# IoT Enabled Fleet Management System

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***Abstract*—Fleet Management System is a term being used for a wide range of solutions in the fields of transportation, distribution, and logistics. It comprises target-based planning, as well as supervision and control of fleet operations based on available transportation resources and application constraints. FMSs have an objective to reduce risk, increase quality of service, and improve a fleet's operational efficiency while minimizingits costs. This holds great significance as the dynamic route allocation, seat management, request handling and transaction logging reduces a huge amount of labor effort and time, and even a minor mistake or omission on these features can lead to severe issues. Hence, this project aims to develop a fleet management system which can be readily plugged in and can manage any intended fleet such as buses, ships, cargo carriers, etc. This widens the aspect of the project to such an extent that it addresses the problems of several sectors of customers at the same time.**

***Index Terms*—logistics, dynamic route allocation, transaction logging**

## I. Introduction

The current fleet management system can evolve to a greater level, by addressing and resolving problems from a wider perspective, considering various customer segments. The administration wing suffers great pain in terms of time and labour to manually allocate buses to each and every student requests. Also, manually validating the bus passes of the students while they enter the bus, has become a headache for the faculties as well. Many a times, students are confused over the current location of the bus and whether it has already left the boarding point.

The best way to resolve these, as well as many adhesive problems is to automate the management system to reduce human efforts, feeding the user requests through a dynamic request management system. Any and all requests from a student for a specific route could be fed through a machine learning based, dynamic requirement analysing algorithm, so as to assign the student to the most appropriate bus. Also, an RFID based check-in and checkout system for the users can effectively log their boarding and offboarding points. The system should makes sure that neither is a student gets expelled from the bus due to the absence of a pass, but also that the management suffers no loss from it. The system will also provide real time tracking of buses, providing users with info on where the bus is right now, and the approximate timeit would take to reach the user's position.

## II. Objective and Scope

The objective or aim of this project is to create a Fleet Management Software intended specifically for college transportation system, addressing problems from different customer segments.

- Dynamic Request Management, so as to assign the student to the most appropriate bus.
- An RFID based check-in and checkout for the students, logging their on- boarding and off-boarding points.
- In case a student without a pass decided to take the bus, he would have to register a daily pass request on the app, and his on-boarding would be charged on the due record of the student.

## III. Background

Several authors have developed a wide range of static and shallow feature-based solutions for some of the problem statements addressed. The fact that software's thus developed solved only one of the problem statements only was one of their key flaws.

### *A. TrackSchoolBus*

TrackSchoolBus is a software solution by Edsys Pvt Ltd. for parents and school authorities so as to create a safe and efficient school bus management. It provides GPS tracking solutions to ensure student safety to and from their schools [1]. The software helps the transport manager to maintain school bus fleet efficiently. As it has auto routing feature, it collects

data from the system and automatically prepares the route. TrackSchoolBus software also uses facial recognition to mark the attendance of each student.

But unlike the required solution, the auto routing feature may result in some boarding points being junked out, whichis most undesired in an institutional fleet management system.Also, the facial recognition may not properly work in a rainy or foggy environment where the camera gets blurred out.

### *B. FASTag*

FASTag is a device used in automated unmanned toll booths that employs Radio Frequency Identification (RFID) technology for making toll payments directly from the prepaid account linked to it [2]. The tag is affixed on the windscreen of your vehicle and enables you to drive through toll plazas, without stopping for cash transactions. For verification, all vehicles that drive through the lane are picked up by a motion detector, triggering a camera to take a photo of the vehicle's license plate. The photo of the car and license plate is timestamped, and then software visually decodes the license plate number and sends it for validation. But the major flaws is that tag readers must be fitted in every toll station.

## IV. Literature Survey

The system proposed by H. Gull et.al aims to improve the efficiency of bus routes by introducing a tracking website and an android application for school administrators, drivers and parents [3]. The system will generate a QR code for each student and track the bus location through the driver's mobile device. The parents application will display a map showing the current bus position, updated after each period, ensuring safety. However, the system has some limitations, such as handling new route requests manually and creating a queue at the bus door in rainy environments.

Another research focuses on analyzing and designing automated and dynamic bus route allocation [4]. Two algo- rithms are proposed: one focusing on converging bus routes at populous hubs, and the other focusing on de-congesting routes away from densely populated areas. Data analytics is used to implement a two-pronged algorithm to solve dynamic allocation of buses, maximizing resource utilization.

An improved bus tracking system, developed by A. Badkul and A. Mishra, involves high-frequency RFID tags atbuses and RFID receivers at stops [5]. The system uses the NodeMCU module for internet connection to collect real- time RFID tagging information, allowing users to access bus running and status from the cloud on the mobile app. However, the proposed system falls behind in several aspects, such as not being perceived as a bus management system and not being digitalized, as tickets or bus passes must be carried and validated manually.

The Floating Bus system, proposed by C.McKenna et al., aims to improve public transport by adapting to the dynamic demand of passengers and real-time demand. This system allows passengers to request a ride, aggregates requests, appoints the most convenient stop, and allocates a bus to complete the journeys [6]. The Floating Bus system increases passengers' convenience by appointing dynamic bus stops, decreases emissions, and reduces travel time. However, the system cannot be effectively implemented on a public transport system, as ticket or bus pass validation is manual.

An automated parking access control system based on RFID technology, proposed by E.H. Rouan et al. [7], addresses parking management issues by utilizing RFID tags for quick identification and check-in/check-out. This system ensures security and allows only registered vehicles to access parking lots.

A dynamic framed slotted ALOHA algorithm for RFID systems with enhanced tag estimation technique was proposed, achieving a throughput of 0.36 as the frame size changes dynamically up to 1024 tag populations [8]. These advancements aim to enhance passenger convenience and reduce emissions in the parking industry.

Reinforcement learning-enabled genetic algorithm is proposed for school bus scheduling optimization, focusing on transporting students distributed across a designated area to relevant schools [9] was proposed by Eda Koksal et al. The algorithm uses processed data from an intelligent transportation system framework to decide genetic algorithm parameters on-the-fly, improving the efficiency and achieving near-optimal schedules in shorter durations. Experiments on a geospatial dataset show that the genetic algorithm improves travel distance and time compared to existing schedules. The algorithm saves 8.63% and 16.92% for travel distance and 14.95% and 26.58% for travel time for buses and students, respectively.

An advanced automated bus ticket fare collection system for metropolitan cities uses GPS and RFID technologies. RFID is used to identify passengers, while GPS is deployed to identify initial and destination locations [10]. Ticket fare is issued based on GPS information, and passengers receive confirmation messages with the help of GSM modems. The real-time on-demand bus routing problem (ODBRP) supports online routing of buses in large-scale ride-sharing systems.

## V. Proposed System

### *A. Dynamic Request Management*

The prior concern of the project is is to tackle the problem of manual request management, where any and all requests submitted by a traveller to book seat in a specific bus so as to reach a specific route is being analysed and solved by the faculties by hand, consuming both time and effort needlessly. The dynamic request management feature of the management module enables to:

- Allocate bus seats based on demand for any new requests.
- Reroute a bus, or concatenate two separate routes into one to avoid loses on less demanded routes.

In dynamic request management, when the user requests for a boarding point x, it is being verified by the server, and in reference with the database, is checked whether or not the concerned bus has seat availability. If yes, it is being allotted

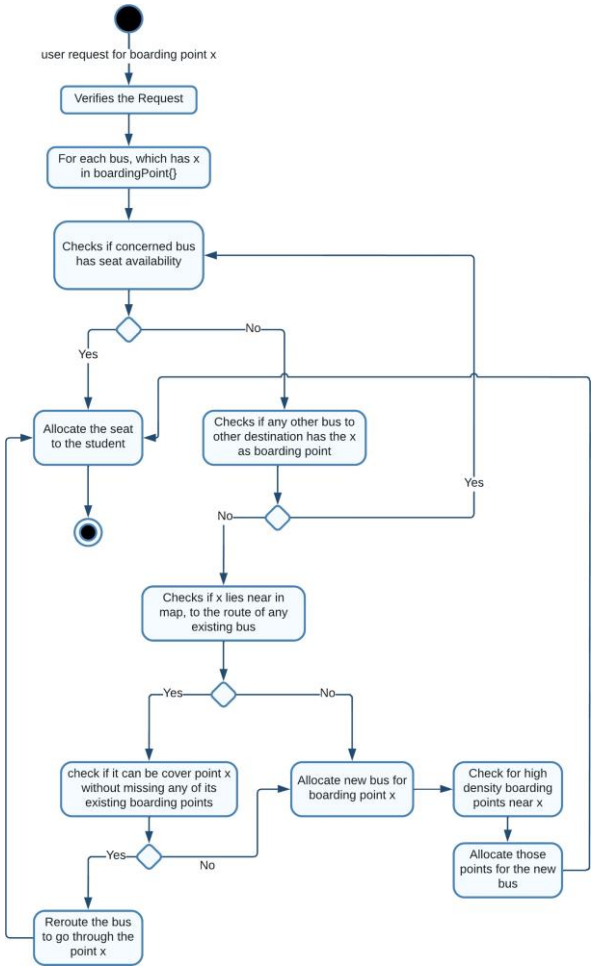


Fig. 1. Activity diagram of dynamic request management

to the student. Otherwise, the server checks if any other bus to other destinations have x as its boarding point. If so, the seat availability is being checked and it gets allotted to the student. Else, the server would check if x lies near in map to the route of any other buses. In such a case, the server would check if x can be covered by that bus, without missing any of its existing boarding points. If so, then the server would suggest the management team to reroute the bus to go through the point x. Else, the software would suggest for allotting a new bus to cover boarding point x. If it is approved by the management team, the server would check for the high-density points near x, and would allocate the students from those into the new bus.

### *B. Business Analysis*

Business analysis proves helpful to both administration and management teams. The server would fetch the various expenditures such as fuel prices, maintenance fees, driver fees, vehicle rents, etc and the income details from the database, and would analyse them to determine whether the bus is profitable or not. If profitable, the server generates a profit chart. Otherwise, it would generate a detailed expenditure report, describing various ways the bus became an overhead. It would also suggest a bus seat reorder, so as to eliminate the loses in the following month. The server would check the percentage of occupied seat in the bus, and if it is less than 50%, then it would fetch the list of all boarding points of that bus. This list is being compared with the total list of all existing boarding points, so as to identify any bus with the most similar set of boarding points. Then, if the seat occupancy of that bus is below 75%, then the students from the bus at loss are being transferred to this bus.

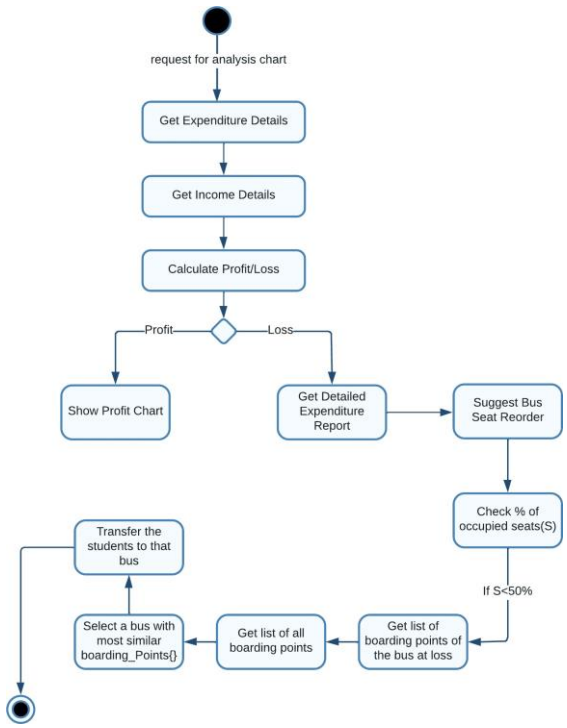


Fig. 2. Activity diagram of business analysis system

The module also provides an interface for the bus staffs and bus maintenance team to have a proper manage on several matters of the bus such as view bus maintenance logs, keep various documents up-to-date, expenditure and tax management, business analysis, etc. Also, the service and maintenance record of each bus are being stored and analysed in the cloud, and on accidents, approaching due dates on insurance, etc, alerts are given to both administrative and service staffs.

### *C. Travelers Module*

The travelers module provides several features to the students and faculties travelling in the bus. One of such relevant features is the RFID-based attendance system. The RFID system attached on the bus would prove to be a non-contact attendence logger, keeping track of the on-boarding and off-boarding points of each student. This would come especially

useful when students go missing and, authorities need to know their recent activities (such as getting out at unusual places). When the student enters the vehicle, his RFID gets scanned by the RFID reader, and the attached NodeMCU module uploads the data including the RFID id, log-state and log-location into the server. The server then validates the entry and compares the user-board-point against the logged location. If they are the same, the entry is being added to the log. Else, it is being reported as an abnormality.

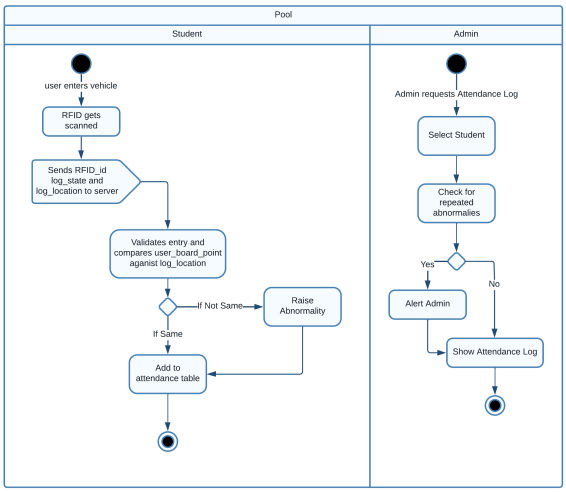


Fig. 3. Activity diagram of attendance system

### D. Abnormality Management

The management module also provides a pretty relevant feature of abnormality management in which several issues faced by the administration team are being addressed as abnormalities and are being dealt with, such as:

- students off-boarding at unregistered locations
- sequential entry and exit by a same student(double entry)
- students travelling without a pass

The software also provides an add-on feature of bus tracking to allow the travellers to know the exact location of the bus. This is expected to be achieved even without the use of a GPS module.

## VI. Results

The system designed for the demonstrational purposes includes the administration segment consisting of features including dynamic request management, route creation and modification via interactive poly-lines and boarding-point management, the management segment consisting of driver and vehicle management and business analysis and the student module consisting of the IoT-empowered logging system and vehicle tracking system without an embedded GPS module. Below provided are some glimpses of the results we have achieved:

1) Login Page The login page serves as the gateway to accessing our software, providing users with a secure and seamless entry point into the system. Robust authentication protocols, such as password hashing and encryption, ensure the confidentiality of user credentials.

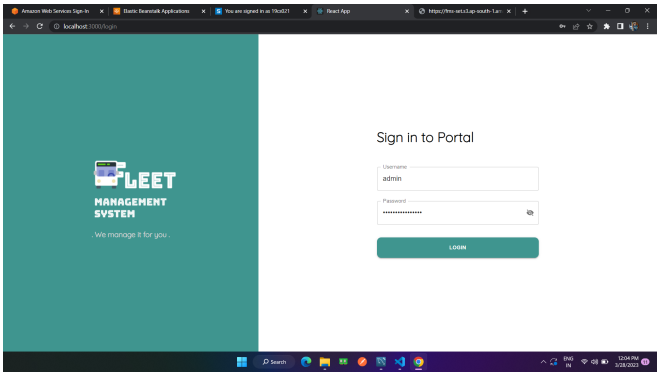


Fig. 4. Login page on web app

2) Students Attendance Log
The attendance log serves as a comprehensive record-keeping system that captures and displays attendance details of all users traveling on a particular bus. The attendance log incorporates a comprehensive user database that contains relevant information, including names, details, and unique identifiers. This facilitates accurate attendance tracking and simplifies record management. Also, the attendance log is designed to associate students with specific buses and routes, enabling administrators to track attendance details for each bus separately. This feature enhances bus monitoring and simplifies record management for different routes.


Fig. 5. IoT enabled Attendance System

Since attendance log employs efficient data capture methods such as the RFID technology to accurately record student presence and absence, the real-time data capture ensures timely and reliable attendance information. As soon as a user scans his RFID card, his entry is being cross-verified with several factors such as the user

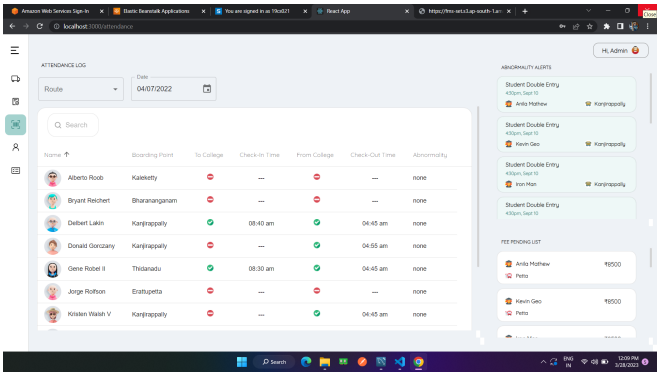

Fig. 6. Students Attendance Log

details, route map, boarding point, user's travel history, etc. If successfully verified, he is allowed to travel. Else, the system would raise an abnormality, and the alarm would set off.

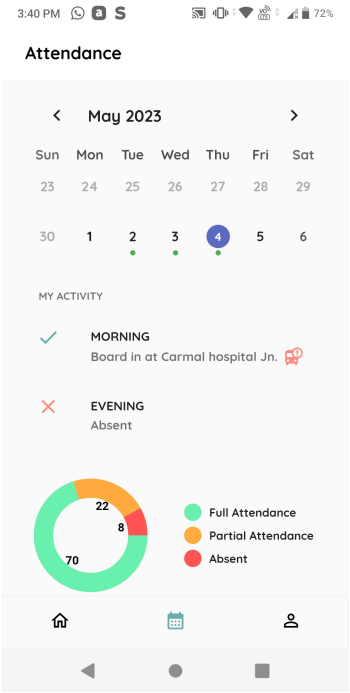


Fig. 7. Attendance: User View

The attendance module of the software also generates comprehensive reports and analytics, providing administrators with valuable insights into student attendance trends, punctuality, and overall bus utilization, which provides a user view of his attendance also(Fig. 7). This information aids in decision-making processes and supports resource optimization.

3) Dynamic Request Management

Managing seat requests and allocations across multiple bus routes can be a complex task. This software presents a dynamic request management system designed to streamline the process by intelligently assigning seats to users requesting a boarding point on various bus routes. The system leverages real-time data analysis, route-based seat allocation algorithms, and user-friendly interfaces to optimize seat allocation and improve the overall user experience.

User Request Interface: The request management system provides users with an intuitive interface to specify their desired boarding point and submit seat requests. The interface ensures a seamless user experience, simplifying the request submission process. Once a user submits a seat request, the system automatically assigns them to an available seat on the most suitable bus within their desired route. The seat assignment process prioritizes fairness and efficient space utilization.

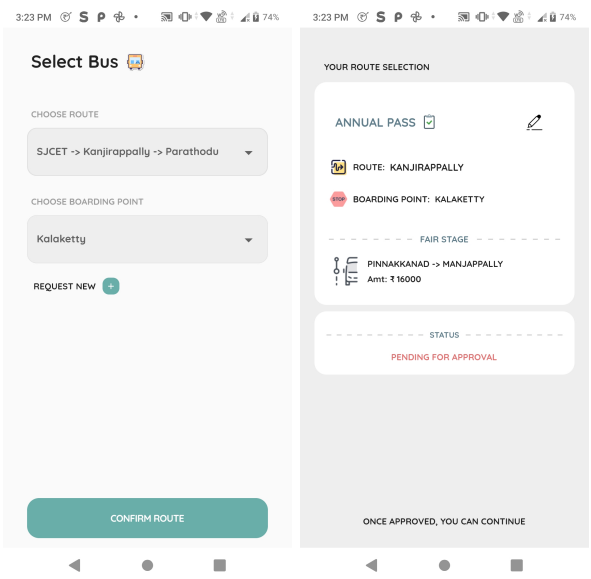


Fig. 8. Seat Request by User

Real-time Data Synchronization: The system synchronizes data in real-time across multiple bus routes, capturing the current status of seat availability, bus capacity, and boarding point information. This allows for accurate and up-to-date seat allocations.

Route-based Seat Allocation Algorithms: Using intelligent algorithms, the system analyzes user requests and considers factors such as proximity to the desired boarding point and bus capacity on each route. This ensures optimal seat allocation and minimizes the chances of overcrowding on any particular bus.

Real-time Updates and Notifications: The system provides real-time updates and notifications to users regarding the status of their seat requests, including confirmation of seat allocation and any changes or updates. This ensures transparent communication and keeps users informed throughout the process.

4) Route Mapping and Boarding point management

The module combines advanced route mapping functionalities with efficient boarding point management features

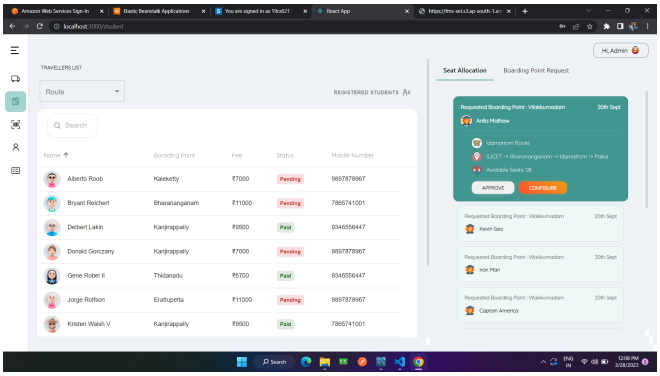

Fig. 9. Dynamic Request Management

to enhance operational efficiency, improve passenger experience, and ensure timely and accurate transportation services. Route Mapping and Visualization: The module provides a comprehensive visual representation of bus routes, including stops, junctions, and alternate routes. Real-time mapping allows operators to monitor buses and optimize routes to minimize travel time and congestion. The system also enables efficient management of boarding points, allowing operators to designate and track specific locations where passengers can board or disembark. This feature helps streamline the boarding process and ensure accurate passenger counts.

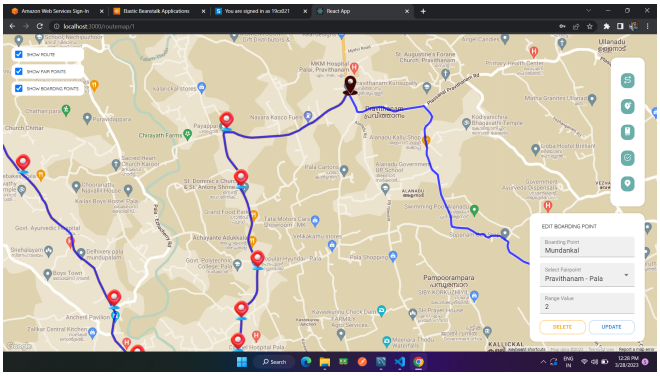

Fig. 10. Route Mapping and Boarding point management

Real-time Updates and Notifications: Passengers receive real-time updates regarding bus locations, estimated arrival times, and any changes or delays. Operators can proactively communicate information about boarding point changes, route diversions, or cancellations to minimize inconvenience.

Data-driven Decision-making: The module leverages historical and real-time data to generate insightful analytics, enabling operators to make data-driven decisions. This includes optimizing bus routes, adjusting boarding point capacities, and improving overall operational efficiency.

5) Transactions and Payment Processing:

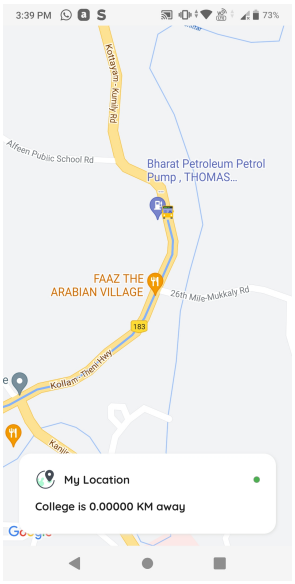


Fig. 11. Bus Tracking for Passengers

The transaction management system incorporates secure payment gateways, allowing passengers to make fee payments conveniently through various channels, such as online platforms, mobile applications, or in-person at designated payment centers. Robust encryption protocols ensure the security of financial transactions.

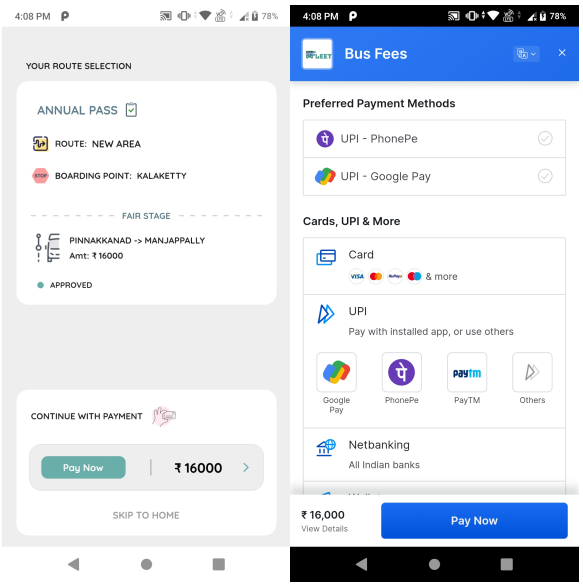


Fig. 12. Fee Payment page

Expense Tracking and Categorization: The system enables efficient tracking and categorization of expenditure, including vehicle repairs, fuel costs, maintenance expenses, and other operational costs. This feature provides operators with a comprehensive overview of expenses and facilitates accurate financial reporting.

Financial Reporting and Analytics: The system generates detailed financial reports, providing operators with insights into income streams, expenditure trends, and overall financial performance. Analytics tools allow for data analysis and visualization, enabling informed decision-making and strategic planning.

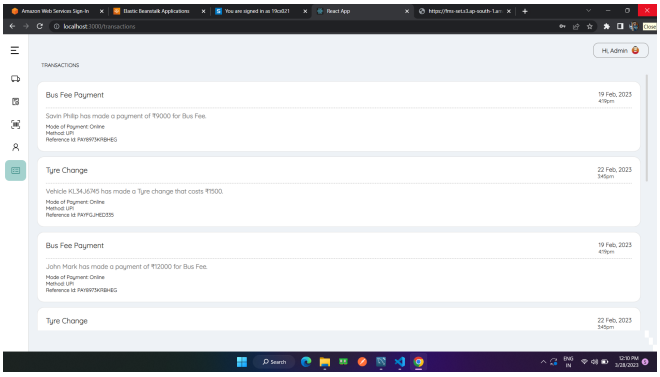


Fig. 13. Transactions page

6) User Management

Efficient user management and secure access control are essential aspects of bus transportation systems. This software presents a comprehensive User Management system with RFID mapping capabilities, designed to streamline administrative tasks, monitor user activities, and enhance security measures.

User Registration and Authentication: The User Management system enables administrators to easily add new users by capturing essential details such as name, contact information, and role. Secure authentication mechanisms ensure that only authorized individuals have access to the system.

User Activity Monitoring: The system tracks and records user activities related to bus transportation, including boarding, disembarking, and other relevant actions. This feature allows administrators to monitor user behavior, track attendance, and generate activity reports for enhanced accountability.

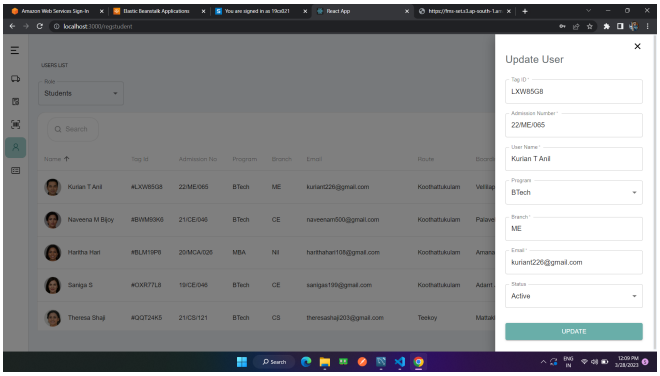


Fig. 14. User-RFID mapping feature for administrator

RFID Mapping: The system incorporates RFID technology to establish User-RFID mapping. Users are assigned unique RFID tags or cards that are scanned to authenticate their identity and provide access to buses or restricted areas. This mapping enhances security and simplifies user identification processes

## VII. Conclusion

Overall, the system helps transportation enterprises to manage their fleet operations more effectively, from managing dynamic requests to analyzing data and tracking vehicles in real-time. By providing visibility into fleet operations and performance, these systems can help businesses reduce costs, improve efficiency, and increase customer satisfaction. The system would provide an all way solution to many of the problems faced by various customer segments such as the bus administration, the management team, maintenance team and the students, as well as their parents. Dynamic request management system handles route requests by travellers in a dynamic way, reducing the work load of admin team by eliminating manual bus allocation. The software also makes the transportation sector safer by lively informing the authorities about any accidents involved by the fleet(bus). Besides, by helping the service team to keep the vehicle up-to-date, the fleet management system reduces chances of accidents due to failures of vehicle parts.

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