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MACHINE LEARNING - BASED CASHLESS FARE SYSTEM USING RANDOM FOREST AND NEURAL NETWORKS FOR SMART URBAN MOBILITY

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ABSTRACT

Public transportation in Cebu City remains the primary mode of travel; however, manual fare collection creates inefficiencies such as inconsistent pricing, long waiting times, delayed boarding, and passenger-operator disputes. This study aimed to identify key stakeholder challenges and develop RidePay, an AI-enabled cashless fare collection system. A descriptive research design was used, involving 384 respondents, including commuters, drivers, conductors, and operators. Data were collected through structured surveys and analyzed using descriptive statistics. Findings revealed that 69.6% of commuters experience waiting times exceeding 30 minutes, while 68.8% prefer modernized transport systems. Additionally, all drivers and conductors rely on cash-based transactions, highlighting inefficiencies in fare management. The proposed system demonstrated high acceptability (M = 4.09), indicating strong stakeholder support. Developed using Agile methodology, RidePay integrates technologies such as Arduino, RFID, GPS, React, Node.js, and Firebase, with analytics supported by AI-driven insights. Results show that the system enhances efficiency, transparency, and operational performance, demonstrating its potential to support smart and sustainable urban transportation in Cebu City.

Keywords *- smart transportation, cashless fare collection, AI-enabled systems, Internet of Things (IoT), RFID, Cebu City*

1. INTRODUCTION

Public transportation plays a fundamental role in the socio-economic development of urban areas by enabling mobility, access to employment, education, and essential services. In Cebu City, public transport systems such as jeepneys and buses serve as the primary means of mobility for a large portion of the population. However, despite its importance, the current transportation system continues to face persistent operational challenges that affect both efficiency and user satisfaction.

One of the most critical issues lies in the reliance on manual, cash-based fare collection. This traditional method often results in inaccurate fare handling, delays in issuing change, and frequent disputes between passengers and conductors. These inefficiencies contribute to longer boarding times and increased congestion, ultimately affecting travel time and service reliability [4]. Additionally, drivers and conductors are burdened with the dual responsibility of operating vehicles and managing fare transactions, which increases cognitive load and the risk of errors.

Commuters also experience significant inconvenience due to overcrowding, long waiting times, and inconsistent fare practices. These issues are further exacerbated by the lack of real-time monitoring and data-driven decision-making in transport operations. Studies have shown that inefficient fare collection systems negatively impact both operational performance and passenger satisfaction [3]. With the rapid advancement of financial technologies and mobile applications, digital payment systems have emerged as viable solutions to modernize public transportation. Cashless fare collection systems offer benefits such as faster transaction processing, improved fare accuracy, enhanced transparency, and better revenue tracking [7]. Furthermore, these systems provide opportunities for integrating

additional features such as real-time tracking, automated passenger counting, and data analytics for route optimization.

This study aims to identify the key operational challenges faced by public transport stakeholders in Cebu City and to evaluate the feasibility and acceptability of implementing an automated cashless fare collection system, referred to as RidePay. By addressing both technical and user-related aspects, the study contributes to the ongoing efforts toward developing smarter and more efficient urban transport systems.

2. METHOD

This study employed a descriptive-developmental research design to systematically analyze the challenges present in Cebu City's public transportation system and to evaluate the acceptability of a proposed automated fare collection system. Descriptive research is appropriate for identifying patterns and existing conditions without manipulating variables, making it suitable for understanding real-world transport issues (Ahmad, 2019).

A total of 384 respondents were selected using purposive sampling to ensure that participants had relevant experience with public transportation. The respondents included commuters, drivers, conductors, and transport operators, providing a comprehensive perspective of the system. Data were collected through structured survey questionnaires designed to measure both the severity of transportation-related challenges and the level of acceptability of the proposed system.

Prior to data collection, Institutional Review Board (IRB) clearance was obtained to ensure compliance with ethical research standards. Additionally, informed consent was secured from all participants, ensuring that respondents were fully informed about the study's purpose, procedures, and their rights, including voluntary participation and confidentiality of their responses.

The study covered multiple transportation modes, including traditional jeepneys, modern jeepneys, and buses to ensure broader applicability of the findings. Data analysis was conducted using descriptive statistical tools such as frequency distribution, percentage, and weighted mean. These techniques were used to identify trends, assess the severity of transportation challenges, and evaluate the level of system acceptability among stakeholders.

To support both the research process and system development, the study utilized various development platforms, programming languages, and analytical tools. The technologies used in system development are presented in Table 1.

Table 1. Development Platforms and Programming Languages Used

Category	Tool/Technology	Purpose
Hardware Platform	Arduino	Microcontroller for fare validation and device control
Hardware Platform	Orange Pi	Embedded computing for system processing
IoT Components	RFID Reader	Contactless fare payment validation
IoT Components	GPS Module	Real-time vehicle tracking
Frontend Development	React	Web-based admin interface
Frontend Styling	Tailwind CSS	User interface design and responsiveness
Mobile Development	React Native	Passenger mobile application
Backend Development	Node.js (JavaScript/TypeScript)	Server-side processing and API handling
Programming Languages	JavaScript, TypeScript	Core development languages
Cloud Services	Firebase	Database, authentication, and real-time data storage

Tools for data collection, processing, and visualization were utilized to ensure the accurate and efficient analysis of survey responses, as presented in Table 2. These tools also helped streamline the organization and interpretation of the gathered data, enhancing the reliability of the study's findings.

Table 2. Data Collection and Analysis Tools

Category	Tool	Purpose
Data Collection	Google Forms	Distribution of survey questionnaires
Data Storage	Google Sheets	Organization and storage of collected data
Data Analysis	Google Sheets	Computation of frequency, percentage, and weighted mean
Data Visualization	Google Charts	Graphical representation of survey results

3. RESULT AND DISCUSSION

This chapter presents the results and discussion of the study, organized according to the flow of the research objectives: the identification of challenges in Cebu City's public transportation system, the development of the proposed automated fare collection system called RidePay, and the evaluation of its acceptability among stakeholders. The presentation begins with the analysis of existing transportation challenges experienced by commuters, drivers, conductors, and operators. This is followed by the description of the proposed system framework designed to address these issues. Finally, the level of acceptability of the RidePay system is

discussed based on stakeholder responses, highlighting its feasibility and potential for implementation.

Stakeholder Challenges in Public Transportation

This section presents the distribution of respondents, the key challenges identified in Cebu City's public transportation system, and the level of acceptability of the proposed RidePay automated cashless fare collection system.

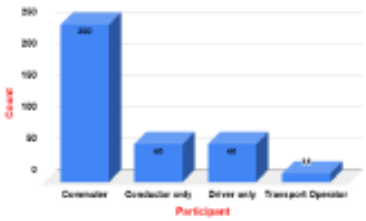


Figure 2. Distribution of Respondents

The distribution of respondents indicates that the majority are commuters, which provides strong insight into the user experience of the transport system. The inclusion of drivers, conductors, and operators ensures that operational perspectives are also represented.

The results in Table 3 reveal that challenges in Cebu City's public transportation system vary across stakeholder groups but are largely interconnected. Commuters experience operational inefficiencies such as overcrowding, long waiting times, and inconsistent fare collection, which directly affect travel comfort and reliability.

Drivers and conductors, on the other hand, face operational and workload-related challenges. The need to handle cash transactions while managing passengers increases both physical and cognitive strain. This is further intensified by traffic congestion and poor road conditions, which disrupt service efficiency.

Table 3. Significant Challenges Identified by Stakeholders in Cebu City's Public Transportation System

Stakeholder Group	Significant Challenges (Mean, SD)	Key Insights
Commuters (n = 250)	• Overcrowding (3.72, 0.77) • Frequent stopovers (3.70, 0.70) • Inaccurate fares (3.58, 0.81) • Safety concerns (3.78, 0.85)	• 69.6% wait >30 minutes • Prefer modern jeepneys (68.8%) • Open to digital systems with incentives
Drivers (n = 60)	•Traffic congestion (3.98, 0.34) •Poor road conditions (3.73, 0.57) • Communication issues (3.68, 0.65)	• Traffic and infrastructure reduce efficiency
Conductors (n = 60)	• Difficulty managing fares (3.90, 0.47) • Crowded vehicles (3.68, 0.65) • Fare disputes (3.58, 0.67)	• High physical and emotional workload
Drivers & Conductors (n = 120)	• Cash handling burden (3.80, 0.48) • Income recording issues (3.55, 0.67) • Security risks (3.46, 0.66)	• 100% rely on cash • High willingness to adopt digital (4.09, 0.46)
Operators (n = 14)	• Fare tracking issues (4.00, 0.67) • Traffic congestion (3.85, 0.36) • Lack of terminals (3.85, 0.66) • Fraud concerns (4.07, 0.62) • Privacy concerns (4.00, 0.68)	• Mostly traditional jeepneys (78.6%) • Concerned about fraud/privacy

Operators highlight concerns related to revenue tracking, fraud risks, and lack of infrastructure such as designated terminals. These findings indicate that the current manual fare system not only affects service delivery but also weakens financial transparency and operational control.

Overall, the results suggest that manual, cash-based fare collection is a central issue that contributes to inefficiencies across all stakeholder groups. These findings support the need for a more modern and automated solution to improve system performance.

Proposed System Design and Framework

To address the identified challenges in Cebu City's public transportation system, this study proposes an AI-enabled automated cashless fare collection system called RidePay. The system was developed using an Agile development approach, enabling iterative improvements through continuous testing and user feedback. The architecture integrates mobile applications, hardware components, and cloud-based services to ensure seamless and efficient system operation. Machine learning models such as Random Forest are proposed for fraud detection in fare transactions, while Neural Network models are utilized to analyze passenger behavior and support dynamic fare optimization.

The system architecture consists of three main components: a passenger mobile application, an onboard scanning device, and a centralized desktop application for administrators. The mobile application enables users to perform digital transactions, while the scanning device validates payments in real time. All transaction data are recorded and monitored through the admin dashboard, allowing efficient tracking and reporting for transport stakeholders.

The proposed admin interface is shown in Figure 3

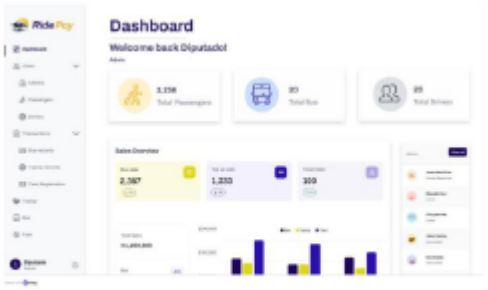
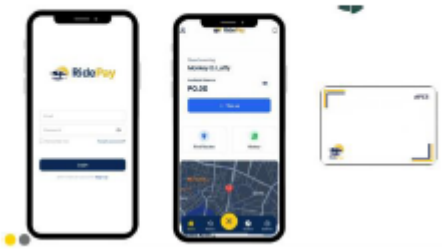


Figure 3. RidePay Desktop Application Interface for Admin

The passenger interface is shown in Figure 3.1.



The workflow of the RidePay system is illustrated in Figure 4.

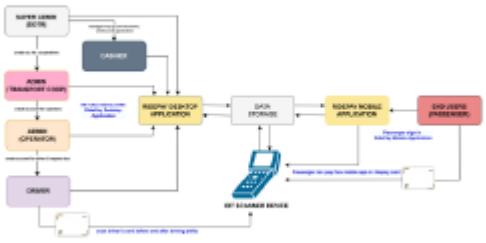


Figure 4. Workflow of the RidePay Cashless Fare Collection System

As shown in Figure 4, the process begins when a passenger initiates a transaction using the RidePay mobile application or by scanning an RFID card on the onboard device. The system validates the transaction through an integrated database, after which the scanning device confirms successful payment in real time.

Once completed, transaction data are automatically recorded in the admin system, enabling real-time revenue tracking. This information is accessible to transport operators and cooperative administrators through a centralized dashboard, allowing them to monitor financial performance and operational activities. Additionally, cashiers and cooperative personnel facilitate account management and cash-in services, ensuring accessibility for users without direct access to digital payment platforms. At a broader level, regulatory oversight can be supported through integration with agencies such as the Department of Transportation, which may utilize aggregated system data for policy enforcement, planning, and decision-making.

The identified system features highlight the system's ability to provide cashless transactions, real-time monitoring, passenger tracking, and transparent reporting. These functionalities directly address the previously identified challenges and improve operational efficiency and user experience.

Acceptability of the RidePay System

Following the identification of key challenges and the development of the proposed solution, this section evaluates the level of acceptability of the RidePay automated

System Component	Feature	Description
Desktop Application for Admin	Login, Session Management, Top-Up Management, Passenger Management, Admin Management, Bus Management, HR Management, Fare Management, Records, Access Control	Provides centralized administrative control, including user management, fare configuration, financial transactions, and system monitoring with role-based access
Mobile Application for Passengers	Session Management	Enables passengers to perform cashless transactions, manage accounts, track buses in real time, and access travel and payment information
IoT System (RFID & GPS)	RFID Scanner, GPS Tracking	Supports automated fare collection and real-time vehicle monitoring through RFID-based payments and GPS location tracking

cashless fare collection system among stakeholders in Cebu City's public transportation sector. Assessing system acceptability is essential in determining the feasibility of implementation, as it reflects users' perceptions in terms of usability, efficiency, reliability, and overall satisfaction.

The evaluation covers responses from commuters, drivers, conductors, and transport

operators, providing a comprehensive understanding of how the system is perceived across different user groups. Key indicators such as ease of use, operational efficiency, transparency, and willingness to adopt were measured using descriptive statistical analysis. The results presented in this section highlight the readiness of stakeholders to transition from traditional cash-based transactions to a digital fare collection system.

Table 5. Acceptability of the RidePay Cashless Fare Collection System

Stakeholder Group	Significant Challenges (Mean, SD)	Key Insights
Commuters (n = 250)	• Ease of Use (3.80, 0.40) • Efficiency & Accessibility (3.85, 0.42) • Satisfaction & Trust (4.00, 0.46)	• Easy to use and convenient • Improves boarding and commuting • High trust and recommendation
Drivers (n = 60)	• Ease of Use (3.75, 0.36) • Efficiency (3.85, 0.40) • Transparency (3.90, 0.44) • Acceptance (4.05, 0.46)	• Reduces cash burden and disputes • Improves workflow • High willingness to adopt
Conductors (n = 60)	• Fare Efficiency (3.90, 0.42) • Work Improvement (4.00, 0.44)	• Faster fare collection • Reduced stress and errors
Operators (n = 14)	• Integration (3.85, 0.40) • Financial Management (4.00, 0.45) • Transparency (4.05, 0.46) • Future Use (4.10, 0.46)	• Improves monitoring and accountability • Strong support for long-term adoption

The results indicate a high level of acceptability of the RidePay system across all stakeholder groups. Commuters perceive the system as convenient, efficient, and easy to use, highlighting its potential to enhance daily travel experiences. The ability to eliminate the need for exact change and reduce waiting time contributes significantly to user satisfaction.

Drivers and conductors recognize the operational benefits of the system, particularly in reducing the burden of cash handling and minimizing fare disputes. The system also improves workflow efficiency by enabling faster boarding and more organized passenger management.

From the operators' perspective, the system enhances financial transparency and accountability by providing accurate and real-time transaction records. This reduces the risk of revenue leakage and strengthens trust between operators and their staff.

Despite the positive reception, stakeholders emphasized the importance of proper training, reliable internet connectivity, and system security. Addressing these factors is essential to ensure successful implementation and long-term sustainability of the system.

Overall, the findings demonstrate strong readiness among stakeholders to adopt a cashless fare collection system, supporting the feasibility of implementing RidePay in Cebu City's public transportation system.

4. CONCLUSION

This study highlights the significant challenges faced by Cebu City's public transportation system, particularly in relation to manual fare collection processes. The findings demonstrate that these inefficiencies negatively affect both operational performance and commuter satisfaction.

The proposed automated cashless fare collection system presents a practical and effective solution to these challenges by improving transaction speed, accuracy, transparency, and overall system efficiency. The high level of acceptability among stakeholders indicates strong readiness for digital transformation.However, successful implementation requires coordinated efforts in terms of infrastructure development, user training, and policy support. Future studies may focus on pilot testing, financial feasibility, and integration with smart city initiatives to further enhance the system's impact.

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