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Original Article

A TRACKMON: INNOVATIVE BUS TRACKING AND MONITORING SYSTEM

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Abstract: The purpose of TrackMOn is to provide a solution to the challenges that passengers have while attempting to follow bus locations, schedules, and routes, which are frequently inefficient or unavailable. This results in extended waiting times, uncertainty, and unpredictable delays, particularly during off-peak hours, which makes it difficult for individuals who have set schedules to arrange their visits. In order to address these issues, TrackMOn offers a cutting-edge solution that enables real-time bus tracking and monitoring, as well as anticipated arrival times, through an application that is simple to use. By providing users with the ability to make educated decisions regarding their travel routes and schedules, the system improves the effectiveness and convenience of public transit. Super Admin, Admin, and User are the three primary modules that make up the system functions. Each of these modules is accountable for a certain set of responsibilities. Functional suitability, performance efficiency, reliability, usability, and compatibility were the primary elements that were evaluated during the examination. The findings indicated that users were extremely satisfied with the system, as indicated by the overall mean score of 4.87 (Strongly Agree), which highlighted the system's high level of responsiveness, effectiveness in tracking, and ease of use. In general, the system enhanced the monitoring and control of transportation schedules and routes by lowering the amount of uncertainty that users experienced and reducing the amount of time that they had to wait. This project contributes to the achievement of Sustainable Development Goal 9 (Industry, Innovation, and Infrastructure).

Keywords: *Bus Tracking, Monitoring System, Web-based, Android-Based, Real-Time Data, SDG 9: (Industry, Innovation, and Infrastructure)*

Introduction

New bus tracking and monitoring technology has changed the way public transit works. This system uses cutting-edge technologies to let you track things in real time, which makes things more efficient and convenient. To cut down on waiting times and uncertainty, customers may see when their buses will arrive. This way, consumers have a smooth and stress-free experience with the bus tracking and monitoring system, which makes daily travel easier. The device also helps drivers and conductors by giving them fast updates that help them make better decisions while on the road. It also makes service better by letting administrators keep an eye on how well the system is working, which leads to reliable and efficient transportation services.

The growing need for dependable public transportation has resulted in the implementation of GPS- and IoT-based tracking systems, which provide real-time updates and enhanced operational efficiency (Namithadevi & Hira Bai, 2023). However, despite these technological advancements, several studies highlight persistent challenges that limit the effectiveness of such systems in real-world deployment. For instance, inaccuracies in real-time updates have been attributed to GPS signal instability, network latency, and inconsistent data transmission, which may result in delayed or misleading location information for both operators and passengers (Al-Hawari *et al*., 2020). These inaccuracies can negatively affect trust in the system, particularly when reported bus positions or travel distances do not align with actual movement.

In addition to data accuracy concerns, usability issues remain a significant barrier to the successful adoption of GPS-based transport monitoring systems. Bagad *et al*. (2024) emphasize that complex interfaces, poorly designed dashboards, and limited visualization capabilities often hinder users' ability to interpret system-generated data effectively. This challenge is particularly evident in systems that present aggregated metrics—such as average passenger trips or total distance travelled—without sufficient contextual explanations, interactive features, or intuitive visual cues. As a result, even technically accurate systems may receive lower usability ratings due to difficulties in interpretation and decision-making.

Furthermore, inequitable or inefficient route design has been identified as a structural issue that technology alone cannot immediately resolve. Baumgartner *et al*. (2024) note that route optimization algorithms may unintentionally favor certain corridors or demand patterns, potentially leading to uneven service distribution. When monitoring systems fail to clearly visualize route performance and passenger-demand trends, transport planners may find it difficult to identify inefficiencies or to redesign routes fairly and effectively. Hardware-related limitations also continue to affect system reliability and performance. According to Mundada *et al*. (2023), constraints such as low-cost GPS modules, limited sensor precision, power instability, and environmental interference can reduce data

accuracy and system responsiveness. These constraints are particularly relevant in developing transport environments, where cost considerations often necessitate the use of budget hardware components. Consequently, performance degradation at the hardware level may propagate through the system, affecting reporting accuracy, visualization quality, and overall user satisfaction.

Taken together, these studies suggest that while GPS- and IoT-based transportation systems offer significant benefits, their success depends not only on data collection but also on system usability, visualization clarity, algorithmic fairness, and hardware reliability. These challenges provide critical context for the present study, as they help explain why certain visualization indicators—such as average successful passenger trips and distance travelled by each bus—may receive lower evaluation scores despite the overall effectiveness of the TRACKMON system

However, these technological issues indicate that trip planning isn't reliable because it lacks the speed and accuracy it requires. Without real-time updates, customers may have to wait longer and not know when their bus will depart. This is especially true as buses may wait until they are full before leaving. This issue is especially problematic during off-peak hours, causing additional delays and making it difficult for people with set schedules to rely on public transportation.

To address these challenges, the researcher created a "TrackMOn: an innovative bus tracking and monitoring system" aimed at enhancing the efficiency and convenience of public transportation through real-time bus tracking, guaranteeing punctual arrivals, minimizing waiting times, and enriching the commuting experience, as shown in Figure 1. Also, the TrackMOn system helps make the future more sustainable by supporting important Sustainable Development Goals (SDGs). It supports SDG 9 (Industry, Innovation, and Infrastructure) by enhancing public transportation infrastructure through new technologies that improve reliability and efficiency.

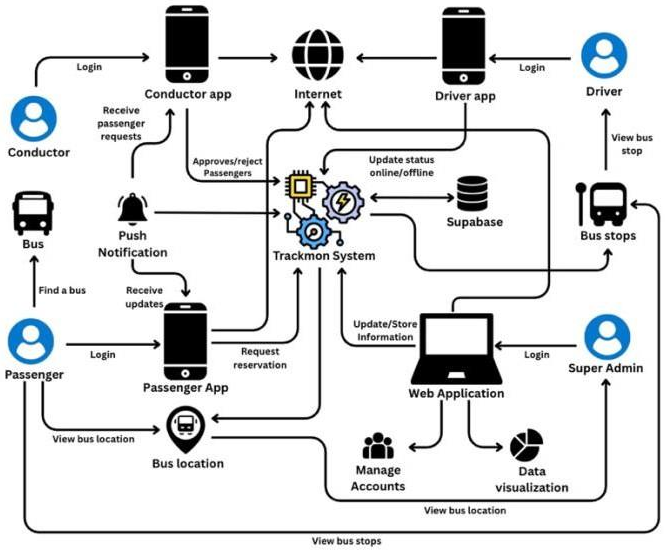

Figure 1. *Conceptual Framework of the Study*

Methods and Materials

To make sure that the TrackMOn Innovative Bus Tracking and Monitoring System worked well, accurately, and reliably, the developers used a systematic software development process and combined different hardware and software parts. The project used hardware to set up the system, software tools and technologies to build it, the Agile Methodology as the Software Development Life Cycle (SDLC) model, and a Level-0 Data Flow Diagram (DFD) to show how data moves and how the system interacts with other systems. All of these parts worked together to make the design, development, and testing processes go smoothly, which were all needed for the system to work and operate well.

Hardware Was Used

The hardware utilized to build the system was made to work well with computers that run Windows 11 Home. The development environment needed a CPU that could perform system simulations and coding duties. The AMD Ryzen 5 5500U with Radeon Graphics, which has 6 cores and 12 logical processors running at 2.10 GHz, was the right one. A minimum of 8GB of RAM was needed to make sure that system development and testing went smoothly, and that multitasking worked well. Also, a Solid-State Drive (SSD) was needed to store development tools, libraries, and databases, with space ranging from 800MB to 210GB. With this design, the system could run integrated apps and do real-time monitoring without any lag or drop in performance.

Used Software

The software environment has a lot of different tools and technologies that work together to construct and set up the TrackMOn system. Visual Studio Code is an Integrated Development Environment (IDE) that gives programmers a flexible and efficient place to write code. Supabase, an open-source backend-as-a-service platform for managing databases, authentication, and real-time data operations, supported the backend infrastructure. For frontend development, SvelteKit and TailwindCSS were utilized—SvelteKit for constructing dynamic and responsive web interfaces, and TailwindCSS for efficient and consistent style. FlutterFlow, a low-code development platform, was also used to speed up the process of making the mobile app part, which made it easier to make prototypes and release them. Google Maps API was added to add location-based functionality, which made it possible to track and map buses in real time. All of these technologies together made a strong and up-to-date technical stack that made sure the system could grow, be easy to maintain, and have a user-friendly interface.

Used Data

TrackMOn Innovative Bus Tracking and Monitoring System data includes all necessary information gathered, structured, and used to support its features and functions. This data underpins the system's operations, ensuring that booking, tracking, notification, and

management work properly. The dataset simulates real-world transactions and user interactions, allowing thorough system performance and reliability testing.

Thus, the system uses “Booking sample data” from the booking table, which contains passenger booking details. Booking IDs, passenger names, bus details, route information, fare amounts, and booking date and time timestamps are included. The system uses this table to handle reservations, verify seat availability, and create passenger activity reports.

In addition to the booking table, other connected tables represent system components and operations. The admit stores platform administrators' information. The bus list lists bus plate numbers, capacity, and routes, whereas the bus stops list bus stops and their locations to aid route mapping. Drivers’ and conductors' personal and professional information is stored in the driver and conductor tables for accountability and scheduling.

Users receive alerts and announcements about bus timetables, delays, and route changes via the notification. Passenger contains user credentials and contact details for account-based bookings and personalized notifications. The route sets the travel pathways and destinations between bus stops, whereas the trip records start and end points, drivers and conductors, and trip statuses.

These linked tables comprise a well-structured relational database that ensures system-wide data flow, consistency, and integrity. This unified data structure allows TrackMOn to provide real-time tracking, fast booking administration, and accurate reporting to improve public transit monitoring and customer experience.

Research Design

The TrackMOn adopted the Agile SDLC model, as shown in Figure 2, which combines an iterative and incremental process that focuses on adaptability for customer satisfaction.

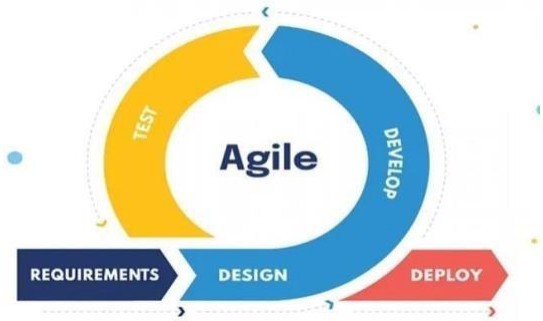

Figure 2: *Agile Methodology*

Dataflow Diagram

An automated level-0 data flow diagram is incorporated into the design of the system. This diagram features three main entities: the Super Admin, the Admin, and the User. Based on the information presented in Figure 3.1, the Super Admin is responsible for managing

information concerning passengers, conductors, drivers, notifications, routes, and bus stops. The Conductor, an administrative function, is depicted in Figure 3.2. This role is responsible for handling notifications, processing booking approvals, and setting bus availability. As depicted in Figure 3.3, the Driver, who also holds the admin position, is able to observe the present bus stop locations as well as the impending stops. As shown in Figure 4.4, the Passenger, in their capacity as the User, has the ability to create an account, make booking requests, and then communicate these requests to the Conductor on their behalf. It is possible for passengers to obtain confirmations and updates regarding their reservations.

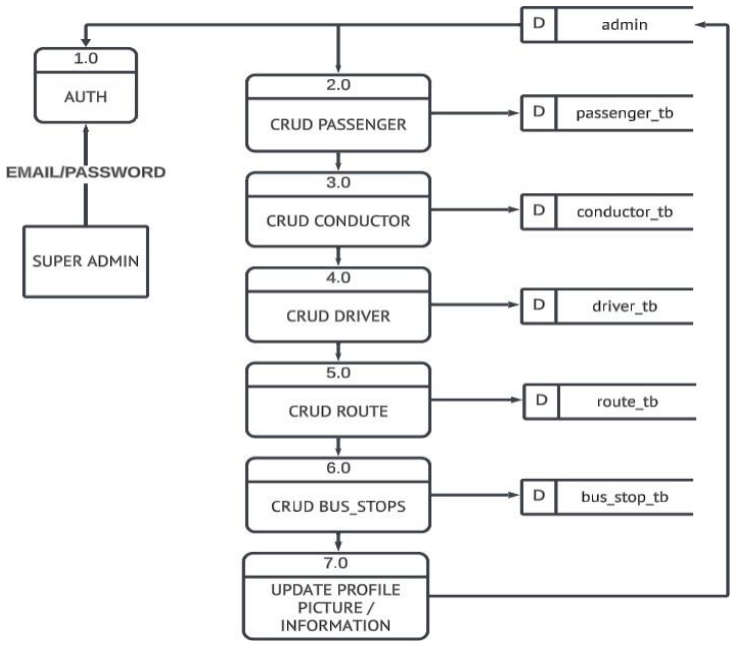

Figure 3.1. *Level 0 Super Admin Data Flow Diagram of the Project*

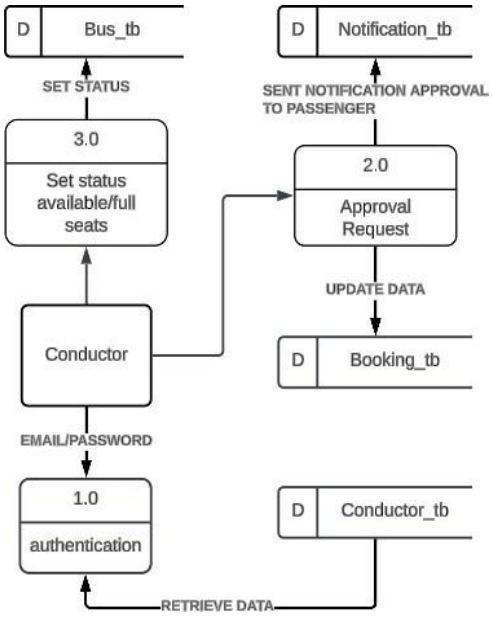

Figure 3.2. *Level 0 Conductor Data Flow Diagram of the Project*

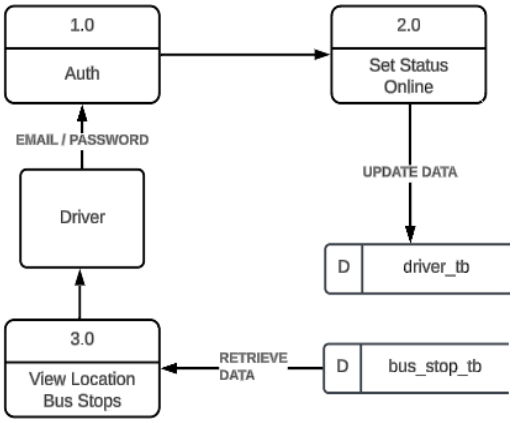

Figure 3.3. *Level 0 Driver Data Flow Diagram of the Project*

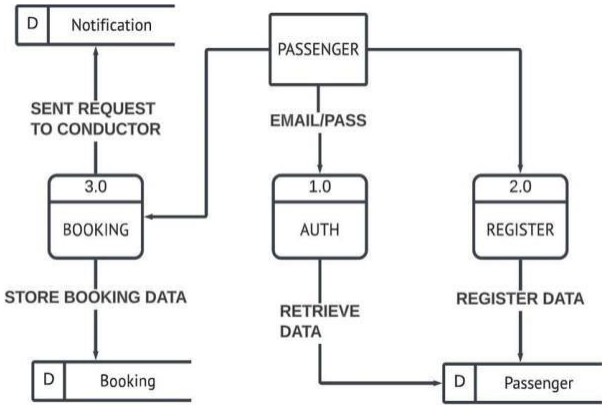

Figure 3.4. *Level 0 Passenger Data Flow Diagram of the Project*

Testing and Evaluation

The research was conducted using an approach known as purposive sampling, which entails selecting participants who have the necessary knowledge, experience, and involvement in the study in order to provide accurate data and ensure that all participants are represented fairly. for the purpose of determining the reliability and consistency of the system. It was the Likert scale method that the researcher adopted. The formula for the equation that is used to calculate the mean value is shown below. The average score will be computed by dividing the total number of scores by the total number of respondents. The weighted mean will then be used to assess the influence that the TrackMOn system has had on the respondents. This allows for the determination of the system's impact on the respondents.

$$\overline{X} = \frac{\sum X}{N}$$

Where;

$\overline{X}$ = represents the score

Σx = represents the sum of all scores from every evaluator

n = represents the total number of evaluators

The distribution of respondents is illustrated in Table 1. The respondents are requested to evaluate the TrackMOn system and provide opinions using the Likert Scale method, which comprises five categories: Strongly Agree, Agree, Fairly Agree, Disagree, and Strongly Disagree. The questionnaire was adapted from the International Standard Organization's (ISO) Software Quality Model 25010, and twenty-two (22) respondents served as distribution evaluators. They assessed the study's functional suitability, performance efficiency, reliability, usability, and compatibility.

Table 1. *Distribution of Respondents*

Evaluators	**Sample Size**
IT Experts	5
Bus Drivers	5
Bus Conductors	5
Bus Manager	1
Passengers	6
TOTAL	22

Result and Discussion

The results and discussion of the project "TrackMOn: Innovative Bus Tracking and Monitoring System" are presented in this section. It describes the system's performance in accordance with the data that has been collected and emphasizes the most significant discoveries. The analysis concentrates on the extent to which the system achieved the intended objectives and its capacity to enhance the commuter experience and bus monitoring.

The Innovative Bus tracking and monitoring system is deployed by the researcher through the acquisition of a cloud-based SaaS project, the application of Cloudflare Services, the intelligent use of Supabase, and the potent capabilities of FlutterFlow. This method guarantees that the system is accessible to both super admins, admins, and users in real time.

Super Admin Account Module Dashboard

Figure 4 demonstrates the Super Admin Module of the TrackMOn Innovative Bus Tracking and Monitoring System, which displays the primary user interface of the administrative dashboard. This module functions as the central control panel for system administrators, enabling the efficient administration of all system components and providing a comprehensive overview of key operational metrics. The dashboard is designed with a user-friendly interface and intuitive architecture, which allows the super admin to monitor, analyze, and control the various aspects of the system in real time.

A series of summary panels is displayed at the top of the dashboard, each of which emphasizes critical information regarding the system's current status. The total number of registered passengers, buses (with distinctions between active and inactive units), drivers (categorized as online or offline), and conductors (also identified as online or offline) is all included. The administrator can promptly evaluate the system's activity and detect any potential issues or irregularities, such as inactive buses or offline drivers, that may impact operations, using these metrics. A graphical data visualization component is located beneath the summary section, providing a visual representation of the total number of passengers per day or the number of passenger journeys per day. This chart offers administrators a comprehensive analysis of commuter activity, enabling them to monitor system performance, peak travel times, and utilization trends over specific time frames. Date pickers are integrated to increase flexibility, enabling the super admin to filter and observe data within a specified date range. This feature facilitates data-driven decision-making by facilitating the focused analysis of specific operational intervals.

A sidebar navigation menu is located on the left-hand side, which offers access to a variety of administration functions and modules. This comprises connections for the management of passengers, buses, routes, drivers, conductors, notifications, and system settings. The super admin can more easily oversee system operations, update information, and maintain service efficiency due to the sidebar's organized structure, which ensures smooth navigation and fast access to critical administrative tools.

In general, the Super Admin Module functions as the TrackMOn system's command center, providing real-time monitoring and analytical capabilities. The dashboard enables administrators to guarantee data accuracy, deliver a seamless experience for both operators and passengers, and maintain optimal system performance by integrating visual summaries, interactive data charts, and structured management controls.

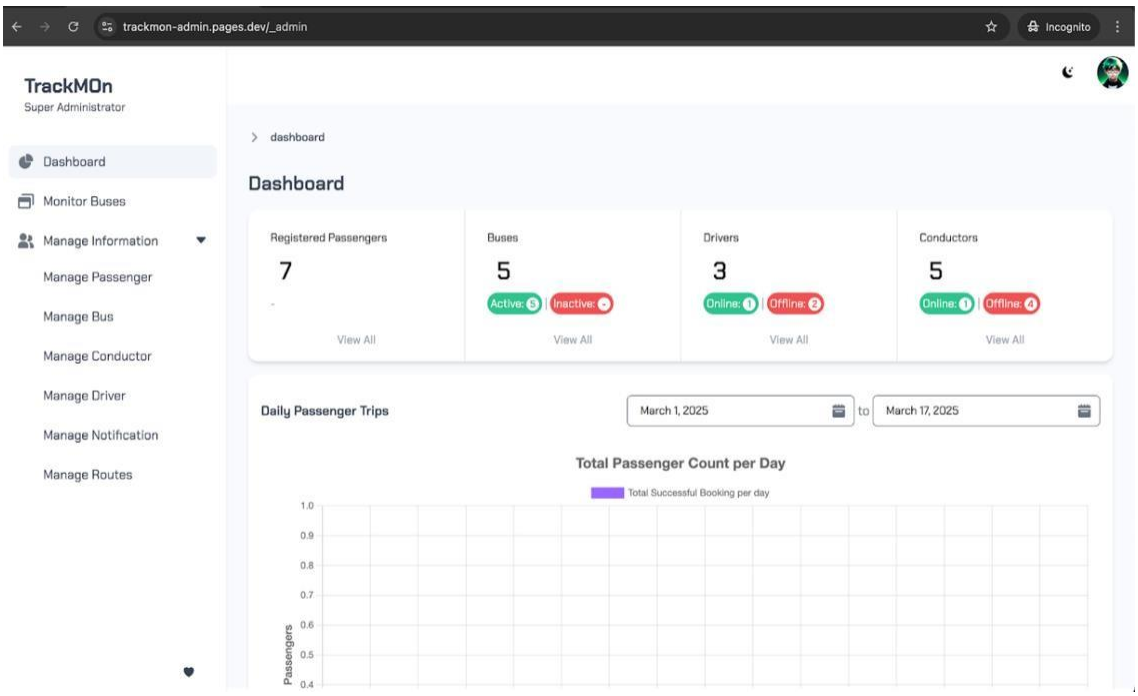

Figure 4. *Super Admin User Interface Dashboard*

Module for Super Admin Accounts in Conductor Information Management

Figure 5 shows the user interface of the Super Admin Module, which is specifically designed to manage conductor information within the TrackMOn Innovative Bus Tracking and Monitoring System. This module is essential for the proper organization, monitoring, and maintenance of all conductor accounts that are registered in the system. It facilitates the efficient management and supervision of personnel who are actively involved in bus operations by providing the super administrator with a clear and systematic view of conductor-related data. A comprehensive data table that lists all registered conductors in the system is the foundation of this interface. The conductor's full name, email address, account status (indicating whether the conductor is presently online or offline), and the date the account was created are all included in each record in the table. The super admin can promptly verify conductor information, monitor real-time activity, and identify those who are available or active in the field as a result of this organized presentation.

Additionally, the module includes a variety of interactive functions that are intended to improve operational efficiency and user convenience. The supreme administrator can effortlessly locate a particular conductor by inputting keywords such as a name or email address into the search bar located at the top of the interface. This function is especially beneficial when managing a large number of documents, as it reduces the time required to access or update information. Furthermore, pagination controls are incorporated at the bottom of the table to facilitate the efficient management of data display. This enables the administrator to navigate through multiple pages of conductor profiles without overwhelming the screen with an excessive amount of information at once.
Additionally, the interface features an "Add New Conductor" feature that enables the supreme admin to seamlessly register new personnel into the system. In order to guarantee that the new conductor is properly identified and authenticated, it is possible to input pertinent information, including their name, contact information, and credentials, when establishing a new account. This feature guarantees that the TrackMOn system is accessible only to authorized users, thereby ensuring accountability and security.

In general, the Super Admin Account Module for Managing Conductor Information functions as a centralized and efficient management utility. It enables the supreme administrator to supervise conductor-related activities, maintain precise personnel records, and guarantee seamless coordination among staff members who are involved in daily bus operations. This module significantly enhances the system's overall efficiency, transparency, and ease of administration by integrating a practical administrative tool kit with an intuitive interface**.**

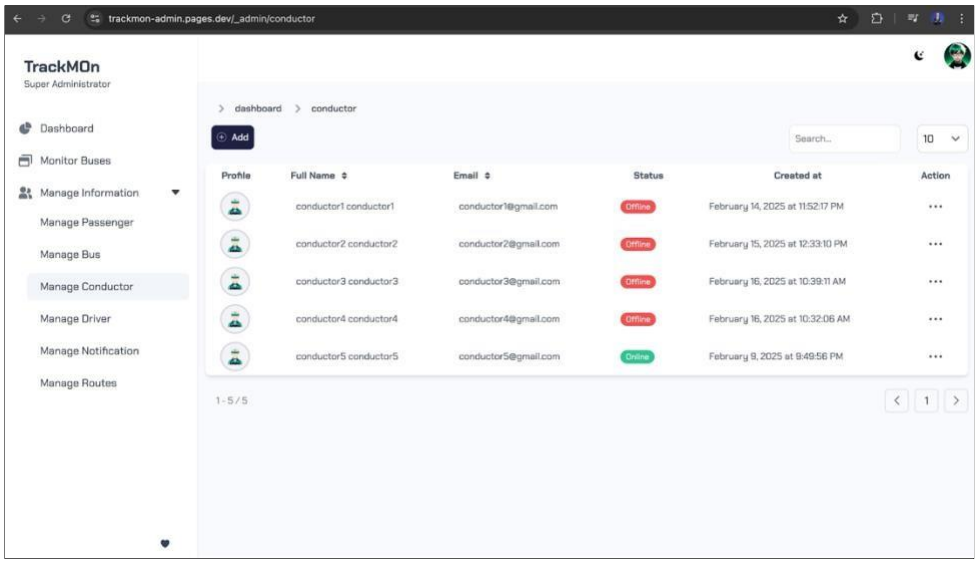

Figure 5. *Super Admin User Interface for Managing Conductors*

Module for User Accounts in Request Reservation

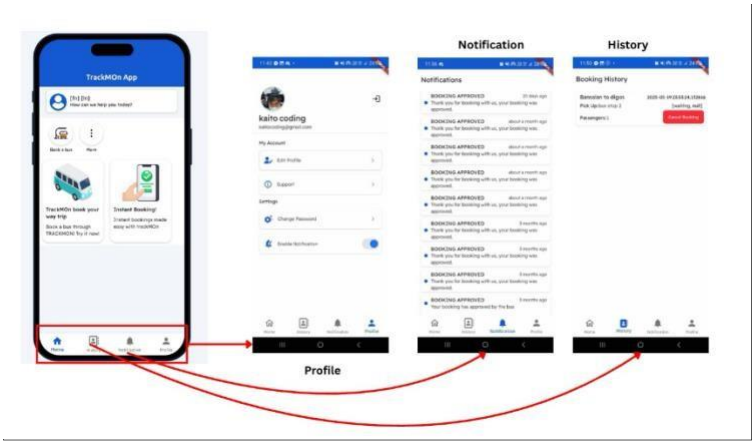

Figure 6. *Super Admin User Interface for Managing Conductors*

The Request Reservation process within the TrackMOn Innovative Bus Tracking and Monitoring System is the primary focus of the User Account Module, as illustrated in Figures 6 and 7. This module is a fundamental component of the system, and it is intended to offer passengers a convenient and efficient method of reserving bus seats in advance. Within a few straightforward steps, users can effortlessly browse available bus journeys, select their preferred routes and schedules, and finalize the booking process through this interface. The module's intuitive design guarantees a seamless user experience while simultaneously reducing errors and improving the overall efficacy of bus reservation management.

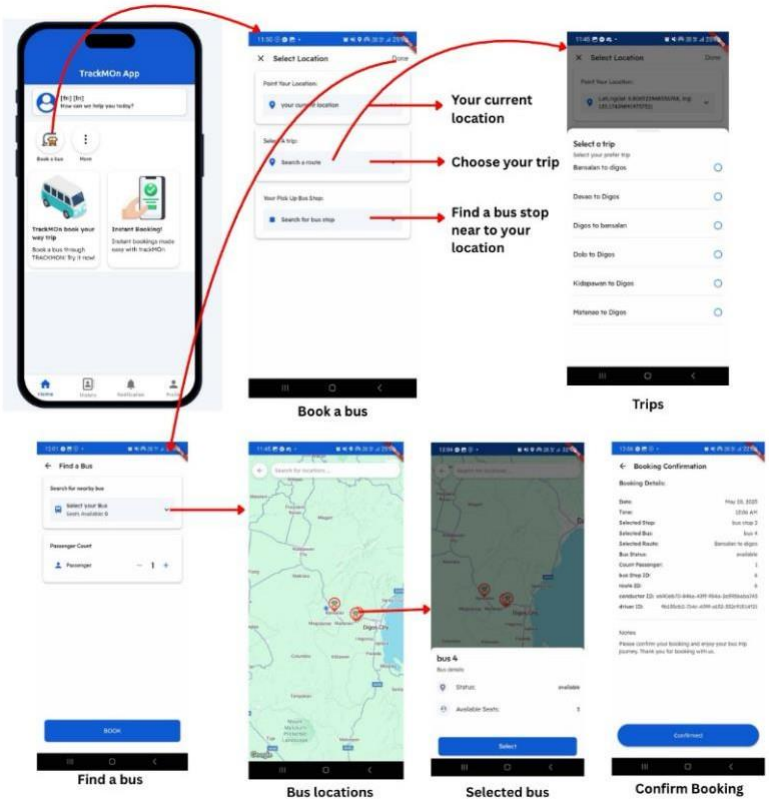

Figure 7. *User Interface for Booking Reservation*

The user is initially presented with the primary navigation and action icons on the homepage, where the process begins. The passenger clicks the "Find Buses" button to initiate a reservation, which results in a dynamic list of buses available for booking. The list includes essential voyage details such as the bus name or number, route, schedule, and current seat availability. To support rapid, precise decision-making, the system filters and organizes this information.

After the inventory of buses is displayed, the passenger can browse and select a bus marked as "Available." A "Book Now" button is prominently displayed for each available bus, enabling the user to begin the booking process. Selecting this button directs the user to the seat selection interface, where they can view a visual representation of the bus's seating arrangement. The user can choose their preferred seats from the available options, ensuring a comfortable travel experience that aligns with their preferences. The system prevents double bookings and ensures real-time seat status accuracy by automatically disabling or graying out seats that are already reserved.

After the passenger has selected the desired quantity of seats, the system advances to the confirmation page. The reservation details are summarized on this page, including the bus name, route, travel schedule, selected seats, and total fare amount. The user is then prompted to examine and verify all of the information before completing the request. The system ensures that the passenger is advised of their successful reservation by recording the booking request in the database and sending a confirmation message or notification.

In general, the User Account Module in Request Reservation is essential for improving the system's efficacy and the convenience of passengers. It streamlines the process of locating and reserving buses, minimizes waiting time, and guarantees a dependable seat reservation experience. By integrating features such as visual seat selection, real-time bus availability, and detailed booking confirmation, this module significantly enhances the overall functionality and user satisfaction of the TrackMOn system.

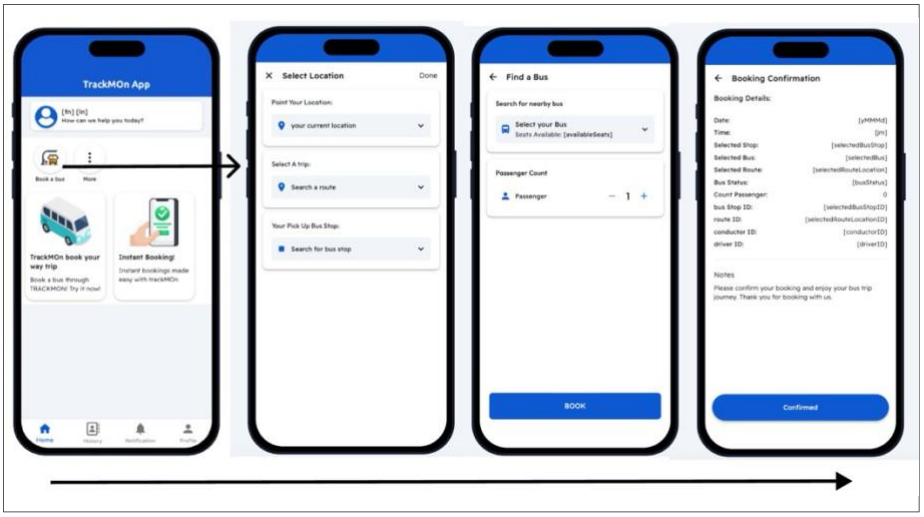

Figure 8. *Passenger Request Reservation in User Module*

Admin Account Module for Drivers to View Assigned Bus Information and Upcoming Stops

The Driver Application within the TrackMOn Innovative Bus Tracking and Monitoring System is supported by the Admin Account Module interface, as illustrated in Figure 9. This module primarily aims to provide drivers with real-time access to their assigned bus details, passenger information, and upcoming stops, which is vital for effective management and monitoring of bus operations. It enhances coordination, accuracy, and efficiency in transportation activities by enabling communication between the administrative system and the drivers. The graphical user interface (GUI) of this module is designed to offer drivers an intuitive experience, emphasizing simplicity, clarity, and functionality in their daily tasks.

The driver's workflow is streamlined through the integration of three main screens within this module. The initial interface, the Login Page, allows drivers to securely access their accounts. To ensure only authorized personnel gain entry, this page requires authentication via a valid username and password. During this process, the driver’s identity is verified, and personalized data associated with their account—including assigned routes, schedules, and operational details—is retrieved. This approach bolsters data security and accountability within the system.

Upon successful login, the driver is directed to the Dashboard Screen, which serves as the primary control interface for viewing critical trip-related information. The dashboard

provides an overview of essential operational details such as the bus number, route name, and schedule of the assigned bus. Additionally, it displays real-time passenger data, allowing the driver to monitor the number of passengers onboard or scheduled for pickup.

A crucial feature of the dashboard is the list of upcoming stops, presenting a concise sequence of destinations or pickup points along the route. This structured presentation ensures adherence to the travel sequence and promotes punctuality at each stop.
The third component of the module includes an interactive map view, visually depicting bus stops and pickup points. This map, integrated with real-time location tracking using services such as Google Maps, enables drivers to observe their current positions relative to upcoming destinations. It facilitates navigation, reduces route confusion, and ensures drivers can readily identify each stop along their journey. The visual depiction of routes and stops further enhances operational awareness, particularly when dealing with traffic variations or route modifications.

Overall, the Admin Account Module for Viewing Upcoming Stops and Assigned Bus Information enhances the efficiency and transparency of bus operations within the TrackMOn system. This module allows administrators to oversee performance and maintain service reliability, while equipping drivers with tools such as real-time mapping, informative interfaces, and secure login access for effective route management. Consequently, this results in a more organized, data-driven transportation system that promotes punctuality, safety, and improved passenger satisfaction.

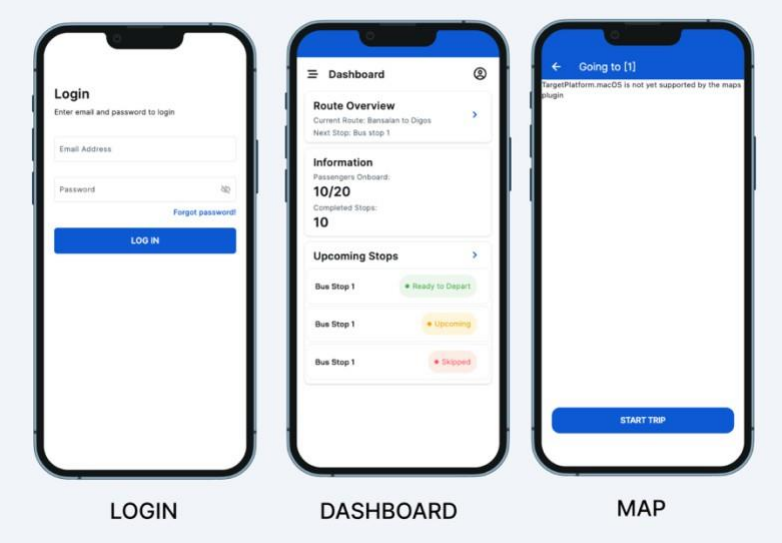

Figure 9. *Driver User Interface for Admin Module*

Admin Account Module in Viewing Details assigned bus for Conductor

Figure 10 of the TrackMOn Innovative Bus Tracking and Monitoring System Admin Account Module illustrates the Conductor User Interface. This module provides

conductors with trip details, bus information, and personal account management features to facilitate bus operations. It ensures that conductors have access to accurate, current route and schedule data, thereby enhancing accountability, coordination, and efficiency within the transportation system. The interface's three primary displays perform essential functions integral to the conductor's daily workflow.

Conductors access the system securely via the Login Interface. This portal requires user authentication through the conductor's email and password prior to gaining access to system data. The "Forgot Password" link facilitates password recovery, while the "Login" button verifies credentials and grants access to the conductor's dashboard. This secure authentication process safeguards critical data by restricting bus details and travel schedules to authorized personnel.

Upon successful login, conductors are directed to the Dashboard Screen, where they can view and manage operational data. This panel prominently displays the conductor's scheduled trips and bus information. A conductor without an assigned bus appears on the dashboard as "Not Assigned Bus," indicating that the Super Admin must allocate a vehicle and route to the conductor. The clear identification of staff awaiting assignment fosters collaboration between administrators and conductors. The dashboard may also present real-time passenger status updates, route changes, operational announcements, and trip timetables.

Conductors can manage their accounts through the third interface, the Profile Interface. This section displays the conductor's name, email address, and profile picture, allowing for account customization and management. Options such as Edit Profile, Account Settings, Enable Notifications, and Logout are provided. These functionalities enable conductors to update their personal information, modify their notification preferences related to trips or announcements, and securely log out at the end of their session.

The Admin Account Module for Viewing Assigned Bus Details for Conductors is vital to the operational efficiency, communication, and transparency of TrackMOn. By providing conductors with secure login access, an informative dashboard, and straightforward profile management capabilities, this module ensures that staff remain connected to their responsibilities and informed. This optimized digital process minimizes administrative errors, enhances service reliability, and streamlines transportation operations.

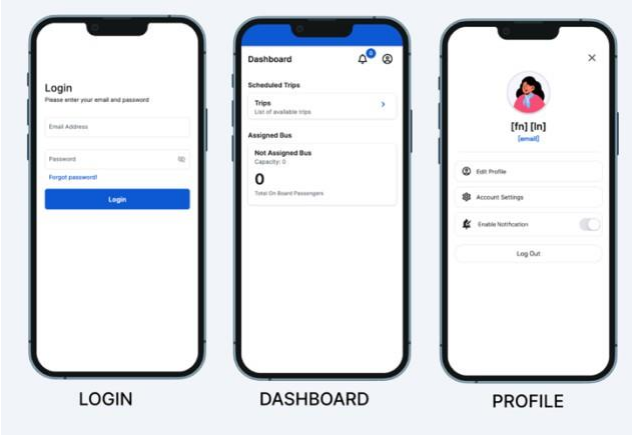

Figure 10. *Conductor User Interface for Admin Module*

User Account Module in Tracking and Monitoring Bus Locations

Figure 11 illustrates the User Account Module interface, designed to track and monitor bus locations within the TrackMOn Innovative Bus Tracking and Monitoring System. This user-centric module is an essential feature of the system, allowing passengers to plan their journeys efficiently and gain real-time visibility into bus movements. The design prioritizes interactivity, clarity, and convenience, ensuring that users can comfortably navigate the system and access real-time transportation data.

Passengers can access a variety of functionalities through the module's homepage. The "Book a Bus" service is prominently displayed, enabling users to directly request and reserve a seat from the same page. The homepage also includes straightforward step-by-step instructions that guide passengers through the booking process, improving accessibility and ensuring seamless navigation. These instructions help both new and returning users efficiently search for available buses, select routes, and finalize their reservations, thereby enhancing the overall user experience and reducing confusion.

The system displays an interactive map view on the right-hand side of the homepage, providing real-time visualization of bus locations. Through integration of JavaScript, the Google Maps API, and GPS technology, this feature enables dynamic rendering of data. The system continuously updates the positions of active buses on the map, allowing passengers to monitor bus movements in real time along their itineraries. Users are typically provided with precise, current location information through identifiable symbols or markers that move in accordance with the bus's movement.

Passengers gain numerous practical benefits from this real-time monitoring feature. They can determine the distance of the bus from their stop, estimate the arrival time, and make informed travel decisions, such as when to depart for pickup points or whether to modify their travel plans. This feature significantly improves convenience, particularly during peak hours or in unpredictable traffic conditions, by reducing waiting periods and enhancing communication between the transport service and its passengers.

In general, the User Account Module for Tracking and Monitoring Bus Locations illustrates the TrackMOn system's dedication to user satisfaction, efficiency, and innovation. This module revolutionizes the conventional commuting experience by integrating booking capabilities, an intuitive interface, and live GPS tracking data. It promotes transparency, empowers passengers with real-time information, and contributes to a more reliable and intelligent public transportation environment.

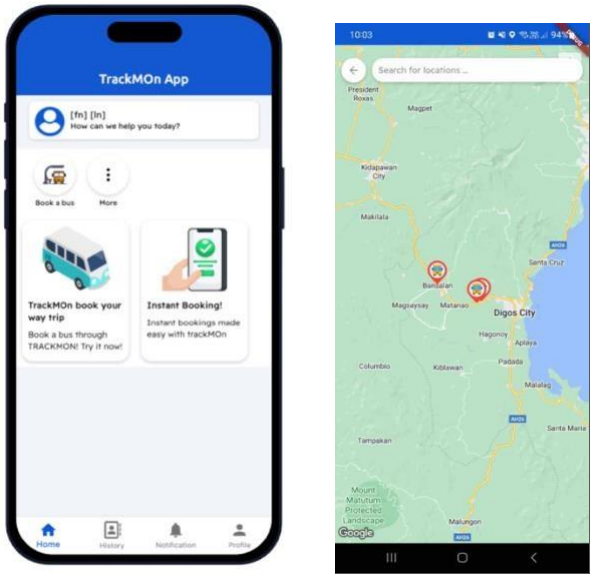

Figure 11. *Passenger User Module*

Visualization of Successful Passenger Trips and Distance Travelled by Each Bus

As part of the system evaluation of TRACKMON: Innovative Bus Tracking and Monitoring System, selected indicators within the Monitoring and Reporting Module were assessed to determine their efficacy in presenting operational data to users. Among these indicators, the Visualization of Average Successful Passenger Trips and the Visualization of Distance Travelled by Each Bus received comparatively lower ratings than other system features, although both remained within the acceptable range.

Table 4. *Evaluation on Visualization of Passenger Trips and Distance Travelled by Each Bus. May 2025*

Indicator	**Mean**	**Standard Deviation**	**Verbal Interpretation**
Visualization of Average Successful Passenger Trips	*3.67*	*0.69*	*Acceptable*
Visualization of Distance Travelled by Each Bus	*3.61*	*0.74*	*Acceptable*
Overall Monitoring & Reporting Module	*4.18*	*0.56*	*Very Acceptable*
Overall System Mean	*4.23*	*0.52*	*Very Acceptable*

The results in Table 4 indicate that, although the overall system performance was rated Very Acceptable, the two visualization indicators scored approximately 0.5–0.6 points below the overall system mean. This gap suggests the presence of specific technical or usability-related factors that affect users' perceptions of these features.

The evaluation results indicate that TRACKMON effectively fulfills its primary purpose of tracking and monitoring bus operations. However, the relatively low ratings for visualization-related indicators highlight areas for further improvement in data presentation and system responsiveness.

These findings do not indicate fundamental system weaknesses but rather highlight opportunities for refinement in visualization design, GPS data handling, and reporting algorithm optimization. Enhancing these aspects would likely improve user confidence, interpretability, and overall satisfaction with the system's monitoring features.

Visualization of Average Successful Passenger Trips

The visualization of average successful passenger trips, as shown in the figure above, is a critical metric for evaluating route efficiency, passenger demand, and operational performance. Despite the system's ability to compute and display this data accurately, respondents rated this indicator with a mean score of **3.67**, indicating only Acceptable satisfaction.

One contributing factor to this result may be **limitations in the user interface (UI) design**. Although the system presented passenger trip averages through bar graphs and tabular summaries, respondents noted that the visualizations lacked interactive controls such as date-range selection, route filtering, and drill-down views per bus unit. This limited flexibility may have reduced the clarity and usefulness of the data, especially for decision-makers who require comparative and trend-based analysis.

Additionally, computing average successful passenger trips involves aggregating multiple datasets, including completed trip records, passenger counts, timestamps, and route identifiers. The **complexity of this reporting algorithm** may have resulted in delayed updates or summary-level outputs that did not fully reflect real-time operational changes. As a result, users may have perceived the visualization as less responsive or less informative, contributing to the lower evaluation score.

Visualization of Distance Travelled by Each Bus

The indicator shown in Figure 4, Visualization of Distance Travelled by Each Bus, received a mean score of 3.61, the lowest among the evaluated monitoring indicators. This metric relies heavily on continuous GPS-based tracking, making it sensitive to external and technical constraints. GPS data latency and signal reliability are likely contributing factors to the observed evaluation result.

During system operation, slight delays were noted between actual bus movement and the reflected distance values on the monitoring dashboard. In areas with weak mobile network coverage, intermittent GPS signal loss may have caused temporary gaps in distance tracking, leading to minor inconsistencies in reported values.

From the user's perspective, these inconsistencies may have reduced confidence in the accuracy of the distance visualization, even if total distance computations remained generally correct. Furthermore, the system primarily displayed distance data in numerical and static chart formats.

The absence of map-based distance overlays or animated route traces may have limited users' ability to intuitively verify and interpret the displayed values.

***Table 5**. Evaluation Ratings of TrackMOn Functional Suitability for Super Admin module. May 2025*

Particulars	**Mean**	**Verbal Interpretation**
Manage Drivers.	5.00	Strongly Agree
Manage Conductors.	5.00	Strongly Agree
Manage Passengers.	4.9	Strongly Agree
Manage Routes.	4.8	Strongly Agree
Manage Buses.	4.9	Strongly Agree
Manage Notifications.	4.8	Strongly Agree
Display Total Number Of Passengers.	5.00	Strongly Agree
Display Total Number Of Buses.	4.9	Strongly Agree
Display Total Number Of Online Drivers.	4.9	Strongly Agree
Display Total Number Of Online Conductors.	4.9	Strongly Agree
Displays Visualization Of Average Successful Passenger Trips Per Day.	4.2	Agree
View Distance Travelled By Each Bus.	4.1	Agree
Displays Daily Successful And Cancelled Bookings Per Driver.	4.9	Strongly Agree
Add Routes And Bus Stops.	4.9	Strongly Agree
Consolidated Mean	4.8	**Strongly Agree**

Evaluation ratings from the respondents in terms of Functionality

Table 5 presents Super Admin users' descriptive ratings of the TrackMOn Innovative Bus Tracking and Monitoring System's functionality. The results show how well the system supports administrative services such as people, bus, route, and data visualization for overall operations management. The consolidated mean of 4. 4.8 indicates that respondents "Strongly Agree" that the TrackMOn system is functionally adequate and useful for Super Admins.

The system achieved scores of 4. 4.8 to 5. 5.0 across most indicators, suggesting that most features are well- implemented and aligned with user needs. The ability for Super Admins to supervise drivers, conductors, and passengers received a perfect mean of 5. 00, indicating high satisfaction and usability. These findings show that administrative control and oversight functions are efficient, allowing Super Admins to easily monitor and manage important system components.

Passenger management (4. 9), routes (4. 4.8), buses (4. 9), and notifications (4.8. 8) also received "Strongly Agree" ratings, demonstrating the system's reliability. These components are crucial for seamless transport operations, and their high ratings indicate that the TrackMOn system has a simple interface for data entry, modification, and retrieval.

The system's interface, which shows the number of buses (4. 4.9), online drivers (4. 4.9), and online conductors (4. 4.9), was also well appreciated. These results show that

TrackMOn provides accurate, real-time data visualization for administrative decision-making and operational monitoring.

However, “The system displays visualization of average successful passenger trips per day” (4.2. 2) and “The system allows Super Admin to view distance travelled by each bus” (4.1. 1) were scored somewhat lower, read as “Agree.” Although still highly rated, these scores show that while the functions are functional, data presentation, accuracy, and interpretation might be improved. Graphical analytics and distance-tracking precision could improve system reporting and monitoring.

Finally, Super Admins' ability to add routes and bus stations had a strong mean of 4. 4.9, demonstrating the system' s flexibility and scalability for operational adjustments and route extensions.

Overall, the TrackMOn system is functionally suitable for Super Admin users. The overwhelming positive replies demonstrate that the technology effectively administers the transportation network and supports informed decision- making. With a combined mean of 4. 4.8 (Strongly Agree), TrackMOn is a functional, reliable, and efficient management tool with only modest upgrades needed in data presentation and analytical reporting.

Table 6. Descriptive Ratings of TrackMOn Functional Suitability for Admin module. May 2025

Particulars	**Mean**	**Verbal Interpretation**
Allows Conductors Receive Push Notifications Effectively And Approve Passenger’s Requests.	4.73	Strongly Agree
Allows Drivers To Automatically Update Status Online After Logging In.	4.73	Strongly Agree
Allows Drivers To View Bus Stops.	4.73	Strongly Agree
Consolidated Mean	**4.73**	**Strongly Agree**

Table 6 shows Super Admin users' descriptive ratings of the TrackMOn Innovative Bus Tracking and Monitoring System's functionality. The results show how well the system supports administrative services like people, bus, route, and data visualization for overall operations management. The computed consolidated mean of 4.8 indicates that respondents “Strongly Agree” that the TrackMOn system is functionally adequate and useful for super administrators.

The system achieved good scores from 4.8 to 5.0 across most indications, indicating that most of its features are well-implemented and match user needs. The system's ability to let super admins supervise drivers, conductors, and passengers has a perfect mean score of 5.00, indicating high satisfaction and usability. These findings show that administrative control and oversight functions are efficient, allowing super admins to easily monitor and manage important system components. Passenger management (4.9), routes (4.8), buses (4.9), and notifications (4.8) also achieved “Strongly Agree” ratings, demonstrating the system's reliability. These components are crucial for seamless transport operations, and their high ratings indicate that the TrackMOn system has a simple interface for data entry, modification, and retrieval.

The system's interface, which shows the number of buses (4.9), online drivers (4.9), and online conductors (4.9), was also well appreciated. These results show that TrackMOn provides accurate, real-time data visualization for administrator decision-making and operational monitoring.

However, “The system displays visualization of average successful passenger trips per day” (4.2) and “The system allows super admin to view distance travelled by each bus” (4.1) were scored somewhat lower, read as “Agree.” Although still highly rated, these scores show that while the functions are functional, data presentation, accuracy, and interpretation might be improved. Graphical analytics and distance-tracking precision could improve system reporting and monitoring.

Finally, super admins' ability to add routes and bus stations had a strong mean of 4.9, demonstrating the system's flexibility and scalability for operational adjustments and route extensions.

Overall, the TrackMOn system is functionally suitable for super admin users. The overwhelming positive replies demonstrate that the technology effectively administratively controls the transportation network and supports informed decision-making. With a combined mean of 4.8 (Strongly Agree), TrackMOn is a functional, reliable, and efficient management tool with just modest data presentation and analytical reporting upgrades needed.

Table 7. Evaluation Ratings of TrackMOn Functional Suitability for User module. May 2025

Particulars	**Mean**	**Verbal Interpretation**
Passengers To Conveniently View Real-Time Bus Locations.	5.00	Strongly Agree
Receive Notification Updates Effectively.	4.82	Strongly Agree
View The Availability Of Bus Status.	4.84	Strongly Agree
Allows Passenger To Request A Reservation.	4.84	Strongly Agree
Consolidated Mean	**4.87**	**Strongly Agree**

Table 7 displays TrackMOn Innovative Bus Tracking and Monitoring System descriptive ratings for the User Module's functional appropriateness from May 2025 data. This area lets passengers follow buses, receive notifications, check availability, and reserve seats. All indicators scored high, with a consolidated mean of 4.87 indicating “Strongly Agree.” This shows that passengers found the transportation and booking system useful, efficient, and effective.

The first indicator, “The system enables passengers to conveniently view real-time bus locations,” earned 5.00, the highest. This suggests that users like the real-time bus tracking service, which uses GPS and Google Maps API. The function helps passengers forecast bus arrival times and make smarter travel decisions. This function is one of TrackMOn's best since it handles bus location and arrival schedule unpredictability, a major public transportation concern.

The second indicator, “The system enables users to receive notification updates effectively,” got 4.82, suggesting “Strongly Agree.” Its real-time passenger-transport service communication got it this high rating. Push alerts notify passengers of booking confirmations, bus delays, cancellations, and itinerary changes. It improves transparency and customer involvement by informing travelers during their trip.

Third, “The system enables users to view the availability of bus status,” averaged 4.84 and was rated “Strongly Agree.” This shows that the system reports bus activity, fullness, and booking availability well. Real-time bus status reduces uncertainty and aids itinerary planning. This functionality demonstrates the system's capacity to deliver timely and accurate data.

The fourth sign, “The system allows passengers to request a reservation,” had a mean of 4.84, suggesting that passengers found booking easy, fast, and reliable. An organized interface facilitates seat reservations, eliminating manual work and the danger of overbooking or miscommunication. The module's high ranking indicates reservation ease.

The TrackMOn User Module's 4.87 consolidated mean indicates good functionality. The system's high ratings in all categories show its capacity to provide travelers with accessible, convenient, and real-time services. The reliable, easy-to-use module improves passenger satisfaction and public transit management efficiency. The TrackMOn User Module is very user-friendly, providing real-time tracking, rapid notifications, bus availability views, and reservation requests. This suggests that using existing technology and interactive design to make bus service more efficient, transparent, and reliable may increase passenger experience.

Table 8. Summary of User ratings based on ISO 25010 Software Quality Framework

Quality Characteristic	Mean	Verbal Interpretation
Functional Suitability	4.8	Strongly Agree
Performance Efficiency	4.68	Strongly Agree
Usability	4.88	Strongly Agree
Reliability	4.62	Strongly Agree
Compatibility	4.8	Strongly Agree
Consolidated Mean	**4.87**	**Strongly Agree**

Summary of User Rating based on ISO 25010 Software Quality Framework

Based on May 2025 data, Table 6 presents descriptive ratings of the TrackMOn Innovative Bus Tracking and Monitoring System's User Module for functional appropriateness. In this section, passengers can track bus locations, receive notifications, view bus availability, and request reservations. All indicators had high mean ratings, with a consolidated mean of 4.87, indicating “Strongly Agree.” This shows that passengers found the system useful, efficient, and effective for transportation and booking.

The first item, “The system enables passengers to conveniently view real-time bus locations,” scored 5.00, the highest of all indicators. This suggests that passengers are highly satisfied with the real-time tracking service, which uses GPS and the Google Maps

API to track bus locations. With this feature, passengers can better predict bus arrival times and make more informed travel decisions. This result highlights this feature as one of TrackMOn's greatest strengths, addressing one of public transportation's biggest issues—unpredictable bus locations and arrival schedules.

The second indicator, “The system enables users to receive notification updates effectively,” scored 4.82, meaning “Strongly Agree.” The system's real-time communication with passengers earned this excellent ranking. Push alerts notify passengers of booking confirmations, bus delays, cancellations, and itinerary changes. This tool keeps travelers informed during their trip, improving transparency and consumer engagement.

Third, “The system enables users to view the availability of bus status,” averaged 4.84 and was graded “Strongly Agree.” This shows that the system efficiently reports bus activity, occupancy, and booking availability. Real-time bus status helps travelers plan their itineraries and reduces uncertainty. This functionality demonstrates the system's ability to provide users with timely and accurate data.

The fourth indicator, “The system allows passengers to request a reservation,” similarly had a mean of 4.84, indicating that passengers found the booking process easy, fast, and dependable. This feature simplifies seat reservations through a well-organized interface, reducing manual work and the risk of overbooking or miscommunication. The module's high rating reflects the ease of making reservations.

The TrackMOn User Module's consolidated mean of 4.87 indicates strong functional appropriateness. The system's strong ratings across all categories demonstrate its ability to provide travelers with accessible, convenient, and real-time services. Users find the module reliable and easy to use, enhancing passenger satisfaction and public transit management efficiency.

Lastly, the TrackMOn User Module is highly functional and user-centered, addressing passenger needs with real-time tracking, fast notifications, bus availability views, and reservation requests. This shows that the system may improve the passenger experience by merging current technology and interactive design to make bus transportation more efficient, transparent, and reliable.

Conclusion

Evaluation of the TrackMOn Bus Tracking and Monitoring System across the Super Admin, Admin, and User modules indicates a high level of overall satisfaction, with all modules receiving strong ratings from respondents. The Super Admin module achieved a consolidated mean of 4. 4.8, suggesting it is highly effective in managing critical components, including drivers, conductors, passengers, buses, and system notifications. The module's high scores indicate its ability to provide real-time monitoring and comprehensive system control.

Nevertheless, there are opportunities to make minor enhancements to the data monitoring and visualization features to offer more detailed reports and dynamic analytical insights. The Admin module achieved a mean score of 4. 73, indicating consistent satisfaction with features such as access to bus stop information, automated driver status updates, and push notifications. These functions facilitate the efficient and seamless execution of daily administrative tasks, thereby guaranteeing dependable communication between the system, conductors, and drivers.

In the interim, the User module achieved a maximum mean rating of 4.87, underscoring substantial positive feedback from passengers. Real-time bus tracking, status updates, and a seamless reservation process were well received by users, underscoring the system's practical usability and intuitive interface for commuters.

The system received exceptional ratings for multiple quality characteristics, including Usability (4. 88), Functional Suitability (4.8), Compatibility (4.8), Performance Efficiency (4.68), and Reliability (4.62), in accordance with the ISO 25010 Software Quality Framework. This resulted in a consolidated mean of 4. 87. The TrackMOn system is user-centered, reliable, and well-developed, as evidenced by these scores.

Overall, the results indicate that TrackMOn effectively meets user expectations across all modules, providing a user-friendly, efficient, and robust solution. Only minor refinements are required to further enhance its analytical and visual reporting capabilities in future iterations.

Recommendations

The following recommendations are derived from user feedback and system evaluation to further enhance the Innovative Bus Tracking and Monitoring System. Unlike existing transportation tracking solutions that primarily emphasize vehicle location monitoring, the system delivers a more integrated and practical platform by combining real-time tracking, reservation management, role-based administration, and commuter-focused safety features.

To enhance its practical relevance, the integration of a secure online payment mechanism is recommended to facilitate ticket purchases and enhance user trust. Continuous collection of passenger feedback is also suggested to guide service improvements, along with the exclusive use of GPS devices to enhance tracking accuracy.

Additional enhancements include distance-based fare computation, location-based transit stop guidance, and the future incorporation of an emergency panic button to further improve transparency, accessibility, and passenger safety

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