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Design and Evaluation of a Web-Based Bus Management and with Real-Time Fleet Tracking: An ISO/IEC 25010-Based Assesment

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Abstract

Public bus transportation in the Philippines remains a widely used mode of travel, particularly for provincial trips. However, the traditional ticketing process requires passengers to visit terminals, wait in long queues, and face uncertainty in securing tickets for their preferred schedule. This results in inconvenience, wasted time, and inefficiency for both passengers and transport operators.

This study developed a web-based bus management system for JACLINER Inc. using the Agile software development methodology. The system integrates online ticket reservation, e-ticketing, fleet tracking, and schedule management. To evaluate the system's quality, the ISO/IEC 25010 software quality model was utilized, focusing on criteria such as usability, functionality, efficiency, and reliability.

The respondents of the study included 20 passengers and 10 company staff who tested the system and participated in the evaluation process.

The results revealed that the system achieved a mean score of 4.43 for Functionality, 4.33 Usability, 4.26 for Reliability, 4.46 for Security and 4.33 for Maintainability, all interpreted as Strongly Agree and with a Grand mean of 4.36. These findings indicate a high level of user satisfaction and system performance.

In conclusion, the developed bus management system effectively improves the ticket reservation process by reducing the need for physical queuing and enhancing user convenience. The system demonstrates strong potential for implementation in public transportation services to improve operational efficiency and customer experience.

Keywords: Bus Management System, Online Reservation, Fleet Tracking, E-Ticketing, Web-Based System

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INTRODUCTION

The transportation industry has increasingly adopted digital technologies to improve operational efficiency and service quality. Web-based systems, particularly those integrating online reservation and real-time monitoring, have become essential tools for modern bus companies. These systems enable passengers to conveniently access schedules and book tickets, while allowing operators to effectively manage fleet operations through technologies such as Global Positioning System (GPS). Despite these advancements, some bus companies continue to rely on manual processes, which can result in inefficiencies, delays, and reduced customer satisfaction.

In **JACLINER Inc.**, a bus company operating in Quezon City, several operational challenges were identified through surveys conducted among passengers and the IT department. Passengers reported that purchasing tickets at terminals is time-consuming and inconvenient, especially during peak seasons such as All Saints' Day, Christmas, and New Year, due to long queues and limited access to schedule information. Meanwhile, the IT department highlighted the absence of an automated system for online ticket reservation and real-time bus tracking. Current practices involve manual monitoring of buses and paper-based reporting, which can lead to inaccuracies and delays in accessing important operational data. These findings indicate a gap between existing manual practices and the potential benefits of integrated digital systems.

Although previous studies have explored transportation management systems, there is a lack of comprehensive solutions that combine online ticket reservation and real-time fleet tracking in a single, user-centered platform tailored to both passengers and administrators. This gap highlights the need for a system that not only improves operational efficiency but also enhances usability and accessibility for end-users.

In response to these issues, this study proposes the development of a web-based Bus Management System that integrates online ticket reservation and GPS-based bus tracking. Specifically, this study aims to evaluate the effectiveness and usability of the proposed system. It seeks to answer the following research questions:

1. How effective is the proposed system in improving bus operation management and real-time tracking?
2. How usable is the system in terms of user interaction and satisfaction?
3. What improvements can be recommended based on system performance and user feedback?

The findings of this study are expected to provide significant contributions to both bus companies and passengers by improving service efficiency, reducing waiting time, and enhancing overall user experience. Furthermore, the study may serve as a reference for future researchers and developers aiming to design integrated transportation management systems.

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LITERATURE REVIEW

E-Ticketing Systems

E-ticketing systems have become a fundamental component of modern transportation services, enabling passengers to purchase and manage tickets electronically. A study by Kuncara et al. (2021) found that QR code-based e-ticketing systems significantly improve transaction speed, convenience, and overall efficiency in ticket purchasing processes. These systems reduce reliance on physical tickets and streamline payment methods, ultimately enhancing customer experience and increasing ticket sales.

Similarly, Marfo and Quansah (2020) emphasized that e-ticketing systems reduce operational costs and improve service delivery in the transport sector. Their findings indicate that such systems are widely adopted due to their practicality and efficiency compared to traditional ticketing methods. However, successful implementation depends on factors such as perceived usefulness, ease of use, and user awareness.

Despite these advantages, challenges remain in integrating e-ticketing systems into existing transportation infrastructures. Integration issues, particularly in aligning scheduling and real-time data, are identified as major barriers to achieving fully functional digital ticketing platforms.

With the expansion of ICTs and social media, smart tourism tools such as mobile booking platforms, digital payments, and e-ticketing are employed to improve service delivery and operational efficiency (M. C. Park et al., 2022). E-tickets are now widely used in transportation, aviation, and entertainment (Mollik et al., 2024) due to the convenience, time-saving nature of these tickets, as well as fraud reduction and decreased paper waste. It remains an important component of sustainable visitor management in tourism (Wandile et al., 2024).

Intelligent Transport Systems (ITS)

Intelligent Transport Systems (ITS) refer to the integration of information and communication technologies into transportation systems to improve efficiency, safety, and service quality. ITS frameworks often incorporate multiple technologies such as automated ticketing, fleet management, and real-time data analytics.

Recent studies highlight that ITS plays a crucial role in modernizing public transportation by enabling better coordination between system components and improving decision-making processes. The integration of digital platforms within ITS enhances operational monitoring and supports data-driven management strategies, particularly in urban transport environments.

However, research also indicates that many transport operators still face difficulties in fully implementing ITS due to technological, financial, and organizational constraints. This limitation results in fragmented systems that fail to deliver optimal performance and user satisfaction.

Real-Time Tracking (IoT/GPS)

Real-time tracking technologies, particularly those using GPS and Internet of Things (IoT) devices, have significantly improved fleet monitoring in transportation systems. These technologies allow operators to track vehicle location, monitor performance, and respond to operational issues promptly.

A study on real-time information systems (2021) found that passengers highly value access to real-time updates, as it improves their travel planning and overall satisfaction.

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Additionally, research conducted in 2023 on GPS-based bus tracking systems demonstrated that integrating tracking with ticketing platforms enhances both operational efficiency and passenger convenience. The study highlighted that combining RFID ticketing and GPS tracking provides a more comprehensive transport solution by addressing both management and user needs.

Despite these advancements, many transportation systems still lack proper integration of real-time tracking with user-accessible platforms, limiting the effectiveness of these technologies.

User Acceptance (TAM/UTAUT Models)

User acceptance is a critical factor in the successful implementation of transportation technologies. The Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) are widely used frameworks to evaluate how users adopt new systems.

Njoku and Adetunji (2021) found that perceived usefulness and perceived ease of use significantly influence users' intention to adopt e-ticketing systems. Their study confirms that systems must be user-friendly and reliable to gain user trust and acceptance.

Further studies also highlight the role of additional factors such as social influence, system quality, and service quality in shaping user behavior. These factors contribute to users' willingness to adopt and continuously use digital ticketing platforms.

Moreover, research on mobile ticketing systems shows that user intention is influenced by system capability, accessibility, and contextual usability, reinforcing the importance of designing systems that meet user expectations.

Synthesis of the Literature

The reviewed studies collectively demonstrate that e-ticketing systems, ITS, real-time tracking technologies, and user acceptance models are essential components of modern transportation systems. E-ticketing improves efficiency and convenience, while ITS provides a framework for integrating various technologies. Real-time tracking enhances operational monitoring and passenger satisfaction, and user acceptance models highlight the importance of usability and perceived value in system adoption.

However, most existing studies focus on individual components rather than a fully integrated system. For instance, some research emphasizes ticketing systems without incorporating real-time tracking, while others focus on GPS tracking without addressing user interaction and reservation features. Additionally, many systems are not designed with a strong user-centered approach, which limits their effectiveness and adoption.

Research Gap

Based on the reviewed literature, there is No existing study integrating online reservation, e-ticketing, GPS tracking, and ISO/IEC 25010 evaluation within Philippine provincial bus operations was identified. Also, there is a clear gap in the development of a fully integrated, web-based bus management system that combines:

- Online ticket reservation
- Real-time GPS tracking
- Centralized data management
- User-centered design and usability evaluation

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CONCEPTUAL MODEL OF THE STUDY

On the basis of the foregoing concepts, theories and findings of related literature, studies present and insights taken from them, a conceptual model is developed.

The input stage consists of Knowledge Requirements. This includes the knowledge of the researchers to develop the proposed project and the basic ideas that the user needs to know in order for them to easily understand the proposed project.

On the other hand, Software Requirements are the computer programs that were used in the system. These are the PHP, HTML, CSS, JavaScript, and My SQL as well as the web browser such as Google chrome, Mozilla Firefox and internet explorer and Windows 10 Operating System.

Hardware Requirements includes the technical requirements of the proposed project. A computer unit, with at least 2GB ram, and 500 GB space for the hard disk is required. An Internet connection with at least 25mbps and a tracking device to track the location of the bus is also needed for this project.

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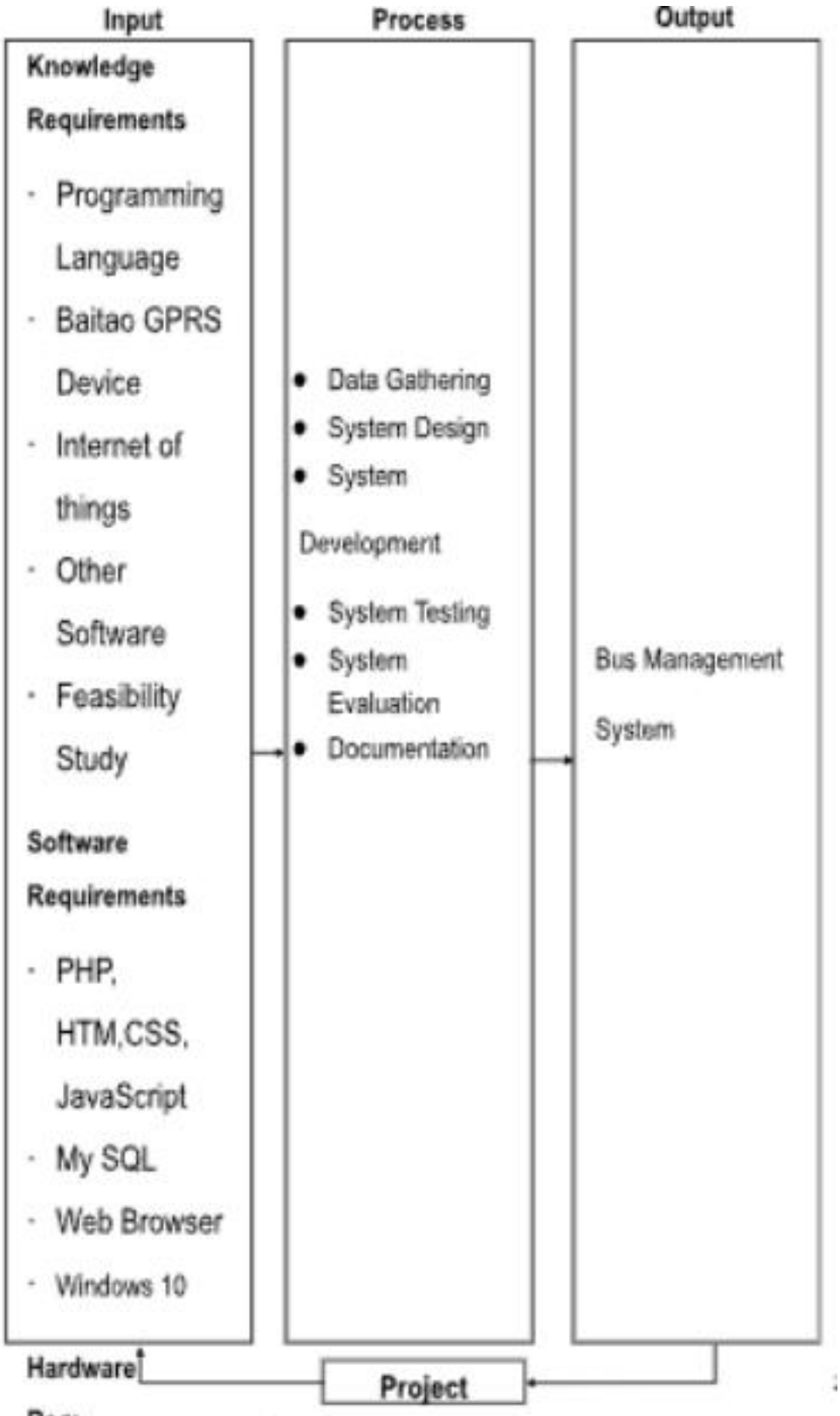

Figure 1. Conceptual Model Development of Bus

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METHODOLOGY AND TECHNIQUES USED

Research Methodology

This study utilized a Developmental Research Design combined with a Descriptive-Evaluative approach. The developmental aspect focused on the design and development of the Bus Management System (BMS) using the Agile (Scrum) methodology. Meanwhile, the descriptive-evaluative approach was used to assess the system's performance based on user feedback and the ISO/IEC 25010 software quality model, covering functional suitability, usability, reliability, security, and maintainability.

Development Methodology

The system was developed using the Agile Development Model (Scrum Framework), which supports iterative, incremental, and flexible system development.

Scrum Phases Applied

a. Requirement Analysis

Interviews, observations, and surveys were conducted with transport operators and commuters to identify existing problems such as scheduling inefficiencies, ticketing errors, lack of real-time tracking, and manual record-keeping issues.

b. System Design

A centralized system architecture was designed to integrate the following components:

- Admin Dashboard for system management
- Driver/Dispatcher Interface for trip operations
- Passenger Application for booking and tracking

c. Iterative Development (Sprints)

The system was developed in iterative cycles, including:

- Database design and scheduling module development
- GPS tracking and geofencing integration
- Ticket reservation and generation system
- Security features and reporting modules

Each sprint allowed continuous testing, evaluation, and refinement of system features.

3. Data Collection Techniques

Primary Data

- Observation of terminal and transport operations
- Manual logbooks from transport terminals
- Passenger flow data, peak hours, and route delay records
- Surveys and interviews with stakeholders

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Secondary Data

- Literature on Intelligent Transportation Systems (ITS)
- GPS API and geofencing documentation
- Related studies, journals, and system frameworks

4. Data Processing Technique

The collected data were processed, cleaned, and structured into a relational database system to ensure:

- Data consistency and accuracy
- Reduced redundancy
- Efficient retrieval of schedules, user records, and transactions

System Development Techniques

Component	Technology / Technique	Purpose
Database Management	SQL Relational Database	Store schedules, tickets, users
Real-time Tracking	GPS + Geofencing API	Bus location and ETA updates
Security	AES Encryption	Protect sensitive data
User Interface	Responsive Web/Mobile UI	Multi-device accessibility

Respondents of the Study

The system was evaluated by three user groups:

- **System Administrators** – manage schedules, fleets, and reports
- **Bus Personnel (Drivers/Dispatchers)** – manage trips and passenger manifests
- **Passengers** – book tickets and track buses

Table 1. Functional Suitability

Indicators	Mean	Interpretation
Scheduling Accuracy	4.45	Strongly Agree
Reservation Function	4.38	Strongly Agree
Ticket Generation	4.5	Strongly Agree
Fleet Tracking Accuracy	4.4	Strongly Agree
Report Generation	4.42	Strongly Agree

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Table 1 assess whether the system's capabilities are appropriate and effective for the people who use or are affected by it.

Table 2. Usability Evaluation

Indicators	Mean	SD	Interpretation
Ease of Navigation	4.35	1	Strongly Agree
Interface Clarity	4.3	1	Strongly Agree
Accessibility (Mobile/Web)	4.4	1	Strongly Agree
System Responsiveness	4.28	1	Strongly Agree
Overall Weighted Mean	4.33	1	Strongly Agree

Table 2 assesses how effectively, efficiently, satisfactorily the users can use the system.

Table 3. Reliability Evaluation

Indicators	Mean	SD	Interpretation
System Stability	4.25	1	Strongly Agree
Error Handling	4.2	1	Agree
Data Consistency	4.32	1	Strongly Agree
Continuous Operation	4.28	1	Strongly Agree
Overall Weighted Mean	4.26	1	Strongly Agree

Table 3 ensures that the responses are dependable and can be confidently used to inform decisions.

Table 4. Security Evaluation

Indicators	Mean	SD	Interpretation
Data Encryption	4.5	1	Strongly Agree
User Authentication	4.45	1	Strongly Agree
Access Control	4.4	1	Strongly Agree
Privacy Protection	4.48	1	Strongly Agree
Overall Weighted Mean	4.46	1	Strongly Agree

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Table 4 analyzes how well the study safeguards the security and privacy of the respondents involved.

Table 5. Maintainability Evaluation

Indicators	Mean	SD	Interpretation
System Update Capability	4.3	1	Strongly Agree
Bug Fix Efficiency	4.25	1	Strongly Agree
Data Structure Organization	4.35	1	Strongly Agree
Ease of Enhancement	4.4	1	Strongly Agree
Overall Weighted Mean	4.33	1	Strongly Agree

Table 5 assess how the participants perceive and rate the ease of maintaining and managing the bus management system based on their experiences or observations during the study.

Table 6. Overall System Evaluation

Criteria	Mean	SD	Interpretation
Functional Suitability	4.43	1	Strongly Agree
Usability	4.33	1	Strongly Agree
Reliability	4.26	1	Strongly Agree
Security	4.46	1	Strongly Agree
Maintainability	4.33	1	Strongly Agree
Grand Mean	4.36	1	Strongly Agree

Table 6 refer to the assessment or feedback provided by the respondents (such as users, stakeholders or participants) regarding the effectiveness, efficiency, usability, and overall performance of the bus management system.

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DISCUSSION

1. Interpretation of Quantitative Results

The overall grand mean of **4.36**, interpreted as **"Strongly Agree,"** indicates that the Bus Management System (BMS) is highly acceptable in terms of ISO/IEC 25010 software quality standards. This suggests that users generally perceive the system as effective, reliable, and easy to use across all evaluated dimensions.

Among all criteria, **Security (M = 4.46)** obtained the highest mean score. This implies that users strongly agree that the system provides effective protection of data through encryption, authentication, access control, and privacy protection. This result highlights that the system's security implementation is its strongest feature.

On the other hand, **Reliability (M = 4.26)** obtained the lowest mean score, although still interpreted as "Strongly Agree." This indicates that while the system performs consistently under normal conditions, there is still room for improvement in areas such as error handling, system stability, and continuous operation.

2. Comparison with Related Studies

The findings are consistent with studies on Intelligent Transportation Systems (ITS), which emphasize that automation, GPS tracking, and centralized scheduling improve transport efficiency and user satisfaction.

Like the study of Rahman et al. (2021), the developed system demonstrates that digital transport solutions significantly reduce manual errors and improve operational accuracy. However, comparable to many prototype-level systems, the absence of integrated payment processing limits the system from achieving full commercial-grade deployment.

3. Analytical Interpretation per Research Objective

Objective 1: Improve scheduling efficiency
The high functional suitability score (M = 4.43) confirms that automated scheduling improves accuracy and reduces manual errors in transport operations.

Objective 2: Enhance passenger experience
The usability score (M = 4.33) indicates that users find the system easy to navigate, accessible, and responsive, improving overall passenger convenience.

Objective 3: Provide real-time tracking
The system's strong security and functional ratings support the effectiveness of GPS-based tracking and real-time bus monitoring, ensuring accurate location updates.

Objective 4: Ensure system security
Security achieved the highest rating (M = 4.46), confirming that encryption and authentication mechanisms are effective in protecting sensitive user and system data.

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4. Overall Interpretation

Overall, the Bus Management System is highly acceptable and functionally effective across all ISO/IEC 25010 quality attributes. The results indicate that digitalizing bus operations through a centralized platform improves scheduling efficiency, enhances passenger experience, and strengthens data security.

However, certain limitations were identified, particularly in reliability and long-term system stability. These areas require further enhancement to support full-scale deployment.

5. Key Insight

The statistical findings confirm that the system is not only functional but also **quantitatively validated as "Strongly Agree" across all evaluation criteria**, demonstrating its readiness for implementation with further refinement.

CONCLUSION

Based on the results of the system evaluation using the **ISO/IEC 25010 software quality model**, the Bus Management System (BMS) obtained an overall **grand mean of 4.36**, interpreted as **"Strongly Agree."** This indicates that the system is highly acceptable in terms of usability, reliability, security, functional suitability, and maintainability.

Among all criteria, **Security obtained the highest mean score (M = 4.46)**, indicating that users strongly agree that the system effectively protects data through encryption, authentication, and access control mechanisms. This confirms that the system's security framework is its strongest component.

In terms of **Functional Suitability (M = 4.43)**, the system successfully performs essential transportation functions such as scheduling, ticketing, reservation, and fleet tracking. This demonstrates that the system effectively meets its intended operational objectives.

The **Usability dimension (M = 4.33)** indicates that users—both passengers and transport personnel—find the system easy to navigate and operate, confirming that the interface design supports user accessibility and efficiency.

Meanwhile, **Reliability (M = 4.26)** obtained the lowest score among all criteria, although still interpreted as "Strongly Agree." This suggests that while the system performs adequately, improvements are needed in system stability, error handling, and continuous operation to ensure stronger long-term performance.

Lastly, **Maintainability (M = 4.33)** shows that the system is reasonably maintainable, but further enhancements in code structure, scalability, and system update mechanisms are recommended for future improvement.

Overall, the system successfully automates key transportation processes such as scheduling, reservation, ticketing, and real-time tracking, resulting in improved operational efficiency and reduced manual workload. The evaluation confirms that all core modules function as intended and meet user expectations.

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In conclusion, the Bus Management System is technically feasible, functionally reliable, and highly acceptable to users, making it suitable for deployment in real-world transportation environments. However, further development is recommended in the areas of reliability improvement, system scalability, and integration of advanced features such as payment systems and mobile application enhancement to achieve full optimization.

RECOMMENDATIONS

Based on the evaluation results and identified system limitations, the following recommendations are proposed to improve the functionality, security, and overall performance of the Bus Management System (BMS):

1. Integration of Secure Online Payment System
   It is recommended to integrate a PCI-DSS compliant payment gateway (e.g., PayMongo, PayPal API, or Stripe) to enable secure and automated fare transactions. This will enhance system completeness by eliminating manual or offline payment limitations.

2. Development of a Dedicated Mobile Application
   To improve accessibility and user experience, a native or cross-platform mobile application (Android/iOS) should be developed using frameworks such as Flutter or React Native, allowing passengers to book, track, and manage trips in real time.

3. Enhancement of GPS Tracking Accuracy
   The system should upgrade its real-time tracking module by integrating high-precision GPS APIs with adaptive refresh rates, and implementing signal correction techniques to improve location accuracy, especially in low-signal areas.

4. Strengthening Cybersecurity and Data Protection
   It is recommended to implement advanced security measures such as multi-factor authentication (MFA), role-based access control (RBAC), and end-to-end encryption (AES-256) to further secure sensitive user and transaction data.

5. Compliance with Data Privacy Regulations
   The system should be aligned with the Data Privacy Act of 2012 (Republic Act 10173, Philippines) by implementing proper consent mechanisms, data retention policies, and secure data storage protocols.

6. Improvement of System Maintainability and Code Structure
   Developers should adopt modular programming and clean architecture principles to improve maintainability, allowing easier updates, debugging, and future system scalability.

7. Deployment of Terminal Surveillance Integration (CCTV System)
   For enhanced operational monitoring and safety, integration with IP-based CCTV systems is recommended to support security tracking and incident documentation at bus terminals.

8. Optimization of System Performance and Scalability
   It is recommended to migrate the system backend to a cloud-based infrastructure (e.g.,

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AWS, Google Cloud, or Azure) to improve scalability, uptime reliability, and performance during peak usage periods.

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