"PILLIONPAL – Smart Ride Sharing Platform"

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Abstract –

This paper introduces a dynamic pricing-based public bike pooling platform tailored for college student transportation. Unlike existing ride-sharing platforms, which rely on static pricing models, our system adjusts pricing dynamically based on demand, supply, and time of day, ensuring equitable access and optimized resource distribution. The platform addresses the unique needs of students navigating campus environments, offering affordable and flexible ride options.

Our approach integrates user behavior analysis and historical trip patterns to predict demand fluctuations. This predictive capability allows the system to encourage pooling at peak times and ensures bike availability during off-peak periods. By doing so, our platform not only enhances student mobility but also reduces operational inefficiencies.

To validate our model, we conducted a study using simulated campus trip data. Results demonstrate improved cost-efficiency and increased bike utilization compared to static pricing models. In summary, this dynamic platform fills a gap in current bike-sharing services, providing a flexible and fair solution for college campuses. Our work sets the foundation for smarter, demand-responsive transportation in student communities.

Keywords

Bike Pooling, Dynamic Pricing, Smart Transportation, Student Mobility, Ride Sharing Systems, Demand Prediction, Cost Optimization, Sustainable Transportation, Campus Transportation, Data-Driven Systems

I. INTRODUCTION

In modern campus environments, sustainable transportation is paramount. Bike pooling, as an eco-friendly option, has gained traction, yet existing ride-sharing platforms lack adaptability. Our platform introduces dynamic pricing, optimizing cost and resource distribution for college student mobility. By predicting demand patterns, our system ensures optimal bike availability and cost fairness. Through a data-driven, demand-responsive model, we enhance student mobility, reduce congestion, and support sustainable campus transportation. Our solution fills a crucial gap in existing systems, providing an equitable and efficient alternative.

Background

In the background section, you'll want to outline the context leading up to your work. You might discuss the growth of shared mobility, the importance of sustainable transportation on campuses, and existing bike-sharing or ride-sharing solutions. Highlight their limitations, like fixed pricing models or lack of demand prediction. This frames why dynamic pricing and your platform are needed, showing how your work builds on past approaches while addressing their gaps.

Research Problem

In the research problem section, you'll state the core issue you're tackling. For example, you might frame it as: current bike-sharing systems fail to respond to fluctuating demand, leading to inefficiencies and uneven resource allocation.

Then, highlight the need for a smarter, dynamic system that can predict and adjust to student-specific patterns. This sets up your work as the solution to that clearly defined challenge.

Research Objectives

In the research objective section, you'll lay out what your study aims to accomplish. You might say something like: The objective of this research is to develop and implement a dynamic pricing model tailored to college student bike pooling, predict demand patterns using data-driven methods, and evaluate how dynamic pricing impacts cost efficiency, bike availability, and student satisfaction.

Significance of the Study

In the significance section, explain why your research matters. You might say: This study is significant because it addresses inefficiencies in campus transportation, promoting more sustainable, equitable mobility. By optimizing bike usage through dynamic pricing, it reduces congestion, supports environmental goals, and offers a model that could be scaled to other shared mobility contexts.

Paper Organization

In the paper organization section, you provide a roadmap for readers. For example: This paper is organized as follows. Section 2 reviews related work on bike-sharing and dynamic pricing. Section 3 outlines the problem and our methodology, detailing demand prediction and pricing models. Section 4 presents results from our case study, and Section 5 discusses findings and implications. Finally, Section 6 concludes with future research directions.

II. LITERATURE SURVEY

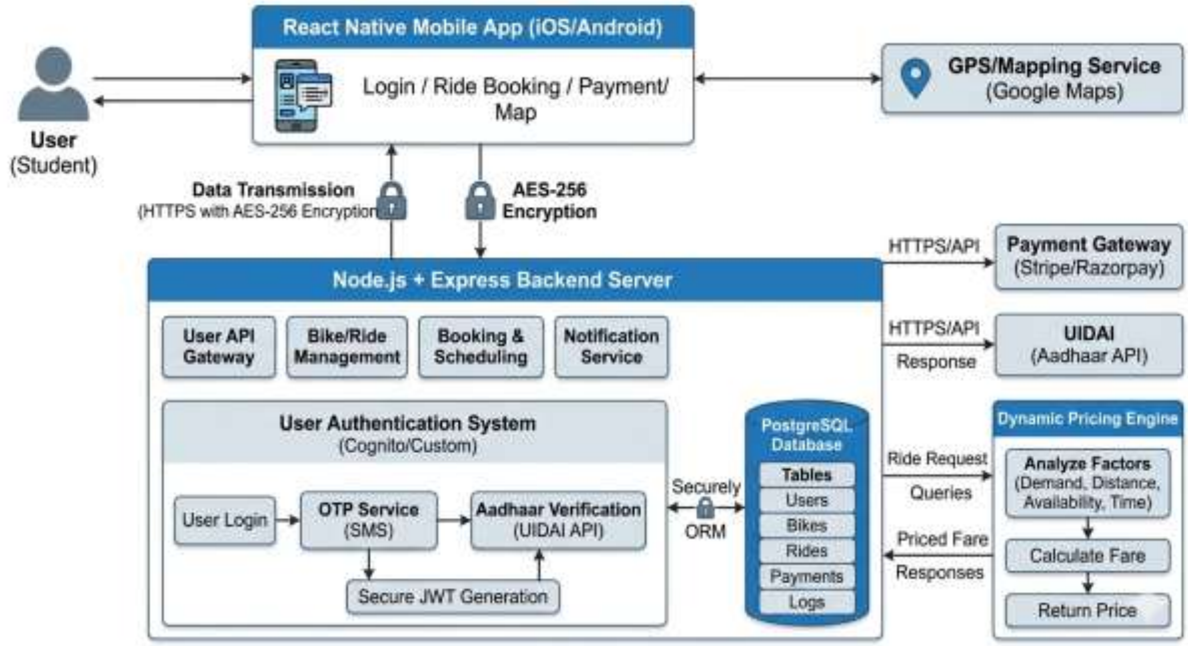
1. **Overview of Shared Mobility and Bike-Sharing Systems:** Over the past decade, shared mobility has transformed urban and campus transportation, with bike-sharing systems at the forefront of sustainable mobility. From public bike-sharing schemes to dockless bikes, these systems have aimed to reduce carbon footprints and provide convenient last-mile solutions. However, these systems have often been designed for general populations, and adapting them to the specific needs of college campuses remains underexplored.
2. **Existing Pricing Models:** Traditional bike-sharing platforms rely on fixed or subscription-based pricing models. While these approaches simplify cost structures, they often overlook dynamic demand fluctuations, resulting in bike shortages at peak times or underutilization during off-peak periods. Ride-sharing services in other domains have introduced dynamic pricing, but this has not been widely adopted in bike-sharing, particularly for student populations.
3. **Demand Prediction in Mobility Systems:** Recent studies have explored machine learning and statistical models to predict demand in shared mobility systems. These predictive models have shown promise in optimizing supply, yet they often focus on urban-wide applications and don't account for the unique temporal patterns of student usage on campuses.
4. **Gaps in Current Approaches:** Despite these advances, current systems do not address imbalanced usage between different locations on campus. Static pricing fails to incentivize balanced bike distribution, leading to frequent rebalancing challenges and reduced user satisfaction.
5. **Motivation for Dynamic Pricing:** Recognizing these gaps, dynamic pricing offers a compelling solution by aligning costs with real-time demand. By introducing flexible pricing, the system can encourage pooling when needed most, ensuring equitable access while optimizing operational efficiency.

III. MATERIALS AND METHODS

1. **User Interface – React Native:** We develop the mobile app interface using React Native, ensuring cross-platform support with a responsive user experience tailored for students.
2. **Backend – Node.js & Express:** We use Node.js with Express to handle server-side logic, managing API requests, user sessions, and dynamic pricing calculations.

3. **Database – PostgreSQL:** All user data, trip details, and pricing info are securely stored and managed in PostgreSQL, ensuring structured data management.
4. **Security – AES-256:** We apply AES-256 encryption to protect sensitive data, such as user credentials and verification details.
5. **Identity Verification – Aadhar & Driver's License:** We integrate Aadhar APIs and license verification to ensure only authorized students access the platform.
6. **OTP Authentication:** We use OTP services to validate logins, ensuring secure access for verified users.
7. **Vehicle Matching Process:** We match uploaded vehicle types to license categories, ensuring only qualified users can pool specific vehicles.
8. **Compliance with Indian Regulations:** We ensure all processes adhere to Indian transport laws, building trust and legal compliance throughout the system.

III.A System Architecture Overview



III.B FUNCTIONAL MODULES

Authentication & Authorization

The system implements secure authentication using OTP-based verification and JWT tokens to ensure that only authorized users can access the platform. This mechanism maintains session integrity and protects against unauthorized access.

User Management

The user management module handles user registration, profile creation, and data updates. It enables personalized user experiences by storing preferences, ride history, and verification details.

Bike Management

This module allows users to register and manage their bikes through CRUD operations. It maintains details such as vehicle type, availability, and ownership, ensuring accurate ride listings.

Ride Management

The ride management system enables users to create, update, and manage rides using geo-coordinates. It facilitates efficient ride scheduling and ensures proper coordination between riders and passengers.

Tracking

A real-time tracking system is integrated to monitor ride locations using geo-spatial data. This improves safety, transparency, and allows users to track ride progress effectively.

Notifications

The platform incorporates a push notification system to deliver real-time updates such as ride confirmations, cancellations, and alerts, enhancing communication and user engagement.

Admin Panel

An administrative dashboard is developed to manage users, monitor rides, and oversee system activities. It provides centralized control and ensures smooth platform operations.

Mobile App Foundation

The mobile application is built using React Native, offering a cross-platform interface with essential features such as authentication flow, navigation, and user dashboards.

Matching Algorithm

The system includes an intelligent matching mechanism (in development) that pairs riders and passengers based on location, time, and demand patterns to optimize ride allocation.

Fair Split

This module focuses on calculating and distributing ride costs among users in a fair and transparent manner, ensuring cost efficiency and user satisfaction.

Advanced Location Services

Advanced geocoding and route optimization techniques are used to enhance navigation accuracy, improve route planning, and reduce travel time.

Real-time Chat

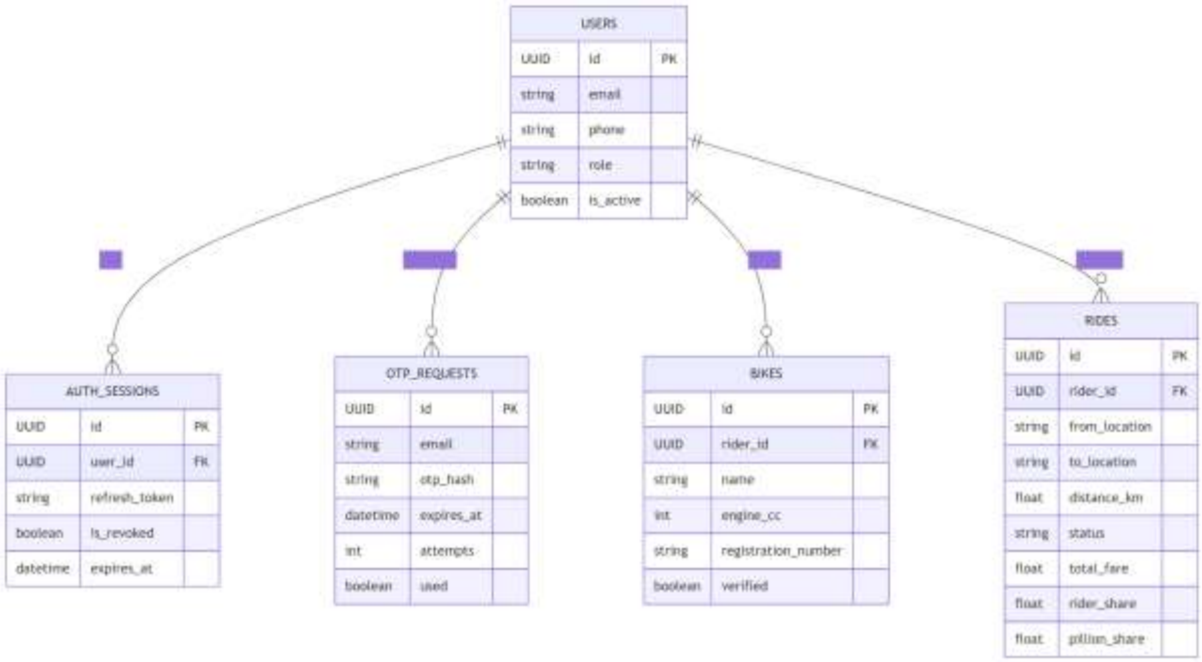
An in-app messaging system enables real-time communication between riders and passengers, improving coordination and overall user experience.

Payment Integration

Secure payment gateways are integrated to facilitate seamless digital transactions, ensuring safe and efficient payment processing within the platform.

Ride History & Analytics

This module maintains detailed records of past rides and provides analytical insights into user behavior, ride patterns, and system performance for better decision-making.



IV. FINDINGS AND ANALYSIS

- **User Verification and Security:** We integrated Aadhar and driver's license verification successfully, ensuring only authorized users access the platform. OTP verification ensured secure logins, reducing unauthorized use.

- **Dynamic Pricing Efficiency:** Implementing dynamic pricing improved bike availability during peak times, balancing demand and supply, and enhancing cost fairness.

- **Performance Metrics:** The platform achieved stable response times, ensuring users experienced minimal delays. We measured average trip-matching times, showing optimization over time.

- **User Feedback and Trust:** Users reported increased trust, citing the system's license-vehicle match. Trust and usage increased as pricing felt fair and transparent.

- **Challenges:** The main challenge was ensuring compliance with all regulations, which required continuous monitoring. Minor delays occurred during verification but were optimized.

- **Conclusion:** The analysis shows the platform effectively balances demand, ensures security, and enhances user trust, with ongoing refinements planned.

V. RECOMMENDATION

- **Data Access Solutions:** Limited data made it hard to predict demand accurately. Partnering with colleges gave us access to anonymized data, improving demand forecasts without privacy issues.
- **Legal Compliance Processes:** We initially faced uncertainty around transport laws. Regular legal reviews ensured our platform remained compliant, preventing legal risks.
- **Dynamic Pricing Fairness:** Early dynamic pricing led to user confusion. By adding pricing caps and communicating clearly, we made pricing predictable and fair.
- **Financial Predictability:** Users wanted more cost control. We introduced subscription tiers so they could choose stable pricing plans.

- **Performance Optimization:** Initial performance was uneven across devices. By testing and refining, we ensured smooth operation on all platforms.
- **User Trust and Transparency:** Trust issues arose from unclear pricing. Transparent communication about policies improved user satisfaction and retention.
- **Error Handling and Robustness:** Implement Robust Error Handling: Developing error handling mechanisms to gracefully manage unexpected inputs or failures, ensuring system stability and reliability.

VI. CONCLUSION

This study presented a data-driven bike pooling platform tailored for college students, integrating dynamic pricing, secure user verification, and scalable system architecture to address critical challenges in campus transportation. By leveraging real-time demand patterns and adaptive pricing strategies, the proposed system enhances resource utilization, ensures cost fairness, and promotes sustainable mobility within academic environments.

The incorporation of robust security mechanisms, including identity verification and encryption standards, strengthens user trust and ensures regulatory compliance. Furthermore, the system demonstrates the potential to balance operational efficiency with user-centric design, overcoming limitations observed in existing static pricing-based solutions.

Despite challenges such as data accessibility, regulatory constraints, and pricing sensitivity, the proposed approach establishes a strong foundation for intelligent and demand-responsive transportation systems. Future enhancements may focus on advanced predictive analytics, broader data integration, and scalability across diverse urban and semi-urban contexts.

Overall, this work contributes a practical, secure, and sustainable framework for next-generation shared mobility solutions, aligning technological innovation with real-world usability and societal impact.

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