card Details

Name: Dhanu

Card Number: SVL932

Figure 7: Apply New Card Page

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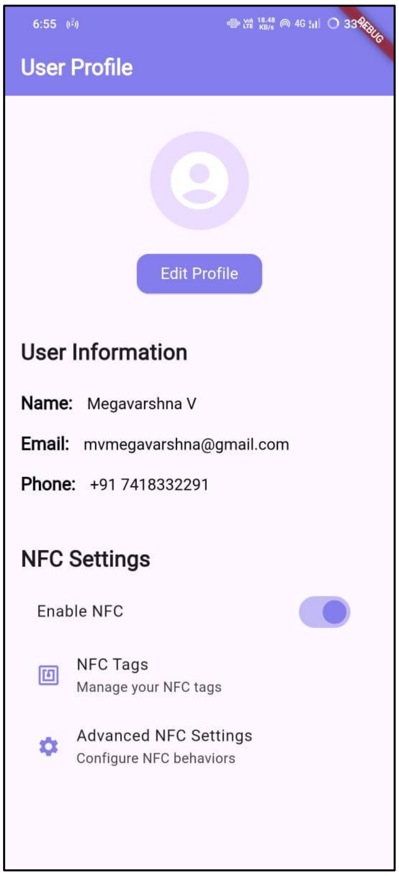
The Apply New Card Page allows users to request a new fare card by entering their name and viewing the assigned card number. The "Apply" button submits the request for processing.



User Information

Name: Megavarshna V

Email: mvmegavarshna@gmail.com

Phone: +91 7418332291

NFC Settings

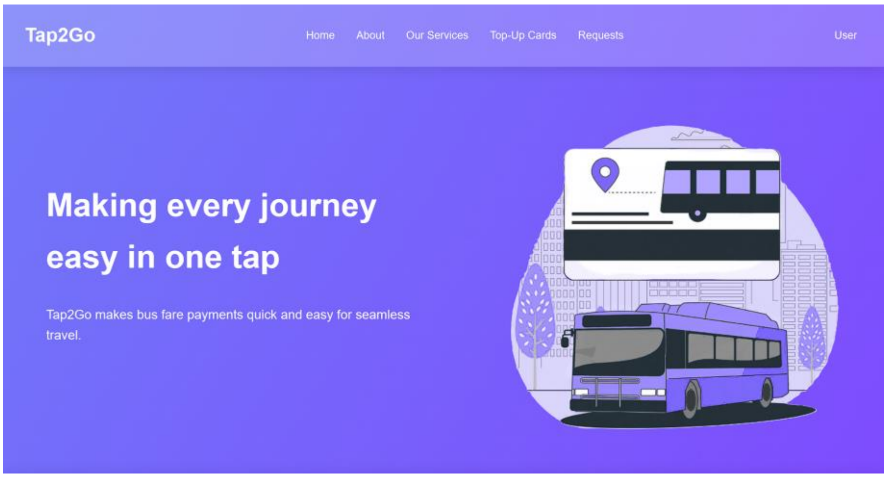
Enable NFC ●

NFC Tags
Manage your NFC tags

Advanced NFC Settings
Configure NFC behaviors

Figure 8: Profile Page

The User Profile Page displays user details such as name, email, and phone number, with an option to edit the profile. It also includes NFC settings to enable or manage NFC tags for seamless transactions.



Making every journey easy in one tap

Tap2Go makes bus fare payments quick and easy for seamless travel.

Figure 9: Web Portal Home Page

The Tap2Go Web Porta. It features an intuitive interface with navigation options for services, top-up cards, and requests.

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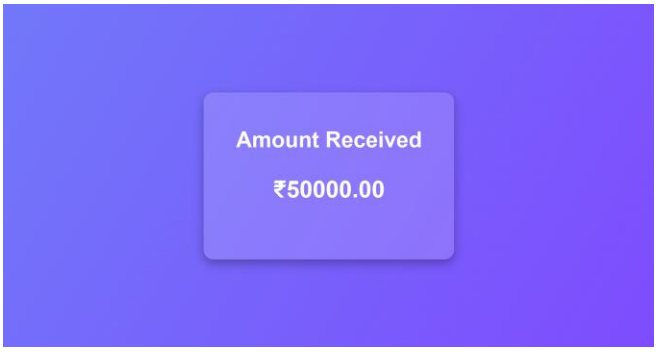
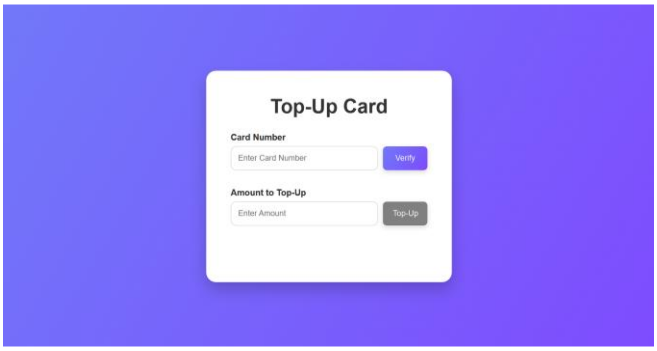


Amount Received

₹50000.00

Figure 10: Fare Tracking Page

This screen indicating that the total fare amount collected from the passengers.



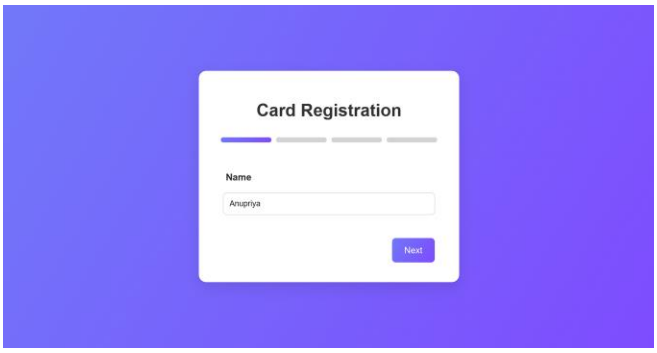
Top-Up Card

Card Number

Amount to Top-Up

Figure 11: Top Up Page

This screen represents a Top-Up Card interface, to recharge their cards. By entering the Card Number and amount.



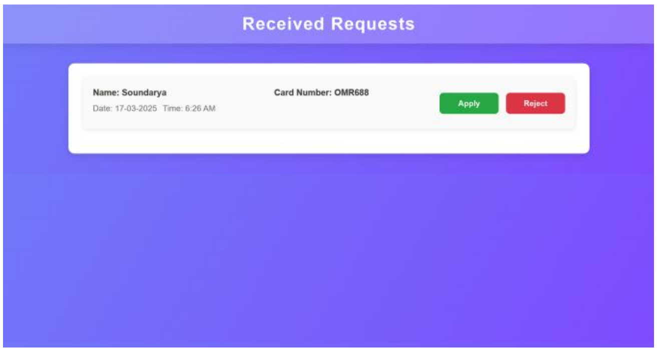
Card Registration

Name

Anupriya

Figure 12: Card Registration Page

This screen represents a Card Registration process. The progress bar at the top suggests a multi-step registration flow. Users start by entering their name and then click "Next" to proceed to the next step.



Received Requests

Name: Soundarya

Date: 17-03-2025 Time: 6:26 AM

Card Number: OMR688

Figure 1: Request Receiving Page

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This screen displays received card requests with details like name, card number, date, and time. Admins can either approve (Apply) or reject (Reject) the request. It streamlines card application and approval management.

VI. RESULT

The Digital Bus Fare Management System successfully enhances the efficiency and security of fare collection by integrating RFID technology, a Flutter-based mobile app, and a web portal. The system enables passengers to make contactless payments using RFID smart cards, reducing cash handling and speeding up transactions. The mobile app allows users to check balances, view transaction history, and top up cards, ensuring convenience and accessibility. Bus operators benefit from the web portal, which provides real-time monitoring of fare transactions, card registrations, and revenue tracking. The cloud-based database ensures secure data storage and smooth communication between components. Overall, the system significantly reduces manual errors, enhances security, and improves the public transportation experience for both passengers and operators.

VII. DISCUSSION

The Digital Bus Fare Management System enhances fare collection by integrating RFID-based payments, a mobile application, and a web portal, ensuring faster, more secure transactions while reducing cash dependency and manual errors. Passengers benefit from contactless payments, balance checks, transaction history access, and online top-ups via the mobile app, while bus operators can efficiently monitor transactions and manage RFID cards through the web portal. Despite challenges such as initial setup costs, infrastructure dependency, and periodic card recharges, the system significantly improves efficiency, security, and scalability in public transportation fare management, making it a reliable and modern alternative to traditional methods.

VIII. CONCLUSION

The Digital Bus Fare Management System revolutionizes fare collection by integrating RFID-based smart cards, a mobile application, and a web portal, replacing traditional cash-based transactions with a faster, secure, and contactless payment method. Passengers can conveniently manage their fares through a Flutter-powered mobile app, allowing them to check balances, view transaction history, and top up their cards online, eliminating the need for physical cash handling. The RFID-based payment system reduces transaction time, minimizes errors, and enhances the overall commuting experience, making public transportation more efficient and user-friendly. For bus operators, the centralized web portal enables real-time fare collection monitoring, passenger data management, and revenue tracking, improving transparency and operational efficiency. The system ensures secure data storage and seamless integration between the RFID machines, mobile app, and web portal, creating a reliable and scalable infrastructure. Although challenges such as initial setup costs, infrastructure requirements, and internet dependency exist, the system's advantages, including improved efficiency, reduced transaction delays, and better revenue management, make it a sustainable and future-ready solution for modern urban transit.

REFERENCES

[1]. **Chawla, V., & Ha, D. S.** (2007) – *"An Overview of Passive RFID Technology,"* IEEE Communications Magazine, 45(9), 11-17. This paper provides an overview of RFID technology.

[2]. **Espressif Systems** (2023) – *"ESP32 Technical Reference Manual: Wi-Fi & Bluetooth Capabilities."* This manual provides technical details on ESP32, which is used in the RFID-based fare collection machine for wireless communication and data transfer.

[3]. **J.Duckett**(2011)–*"HTML&CSS: Design and Build Websites"* This book provides a comprehensive introduction to HTML and CSS, covering website structure, layout, and responsive design principles.

[4]. **B. Wargo** (2021) – *"JavaScript: The Definitive Guide"* This book explores JavaScript fundamentals, including DOM manipulation, event handling, and API integration for dynamic web applications.

[5]. **Firebase Documentation** (2023) – *"Cloud Firestore and Realtime Database"*, Google Developers. This official documentation provides insights into Firebase Realtime Database, which is used for storing violation records and managing user data.