JeePS 2.0: Enhancing a Real-Time PUV Tracking System

Ryan Decena*, James Ducay, and Jozelle Addawe

Service Science and Software Engineering Laboratory, University of the Philippines Diliman, Philippines
decenaryancarlo@gmail.com

Abstract. JeePS, a real-time transportation tracking system, is a web and mobile application designed to improve passenger satisfaction with Public Utility Vehicles (PUVs). This paper introduces JeePS 2.0, an improved version designed to overcome the limitations of the original system through new features, including an Automatic Passenger Counter (APC) with 85.33% accuracy. Various tests validated the system's functionality, effectiveness, and usability. While the increase in passenger satisfaction was not statistically significant, the enhancements were well-received.

Keywords: service quality, passenger satisfaction, automated passenger counter (APC), public utility vehicle (PUV), jeepney

1 Introduction

Public transportation plays a significant role in supporting individuals' access to essential needs and life satisfaction [19]. However, the 2023 Urban Mobility Readiness Index ranked Manila, the capital of the Philippines, among the worst cities for public transit systems across the world, which indicates high public transit density, low efficiency, and poor utilization of mobility services [1].

To address the inadequate state of public transportation, it is crucial to closely examine PUVs as they make up a significant portion of daily commuting options. Jeepneys, an elongated shared vehicle, constitute the most dominant mode of informal public transportation in the Philippines because of their affordable fare and flexible operations that allow passengers to board and alight anywhere along fixed routes [13][20]. However, little is known about informal transport operations, causing difficulties in improving the transportation system, which negatively influences the service quality provided by jeepneys [6].

In a study by Ong et al. [16], service quality dimensions relevant to jeepneys were used to identify the factors that mostly affect passenger satisfaction. The main factors include safety, value for money, driver's behavior, information materials, and service adequacy. Findings from this study state that the government and jeepney drivers can improve service quality by focusing on these specific dimensions.

Several solutions have been developed to address the challenges in public transportation in the Philippines. One possible solution is JeePS, a real-time

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transportation tracking system. It is composed of a web and mobile application with features like GPS tracking, information display, feedback system, report system, rough time estimation, and passenger demand system. The web application is designed to address the transportation problems of passengers. Additionally, it provides tools for route managers to assist jeepney drivers with their operations. It also includes a mobile application intended for drivers to help them in data collection and with their jeepney operations [18].

Notably, JeePS has successfully addressed the factors affecting passenger satisfaction towards jeepneys. However, certain limitations could be identified based on the results from previous research [18]. In addition, the researchers conducted an interview with the jeepney drivers and identified other areas for improvement, such as the feedback system, report system, and passenger demand system.

Building on the foundations of JeePS, this paper presents JeePS 2.0, an enhanced version that addresses the limitations of the original application. In the next section, the authors evaluate the previous version to establish what improvements are needed for the design, along with the new and improved software features and the hardware design to support the system.

2 Problem Statement

The current lack of available technology that improves the service quality and passenger satisfaction of jeepneys highlights the need for a system that effectively addresses these challenges. One such system is JeePS, designed to address several concerns in passenger satisfaction and challenges faced by jeepney drivers, including:

1. **Loss of Personal Items** - Losing an item in a PUV is cumbersome as there is no direct way of reporting it, especially if the passenger has no information about the jeepney or the driver.
2. **Safety Concerns** - Passengers may worry about the road conditions, the state of the jeepney, and potential encounters with malicious individuals.
3. **Operational Hazards** - Drivers may face road accidents or criminal activities during their trip.
4. **Unsatisfactory Driver Behavior** - Drivers may speed excessively or exhibit poor attitudes toward passengers.
5. **Challenges in Route Identification** - There could be difficulty in identifying jeepney routes due to small handwritten signs, irregular routes, and road conditions.
6. **Lack of Passengers** - Drivers may be unaware if there are passengers waiting in certain areas within their route.
7. **Uncertainty About the Trip Cost** - Passengers new to the area may have no idea about the fare prices. It is also possible that there are changes or inconsistencies in fare prices.

8. **Uncertainty About Jeepney Availability** - Passengers would have no way of knowing if there are still available jeepneys within the route at a given time.
9. **Uncertainty About Waiting Time** - Given the uncertainty surrounding jeepney availability and capacity, passengers have no way to determine when they will be able to secure a ride.
10. **Uncertainty About Jeepney Capacity** - Lacking information on the jeepney's current capacity creates uncertainty regarding the waiting time.

JeePS provides a range of features that help address the aforementioned problems, however, there are certain limitations and room for improvement that could be identified. The following outlines the identified limitations for potential improvements:

1. **Limited Feedback and Report Context** - Without image attachments, feedback and reports may have insufficient contextual information, especially when reporting accidents or lost items. Moreover, the system operates as one-way communication, preventing users from knowing if their reports are acknowledged.
2. **System Integrity** - There is no way of moderating the feedback and reports sent by users to prevent abuse, such as spamming false reports or submitting troll feedback. According to Gosman et al. [7], the reliability of the transportation system is undermined without controlling or filtering the data shared by the user. Data submitted by malicious participants regarding jeepneys, routes, or drivers may contradict the observations of the majority, which can lead to inaccurate information and hinder the system's effectiveness.
3. **Passenger Demand View** - Passenger demand data is only visible in the route manager's web application and the driver's mobile application instead of being visible to passengers. Without this information, perceived waiting time is affected, influencing passenger satisfaction [5].
4. **Passenger Demand Data** - Passenger demand data is exclusively available to the route manager, and remains unutilized for potential applications, like in short-term passenger demand forecasts [9].
5. **Limited Fare Matrix** - Fare prices displayed only include base prices for the routes, leaving passengers without information on pricing adjustments based on varying distances and discounts.
6. **Unreliable Location Updates** - The jeepney's location does not update when the mobile application is running in the background or when the driver's mobile phone is locked, which may impact real-time tracking accuracy.
7. **User Data Exposure** - The driver's location may unintentionally be exposed when the app is left open even when not operating. According to Gosman et al. [7], this is a potential for misuse as malicious users could exploit the GPS data to deduce location patterns and geographical habits.
8. **Inefficient Passenger Counter** - The passenger counter was implemented through a manual counting mechanism where drivers must manually click a

button through their mobile application whenever passengers enter or exit the jeepney. However, user test results have shown that this implementation was too cumbersome for drivers.

9. **Passenger Safety** - With limited GPS tracking capabilities, users cannot track the current location of other passengers of their concern, similar to the location-sharing feature found in ride-sharing platforms [4].
10. **Limited User Testing** - Given the time constraints and communication bottlenecks with the jeepney operators, the JeePS developers only had one day for the live testing, resulting in limited results.

3 Scopes and Limitations

1. **Software Compatibility** - The driver's mobile application is only compatible with Android devices version 9 or higher and is not supported on iOS. Meanwhile, the web application can be accessed through various web browsers on different devices. It has been tested on Chromium-based browsers (Chrome, Edge, and Brave), Firefox, and Safari.
2. **Jeepney Hardware Setup** - The hardware setup implemented in the system is unable to count passengers seated in front of the jeepney beside the driver, as these seats are outside the detection range of the sensors. Additionally, the setup is only compatible with jeepneys that have hollow handrails at the entrance, which allow proper installation and detection.
3. **Field Testing** - The field testing was conducted at the University of the Philippines Diliman (UPD) to evaluate the effectiveness of the system. It was limited to the Ikot route since the choice of route does not significantly affect passenger satisfaction, and for the ease of coordination with drivers. Tests were done on regular weekdays to avoid disruptions, providing a controlled simulation of typical urban operations and ensuring realistic passenger and vehicle flow data.

4 Objectives of the Study

This project aims to improve the passenger satisfaction and service quality of jeepneys. Specifically, it focuses on improving the software component of JeePS, which includes the web and mobile applications, while also integrating a new hardware component for automating passenger counting. The following highlights the improvements made based on prior recommendations and inspirations from existing solutions, to address the gaps of the initial JeePS implementation. These improvements are designed to further address the factors affecting passenger satisfaction and service quality of jeepneys.

1. **Enable Image Attachments** - Allows image attachments for both feedback and report systems.
2. **Account Penalty System** - Accounts found to be spamming false reports or submitting troll feedback will be temporarily disabled. Upon a second offense, the account will be permanently disabled.

3. **Feedback and Report Moderation** - Allows route managers to delete troll or inappropriate feedback, and to acknowledge and manage submitted reports.
4. **Passenger Demand System Visibility** - Allows logged-in passengers to view the location of other waiting passengers on the map through the mobile application.
5. **Passenger Demand Summary** - Provides drivers with a summary of periods and locations with high passenger demand in the web application.
6. **Extended Fare Matrix** - Allows users to view fare prices based on varying distances and discounts.
7. **Persistent Location Sharing** - Allows drivers to continuously share their location even when the mobile application is running in the background or their phone is locked.
8. **Location Sharing Timeout** - Automatically stops continuous location sharing after a set period.
9. **Automatic Passenger Counter** - Integrates a hardware component with the mobile application that automatically counts the passengers on board for drivers.
10. **Live Location Sharing** - Lets logged-in passengers share the live location of the jeepney they are riding, along with its basic information, through the web application.

Furthermore, the study aims to conduct the following testing methods to ensure the functionality, effectiveness, usability, reliability, and completeness of the improvements.

1. **Functional Testing** - verifies that the features work according to the specified requirements.
2. **Field Testing** - simulates the project for limited users to evaluate its effectiveness in a real-world environment.
3. **Domain Expert Validation** - Involves consultation with a professional within a relevant field to gain valuable insights that may not be apparent through standard testing methods.

Figure 1 presents the outline and structure of how JeePS contributes to improving passenger satisfaction and service quality of jeepneys. The study is grounded in the service quality dimensions identified as key factors affecting passenger satisfaction. These factors are mapped to specific user problems experienced by both drivers and commuters. In response, the features of JeePS were designed to directly address these user problems. Each feature includes a specific improvement aligned with a particular limitation identified in Section 2.

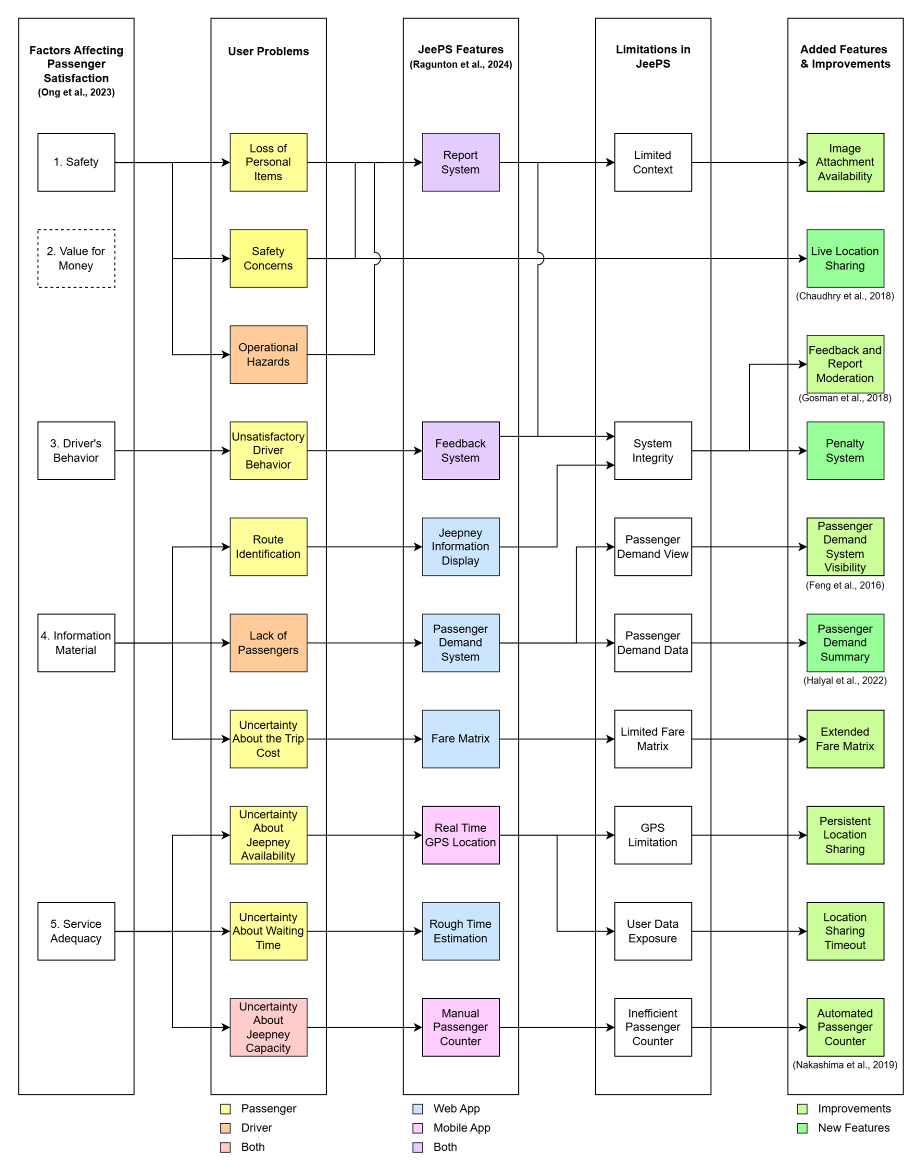

Fig. 1. Theoretical and Conceptual Framework

5 Methodology

5.1 System Design

The system is composed of a mobile application for drivers and a web application for route managers and passengers, as shown in Figure 2. The passenger,

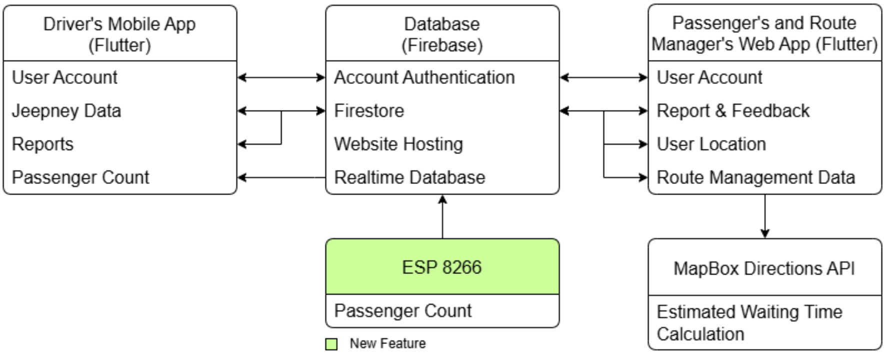

Fig. 2. System Architecture

route manager, and driver each have their respective accounts within the system, while a passenger who is not logged in is considered a guest user. Only the drivers use the mobile application, whereas route managers and passengers use the web application. Route managers can use all passenger features in addition to specialized tools that let them moderate and manage the information displayed on the web app.

User authentication is handled securely via Firebase Authentication, while all other data required by JeePS is stored and managed efficiently using Firebase Firestore and Realtime Database.

An ESP8266 microprocessor is responsible for updating the passenger count in the Realtime Database. Furthermore, the system's estimated waiting time calculation is powered by the MapBox Directions API.

5.2 Software Implementation

JeePS 2.0 retains all the key features from its previous versions, ensuring continuity in functionality. The following are the features that have been carried out from the earlier versions.

1. **Account System** - Controls access to certain features for logged-in users. Guests can still use the web app but cannot access the Passenger Demand System, Feedback System, or Report System.
2. **Basic Information** - Displays key information to passengers, such as the driver's name and jeepney plate number, in the web application
3. **Rough Time Estimation** - Provides an estimated arrival time for each jeepney, giving passengers a rough idea of their waiting period through the web application.

From the existing features, several improvements have been made to the following features to further enhance user experience and data privacy.

4. **Real-Time GPS Location** - Displays the live location of jeepneys on the map, even if the driver's phone is locked or in the background, addressing unreliable location updates of PUVs. This also allows drivers to share their location without having their phone open for the whole trip.
5. **Passenger Counter** - Utilizes a hardware-based APC to display real-time occupancy in both web and mobile apps, addressing problems with manual counting.
6. **Feedback System** - Enables logged-in passengers in the web app to view and provide feedback on the driver and their respective jeepney through a 5-star rating system and comments, with the option to attach images for additional context. Route managers can also moderate feedback as shown in Figure 3 to ensure system integrity. They now have the option to remove troll or inappropriate feedback, ensuring that only relevant and constructive feedback remains visible. This helps create a more reliable feedback system and fosters a better community environment for users.

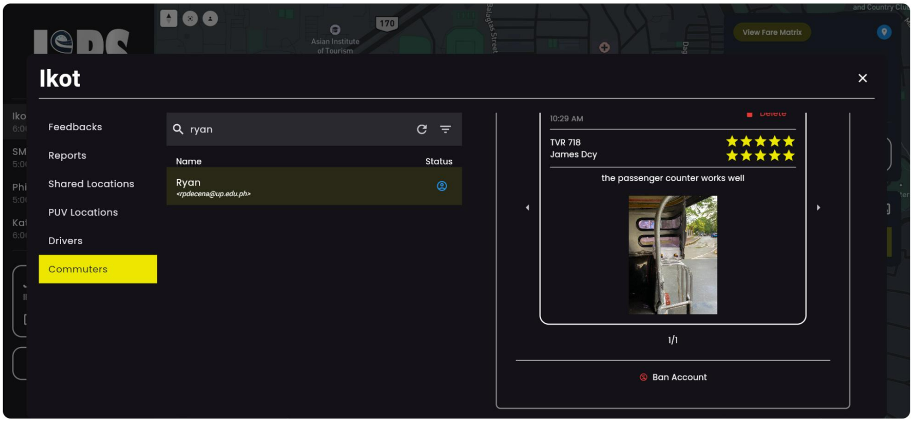

Fig. 3. Penalty System UI

7. **Fare Matrix** - Allows passengers to view fare prices based on the usual stops within the route, extending the fare matrix in the web app shown in Figure 4.

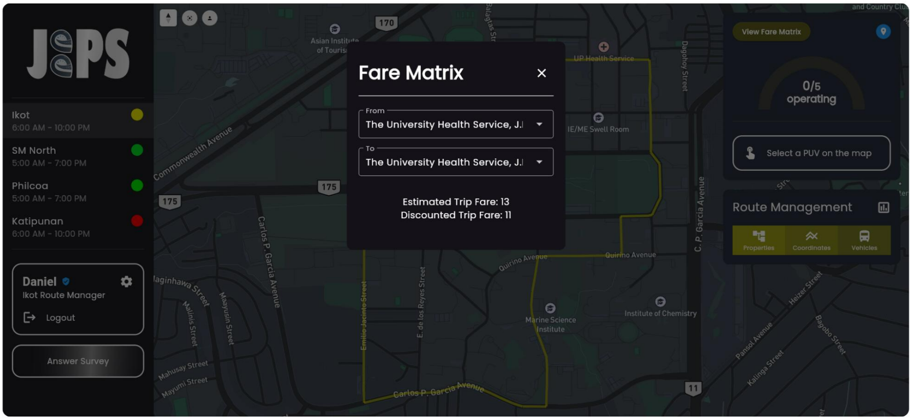

Fig. 4. Fare Matrix UI

8. **Report System** - Allows drivers to report crimes, accidents, or vehicle issues from the mobile app directly to web app users. Logged-in passengers can also report lost items and other concerns with short descriptions and optional images. As shown in Figure 5, these reports alert drivers and route managers, who can acknowledge and moderate them to improve response time and maintain system integrity.

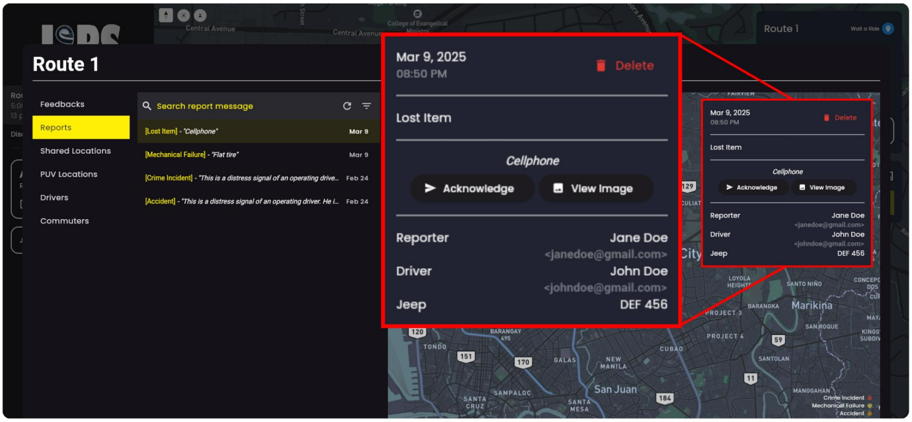

Fig. 5. Report System UI

9. **Passenger Demand System** - Allows logged-in passengers to mark their location on the map, making their location visible to the drivers in the mobile application. In addition, logged-in passengers can also view other waiting

passengers on the map through the web application, improving perceived waiting times.

Building on the success of its earlier versions, JeePS 2.0 introduces new features aimed at improving passenger satisfaction and enhancing operational efficiency for jeepney drivers.

10. **Live Location Sharing** - Passengers with an account in the system have the option to share their live location and jeepney details to family members or friends while they are commuting. This effort, which has been successfully implemented by the Grab application for commuting on private vehicles, is adopted in JeePS 2.0 to offer additional measures for enhancing passenger safety [8]. As shown in Figure 6, the interface displays the live location sharing feature after the user copies the shared map URL, along with the view from another user accessing that map.

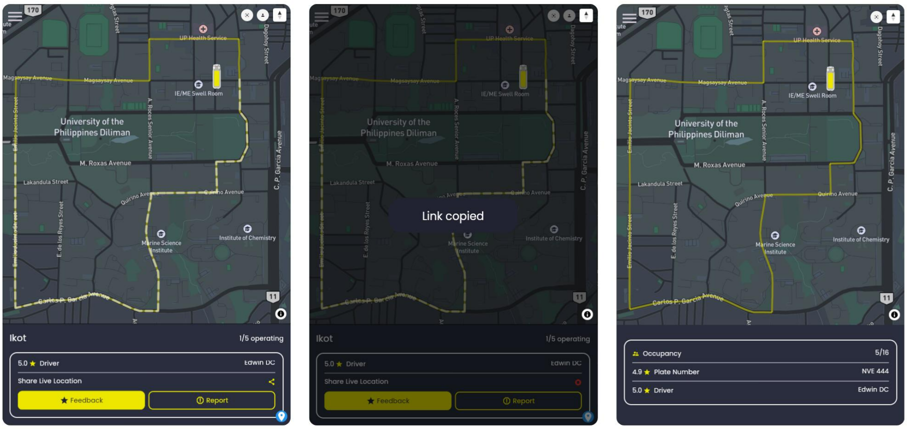

Fig. 6. Live Location Sharing UI

11. **Passenger Demand Summary** - As shown in Figure 7, the passenger demand summary displays times and locations along the jeepney route with high passenger demand based on historical data from pinged passenger locations. This helps drivers using the mobile application make informed decisions on scheduling their trips and avoid idle times that may reduce fuel consumption and maximize profitability.

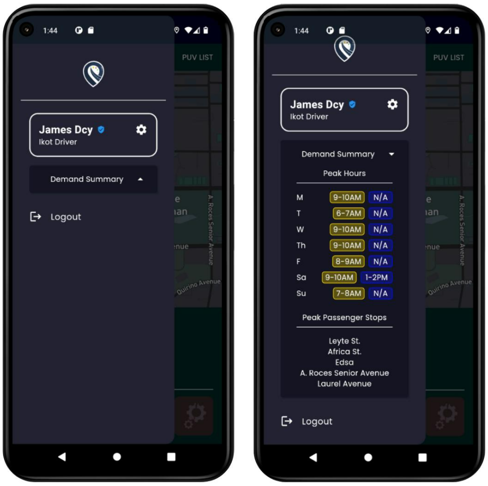

Fig. 7. Passenger Demand Summary UI

12. **Account Penalty System** - Maintains platform reliability by banning accounts that submit false reports or feedback, with reactivation only after contacting the route managers.

The features of JeePS 2.0 are designed to address key factors that influence passenger satisfaction, including safety, driver's behavior, information material, and service adequacy.

5.3 Hardware Implementation

The original JeePS system featured a manual passenger counter to report jeepney seating capacity, helping improve service adequacy and inform waiting passengers. However, user testing showed the feature was inefficient [18]. This paper proposes a hardware-based passenger counter design tailored to jeepney constraints while minimizing costs.

APC systems offer an effective way to track passenger flow, improving resource use and service quality [11]. These are often implemented in buses with a sensor-integrated counter [15]. For PUJs, possible implementations include video-based systems, floor-based sensors, and infrared (IR) sensors.

Video-based passenger counters offer a range of configurations. One implementation includes image processing and machine learning techniques [17]. This utilizes CCTV cameras mounted at vehicle entry points, typically on ceilings, to capture overhead views of passengers. The implementation involves preprocessing techniques such as foreground/background subtraction, feature extraction, and image segmentation to prepare video footage for analysis. Deep learning models, particularly Convolutional Neural Networks (CNNs) [12], process the images to detect and track passengers. These systems define regions or lines of interest near doorways where passenger detection occurs, focusing on identifying passenger heads to minimize occlusion issues. Modern implementations can reach accuracy rates of 92-99% when properly trained and deployed [17]. However, this requires substantial computational resources and cost for cameras, which may not be applicable in a jeepney setting.

On the other hand, one of the least computationally expensive video-based APCs is the barrier simulation method [11]. This approach divides the video feed into four zones to detect whether a passenger is boarding or alighting based on the sequence of pixel activations. However, factors such as lighting conditions, camera angle, and installation cost may affect accuracy in jeepneys. The jeepney's low floor-to-ceiling height could also obstruct the camera's view as passengers move through the vehicle.

Floor-based sensing uses a mat embedded with pressure sensors at the vehicle entrance, combined with a counting algorithm to determine the number of passengers. This addresses the challenge of video-based sensing in detecting multiple passengers. However, other challenges may arise, such as fluids penetrating through the mat and vehicle vibration, which affects the accuracy of the data recorded by the system. Its application in jeepneys is further limited by the small 25 cm stepboard and the lack of doors, which restrict sensor installation [2].

Infrared (IR) sensors apply a similar logic to barrier simulation, where multiple beams across the door detect passenger movement [10]. Multiple IR beams crossing the vehicle door identify whether a passenger is boarding or alighting the vehicle. A passenger entering would break the beam closest to the vehicle door, and those who are leaving would break the beam furthest from the door first.

In jeepneys, IR sensing is the most suitable option given the vehicle's low floor-to-ceiling height, side-facing seats, and small stepboard area, as well as its balance between cost and accuracy. Video-based APCs are less practical since they require front-facing seats and optimal camera angles to capture passengers accurately. Moreover, integrating machine learning for image-based detection is difficult due to camera placement constraints and the high computational cost of processing video data in real time. In contrast, floor-based sensors are limited by the narrow stepboard space, which can reduce detection accuracy [10]. IR sensing performs effectively despite these physical constraints and remains more cost-efficient than other options while maintaining reliable accuracy [14][21]. Additionally, this approach can be extended to other PUV types with fewer spatial limitations.

Figure 8 shows the schematic and installation of the IR-based APC. The system has four main components: an ESP8266 microprocessor powered by an auxiliary source via USB, and two IR proximity sensors connected to the 5V and GND pins, with signal pins linked to digital pins D7 and D8. The sensors send signals to the microprocessor, which processes them and updates the passenger count in the database. Boarding is detected when IR1 (near the exterior) triggers before IR2 (near the interior), and alighting is detected when IR2 triggers first.

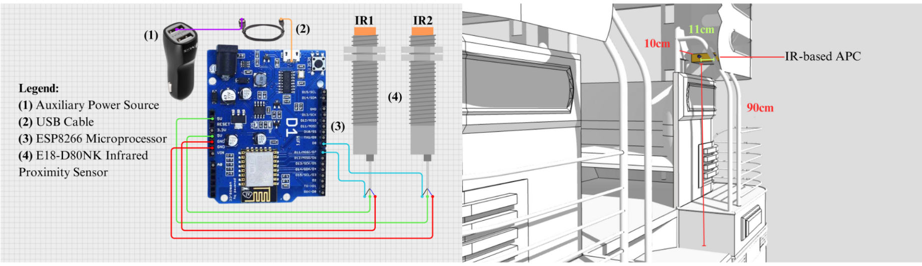

Fig. 8. Hardware Implementation

The sensors are mounted 90 cm above the stepboard, 10 cm from the entrance handle, and 11 cm apart. This placement reduces false readings compared to ceiling or stepboard installations. A junction box protects the components, and the system is powered directly by the jeepney's auxiliary source, avoiding battery maintenance costs.

5.4 Validation

5.4.1 Functional Testing Functional testing was conducted to verify that the features work according to the specified requirements. This served as the alpha testing of the web and mobile applications conducted by the Service Science and Software Engineering (S3) Lab members of the Department of Computer Science in the University of the Philippines Diliman. Each tester assumed the roles of different types of users, namely guest, passenger, driver, and route manager. Testers evaluated a list of features, including both the original and improved features of JeePS, with a pass or fail remark based on a set of use cases and their expected results. This ensured that no changes were made to the original features and that the improved features work as intended in different use cases.

On the other hand, the hardware component was tested in a stationary jeepney to ensure the feasibility of the implementation. A total of 120 test runs were conducted to cover different scenarios of passengers entering and exiting the vehicle, each tested 20 times. These included (1) single passengers who entered and exited at a normal pace, (2) multiple passengers who boarded and exited continuously one at a time, (3) simultaneous passengers who entered or exited almost at the same time, (4) hesitant passengers who stepped in but immediately exited, (5) slow-moving passengers who took longer to board or leave, and (6) passengers carrying bags or other accessories that might affect detection. The latency between transmitting the count to the database and when it is displayed in the web application was also measured.

5.4.2 Field Testing Field testing was conducted to assess the effectiveness of the web and mobile applications in a real-world environment. This took place over two days, with JeePS tested on the first day and JeePS 2.0 on the second day.

Testing involved five jeepney drivers who navigated the mobile app independently during their trips, completed the SUS questionnaire [3], and participated in interviews to provide further insights on their experience. In addition, 29 commuters used the web app to get on and off any of the selected jeepneys at any stop along the route. They answered the same SUS questionnaire [3] and an effectiveness questionnaire at the end of each day. The same group of participants responded to the set of questionnaires for both days.

The effectiveness questionnaire is a Likert scale-based survey adapted from the study by Ong et al. [16], with each question targeting a factor affecting passenger satisfaction. The questionnaire focused on the improvements made in JeePS while ensuring that the questions remain applicable to both versions to avoid bias.

The results of the effectiveness questionnaire were evaluated using the Wilcoxon Signed-Rank Test at a 0.05 significance level to determine whether the null hypothesis could be rejected, indicating a significant difference in passenger satisfaction between JeePS and JeePS 2.0.

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5.4.3 Domain Expert Validation An interview was conducted with Dr. John Justine Villar, an expert in transportation and technology from the National Center for Transportation Studies (NCTS), to ensure the reliability and completeness of the system. Dr. Villar reviewed the features of JeePS 2.0 and provided valuable insights to validate the design choices made in the development of JeePS 2.0.

6 Results and Discussion

6.1 Functional Testing

6.1.1 Software A total of 149 test cases were executed during the alpha testing. All 149 test cases passed, with only some browser-specific behaviors and minor issues that do not affect the main functionality of the features.

Table 1. IR-based APC Accuracy Testing Result

Test Case	False Positives	False Negatives	Correct Detections
Single Passenger	0	0	1.0
Multiple Passenger	0.05	0	0.95
Simultaneous Passengers	0.1	0.2	0.7
Hesitant Passenger	0	0.3	0.7
Slow Movement	0	0.2	0.8
With Obstructions	0	0	1.0

6.1.2 Hardware Table 1 presents the functional testing results for the hardware component of JeePS 2.0. False positives occur when the counter incorrectly updates the passenger count by increasing the count when it should have decreased, or vice versa. False negatives, on the other hand, happen when a passenger enters or exits the jeepney, but the counter fails to update the count.

The counter demonstrated 100% accuracy for single passengers and passengers carrying items like bags. The accuracy remained high at 95% for multiple passengers boarding one after another. However, accuracy dropped to 80% for slow-moving passengers since lingering in the sensor's range sometimes caused missed detections. Both hesitant and simultaneous passengers had the lowest accuracy at 70%, as hesitation at the entrance or people entering close together made it harder for the sensors to detect them correctly. This may be due to the APC's limitation in concurrent detection, where both sensors are triggered almost simultaneously.

Across all test cases, the system achieves an average accuracy of 85.83%, with potential for further improvement. In real-world use, performance may be affected by network issues, passengers carrying large items like boxes, and weather conditions such as heavy rain that could damage the APC.

6.2 Field Testing

Table 2. Wilcoxon-Signed Ranked Test for Factors Affecting Passenger Satisfaction

Factor	JeePS Score	JeePS 2.0 Score	p-value
Safety	4.60	4.79	0.23014
Driver's Behavior	4.55	4.83	2.5 (w)
Information Materials	4.47	4.68	0.28914
Service Adequacy	4.17	3.83	0.17702
Overall	4.45	4.53	0.9124

6.2.1 Effectiveness

1. **Safety**
   The mean passenger satisfaction score in terms of safety in Table 2 had a 4.12% increase, from 4.60 to 4.79. However, the p-value of 0.23014 is greater than 0.05, so the null hypothesis is not rejected. The increase is not statistically significant, likely because no safety incidents occurred during testing, leaving the report system unused. As a result, the route manager's report acknowledgement feature was not utilized, which may have had little effect on perceived safety.
2. **Driver's Behavior**
   Table 2 shows a 6.06% increase in the driver's behavior rating from a mean of 4.55 to 4.83. After removing zero differences, the sample size was too small for a normal distribution, so the w-value of 2.5 was used, exceeding the critical value of 2 for $N = 7$. The null hypothesis is still accepted, meaning the increase is not statistically significant. The limited number of commuters during testing likely reduced the amount of feedback despite having enough participants for the test.
3. **Information Materials**
   Table 2 shows that Information Materials gained 4.63% in the mean satisfaction score from 4.47 to 4.68. The p-value of 0.28914 is greater than 0.05, so the null hypothesis is not rejected. This may be because "Wait a Ride" requires multiple commuters to use it at the same time to show passenger demand, but low user density and time gaps reduced visibility. Also, while other route details were available, the fare matrix was viewed as unnecessary due to fixed Ikot route fare price. These may have limited perceived improvements.
4. **Service Adequacy**
   Service adequacy score decreased by 8.26% from 4.17 to 3.83 shown in Table 2. The p-value of 0.17702 is greater than 0.05, so the null hypothesis is accepted. The main factor was the unreliable passenger counter, which often lost connection due to poor signal along parts of the Ikot route. Inaccuracies in the counter may have lowered the perception of service adequacy.

Overall, the passenger satisfaction score increased by 1.84% from 4.45 to 4.53, shown in Table 2. The p-value of 0.9124 is not less than 0.05, so the null hypothesis is accepted. Hence, the test results are inconclusive due to the external factors discussed in each factor and may require further testing to determine statistical significance. Still, the upward trend in satisfaction suggests that the improvements in JeePS 2.0 were generally well-received. More importantly, the features of the system were complete and functional throughout the testing, which demonstrates that it is ready for use in a real-world setting.

Table 3. SUS Scores

Application	Sample Size	JeePS Score	JeePS 2.0 Score	Difference
Web	29	77.07	85.43	+8.36
Mobile	4	76.88	88.13	+11.25

6.2.2 Usability

1. **Web Application**
   Table 3 shows the average and final SUS scores from 29 passenger testers, both indicating good usability. JeePS scored 77.07 (80–84th percentile) and JeePS 2.0 scored 85.43 (96–100th percentile), showing improved usability in the newer version. The 8.36-point increase suggests better performance, supported by the Wilcoxon Signed-Rank Test ($p = 0.012$), which confirms the difference is statistically significant. Although percentile rankings offer useful context, they can still be affected by the number of respondents.
2. **Mobile Application**
   Table 3 presents the average and final SUS scores from four out of five drivers, both indicating good usability. JeePS received a final SUS score of 76.88, placing it in the 70–79th percentile, while JeePS 2.0 scored 88.13, corresponding to the 96–100th percentile. These results suggest a notable improvement in usability for JeePS 2.0 compared to the original version. However, this conclusion should be interpreted with caution due to the small sample size. Conducting a statistical test to compare the two scores would not yield reliable results with only four participants.

6.2.3 Importance In terms of feature importance, the Real-time GPS Location was ranked the highest by the participants. This highlights the strong value placed on being able to track jeepneys when commuting, where timing and visibility are crucial. Information Display came in second, emphasizing the importance of accessible information on routes and jeepneys. Rough Time Estimation ranked third, showing that user found this feature helpful for planning their trips. Lastly, the fare matrix ranked the lowest.

6.3 Domain Expert Validation

Dr. Villar appreciated that the APC is not disruptive, addressing a major issue in the previous JeePS version where the manual system posed safety risks to the drivers. He also agreed that the IR-based sensing is the most suitable implementation for APC, as video-based and floor-based sensing are expensive and require significant resources. He added that the APC is acceptable as long as it works in common scenarios, like single or multiple passengers entering or exiting. While not fully accurate in rare cases, such as when passengers hesitate at the entrance, it can be improved with more calibration and testing.

For the passenger demand summary, he noted that historical data helps drivers plan trips and that adding evidence like images can help verify feedback and reports.

Overall, it was validated that JeePS 2.0 covers the necessary features and addresses the challenges faced by the original JeePS.

7 Conclusion

The enhancements in JeePS 2.0 have directly aligned with the primary objective of further improving passenger satisfaction and service quality of jeepneys. Although test results were not statistically significant, most likely given the testing constraints, the slight increase in passenger satisfaction indicates that users received the improvements positively.

The addition of new features aligns with the objective of improving the software component of JeePS. These include image attachment for feedback and reports, an account penalty system, feedback and report moderation, demand visibility on the commuter's map, a driver's demand summary, an extended fare matrix, persistent location sharing with timeout, and live location sharing of passengers. The functional testing demonstrated that all 149 test cases passed, which confirms that the new features function as intended.

The integration of a hardware component, specifically the APC, aligns with the objective of automating passenger counting. The APC was implemented using IR-based sensing with 85.33% accuracy, mostly covering typical scenarios of passengers entering and exiting the jeepney. This level of performance demonstrates the feasibility and practicality of the hardware for optimizing jeepney services and supporting load-based decision-making.

The system was validated through multiple tests that align with the objective of ensuring its functionality, effectiveness, usability, reliability, and completeness. Functional testing verified that all improvements to the features worked properly. Field testing evaluated the effectiveness and usability of the web and mobile applications in a real-world environment. Lastly, a domain expert validated the system's reliability and completeness.

In conclusion, JeePS 2.0 delivered a functional, usable, complete, and reliable system that meets the objective of further enhancing passenger satisfaction and service quality of jeepneys.

8 Recommendations for Future Works

Based on insights from the field testing, future tests can simulate scenarios where users are required to use the report system to assess how fast safety concerns are addressed. This approach could enhance commuters' sense of security. It is also recommended to design tests with larger, concentrated groups or to schedule synchronized use of features such as the "Wait a Ride" to influence perceptions of drivers' behavior and information materials. Additionally, future tests can be conducted on routes with varying prices to better assess the effectiveness of the fare matrix. To improve service adequacy, the system could store passenger count and GPS updates locally, then periodically poll and send the latest data to the server once the mobile data connection is available. This wouldn't give true real-time updates, but it would reduce data loss and keep records consistent.

Building on the foundations of JeePS 2.0, extending the system to other types of PUVs, such as modern jeepneys and buses, would be beneficial for improving public transportation in future works.

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