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The Potential of Blockchain based Ridesharing System to Enhance Trust and Security: A Conceptual Framework

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Abstract— *Ridesharing has been a popular concept in the 21st century due to the rapid growth of technology. However due to its centralized architecture, it suffers from transparency, safety, and data privacy issues. This conceptual research paper aims to explore the potential solution for enhancing trust and security of the traditional ridesharing systems through the implementation of a blockchain based decentralized ridesharing system and a reputation management system.*

The research methodology consisted of a systematic review of existing literature to gather insights and theoretical underpinnings and also a questionnaire to collect empirical data from the current ridesharing users. The systematic review provided theoretical support for the proposed system, and the questionnaire responses shed light on user preferences and concerns, highlighting the significance of transparency and security in ridesharing experience. This paper contributes insights into the design, implementation, and evaluation of a blockchain-based ridesharing system that prioritizes user trust, security, and privacy, enhancing the understanding and application of blockchain technology in the ridesharing domain.

Keywords— **Blockchain technology, decentralized governance, ridesharing systems, smart contracts, transparency**

I. INTRODUCTION

Transportation plays a vital role in fostering a nation's economic advancement. As our world continues to progress, the transportation industry undergoes a series of transformations. With the relentless expansion of urban areas, conventional transportation approaches have witnessed a decline in efficiency. This, in turn, has led to escalating congestion levels, longer commutes, and increasing carbon emissions. Consequently, ridesharing services have emerged as a noteworthy alternative to the traditional modes of transportation, offering a more efficient and eco-friendly means of commuting from one location to another. Ridesharing, encompassing practices such as carpooling, vanpooling, ride renting, and moto pooling, facilitates the sharing of rides among commuters, with the fare divided among participants. Beyond its fundamental concept, ridesharing embodies a shared economic model that contributes to the sustainable economic progress of a nation (Dabbous and Tarhini, 2021).

Although ride sharing has gained immense popularity in recent years, its origins can be traced back as early as 1605 when the world witnessed the introduction of the first taxi service, utilizing horses and carriages. In 1914, during the economic crisis in the United States, car owners began offering rides to others in exchange for a nominal fee. This practice gained traction through the establishment of car clubs during World War II, providing a means of transportation for workers commuting to their workplaces. The early 1970s saw an upsurge in ride sharing due to the oil crisis in Europe, prompting more individuals to share rides and conserve fuel. Ride sharing brings forth numerous advantages such as reducing traffic congestion in urban areas, cost-sharing for travelers, and reducing carbon dioxide emissions, air pollution, and fuel consumption. Hence it can contribute to several Sustainable Development Goals (SDGs) including Sustainable Cities and Communities, Climate Action and Industry, and Innovation and Infrastructure as it supports economic growth and job creation.

The advent of modern technological advancements and the transition to the digital world have revitalized ride sharing among people. Its profound impact on economies worldwide and the employment opportunities it has generated cannot be overlooked. It is evident that a blockchain based ride sharing system holds the potential to eliminate intermediaries within the

industry, fostering a secure, transparent, and efficient environment for all participants. An in-depth analysis of the challenges in traditional systems will be performed in this paper, along with a novel proposal for a blockchain based, decentralized ridesharing system that addresses them.

A. Background and Motivation

The concept of ridesharing has gained worldwide popularity in recent years due to its potential for reducing traffic congestion, lowering transportation costs, and decreasing carbon emissions to the environment. According to the International Energy Agency, transportation is responsible for 23% of global CO2 emissions and about 30% in well developed countries (*Impact of Carsharing on Household Vehicle Holdings: Results from a North American Shared-use Vehicle Survey | Transportation Sustainability Research Center*). It was found out that transportation sector generates the largest amount of greenhouse gasses in the United States which is around 28% in 2021. It was further identified that Passenger cars, medium- and heavy-duty trucks, and light- duty trucks, including sport utility vehicles, pickup trucks, and minivans, are the main producers of transportation-related greenhouse gas emissions (US EPA, 2015).

According to 'Suburban Sri Lankans spend six years in traffic' (2019), the average person living around the suburbs in Sri Lanka spends around 5 to 6 years of their life waiting in the traffic. Moreover, due to a lack of reliable public transportation, 44 percent of individuals entering the city use personal vehicles, which uses around 87 percent of the road space. A study by Texas A&M Transportation Institute identified that the average commuter spends around 54 hours in traffic per year (Willingham, 2019). These statistics highlight the significance of ridesharing in eliminating these challenges in the modern world. A study by the University of California, Berkeley found out that ridesharing can take away around 90,000 to 130,000 vehicles on the road which means that one shared car can replace 9 to 13 vehicles on the road (*Climate Change and Sustainable Transport | UNECE*).

The concept of ridesharing is not novel as it was found that around 23.5% of the travelers in United States were utilizing ride sharing in the late 1970's ('History of Ride-sharing Revealed'), which shows the significance of ridesharing in the past. Currently, the revenue of the global rideshare market is valued at around 85billion US Dollars in 2021 and is expected to reach up to 370 US Dollars by the year 2027 with an annual growth rate of 16% (*Ride-hailing & Taxi - Worldwide | Statista Market Forecast*). However, issues with data privacy, pricing transparency, and safety have appeared as a result of the centralized nature of the current ridesharing platforms. The personal information of the riders and drivers is vulnerable to malicious attacks and also misuse or misconduct by intermediaries, when stored in central servers. Moreover, a higher percentage from a ride is taken by the intermediaries resulting in inconsistency and lack of transparency in pricing. Hence, decentralized ridesharing platforms that make use of blockchain technology have come into focus as a possible solution for these issues.

Decentralized ridesharing systems could prove beneficial, but there hasn't been much research or application of these systems. The purpose of this research is to investigate if a blockchain based ridesharing system is feasible and further to provide a framework that could enhance the system's overall effectiveness and security.

The rest of the paper is organized as follows. A review of the existing literature is presented in section 2 followed by the methodology utilized for this study in section 3. In section 4, the findings and theoretical framework of the conceptual study are presented followed by the conclusion of this study.

II. LITERATURE REVIEW

To obtain a comprehensive understanding of the current state of blockchain based ridesharing systems and their utilization, a systematic review of the existing literature was conducted by utilizing a rigorous search strategy (Tharuka and Gunathilake, 2023). The systematic review explored the existing research and applications on technical, economic, and social aspects of decentralized ridesharing systems as well as identified knowledge gaps at present. An analyzation of the systematic review is presented below.

Panchalika Pal and Sushmita Ruj (2019) proposed a blockchain based peer to peer ridesharing system called BlockV, which was designed as a solution for the biased nature of the centralized system. It was further developed to ensure fairness among the rides as details about each ride are stored in the blockchain and is

available to everyone in the peer-to-peer network. They were able to show that Ethereum is scalable, and the software can be profitable. This was significant as studies have shown that scalability is one of the biggest challenges of blockchain along with privacy leakage and selfish mining (Zheng *et al.*, 2018). Although there has not been a perfect consensus algorithm, it was found that Proof-of-Stake (POS) better addresses the scalability issue of blockchain compared to POW (King and Nadal).

The study by Badr *et al.* (2021) has presented a blockchain based ridesharing application called GreenRide which was designed to promote the reduction of carbon emissions to the environment. The significant idea of this application is that for every CO2 kilogram saved by using this application, each user is rewarded with GreenRide Tokens (GRT). Ethereum and Metamask were used for the deployment of the system but Pal and Ruj (2019) further utilized the KOVAN test network for additional testing. A filtering method was adopted by Aïvodji *et al.* (2018) for matching the best riders and in order to improve the security, and the system has utilized Goldreich-Micali-Wigderson and Fan-Vercauteren (FV) protocols. The study by Khot *et al.* (2021) explains that the current ridesharing system is vulnerable to distributed denial of carrier attacks and single points of failure. Moreover, to eradicate these issues, a decentralized ridesharing application utilizing smart contracts and the Ethereum blockchain has been proposed by the authors. The system proposed by Badr *et al.* (2021) was designed to face Denial of Service attacks and single point of failure attacks. The results have shown that the system only requires low computation and communication overheads.

M. Baza et.al (2021) has introduced a time-locked deposit protocol where a rider must deposit a certain amount of money before the start of the ride. This was designed to protect the system from multiple ride requests from malicious users. Furthermore, the system has introduced a method called “pay as you drive” where the fare will be calculated based on the elapsed distance of both the rider and driver. A real data set of Uber and Lyft was adopted by Pham *et al.*, (2017) to test the system and the results of it have shown that out of 95% of the rides, the relative error of fare calculation is less than 10%.

Geolocation API and Direction API are used for finding the shortest path to the destination in the system proposed by Joseph *et al.* (2021). The application was built using React native and it was connected to the blockchain via Drizzle. Furthermore, the user details and ride details are stored on the blockchain, but the public keys and the cache data are stored on MongoDB and Redis databases respectively. A similar work called Ridematcher (Bozdog *et al.*, 2018) was deployed in distributed infrastructures with the use of edge or fog computing. This study was conducted on 34,837 taxi rides in New York. The results of this study have shown that it was able to reduce the number of taxi rides in New York by 65% and was able to reduce the cost of the rides by 66%.

III. METHODOLOGY

This conceptual study was aimed to provide a theoretical framework of a blockchain based ridesharing system that will establish trust and security. Hence the hypothesis of this study is that by implementing a decentralized ridesharing platform, the security can be enhanced, transaction cost can be reduced, and the transparency and accountability can be improved by further providing greater flexibility for the riders and drivers. To accomplish this goal, a systematic review was conducted, followed by a questionnaire to collect data from ridesharing participants (Tharuka and Gunathilake, 2023). The methodology utilized in the case study is thoroughly explained below.

Figure 1 below shows the study selection of the conducted systematic review.

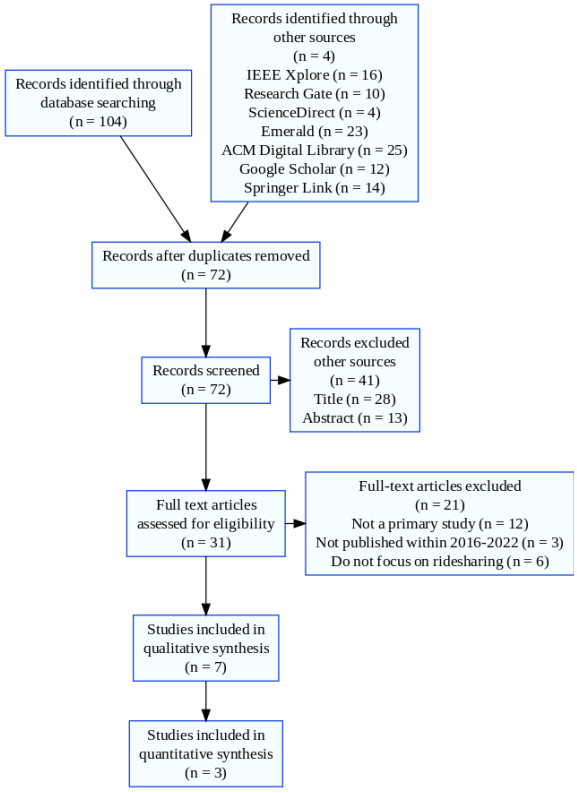

Figure 1. Study Selection
Source: Author created

This systematic review involved a comprehensive and rigorous search of various academic databases and reputable sources to identify relevant scholarly articles, research papers, and publications related to the decentralized ridesharing system with reputation management. Moreover, the analyze and synthesize of the existing literature, enabled a thorough examination of the current research scope in this area and eventually identifying of the research gap.

A questionnaire was distributed among the target audience of the proposed decentralized ridesharing system, which includes both riders and drivers. The questionnaire was designed to gather information on various aspects of the ridesharing system, such as user requirements, features, and preferences. The questionnaire was distributed online using Google Forms, which allowed for easy distribution, collection, and analysis of the responses. The results provided valuable insights into the user requirements and preferences for the proposed ridesharing system, which were used in the design of the proposed system. It further helped in identifying the preferences of the users and also their willingness to share a ride with a random stranger.

Drawing upon the insights obtained from the questionnaire responses and the comprehensive analysis of existing literature, a conceptual framework has been constructed. This framework aims to enhance transparency, security, and user control in ridesharing systems. This conceptual framework serves as a valuable guide for the design and development of future ridesharing platforms that prioritize user trust, privacy, and overall system efficiency. Furthermore, the required modules, users within the system, requirements, interfaces and their interactions are clearly identified.

IV. RESULTS

The distributed questionnaire targeted riders and drivers in the ridesharing community, with a total of 203 valid responses received. The questionnaire was distributed online and aimed to capture insights from individuals across various age groups and occupations. A significant proportion of respondents expressed concerns regarding the lack of information about the driver and the potential misuse of personal information. A significant proportion of respondents (51%) expressed concerns about data breaches and hacking attacks in the ridesharing industry. This highlights the need for robust security measures and data protection protocols to address user apprehensions. 82% of the respondents indicated that they would like to have access to the driver's and rider's names, while 97% wanted to see driver and rider ratings as part of the information provided before sharing a ride. This indicates a strong need for increased transparency and trust-building measures in ridesharing platforms. Approximately 58% of the respondents believed that cryptocurrencies could improve the security of payments in the ridesharing ecosystem. This finding suggests that there is potential interest in exploring alternative payment systems that prioritize security and privacy. The results of the questionnaire, combined with a systematic literature review, have served as the foundation for developing a conceptual framework aimed at addressing the identified issues in ridesharing. The architecture of the conceptual framework is visually represented in figure 2 below, providing a clear overview of its components and their interrelationships.

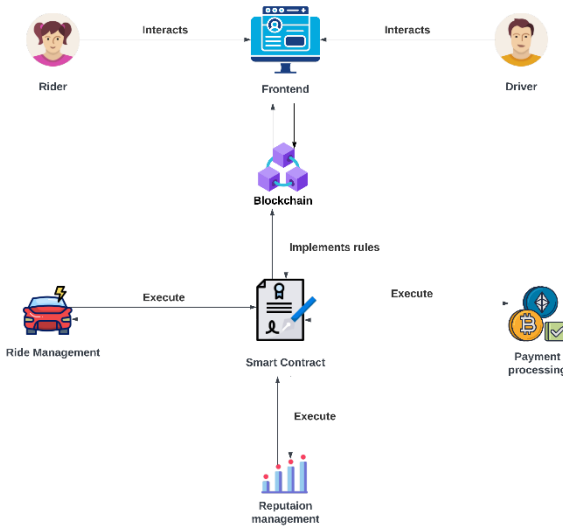

Figure 2. Architecture diagram
Source: Author created

This architecture leverages the Ethereum blockchain, smart contracts, and various supporting modules to enhance transparency, security, and trust within the ridesharing ecosystem. The frontend of the system serves as the user interface, enabling riders and drivers to interact with the platform. Through an intuitive and user-friendly interface, participants can access essential functionalities, including ride requests, driver and rider profiles, and reputation-based information. The blockchain forms the core of the architecture, providing a decentralized and immutable ledger for recording ridesharing transactions, reputation data, and other relevant information. Ethereum blockchain will be utilized in development of this system due to its rich ecosystem of decentralized applications and tools for developing smart contracts. By utilizing blockchain technology, the system ensures transparency, as all transactions and reputation-related activities are visible to all network participants.

Smart contracts, implemented on the Ethereum blockchain, play a crucial role in automating and enforcing the business rules and agreements within the ridesharing system. These self-executing contracts facilitate secure and trustless interactions between riders and drivers, governing processes such as ride matching, fare calculation, payment processing and reputation management. Metamask, which is a browser extension, enables secure interaction between users and the Ethereum blockchain. It acts as a digital wallet, allowing users to sign transactions and authenticate themselves on the platform securely. Metamask enhances the overall security and usability of the ridesharing system by providing a seamless connection to the blockchain network. Finally, Etherscan, which is a block explorer for the Ethereum blockchain, can be utilized by the user to view the system's transactions which establishes transparency.

The pricing mechanisms employed in this system for sharing a ride with additional passengers are designed to ensure fairness and transparency. Initially, the pricing calculation begins with a base fare that covers the cost of the ride, along with distance-based component. When a new passenger joins the vehicle later during the ride, the fare is adjusted to account for their portion of the distance and time traveled. This adjustment can be made by prorating the remaining distance and time among all passengers and recalculating the fare accordingly. The adjusted fare can then be distributed equally among all passengers or assigned based on the distance or time each passenger has traveled. This approach ensures that the fare calculation reflects the actual distance and time each passenger has traveled, promoting equitable cost-sharing among riders while considering the addition of new passengers during the ride.

Once the application's architecture and key components, such as the frontend, Ethereum blockchain integration, smart contracts and Metamask modules, are fully developed, a comprehensive testing strategy will be executed. The testing process will encompass functional testing to validate the core features, security testing to identify and address potential vulnerabilities, and usability testing to assess the application's user experience. Smart contracts should be tested initially as they will be immutable after deployment. By conducting rigorous testing in the future, we aim to ensure the reliability, security, and usability of the decentralized ridesharing application, providing a solid foundation for its successful implementation and adoption in real-world scenarios.

V. CONCLUSION

This research aimed to explore the potential of a blockchain based ridesharing system with reputation management, highlighting its significance in addressing the security and transparency issues in the traditional centralized systems. By leveraging blockchain technology and smart contracts, the proposed system offers transparency, security, and accountability to both riders and drivers. The proposed architecture/framework outlines the various components and modules required for its implementation, including the frontend, Ethereum blockchain, smart contracts, pricing mechanism and

digital wallet such as Metamask. While the actual testing of the application is planned for the future, the conceptualization and design process have laid a solid foundation for the development of a decentralized ridesharing system with reputation management. This research contributes to the growing body of knowledge in the field and paves the way for further exploration and refinement of the system. With its potential to revolutionize the ridesharing industry, this conceptual framework sets the stage for future empirical studies and practical implementations to validate its effectiveness, security, and user acceptance in real-world scenarios.

VI. FURTHER RESEARCH

The future work will focus on the implementation and testing of the proposed blockchain based ridesharing system. Extensive testing will be conducted to validate the system's functionality, security, and usability. This includes unit testing of smart contracts, integration testing of different modules, and end-to-end testing to ensure seamless system operation. The system will be tested to ensure that it establishes transparency and security among its participants.

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ABBREVIATIONS AND SPECIFIC SYMBOLS

SDG - Sustainable Development Goals

CO_2 – Carbon Dioxide

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