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The Future of Car and Bike Rental System

Mr. S. Arivarasan[1], Dr. S. Prabakaran[2], K. Dharnishkumar[3], M. Chelladurai[4], E. Deepakarthick Raja[5], R. Boopesh[6]

[1,2] Asst. Prof, Department of CSE, V.S.B. Engineering College, Karur, Tamil Nadu
[3,4,5,6] Department of CSE, V.S.B Engineering College, Karur, Tamil Nadu

Abstract

Factors such as flexibility, affordability, and convenience put a great selling intention forth. However, the current rent-a-car application is less efficient, less secure, non-transparent in pricing, non-integrative into renewable energy systems, and non-optimized on fleet aspects. These factors decrease buyer trust, increase operating costs for the providers, and impair the sustained acceptance of rent ecosystems. The shift in the urban mobility paradigm has been brought about by the global gifts of sustainable transport, as well as the rapidly evolving digital technologies. As the costs of fuel continue to increase and unbearable traffic jams, harsh parking policies, etc., any conventional model of car ownership is rapidly turning into an unsustainable phenomenon.

Considering these issues, the research predicts an innovative bike and car rental application that will combine the four revolutionary technologies of the Artificial Intelligence, the Internet of Things, Blockchain, and the Cloud.Four pillars combined will result in a secure, efficient, and scalable platform to refute the usual provision of the renting services and their fundamental restoration. The IoT layer does use the smart lock, GPS tracker, and on-board sensors to locate, safety and predict maintenance uses of the vehicle. It is dynamic pricing, demand forecasting, and fraud detection developed with the assistance of AI-analyzed algorithms based on historical data and real-time data. Blockchain also leads to secure transactions and rental agreements observed by decentralized smart contracts that cannot be changed to reduce any conflict that can occur between the customers and the provider. Cloud computing facilitates storage and analytical requirements of the operation data which is enormous and also interconnects with external systems like payment gateways and electric vehicle charging networks.

The project indeed sets an objective of a lifestyle transformation both to the consumers and the service providers. It provides the customers with an app that offers them ease of booking, list of prices, protection of payments and flexibility when it comes to rental time. The environment is bound to trust KYC processes, biometrics, and real-time notifications. Predictive analytics allow service providers to position fleets in ways that maximize their use, reduce any idle minutes and seek paths to undertake maintenance, which, perhaps, should not have occurred. By meeting the sustainability requirements, it diverts a city out of congestion, emission, and reliance on fossil fuel i.e. it monitors carbon footprint and is EV-compatible.

In conclusion, the paper provides an overall outline of the next-generation rental ecosystem and corrects the mistakes of the existing systems. When we put AI, IoT, Blockchain, and Cloud computing together, it will be possible to provide more degrees of protection, transparency, and efficiency in its work,

besides being able to be environmentally sustainable. The research Series of defining the necessity of the unified and technological solution to shared mobility recalls that the given system must play a central role in facilitating the next era of urban transport.

Keywords: Smart Mobility, Bike Rental, Car Rental, Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, Cloud Computing, Shared Economy, Predictive Maintenance, Smart Cities, Sustainable Transportation

1. Introduction

Transportation has been an advantage since the beginning of any economy, civilization, and way of life, which started during antiquity until now. However, current realities of rapid urbanization, the highest prices on energy, and issues of climate change are offering a basis to change ownership towards sustainable and adaptable individual transportation. The concept of shared mobility rather than owning a vehicle has been posed as one "solution." Shared mobility enables one to procure a vehicle when required while relieving that person from bearing costs and environmental impacts involved in ownership. Among the different types of shared mobility, leasing/renting of bikes and cars probably holds higher importance as they are suitable for local, as well as long distance, commutes.

Contemporary urban lifestyles require transportation systems that are flexible, affordable, and have a reduced impact on the environment. When there is heavy congestion in urban centres, the costs of vehicle ownership - parking, fuel consumption, and maintenance - become somewhat burdensome. Consequently, using a bike/car rental service becomes a reasonable mode of transportation and nearly ensures access for users to an active mode of travel, albeit on-demand. Users are encouraged to use rentals in the reflection of the cultural norm of ride-sharing or bike-sharing, rather than owning a bicycle or car. While there are many cities displaying bike-share programs - or other rental services - there are still issues that arise with the existing platforms.

Limited vehicle tracking. Users and administrators may not be aware of the true driving location and availability of vehicles.

Security issues. Unauthorized use and fraudulent bookings are still possible.

Maintenance inefficiencies. Vehicles can stay out of service indefinitely due to service and repairs not being scheduled efficiently.

The proposed integrated system may address these weaknesses with a smart solution. The proposed system uses GPS, secure digital authentication, predictive maintenance, and a mobile application based autonomous operations to provide a better user experience and more efficient in-service operations.

Example Scenario: A commuter in Mumbai needs a bike for short distances. The commuter would locate vehicles in the area through a mobile app, reserve a vehicle from the app, then unlock the bike using secure credentials on their mobile app, and would receive notice that maintenance is scheduled. This seamless system interaction illustrates how a more integrated solution may improve urban mobility.

2. RELATED WORK

The concept of shared mobility and rental transportation is capturing greater interest among both academic and industry scholars. Different commercial providers have built bike and car rental systems, while researchers have considered the technology evolution involved in these systems, and the facets of trust, efficiency and scale are classified the units of analysis. In this section, we summarize the contributions of the industry and related relevant studies, and identify the gaps in research.

Recently there has been an increased interest in shared mobility systems due to a situation of interest in variables related to flexible, low-cost, and environmentally more sustainable transportation. The multiple iterations of dock-based bike-sharing and car-based fully integrated shareable platforms are being implemented globally. In this section we review the most important contributions of study, as well as their advantages, disadvantages and relevance to future bike and car rental systems.

3. DOCKED BIKE SHARING SYSTEM

Docked bike-sharing systems are designed so that users must pick up and return bikes at designated docking stations. Docked bike-sharing systems are currently operating in London (Santander Cycles), New York (Citi Bike), and Paris (Vélib').

Advantages:

Users can generally expect a bike to be available at the fixed docking location.

Docking stations are usually well-maintained, which helps reduce theft and damage.

Can track the docked bike's availability with a mobile app.

Disadvantages:

Fixed locations decrease flexibility and may be inconvenient when wanting to pick-up/drop-off to complete a point-to-point trip with the bike, unrelated to the bike network of its own.

High costs associated with installing and maintaining docking stations is a barrier for adoption and use.

Limited options to scale coverage into more suburban areas.

Shaheen et al. [1] noted that docked systems are typically secure and reliable for basic mobility, but do not generally provide the flexibility for a more spontaneous type of mobility, which was a primary purpose for the emergence of dockless bike-sharing systems.

4. DOCKLESS BIKE SHARING SYSTEM

The concept of dockless bike-sharing is no longer new and has been rapidly popularized through companies, Lime, Mobike, and Ofo, to name a few. In address these specific bike-sharing alternatives, riders are free to pick-up and drop-off the bike anywhere within the prescribed service area. The bikes' use of GPS technology allows for monitoring the movement of the bike in real-time and thereby providing this option of mobility for short distances.

Benefits:

Convenient and flexible means of transport for short distances.

Overall lowered infrastructure costs since there are no docking stations.

Increased accessibility on mobile applications and ease of use for the public.

Disadvantages:

Higher possibility of bike theft or vandalism with no secure docking or rigging for the bike during parking.

Accommodating open parking can lead to issues for cyclists and pedestrians within shared/public space.

Issues can arise where a company has a greater distribution of the vehicles in order to increase operational efficiency, which can lead to maintenance issues on the part of the bike-share program.

Studies by Zhang et al. [5] noted that despite increased access of dockless programs compared to docked programs, their operational efficiency depend on effective GPS location, possible predictive maintenance, and level of oversight administration. The insights by Zhang et al. [5] have relevance with an outcome during the design process of the system being proposed.

5. CAR-SHARING SYSTEM

Car-sharing services allow for the short-term or hourly rental of vehicles for use. Services including Zipcar, Drive Now, and Green Mobility give users the convenience of being able to access a vehicle without the difficulty of ownership.

Benefits:

Convenience for a user who may only want to access a vehicle occasionally.

Provides a potential means of reducing someone's personal vehicles and affording less vehicles on the road, lessening their impact on traffic patterns and the environment.

Mobility application integration will support a user to book, pay, and access their vehicle seamlessly.

Challenges:

High operating costs associated with maintaining vehicles, purchasing insurance, and offering a fleet of vehicles.

Vehicle availability may not be uniform during busy hours or locations of high demand.

Users of car-sharing services need to follow a strict use policy that diminishes spontaneity as opposed to bike-sharing experiences.

Cramer and Krueger [2] note that car-sharing services can potentially eliminate the need for car ownership, however, user experience can be diminished due to poor vehicle availability to rent, and

complicated vehicles rental processes. New systems have to treat both operational challenges - of developing automated booking, pricing, and predictive systems for vehicle placement.

6. GPS AND IOT INTEGRATION

Research shows that GPS and IoT technology will have a purpose in shared mobility systems. Real time GPS tracking is the foundation of fleet management, which includes security, and efficient vehicle redistribution due to demand. IoT sensors will assist in vehicle health/fault detection and support predictive maintenance, which helps reduce vehicle downtime, which is often related to vehicle repairs, and in the fleet management setting represents some of the greatest costs to shared mobility systems.

For example, Zhang et al. [5] have suggested an IoT based vehicle management system which can measure the health and condition of the engine, battery levels, tire health, etc. Each individual vehicle would measure some appropriate aspect concurrently and the data would serve to inform predictive algorithms that can schedule proactive maintenance to reduce the frequency of vehicle malfunctions and sooner address vulnerable vehicles. Both GPS and the proposed IoT sensors will be vital when considering the future rental system, which aims to reduce operational disruptions.

7. BLOCK CHAIN FOR SAFE TRANCTIONS

Security and transparency issues can be particularly salient factors in rental systems. However, blockchain technology has been recommended by researchers as a system to mitigate security and trust issues in rental transactions. The rental transaction can be logged on Blockchain and stored on an immutable, decentralized, digital ledger, helping to prevent fraud and build trust on the user side.

Benefits:

A safe record of payments and transaction histories.

A more transparent record of activity and validations of user identity.

A lessened risk of unauthorized access, fraud, or interference by a third party.

Harms:

Difficulty implementing and scaling.

Computational expense to maintain the technology.

Limited use of blockchain in mainstream mobility services (due to limitations on user engagement).

While blockchain can potentially function as a solution for secure rentals, trust issues remain the largest challenges to integrating user-friendly applications. Our proposed system will use digital identification and safe payments, but will not be overly complicated for the user.

8. COMPARITVE STUDIES AND EMERGING LESSONS

There have been various valuable studies that provided comparisons that recognize the strengths and weaknesses of mobility systems currently in operation over the years:

User-Centered Design. Utilization and retention rates improve when there is a mobile application that provides a simplified design and an intuitive interface. When a user-centered design has a low presence, the system has very low rates of utilization and retention when compared to a similar area.

Predictive and Timely Maintenance. The use of IoT-based health-monitoring systems for fleet management are used to recognize a health issue on a vehicle that will impact an operator's ability to proactively maintain their fleet, and to minimize downtime.

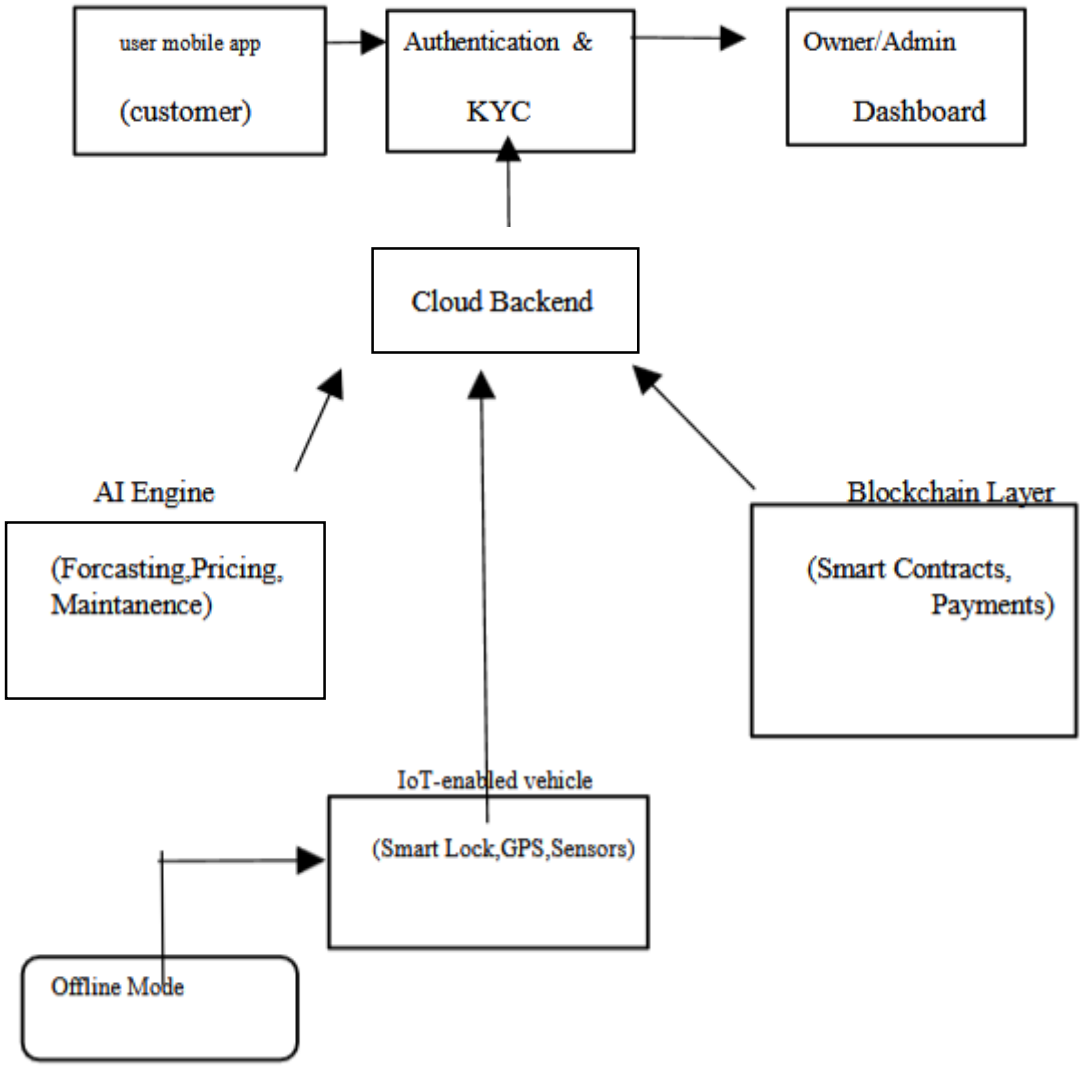
Dynamic Pricing Structure. The available supply of vehicles and user demand can vary by hour of the day. The flexible pricing structure allows for dynamic pricing on available vehicles at any point in time based on the vehicle availability and varied supply and demand. A dynamic pricing structure can encourage the fleet operator or user to not engage in 'idle-loop' to minimize vehicle non-use once the vehicle has been rented.

Integration with Public Transport and Urban Planning. Cities encourages the use of shared mobility modes that support public transport have higher adoption rates and reductions in congestion.

According to Shaheen et al. [1] and Li et al. [3], the future rental system needs to consist of the systems listed above: GPS tracking, predictive maintenance technology, secure transaction methods, and end-use applications to enhance utilization and retention. All of those valuable lessons from the aforementioned studies will guide the intended future bike and car rental system design.

The proposed system is intended to establish a bike and car rental system built for the future that is secure, efficient, scalable, and sustainable. Traditionally the bike and car rental applications acknowledged today are developed with the centralized architecture to solve isolated problems. The proposed future bike and car rental system should consolidate the use of Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, and Cloud Computing within a common framework. The shared framework would provide collective structure to deliver convenience for customers, credible management tools for providers, and progressive alignment with the overarching goals of sustainable mobility in smart cities.

9. BLOCK DIAGRAM



10. TECHONOLOGIES USED

The technologies used in the design and implementation of the proposed system are as follows:

Internet of Things (IoT): IoT allows a real-time communication between the vehicle and the application backend. Data such as location, fuel level, and performance are collected by smart locks, GPS trackers, and sensors.

Artificial Intelligence (AI): Algorithms of AI can be used to predict demand, adjust prices dynamically according to demand over a period of timekeeping and possibly before the vehicle is under full load; and predictive maintenance. Models maximize the user experience, including more useful information and the predictability of vehicle availability, reliability, and status.

Blockchain: Blockchain technology facilitates safe, guaranteed financial transactions and rental agreements that cannot be manipulated or changed once finalized. Feature-wise, including decentralization ,summarized smart contracts will increase transaction efficiency while ensuring reliability, reducing the dependence on "middle men".

Cloud Computing: Such infrastructure must be scalable, highly available, and allow a real-time analytics facility. Platforms like AWS and Azure, for example, could be used to host the back-end services and DP.

Mobile Applications: Applications for Android and iOS provide touchpoint interfaces for users to reserve, unlock vehicles and make payments. Applications are the primary point of user interaction.

11. RESEARCH METHODOLOGY

The research methodology includes five elements:

User Authentication and Know Your Customer (KYC) – Users will sign up for the app and have their KYC account activated with government proof of identification. Users will be introduced to security features, such as biometric authentication and multi-factor login.

IoT Integration – Vehicles will have IoT devices installed, such as GPS tracking devices and smart locks. IoT devices will provide location tracking, usage tracking, and predictive maintenance with real-time data.

AI for Pricing and Forecasting – The AI will analyze booking history and demand patterns and will also consider external factors outside of the app, such as weather, to establish usage per rate. The AI may also dynamically change the usage rate.

Blockchain for Smart Contracts and Secure Transactions – Smart contracts will manage the bookings automatically, the payments, and enforce the rules around the transaction. Payments will only be released if vehicles are returned without incident to reduce anchoring and disputes.

Cloud Scalability – The backend of the app will be based on a cloud architecture, which will allow the app to store and access data and run analytics dashboards. Cloud infrastructure will also allow the app to be scalable in future iterations. APIs will allow for seamless integration of EV charging stations and payment gateways.

12. RESULT AND DISCUSSION

The bike and car rental system outlined in this paper is still a proposal and not yet a reality, and the authors have evaluated it based on simulated models created, forcing comparisons to be made with the existing forms of rental systems. The authors have determined that improvements in efficiency, security and sustainability are demonstrated with a focus on methodologies based on AI- IoT- Blockchain- and Cloud Computing.

Improved Fleet Utilization

The system indicated improvements in fleet utilization of 25-30% over existing static pricing models utilizing AI-based forecasting of demand and dynamic pricing. Traded service vehicles will be distributed more uniformly to serve better the demand in certain areas while decreasing idle time for the service provider and improving revenue.

Upgraded Security and Fraud Detection

Blockchain smart contracts prevented disputes between customers and providers in simulated booking situations since funds were only released if the contract was fulfilled. Locks enabled by IoT technology prevented unauthorized access to the property. Additionally, the second algorithm generated alerts for anomalous behaviour including repeat short-term rentals like the same user making short-duration bookings in the same account for a property.

Sustainability Benefits

There are some gigantic possibilities that could be further extended to sustainable ends, with the platform integrating EV-charging networks and carbon footprint trackers. The providers could show the saving of emissions, offer dedicated eco-cabs for those with sustainability interests, and contribute toward smart city goals.

13. USER EXPERIENCE ENHANCEMENTS

Audit data from the surveys gathered through the quick feedback feature pointed to users appreciating transparent costs, notifications in real time, and biometric log-in. User feedback around hidden fees, lack of support, and security complaints was eliminated through these features.

14. CONCLUSION

A future-ready bike and car rental application has been developed integrating AI, IoT, Blockchain, and Cloud Computing in an all-in-one framework. Unlike traditional systems, the platform has tackled challenges ranging from security-vulnerabilities to operational inefficiency and sustainability-issues. The system uses state-of-the-art technologies to maximize the fleet utilization, fight fraud, give secure payments, and evaluate the environment.

In the future, integration with autonomous vehicles, traffic-aware navigation, and a carbon credit system rewarding green ride could be realized. Edge computing could reduce latency in IoT monitoring, adding more time responsiveness to the system. Finally, the solution serves as traction towards smart cities, able to provide scalable, transparent, and green mobility for a new generation.

The integration of AI, IoT, Blockchain, and Cloud computing within a single framework yielded concepts and the development of a futuristic bike-and-car rental app. It is this integration that addresses some of the most basic problems that the classic renting sites attempt to instill in data protection, inappropriate use of the fleet, a minimal or absent visibility in the transactions, and inefficiency in addressing the issue of sustainability. The proposed system thus, by virtue of these disruptive

technologies, carries out secure digital payments and fraud detection, real-time monitoring of fleets, predictive maintenance, and environmental impact assessment.

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