THE UNIVERSITY OF NAIROBI.

FACULTY of SCIENCE AND TECHNOLOGY.

DEPARTMENT of COMPUTING AND INFORMATICS.

BLOCKCHAIN-BASED RIDE-SHARING MODEL WITH DECENTRALIZED GOVERNANCE.

BIEGON KIPKOECH COLLINS.

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This project has been presented as partial fulfilment of the prerequisites for the Master of Science degree in Computer Science (Distributed Computing Technology) at The University of Nairobi

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DECLARATION

I, the undersigned, affirm that the work presented here is my original creation and has not been previously submitted to any other college, institution, or university apart from the University of Nairobi.

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DEDICATION

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ABSTRACT.

Digital technologies have gained immense significance in our society and economy. Various sectors embrace technology to optimise operations and achieve efficiency and smooth functioning. One notable example is the rise of technology-powered ride-sharing services, which have witnessed a substantial increase in popularity. These services have emerged as a viable and cost-effective alternative to traditional taxi services, revolutionising people's commutes. This market is undergoing rapid expansion and evolution, with projections indicating a compound annual growth rate of 16.9% between 2022 and 2030. Ride-sharing service companies have received over $100 billion in investments since 2010. However, research showed that these companies struggled to attain profitability and, at the same time, faced a myriad of challenges in governance, labour disputes, regulatory requirements, and transparency. Furthermore, having centralised systems for on-demand ride-sharing services had various drawbacks like surge fees, convenience fees, payment gateway charges, and more, resulting in high costs and inefficient distribution of profits. It was clear that ride-sharing services needed to do better. This study presented a ride-sharing model that employs blockchain technology, tokenomics, and decentralised governance to improve trustworthiness, transparency, and efficacy in addressing the concerns mentioned earlier. The research model aimed to create a community-driven ecosystem to empower riders and drivers while ensuring fair compensation and high-quality services.The proposed model utilised a proof of concept (POC) research design to achieve its objectives and validate its technical feasibility and effectiveness. The POC involved designing and implementing a prototype blockchain-based ride-sharing platform and testing it. The POC also conducts user testing to collect feedback and iterate on the design.After successfully verifying the minimum viable product (MVP), The platform progressed to the piloting phase, subjected to rigorous testing in real-life scenarios. Implementing the pilot program facilitated additional experimentation, data acquisition, and enhancement of the platform's functionalities and administrative framework.The outcomes of the functional testing revealed that the model had effectively met all of its operational and system requirements. Moreover, using blockchain technology and token economics offered a promising solution to the limitations of current centralised ride-sharing platforms.The ultimate goal of this blockchain-based ride-sharing platform was to create a sustainable and equitable ecosystem that benefited all stakeholders. By utilising blockchain technology and decentralised governance, the forum provided a fair and transparent environment for riders and drivers while ensuring the platform's sustainability and scalability.

Keywords: Blockchain, Ride-Sharing, Model, Decentralised Governance

LIST OF ABBREVIATIONS AND ACRONYMS

P2P - Peer to peer

CFI - Corporate Finance International

DAO - Decentralized Autonomous Organization

CAGR - Compounded Annual Growth Rate

POC -proof of Concept

OECD - Organisation for Economic Cooperation and Development

EBITDA- Earnings Before Interest Tax Depreciation and Amortization

CONCEPTUAL AND OPERATIONAL DEFINITION OF TERMS

Model: In this research, the Model refers to the overall framework used to design and operate the ride-sharing platform. The model uses blockchain technology to facilitate secure and transparent transactions between riders and drivers and to support the platform's decentralised governance structure. The model prioritises security, transparency, and community ownership, ensuring the forum operates fairly and equitably for all users.

Blockchain: In this model, Blockchain refers to a decentralised digital ledger that records transactions securely and transparently. Blockchain technology allows for creation of a tamper-proof and transparent system that can securely distribute data, including financial transactions.

DAO: In this model, DAO stands for Decentralised Autonomous Organization. It is an organisation that operates based on rules encoded as computer programs on a blockchain. In a DAO, decisions are made through a consensus of its members, who use tokens to participate in the decision-making process. DAOs are designed to operate decentralised and transparently, with no central authority or single control point.

Governance: This model refers to management as to the decision-making processes and mechanisms that guide the operations of the ride-sharing platform. This includes determining the rules and regulations for the forum, setting fares and fees, managing disputes, and investing in growth initiatives.

Ride Sharing - In this model, ride-sharing refers to the transportation service registered drivers provide on the blockchain network. Passengers can book rides using a mobile application connecting them with available grid drivers.

Decentralised Governance - In this model, decentralised governance refers to the system of decision-making where all network participants have equal voting rights in making decisions related to the platform's operations. Findings may include updates to the system's software, changes to the platform's fee structure, and driver and passenger behaviour policies.

SACCO: In this model, Sacco refers to a cooperative organisation that operates as a decentralised autonomous organisation (DAO). It is a member-owned and member-governed platform where users collectively make decisions about its operations, including setting fares, managing disputes, and investing in growth initiatives.

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CHAPTER ONE

INTRODUCTION

1.0 Introduction

This Chapter provides a background of the fundamental concepts, including; the problem informing the proposed study and the justification for the necessity to offer a ride-sharing model with decentralised governance. It further outlines the research objectives, questions, and the study's scope, assumptions, and significance.

1.1 Background

The sharing economy, or collaborative consumption or peer-to-peer sharing, has emerged as a transformative force in recent years. Enabled by technological advancements and changing consumer attitudes, the sharing economy has disrupted traditional marketplaces and business models across various industries, from transportation and accommodation to goods and services. CFI Team (2021) summarises the sharing economy as “The peer-to-peer (P2P) activity of purchasing, providing, or sharing access to products and services” Sharing economies, leverages technology platforms to enable individuals and organisations to share and access resources, services, and skills in ways that were previously unimaginable. They are furthering people and organisations to profit from underutilised assets. The roots of the sharing economy can be traced back to the early 2000s when platforms labelled peer-to-peer transactions and online marketplaces. (Angela Beklemyshev,2018) However, the advent of innovative technology platforms such as Uber and Airbnb popularised the sharing economy. In 2008 Airbnb was founded, marking the beginning of the modern sharing economy. Airbnb's success was followed by the launch of Uber in 2009, which disrupted the transportation sector by enabling individuals to share rides and utilise their vehicles as taxis. The collaborative consumption movement gained momentum in 2010 by establishing TaskRabbit, a platform that connects individuals with various skills to perform tasks and errands for others. These landmark events catalysed the rapid growth and diversification of the sharing economy ecosystem. Digital platforms play a pivotal role in facilitating sharing economy transactions. These platforms provide the infrastructure for users to connect, negotiate, and complete transactions securely. Trust mechanisms, such as user ratings and reviews, identity verification, and insurance coverage, are often embedded within these platforms to foster trust and ensure a positive sharing experience.

1.1.2 Ride-sharing

Ride-sharing, also known as transportation network services or app-based carpooling, is a prominent and transformative aspect of the sharing economy. It involves individuals offering or accessing rides through digital platforms, connecting drivers with passengers travelling in the same direction. According to Kostas Mouratidis et al., The advancements in information and communications technology (ICT) and the increasing utilisation of mobile and computer-based online applications (apps) have facilitated the extensive integration of tele-activities, the exponential growth of the sharing economy, and the emergence of novel transportation technologies (Kostas Mouratidis et al. 2021). Contemporary cities have embraced the integration of tele-activities, the sharing economy, and emerging transportation technologies as they adapt to the ever-evolving landscape. According to a report by McKinsey & Company 2017, "The rise of ride-sharing has disrupted traditional transportation models, giving birth to a new era of mobility." (McKinsey & Company, 2017).This disruptive innovation has fundamentally changed how people move from one place to another, offering a convenient and cost-effective alternative to traditional modes of transportation.

One of the key benefits of ride-sharing is its optimised utilisation of existing resources. Uber's former CEO, Travis Kalanick, stated in 2014, "Ride-sharing platforms, which connect passengers with drivers already heading in the same direction, have transformed idle passenger seats into potential sources of income and reduced the number of empty seats on the road. This optimisation of resources has not only increased transportation efficiency but has also contributed to reducing traffic congestion and carbon emissions.(Travis Kalanick ,2014)"

Moreover, ride-sharing has provided a new level of convenience and accessibility. As Dara Khosrowshahi, the CEO of Uber, mentioned in 2019, "Ride-sharing has made transportation as reliable as running water." The availability of rides anytime, even in areas with limited public transportation options, has enhanced mobility for millions worldwide.

Additionally, ride-sharing has created new income opportunities for individuals. As Lyft's co-founder, John Zimmer, noted in 2020, "Ride-sharing has transformed ordinary people into entrepreneurs." By becoming drivers for ride-sharing platforms, people can earn money by utilising their vehicles and setting their schedules. This flexibility has empowered many individuals, allowing them to supplement their income or transition to full-time entrepreneurship.

Furthermore, ride-sharing has stimulated innovation in the transportation industry. Traditional taxi services have been forced to adapt and improve their offerings to compete with the convenience and affordability of ride-sharing platforms. This competition has led to technological advancements, such as developing mobile apps for hailing taxis and introducing features like cashless payments and driver ratings. The competition between ride-sharing companies has also fueled innovation, with each platform striving to provide the best user experience and attract more drivers and riders.

Moreover, ride-sharing has had a significant impact on urban mobility. As urban populations grow, traditional transportation infrastructure must improve to meet the demand. In 2018, Susan Shaheen, the co-director of the Transportation Sustainability Research Center at the University of California, Berkeley, expressed the view that ride-sharing services have the potential to decrease private vehicle ownership and complement public transit, thus contributing to creating more livable and less congested cities.

Additionally, ride-sharing has played a crucial role in promoting sustainability and reducing environmental impacts. Shared automobility generally leads to reduced automobile use, carbon emissions and vehicle collisions. By encouraging the sharing of rides, ride-sharing platforms promote resource efficiency and contribute to a more sustainable transportation system. A study by the Union of Concerned, Scientists, study 2016 found that ride-sharing services like Uber and Lyft result in less carbon dioxide emissions per passenger mile than private car ownership.

Ride-sharing has emerged as a game-changer in the sharing economy, revolutionising the transportation industry profoundly. The former Head of Uber's North American Operations, Rachel Holt, aptly described it, "Ride-sharing is more than just an industry; it is a movement that is redefining the way we think about transportation."

However, ride-sharing companies will likely face several challenges in the coming years. According to Christopher Elliott, ridesharing has had a bumpy ride since the pandemic started, and the future of ridesharing is equally uncertain. two years ago, Lyft and Uber ridership dropped 70% - 80%. Only now, with vaccines being more widely distributed, ridership has returned. In addition to uncertainty due to the pandemic, ride-sharing companies face several challenges.

I) Regulatory challenges:

According to the OECD, the taxi industry, along with ride-sourcing and ride-sharing services, has experienced disruptive innovations that have significantly transformed the regulatory and competitive landscape. As a result, regulators and enforcers of competition law are faced with new and pressing questions. Introducing new players and business models has had a profound and disruptive impact on traditional industries by effectively matching real-time demand and supply. However, concerns have emerged, particularly regarding competition with traditional taxi services. In June 2018, the OECD organised a roundtable to address competition challenges associated with taxi and ride-sharing services. The discussion revolved around regulatory and competition challenges arising from the presence of new companies. These challenges encompassed debates surrounding evaluating the existing regulatory framework, technology and big data's role in pricing considerations, the implications of surge pricing from a competition law perspective, and the emergence of alternative business models within the ride-sourcing industry (such as decentralised platforms).

One key aspect of regulatory challenges faced by ride-sharing companies is the clash between their innovative business models and established transportation regulations. Traditional taxi services are subject to specific licensing requirements, fare regulations, and driver qualifications. However, ride-sharing companies introduced a new paradigm that blurred the lines between private and commercial transportation, leading to regulatory debates. As Susan Shaheen, co-director of the Transportation Sustainability Research Center at the University of California, Berkeley, emphasised, "Ride-sharing challenges existing regulatory structures because they typically fall outside traditional taxi and limousine regulations" (Shaheen et al., 2016).

These regulatory disputes have occurred in various countries, with France as a prominent example. In France, ride-sharing companies faced substantial opposition from regulatory authorities and established taxi associations. The primary concern was the perceived unfair competition and lack of compliance with existing regulations. Thibault Lieurade and Marc Baudry examine the regulatory challenges faced by ride-sharing platforms in France, highlighting the conflicts arising from applying existing taxi regulations to ride-sharing services (Lieurade & Baudry, 2019).

The varying legal frameworks across different jurisdictions further exacerbate the complexities of regulatory challenges. Ride-sharing companies often encounter differing interpretations of transportation regulations in each region they operate. This has resulted in a fragmented landscape, with companies needing to navigate a patchwork of regulations that can change from one city to another. The dynamic nature of these regulations adds a layer of complexity for ride-sharing companies seeking to expand their services globally. According to Daniel Oviedo et al., Between 2010 and 2019, the e-hailing industry, encompassing digitally enabled transport services connecting available resources with mobility demand, witnessed a disclosed investment of USD 56.2 billion. Forecasts indicate an anticipated growth of 25% by 2025, encompassing sectors like bike-sharing, ridesharing, car-sharing, and ride-hailing. Most investments have been concentrated in companies from the United States, China, and Europe. These companies have rapidly expanded their presence globally, including significant investments in cities in the global south, which have proven fertile ground for startup ventures. Within this dynamic landscape, homegrown companies have emerged, leveraging entrepreneurship to address gaps in the urban mobility market by offering data-driven innovations and customised services tailored to local conditions. The investments and increasing interest from various stakeholders, including investors, operators, users, incumbents, and decision-makers, have made ride-hailing a significant topic that redefines urban mobility and its implications. Furthermore, the growth, expansion, and operation of urban mobility startups in the sharing economy indicate that emerging innovations such as ride-hailing are likely to endure in various forms. However, the rapid progress in emerging markets has surpassed the ability of decision-makers and legislators to develop guidelines and regulations to manage and govern ride-hailing operations effectively.

II) Competition:

Apart from regulatory challenges, The ride-sharing market has become highly competitive, with multiple companies vying for market share. One of the key benefits of competition in the market is the potential for increased choices and improved consumer services. Ride-sharing platforms strive to differentiate themselves by offering unique features, incentives, and enhanced user experiences. This competition drives companies to innovate and continually improve their offerings to attract and retain customers. As stated by Michael Beckerman, President and CEO of the Internet Association, "Competition in the ride-sharing space has spurred innovation and improved transportation options for consumers" (Beckerman, 2016). The competitive nature of the ride-sharing industry has also fostered a focus on driver incentives and benefits. Ride-sharing companies recognise the importance of attracting and retaining drivers and offer various incentives, such as bonuses, flexible working hours, and additional perks. This competition for drivers benefits individuals seeking flexible work opportunities, as they have more options and can select the platform that best suits their needs.

This intense competition has led to aggressive pricing strategies and driver incentives, impacting profitability(Horan H, 2018). Companies have also faced challenges retaining drivers and passengers as they often switch between different platforms based on incentives and pricing. Sun, Spann, and Fischer (2019). According to McKinsey, while lower prices have contributed to the initial popularity of ridesharing, market share is not simply being “stolen” from providers such as taxis or black-car companies; the market as a whole is expanding. In one large North American city, for example, a single rideshare company grew monthly fare revenues by more than 12 per cent from mid-2013 to mid-2016.

III Public perception and trust:

Public perception and trust are crucial factors for the success of ride-sharing companies. Building and maintaining trust among users and the general public has been a significant challenge for these companies. Negative incidents and controversies have affected public perception and raised concerns about safety, privacy, surge pricing, and fair treatment of drivers. Ride-sharing companies have responded by implementing measures to enhance transparency, address concerns, and improve user trust.

A study conducted by Hugo Guyader (2019) examined the trust-related challenges faced by ride-sharing platforms. The research highlighted the importance of trust in fostering user adoption and long-term sustainability. It emphasised that safety, reliability, ethical practices, and responsiveness to user feedback, shape public perception of ride-sharing companies.

One of the critical areas where trust is established is safety. Ride-sharing companies have implemented safety measures to address concerns and ensure passenger and driver well-being. These measures include driver background checks, vehicle inspections, GPS tracking, and in-app emergency assistance features. Ride-sharing platforms aim to build trust and instil user confidence by prioritising safety. As Lloyd F. George (2019) points out, "Safety is a critical concern for ride-sharing companies, and they have made efforts to implement rigorous safety protocols to protect passengers and drivers."

Transparency plays a vital role in improving public perception and trust. Ride-sharing companies have focused on enhancing transparency by providing detailed information about fares, driver ratings, and trip details. They have also developed user-friendly interfaces that allow passengers to track their rides in real-time and provide feedback on their experiences. These transparency initiatives aim to promote accountability and ensure that users clearly understand the services they receive.

Addressing concerns related to surge pricing has also been a priority for ride-sharing companies. Surge pricing, which adjusts fares based on supply and demand, has faced criticism for its perceived unfairness during peak times. To address this concern, ride-sharing platforms have implemented measures to improve price transparency, provide fare estimates upfront, and introduce features that allow users to schedule rides in advance. These efforts are aimed at mitigating negative perceptions and fostering trust among users.

The actions taken by ride-sharing companies to enhance public perception and trust are indicative of their commitment to improving the user experience. They recognise the importance of listening to user feedback, addressing concerns promptly, and continuously refining their services. Emily Castor, Director of Transportation Policy at Lyft, stated, "Building trust is an ongoing process, and we are committed to being responsive to the needs and concerns of our users" (Castor, 2018).

While ride-sharing companies have tried to improve public perception and trust, it remains an ongoing challenge. Negative incidents or controversies can quickly erode trust, highlighting the need for constant vigilance and proactive measures to maintain positive public sentiment.

It is worth noting that expanding public perception and trust in ride-sharing companies can vary across regions and is influenced by cultural, regulatory, and social factors. Understanding these nuances is crucial for ride-sharing companies to tailor their strategies and build trust effectively in different markets.

IV) Labour Disputes

Labour disputes have been a significant challenge for ride-sharing companies, primarily classifying drivers as independent contractors or employees. This issue has triggered legal battles, public scrutiny, and worker rights and labour protections debates.

The classification of drivers as independent contractors has allowed ride-sharing companies to operate with greater flexibility and cost-effectiveness. However, it has also sparked concerns regarding the lack of traditional employment benefits and protections. Drivers have filed lawsuits seeking employee status and the accompanying benefits, such as minimum wage, overtime pay, and access to healthcare.

One of the key arguments drivers make is that they are economically dependent on ride-sharing platforms and perform work that is integral to the companies' operations. This aligns with the criteria used to determine employee status in many jurisdictions. Alex Rosenblat, a researcher focusing on the gig economy, highlights, "The core tension between gig companies and drivers centres around whether drivers should be classified as employees or independent contractors" (Rosenblat, 2018).

The labour dispute issue gained significant attention when several high-profile cases emerged in different countries. For instance, in the United States, multiple class-action lawsuits were filed against ride-sharing companies, such as Uber and Lyft, alleging that drivers should be considered employees entitled to various employment benefits. These legal battles sparked debates about worker rights and the responsibilities of platform companies.

In response to the labour disputes, ride-sharing companies have argued that their business model is built on the idea of drivers being independent entrepreneurs who enjoy the flexibility to choose when and where they work. They contend that drivers value the platform's autonomy and flexibility and would lose these benefits if classified as employees.

The outcomes of these labour disputes have varied across jurisdictions. Courts have sometimes ruled in favour of drivers, considering them employees entitled to certain benefits. In other instances, legislation or agreements have been reached establishing a new classification or a hybrid model, recognising some rights and protections for drivers without granting full employee status.

As the gig economy continues to develop, the focus remains on the classification of workers and the provision of labour protections. The changing landscape of work and employment relationships has sparked discussions about the necessity of updating labour laws to encompass new business models, such as ride-sharing platforms.

Acknowledging the complexity and multiple dimensions of labour disputes, which involve diverse legal and regulatory considerations across jurisdictions, is crucial. Continuous research and discussions are vital to comprehensively understand the challenges and explore potential solutions for ensuring fair treatment and appropriate protections for gig economy drivers.

1.1.3 Blockchain Technology.

Blockchain technology has emerged as a revolutionary innovation that could transform various industries, including ride-sharing. As ride-sharing companies face challenges such as regulatory hurdles and labour disputes, researchers and industry experts are exploring the applications of blockchain to address these issues. Blockchain, a decentralised and transparent ledger technology, offers features that enhance trust, transparency, and accountability in the ride-sharing ecosystem. By leveraging the inherent characteristics of blockchain, ride-sharing platforms can streamline regulatory compliance, establish fair compensation models, improve safety, and build trust among drivers and passengers. However, some challenges and considerations must be carefully examined to ensure the successful integration of blockchain in the ride-sharing industry.

The ride-sharing industry has garnered considerable attention due to the potential benefits offered by blockchain technology. According to Professor William Knottenbelt, the Director of the Imperial College Centre for Cryptocurrency Research and Engineering, blockchain can revolutionise this industry by facilitating secure and transparent transactions, fostering trust, and reducing reliance on intermediaries (Imperial et al., 2020). The decentralised nature of blockchain ensures that transaction records are distributed across multiple nodes, making it difficult for any single entity to manipulate or tamper with the data. This transparency can cultivate trust among various participants in the ride-sharing ecosystem, including passengers, drivers, and regulators.

An area where blockchain can significantly impact the ride-sharing industry is in addressing regulatory challenges ride-sharing companies face. The intricate and ever-evolving regulations across different jurisdictions often pose significant obstacles for these companies. Blockchain's decentralised and immutable ledger can be a secure and transparent repository for recording transactions and driver data, facilitating regulatory compliance. Alex Tapscott, the co-author of "Blockchain Revolution," elucidates this by stating that blockchain has the potential to enable ride-sharing companies to automatically ensure compliance with local regulations, ensuring that drivers meet the licensing and safety requirements specific to each jurisdiction (Tapscott, 2020).

By utilising smart contracts and self-executing agreements coded on the blockchain, ride-sharing platforms can automate verifying and validating driver credentials, vehicle registrations, insurance information, and compliance with safety standards.

Moreover, the transparency and immutability of blockchain can address concerns regarding the accuracy and reliability of driver and passenger data. Recording ride details, ratings, and reviews on the blockchain make the information tamper-proof and accessible to all relevant stakeholders, including regulators. This transparency can enhance accountability and enable regulators to monitor compliance with safety standards and fair business practices. As Johann Palychata, Founder and CEO of BlockchainHub Berlin, emphasises, "Blockchain technology can offer a more transparent and accountable system for ride-sharing, where data integrity can be verified, and the trustworthiness of drivers can be established through verified ratings and reviews" (Palychata, 2018).

Labour disputes, particularly the drivers' classification as independent contractors or employees, have been a significant challenge for ride-sharing companies. Blockchain technology has the potential to provide a fairer compensation model and address labour-related issues. By using smart contracts and decentralised governance mechanisms, ride-sharing platforms can establish transparent and automated payment systems using smart contracts and decentralised governance mechanisms. These systems can ensure that drivers receive a fair share of the revenue based on predefined rules coded on the blockchain. Eliminating intermediaries and automating payment processes can reduce the potential for payment disputes and enhance the financial stability of drivers. As Natalia Karayaneva, CEO of Propy, highlights, "Blockchain technology can provide ride-sharing drivers with more control over their earnings, enabling them to receive payments in a transparent and automated manner, reducing the reliance on centralised platforms" (Karayaneva, 2020).

While the potential benefits of blockchain in the ride-sharing industry are promising, some challenges and considerations must be carefully examined. Scalability and speed are crucial factors in ensuring the seamless operation of ride-sharing

1.2 Problem Statement

The advent of on-demand taxi services, popularly known as ride-sharing services, has completely disrupted the traditional taxi industry since its launch in early 2010. These services, such as Uber, Lyft, and Bolt, have established a significant presence in 21 African nations, with over 60 ride-sharing businesses operating in the region.(Eleni Mourdoukoutas). The success of these digital services has put traditional taxi services at a disadvantage, making it difficult for them to compete and retain market share. Revolutionising the way we travel, ride-sharing services have undoubtedly transformed the transportation industry, providing affordable and accessible mobility options to millions. However, behind the convenience and affordability lies a troubling challenge that these services face - regulatory challenges, data insecurity, cost determination issues, and exploitative labour practices.

Centralised ride-sharing platforms exhibit various limitations. Intermediaries charge substantial fees for each transaction, resulting in higher passenger costs and reduced driver wages. Moreover, as Nesma Mahmoud et al. highlighted, the centralised governance model of these platforms renders them susceptible to numerous issues, including single points of failure, lack of transparency, inflexibility, and imposition of policies and service conditions. Maintenance and management of central servers can be expensive and prone to distributed denial of service (DDoS) attacks. Service providers' security is also at risk of compromise through hacking, potentially leading to service disruptions, as well as unauthorised access, modification, or deletion of data. These factors threaten user privacy, with data breaches and fraudulent activities becoming increasingly prevalent.

While passengers may benefit from the convenience of centralised ride-sharing platforms, drivers often experience limited control over platform operations and may be subject to exploitative labour practices. According to Andrés Fielbaum and Alejandro Tirachini, the level of transparency in determining driver compensation is ranked as the least satisfying aspect. Many drivers work long hours daily and weekly, posing health and safety risks.

Ride-sharing services need to do better. In order to address these issues, there is a need to explore a blockchain-based ride-sharing model utilising tokenomics and decentralised governance. This research proposes a decentralised, bottom-up approach using blockchain technology to address these challenges and create a more transparent and equitable system. By utilising blockchain, the secure and decentralised exchange of assets without intermediaries becomes possible, allowing for a more equitable distribution of wealth and value. This research aims to outline and comprehensively discuss a novel blockchain-based architecture for on-demand ride services that will enable drivers to organise themselves into worker cooperatives and receive fair compensation for their contributions.

The research will examine the technical feasibility of a blockchain-based ride-sharing model and evaluate the effectiveness of decentralised governance in ensuring fair and inclusive decision-making. By doing so, this research can inform the development of innovative and effective solutions for the future of ride-sharing services. This new approach has the potential to fundamentally alter the existing ride-sharing business model, promoting cooperation and transparency over top-down, hierarchical organisations. By creating a simple, robust, affordable, and reliable system, this research aims to establish a new standard for on-demand ride services, setting the stage for a more equitable and sustainable future for the industry.

1.3 Research Questions:

This study addresses the following inquiries:

1. What are the existing models' weaknesses in ride-sharing services?
2. How can a ridesharing model based on blockchain with decentralised governance be designed?
3. How can a model design for ridesharing based on blockchain with decentralised governance be implemented?
4. How can a blockchain-based ride-sharing model prototype performance be validated and verified?

1.4 Study Objectives:

1.4.1 General Study Objective

The main goal of this study is to create a blockchain-based ridesharing model with decentralised governance to improve the ride-sharing experience.

1.4.2 Specific Study Objectives

The research aims to achieve the following objectives:

1. To explore the weaknesses of existing models in ride-sharing services
2. To design a ridesharing model based on blockchain technology with decentralised governance.
3. To implement the ridesharing model based on blockchain with decentralised governance design
4. To validate and verify blockchain-based ride-sharing model

1.5 Significance:

The integration of blockchain technology in the on-demand ride services sector is a rapidly developing field with the potential to revolutionise how these services are delivered and received. Nonetheless, the effects of blockchain technology on this industry still need to be fully comprehended, necessitating further research to understand its advantages, challenges, and potential. The conventional ride-sharing model has faced criticism for its centralisation and lack of benefits for drivers.

Blockchain technology can facilitate a more democratic and fair system by enabling drivers to partake in decision-making and earn tokens or other forms of incentivisation for their contributions. Decentralised governance can help ensure all stakeholders' interests are represented, resulting in a just and transparent system."

Researching the topic of blockchain-based ride-sharing with decentralised governance can help inform public policy and regulatory decisions related to the sharing economy and emerging technologies. As blockchain-based ride-sharing platforms continue to develop and grow, it is important to understand the potential benefits and challenges associated with these systems to create a regulatory framework that is fair and effective.

Moreover, the research could have practical implications for on-demand ride service companies and their users by providing evidence-based insights into the effects of blockchain technology on user experience, security, privacy, and financial stability. The research findings could also inform the development of new technologies and business models in the on-demand ride services industry.

Overall, researching the topic of a blockchain-based ride-sharing model with decentralised governance is important because it can create a more democratic, secure, and efficient system for all stakeholders. By exploring the benefits and challenges associated with these systems, we can better understand how to create a sharing economy that is fair, sustainable, and beneficial for all.

1.6 Justification

The research of a blockchain-based ride-sharing model with decentralised governance lies in its potential to address many of the challenges traditional ride-sharing services face. This research has significant implications for the future of ride-sharing services helping to inform the development of more equitable and sustainable models for drivers, riders, and the platform itself.

Firstly, this research can help to address the issue of cost determination in traditional ride-sharing services. By leveraging blockchain technology and smart contracts, ride-sharing platforms can eliminate the need for third-party mediators, reducing the cost of transactions and increasing drivers' earnings. This can lead to a more sustainable and equitable business model for all parties involved.

Secondly, the research can address the issue of transparency in traditional ride-sharing services. Using a blockchain-based system, all transactions and decisions are recorded on a public ledger accessible to all parties involved. This can increase transparency and accountability, which can help to build trust between drivers, riders, and the platform.

Thirdly, this research can help to address the issue of data security in traditional ride-sharing services. By leveraging blockchain technology, ride-sharing platforms can create a more secure and decentralised system for storing user data, reducing the risk of data breaches and fraud.

Finally, the research can help address the exploitation issue in traditional ride-sharing services. By using a decentralized governance model, drivers and riders can have a greater say in the decision-making process and help ensure their interests are represented. This can lead to a more democratic and equitable system for all parties involved."

1.7 Limitations of the Study

Although the general objective of this research is to realise a ridesharing model based on blockchain with decentralised governance, blockchain development requires at least 16GB of memory to compile and build the source code at a convenient speed. A new laptop with the required specification was purchased.
The study is limited by the scalability and interoperability issues that may arise when implementing a blockchain-based system for ride-sharing services.

1.8 Assumptions of the Study

This proposal assumes that during the development of the proposed model, participants in the ride-sharing model will be willing to engage in a system based on blockchain technology.
Integrating blockchain technology can address concerns related to trust and governance over content creation and distribution. Ride-sharing is a notable example of the sharing economy, which encourages economic sharing activities on a peer-to-peer basis.
Challenges associated with central authorities, such as single points of failure, lack of transparency, inflexibility, and the dictation of policies and service conditions, can be overcome by decentralising the system. This can lead to a more democratic and equitable system for all parties involved.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction:

The integration of blockchain technology in the ride-sharing sector has attracted considerable interest in recent years due to its potential to address transparency, security, and accountability issues. However, there needs to be more knowledge about the user experiences and perceptions of blockchain-based ride-sharing systems. This literature review seeks to consolidate existing research on the subject, focusing on comprehending the potential advantages and challenges of employing blockchain technology in the ride-sharing industry and the factors that affect user adoption and utilisation of the system. Through this review, we aim to identify areas where further research is needed and lay the groundwork for future studies in this field.

2.1 Overview of Ridesharing

"The emergence of ride-sharing services has revolutionised how people commute and travel within cities. These services have brought convenience, affordability, and flexibility to transportation, transforming the urban mobility landscape." (Smith, 2017) In recent years, ride-sharing has disrupted traditional transportation models and sparked a new era of on-demand mobility. Ride-sharing platforms connect passengers with drivers who use their vehicles to provide transportation services. This innovative concept has gained significant popularity and reshaped the transportation industry. "The concept of ride-sharing dates back to the early 2000s, with the advent of technology-driven platforms that aimed to connect individuals in need of a ride with willing drivers." (Jones, 2019) However, it was only with the launch of Uber in 2009 that ride-sharing truly took off.

"Uber, founded by Travis Kalanick and Garrett Camp, pioneered the modern ride-sharing model by leveraging smartphone applications to connect passengers with available drivers seamlessly." (Johnson, 2020) The introduction of GPS technology, real-time tracking, and digital payment systems revolutionised the customer experience, making it more convenient and accessible.

The success of Uber paved the way for other ride-sharing companies to enter the market, including Lyft, Ola, and Didi Chuxing. These companies introduced similar platforms, each with unique features and strategies, further fueling the growth of the ride-sharing industry. "One of the key factors contributing to the rapid emergence of ride-sharing was the growing popularity and widespread adoption of smartphones. As smartphones became ubiquitous, more people had access to ride-sharing apps, making it easier to request rides with a few taps on their screens." (Clark, 2018) This shift in consumer behaviour, coupled with the rise of the gig economy and a desire for more sustainable transportation options, created a perfect storm for the rise of ride-sharing.

"Ride-sharing services have also presented an opportunity for individuals to supplement their income by becoming part-time or full-time drivers. This flexible employment model has attracted many individuals seeking additional income streams or a more flexible work-life balance." (Harris, 2021) The ability to work on their schedule and be their boss has been a significant appeal for many ride-sharing drivers.

2.2 UBER

One of the most recognisable ride-hail companies globally is Uber Technologies Inc., California, USA. The company provides ride-hailing and meal-delivery services in over 85 countries. It had over 12.5 million downloads in January 2020(uber, 2020), making it the world's most widely used taxi and ride-share app. Uber has achieved sustained growth over the years by implementing various business strategies.

2.2.1 Uber Model

According to Alison Hu from the Harvard Economics Review, Uber’s business model is based on connecting riders with drivers through a mobile app. The company operates on a peer-to-peer model, where drivers use their vehicles to provide rides. Drivers are not considered Uber employees but independent contractors who can set their schedules and pick up riders. This allows Uber to avoid many of the traditional costs associated with running a taxi service, such as owning and maintaining a fleet of vehicles and providing benefits to full-time employees.

The process begins when customers download the mobile app, register, and book their on-demand services. As a customer-focused service, it is essential that passengers feel at ease. Upon booking, the app provides the driver's information and the estimated fare. Passengers can continue to track their journey once on board. The fare is calculated based on car type, distance, and peak hours. A notable feature of their revenue strategy is dynamic pricing, where fares increase during peak hours and decrease during off-peak hours. Various payment options are available for the customer's convenience, including debit cards, credit cards, and online wallets.

Uber earns revenue by taking a commission from each ride, typically around 20-25%. According to the company's financial statements, in 2020, Uber had gross bookings of $22.2 billion and net revenue of $3.1 billion (Uber, 2020). The company also offers services such as UberEATS for food delivery and Uber for Business for managing employee transportation, generating further revenue.

Uber's platform is also integrated with a rating system, where riders and drivers can rate each other after a trip. This allows for a feedback loop where good drivers are rewarded with higher ratings and more trips, and bad drivers can be removed from the platform. This rating system not only helps to ensure the quality of service provided by drivers but also provides an incentive for drivers to maintain good service levels and for riders to provide accurate feedback.

Uber offers a range of services, including UberX, UberBLACK, and UberPOOL, each with varying levels of service and pricing. As stated on Uber's website, Uber Black pairs riders with highly-rated drivers in luxury vehicles for a premium price. Whether for a business meeting or a special occasion, riders choose Uber Black for a top-tier experience. UberX is the most basic and widely used service, while UberPOOL allows riders to share their trips and pay less. This enables the company to serve a diverse customer base, from those seeking affordable options to those desiring more upscale experiences.

Uber's business model has inspired other sharing economy platforms, such as accommodation, more than any other start-up services, accommodation platforms like Airbnb and rental platforms like Turo. According to José G Vargas-Hernández from the University of Guadalajara, Uber's strategy has successfully joined the global market and positioned itself in different countries. This shows the potential of this business model and how it can be applied in other industries.

Uber's business model has revolutionised the transportation industry by using technology to make hailing a ride more convenient, efficient, and cost-effective. Introducing new business models, such as peer-to-peer ride sharing and implementing dynamic pricing, has created new opportunities for riders and drivers. However, it is also important to note that this business model is not without its challenges and criticisms, and the company will need to continue to adapt and evolve to remain successful.

2.2.3 The Strength of the Uber Business Model:

Uber's exceptional performance can be attributed to its user-friendly app, fast server and system responsiveness, and minimal glitches. According to an article on Medium by Didier Hilhorst, Uber's new app design began with a simple concept: 'Start at the end.' Instead of only asking riders to think about getting a ride, the app now prompts them, 'Where to?' Everything is built around that starting point. Passengers can use their smartphones to hail a taxi, making the service accessible to anyone. Uber has established a robust infrastructure, built a reputable brand, and earned consumer trust, with no prior competitors in the taxi service industry.

2.2.4 The Weakness of the Uber Business Model:

Among various startup services, Uber has faced substantial challenges in terms of liability and insurance matters. According to Forbes, while rideshare companies like Uber and Lyft provide some coverage, it may prove insufficient, leaving drivers responsible for significant expenses related to vehicle repairs and medical bills. The company has been embroiled in ongoing legal disputes, as taxi companies and unions in major cities, including New York, have filed lawsuits against Uber. Despite the demand for their service, the considerable overhead costs and expensive legal battles present a significant threat to the business. Uber provides automobile liability insurance for all rideshare drivers in the United States when they actively use the Uber app. Rideshare insurance can be a viable option for drivers seeking to bridge the coverage gap between their car insurance and the protection offered by rideshare companies.

2.3: Taxi 3.0.

Taxi 3.0 describes the next generation of taxi services, incorporating advanced technologies such as blockchain, automation, and connected vehicles (Ryan et al., 2019). The goal of Taxi 3.0 is to create a more efficient, transparent, and cost-effective service for riders and drivers.

Using blockchain technology to establish a decentralised ride-hailing platform is a fundamental aspect of Taxi 3.0. According to Kshetri (2018), the implementation of blockchain technology, a decentralised ledger technology, has the potential to establish an immutable record of all platform transactions, thereby enhancing transparency and security for both riders and drivers. Furthermore, the implementation of blockchain technology has the potential to establish a tokenised framework that can effectively encourage active engagement within the platform. This approach can facilitate a fairer value allocation among all parties involved in the platform (Nakamoto, 2008). Utilising blockchain technology can facilitate the implementation of dispatch systems based on smart contracts. This approach automates the matching of riders and drivers, pricing, and payment handling, resulting in enhanced efficiency and cost-effectiveness. Blockchain technology facilitates reputation-based systems, which allow for and evaluate drivers and riders based on their performance. This mechanism creates a motivating factor for individuals to exhibit positive conduct.

Integrating automation and connected vehicles is a significant characteristic of Taxi 3.0. Using technology to automate tasks, commonly known as automation, can enhance platform efficiency by automating dispatching and routing tasks, resulting in cost reduction and improved user experience, as stated by Li (2018) stated. In contrast, connected vehicles have the potential to furnish instantaneous data regarding the whereabouts and condition of vehicles, thereby enhancing the precision and dependability of the service (Akbari, 2019). Moreover, it has the potential to enhance the precision of traffic forecasts, facilitating the implementation of demand-based pricing strategies, optimising the equilibrium between supply and demand, and guaranteeing prompt ride availability for passengers.

It is noteworthy that the integration of sophisticated technologies poses inherent difficulties. Implementing blockchain technology in the ride-hailing industry poses regulatory and legal challenges. Additionally, the successful implementation of a community ownership model requires a considerable level of organisation and cooperation among drivers. Furthermore, the implementation of automation and connected vehicles has the potential to enhance efficacy and diminish expenses. However, apprehensions have been raised regarding the probable consequences on employment and the necessity to guarantee that the advantages are distributed equitably among all parties involved.

To comprehensively harness the capabilities of Taxi 3.0, it is imperative to undertake additional investigation and advancement in these domains to ascertain the plausible advantages and impediments and devise efficacious approaches for mitigating any eventualities.

2.4: La'Zooz

La'Zooz is a decentralised, community-owned ride-hailing platform that utilises blockchain technology. The platform was first proposed in 2014 by two Israeli entrepreneurs, Matan Field and Dor Konforty, and is currently in development. La'Zooz's primary objective is to establish a business model that is both equitable and sustainable for the ride-hailing industry. This is achieved by decentralising the platform and giving drivers greater autonomy over their working conditions and earnings. The platform employs a token-based mechanism to encourage user engagement, whereby drivers are remunerated with tokens for their involvement in the platform, including providing rides or contributing to its advancement. Subsequently, these tokens can be utilised to procure services on the platform or exchanged on digital currency markets. According to Field and Konforty (2014), implementing the token system establishes a fairer value allocation among the various stakeholders involved in the platform.

Furthermore, leveraging blockchain technology, the platform endeavours to offer enhanced efficiency and cost-effectiveness by leveraging blockchain technology. According to Kshetri (2018), one of the notable features of ride-hailing services is the implementation of smart contract-based dispatch. This technology enables the automation of various tasks, such as matching riders and drivers, setting prices, and handling payments, ultimately leading to increased efficiency and cost-effectiveness.

La'Zooz endeavours to enhance the customer experience by leveraging blockchain technology to offer increased transparency, security, and efficiency. The implementation of blockchain technology has the potential to facilitate the creation of an immutable record of riders' ride history and drivers' earnings, thereby enhancing trust and transparency on the platform.

It is noteworthy to acknowledge that the La'Zooz platform is presently undergoing development and has not been comprehensively executed as of yet. The organisation has yet to introduce a functional product or service, and it remains uncertain whether it will be capable of doing so in the future.

In general, the business model of La'Zooz endeavours to tackle the problems of inequality and inefficiency prevalent in the conventional ride-hailing sector. This is achieved by establishing a decentralised platform owned and operated by the community, enabling drivers to function as a cooperative. The platform employs a mechanism based on tokens to encourage user engagement and leverages blockchain technology to enhance effectiveness and accountability. Nevertheless, akin to numerous blockchain-centric initiatives, the execution of this commercial framework remains ambiguous, necessitating further investigation to comprehensively comprehend the prospective advantages and obstacles of this platform genre.

2.2.0.1: Strengths of the La'Zooz model:

- Decentralization: By decentralising the platform, La'Zooz aims to give drivers more control over their working conditions and earnings and to create a more equitable distribution of value among all stakeholders in the platform (Field & Konforty, 2014).

- Community-based: La'Zooz is community-owned and operated, which allows for a more democratic and transparent decision-making process
- Incentivization: The platform uses a token-based system to incentivise participation in the platform, where drivers can earn tokens by participating in the platform, such as by giving rides or contributing to the development of the platform (Nakamoto, 2008).

2.2.0.2: Weakness of the La'Zooz model:

- Lack of adoption: La'Zooz is a relatively new and experimental platform, and how well the public will adopt it remains to be seen.
- Lack of regulation: As the platform operates on a decentralised model, it may be subject to fewer regulations than traditional ride-hailing platforms, which can pose challenges in terms of safety, compliance, and liability.
- Limited geographic coverage: The platform is currently only available in a limited number of cities and regions, which can limit its reach and impact.

It is important to remember that La'Zooz is still a new and experimental business model, and more research is needed to fully understand this type of platform's potential benefits and challenges.

2.2.1: Arcade City.

Arcade City is a ride-sharing platform based on decentralisation principles, utilising blockchain technology to connect drivers and riders directly, eliminating the need for a central intermediary (Arcade City, 2021). The platform is specifically built on the Ethereum blockchain and employs smart contracts to facilitate transactions between drivers and riders, ensuring a transparent and secure process (Arcade City, 2020).

2.2.1.0: Business model

Arcade City is a decentralised ride-sharing company that focuses on empowering its users and putting control in their hands. Unlike traditional ride-sharing companies such as Uber, which dictate the availability of their service in specific cities, Arcade City operates on a peer-to-peer system that grants full control to its users. According to a Vizologi article, Arcade City's business model revolves around decentralisation and community ownership.

By leveraging blockchain technology and smart contracts, Arcade City aims to establish a platform its users own and operate. This approach grants drivers greater autonomy over their earnings and working conditions while providing riders with more options and flexibility when selecting a ride.

A notable aspect of Arcade City's business model is cryptocurrency integration. Through their native token called Arcade Token (ARCD), Arcade City strives to create a transparent and equitable payment system for its users. This enables drivers to retain more earnings and allows riders to enjoy lower fares.

Another critical aspect of Arcade City's business model is its use of “guilds”. These are peer-to-peer groups of drivers who self-organize to provide ridesharing services in their local communities. Guilds can also create their own branded apps. This approach also aligns with "platform co-operativism" (Scholz, 2016), where users can cooperate in owning and governing the platform. By using guilds, Arcade City aims to create a more localised, personalised and community-driven experience ride-sharing experience for its users.

2.3 Technological Overview

2.3.1 Blockchain Technology

Blockchain, initially created as the accounting system for the digital currency Bitcoin (Eskandari et al., 2018), has now evolved into a versatile technology used in various commercial applications (Lipton, 2018). It operates through the utilisation of distributed ledger technology (DLT). Blockchain operates on a peer-to-peer network, meaning no central authority or intermediary is involved in verifying or processing transactions. Instead, each transaction is verified and processed by nodes in the network, and once a transaction is confirmed and recorded in the ledger, it is permanent and cannot be altered or deleted.

This makes blockchain technology highly secure and resistant to tampering, fraud, and data breaches. It also enables transparency, as every transaction is publicly visible on the ledger, and enables trust between parties without intermediaries.

2.3.2 Blockchain Architecture

2.3.2.1: Nodes

Nodes are a fundamental component of blockchain architecture and play a critical role in the operation and maintenance of a blockchain network. There are several types of nodes, each with its specific responsibilities and functions.

Full Nodes: Full nodes are responsible for storing a complete copy network of the blockchain ledger and validating all transactions and blocks before they are added. They play a crucial role in ensuring the accuracy and integrity of the blockchain by verifying that all transactions and blocks meet the network's consensus rules. Full nodes also help to distribute the blockchain data and make it accessible to other nodes on the network (Narayanan et al., 2016).

Light Nodes: Light nodes, as the name implies, do not store a complete copy of the blockchain ledger. Instead, they rely on full nodes to provide them with information regarding the blockchain. Devices with limited storage and processing capabilities, such as mobile devices, commonly utilise light nodes. They are vital in achieving blockchain scalability (Swan, 2015).

Mining Nodes: Mining nodes actively participate in the consensus mechanism by solving complex mathematical problems to validate transactions and generate new blocks. Mining nodes typically receive cryptocurrency as a reward for their contributions to the network. These nodes play a critical role in upholding the security of the blockchain, preventing malicious actors from tampering with the data stored on the blockchain (Narayanan et al., 2016).

Validator Nodes: Validator nodes are responsible for maintaining consensus regarding the state of the blockchain. They commonly employ consensus algorithms like Proof of Stake (PoS) to agree on the ledger's state. Validator nodes also play a crucial role in ensuring the stability and security of the blockchain, effectively preventing malicious actors from making unauthorised alterations to the blockchain data (Buterin, 2014).

The number and distribution of nodes on a blockchain network can significantly impact the network's performance, scalability, and security. For example, having many nodes can increase the decentralisation and security of the network. However, data storage and processing requirements can lead to slow performance due to data storage and processing requirements. On the other hand, having a small number of nodes can increase performance but may reduce the security and decentralisation of the network (Swan, 2015).

In conclusion, nodes play a critical role in the operation and maintenance of a blockchain network. The type and number of nodes can significantly impact the blockchain's performance, scalability, and security. A well-designed blockchain architecture should carefully consider the types and number of nodes to ensure the network's best possible performance, scalability, and security.

2.3.2.2 Consensus mechanism

Consensus mechanisms play a pivotal role in the structure of blockchain architecture as they ensure the accuracy and integrity of the data within the blockchain. These mechanisms facilitate the agreement among network nodes regarding the state of the blockchain ledger and the validation of transactions. Multiple consensus mechanisms are employed in blockchain technology, each with distinct advantages and disadvantages.

Proof of Work (PoW) is a widely used consensus mechanism that employs computational power to validate transactions and generate new blocks. Originally implemented in Bitcoin, PoW relies on mining nodes engaging in a competitive process to solve intricate mathematical problems. The first node to solve the problem is rewarded with cryptocurrency, and the solution is utilised to validate transactions and create new blocks, subsequently appended to the blockchain (Narayanan et al., 2016).

Proof of Stake (PoS), an alternative consensus mechanism, adopts a different transaction validation and block creation approach. PoS selects nodes based on the amount of cryptocurrency they possess and are willing to "stake" as collateral. Nodes with a higher stake are more likely to be selected to validate transactions and generate new blocks. PoS reduces the computational power requirements of the network and is generally regarded as a more energy-efficient alternative to PoW (Buterin, 2014).

Delegated Proof of Stake (DPoS) is a PoS variant that uses a voting system to elect a limited number of nodes responsible for validating transactions and creating new blocks. In a DPoS system, community-elected validators perform these functions. DPoS helps mitigate the network's computational power demands while enhancing the speed of transaction validation and block creation (Larimer, 2014).

Byzantine Fault Tolerance (BFT): BFT serves as a consensus mechanism that employs a voting system to attain agreement on the state of the blockchain. Within a BFT system, nodes must achieve consensus on the validity of a transaction prior to its inclusion in the blockchain. This approach safeguards the accuracy and integrity of the blockchain's data, even in the presence of malicious actors. BFT is commonly utilised in consortium blockchains, where a limited number of trusted nodes assume responsibility for network maintenance (Cachin et al., 2011).

Consensus mechanisms play an indispensable role in upholding the accuracy and integrity of data within a blockchain network. The selection of a suitable consensus mechanism depends on the specific requirements of the blockchain, considering the trade-offs between performance, scalability, and security. A thoughtfully designed blockchain architecture must carefully consider the consensus mechanism to ensure optimal performance, scalability, and security of the network.

2.3.2.3 Hashing

Cryptographic hashing plays a fundamental role in blockchain technology, ensuring the security and integrity of the data stored within the blockchain. A cryptographic hash function takes an input or "message" and generates a fixed-size output called a "hash." The hash produced is unique to the input; even a slight alteration t will result in a completely different hash. Consequently, cryptographic hashing is a reliable method for detecting unauthorised changes to the blockchain's data.

In blockchain technology, cryptographic hashing is employed in several essential ways. Firstly, it is utilised to generate the digital signature of a transaction, which verifies the transaction's authenticity and integrity. Secondly, it is applied to generate the hash of each block within the blockchain, thereby ensuring the immutability of the blockchain and preventing unauthorised modifications to the data. Lastly, it is utilised to construct a Merkle tree, facilitating efficient data verification within the blockchain (Nakamoto, 2008).

Various cryptographic hash functions are commonly employed in blockchain technology, including SHA-256, SHA-3, and Scrypt. The choice of a specific hash function depends on the particular requirements of the blockchain, considering the trade-offs between security, performance, and computational power (Böhme et al., 2015).

cryptographic hashing is a critical component of blockchain technology, responsible for ensuring the security and integrity of the data on the blockchain. Cryptographic hashing provides a robust method for detecting unauthorised changes to the data by generating unique, fixed-size outputs from inputs. The choice of the cryptographic hash function will depend on the specific requirements of the blockchain, and a well-designed blockchain architecture should carefully consider the cryptographic hash function to ensure the best possible security and performance of the network (Bach et al., 2015).

2.3.2.4: Zero-knowledge proofs.

Zero-knowledge proofs (ZKPs) refer to a cryptographic mechanism that enables a prover to demonstrate to a verifier that they possess a particular piece of information without disclosing it to the verifier (Goldwasser et al., 1989). Zero-knowledge proofs (ZKPs) are employed in diverse domains such as secure multi-party computation, privacy-preserving data analysis, and identity verification. Within blockchain technology, zero-knowledge proofs (ZKPs) can augment the confidentiality and integrity of transactions and user information by enabling data validation without disclosing it.

In a zero-knowledge proof (ZKP), the prover and verifier engage in a sequence of challenges and responses to establish the validity of a claim. According to Ben-Sasson, Chiesa, Tromer, and Virza (2013), the prover furnishes a mathematical demonstration of their possession of the confidential data, while the verifier authenticates the demonstration without acquiring knowledge of the specific information. Zero-knowledge proofs (ZKPs) are engineered to exhibit efficiency, ensuring the verification procedure is expeditious and does not necessitate substantial computational capabilities.

Zero-Knowledge Proof (ZKPs) categories exist, such as zk-SNARKs, zk-STARKs, and zk-rollups, each with distinct characteristics and applications. zk-SNARKs are utilised to verify the legitimacy of transactions in Zcash, a cryptocurrency that prioritises privacy (Ben-Sasson et al., 2013). On the other hand, zk-rollups are employed to augment the scalability of decentralised exchanges based on Ethereum.

Zero-knowledge proofs (ZKPs) have the potential to authenticate digital assets, including artwork and collectables, within the framework of non-fungible tokens (NFTs).

According to Popova (2020), zero-knowledge proofs (ZKPs) can authenticate the identities of riders and drivers while validating the legitimacy of transactions between them.

Zero-knowledge proofs (ZKPs) have the potential to authenticate the identity of a user while preserving their anonymity by not disclosing their data. According to Bentov et al. (2014), the ride-sharing platform can authenticate the rider's age without needing to access their birth date. By implementing this measure, the ride-sharing platform minimises the likelihood of data breaches or unauthorised disclosure of sensitive personal information, thereby safeguarding the privacy and security of its users' data.

Zero-knowledge proofs (ZKPs) have the potential to authenticate the legitimacy of transactions executed between riders and drivers, including remuneration for ride-sharing amenities. Popova (2020) asserts that utilising Zero-Knowledge Proofs (ZKPs) guarantees the authenticity of transactions and prevents tampering. Additionally, ZKPs safeguard the privacy of both parties involved in the transaction.

Zero-knowledge proofs (ZKPs) have the potential to mitigate the likelihood of data breaches, unauthorised exploitation of personal information, and deceitful transactions.

2.3.2.5: Multiparty Computation.

The cryptographic method known as Multiparty Computation (MPC) allows multiple parties to collaboratively execute computation on their private inputs while maintaining confidentiality, per Yao's seminal work in 1986. The outcome of the computation is disclosed to the participating entities, while the specific inputs and interim computations remain undisclosed. The application of MPC encompasses a range of issues, such as the confidential computation of statistical functions, safeguarded voting mechanisms, and the secure analysis of multi-party data.

The utilisation of MPC in the realm of blockchain enables the execution of computations in a secure manner it preserves privacy, even in situations where the involved parties lack mutual trust. Multi-Party Computation (MPC) has the potential to facilitate secure voting in decentralised autonomous organisations (DAOs) and to enable secure computations of financial transactions in a payment system based on blockchain technology.

Multi-party computation (MPC) protocols are specifically engineered to ensure security against malevolent participants in situations where some participants act maliciously or have been compromised (Chaum & van Heyst, 1991). MPC protocols can be categorised into two distinct classifications: information-theoretic and computational. MPC protocols can be classified into two categories: information-theoretic and computational. The former relies on information-theoretic security, whereas the latter is based on computational security. The security of information-theoretic MPC protocols is deemed superior to that of computational MPC protocols, albeit at the cost of increased complexity and greater computational demands.

To conclude, using MPC is a significant asset in facilitating secure and privacy-preserving computation in various applications, including blockchain. Multi-party computation (MPC) facilitates secure and confidential collaboration among multiple parties by enabling them to jointly execute computation on their respective private inputs without disclosing them to one another. This feature of MPC makes it possible for parties to engage in secure collaboration even in situations where mutual trust is absent (Yao, 1986). The utilisation of MPC is versatile and encompasses a range of problem-solving applications, such as secure computation of statistical functions, secure voting, and secure multi-party data analysis. MPC can be categorised into two distinct types, information-theoretic and computational, as outlined by Chaum and van Heyst in 1991.

2.3.2.5: Blockchain Runtime and Smart Contracts

The runtime refers to the operational context within which smart contracts are executed in a blockchain network. The runtime component is accountable for the processing of transactions and the execution of smart contract code, thereby guaranteeing secure, dependable, and efficient code execution. The execution environment enforces the rules and regulations specified in the smart contract code. Additionally, it facilitates access to the essential resources of the blockchain, including its storage and network capabilities.

Smart contracts refer to autonomous computer programmes that enforce the provisions of a contract between multiple parties without the need for intermediaries. Smart contracts offer a mechanism within blockchain technology to automate transaction execution and uphold network regulations and protocols. Contracts can be facilitated, verified, and enforced through their utilisation.

The deployment of smart contracts in a blockchain network involves their execution by the nodes present in the network's runtime. Blockchain technology offers a mechanism resistant to tampering, secure, and transparent, enabling the automation of transaction execution and enforcing contractual terms. According to Szabo (1994), using smart contracts can mitigate conventional contract implementation's expenses and hazards while enhancing effectiveness and openness in the transactional procedure.

The components of blockchain technology that are of utmost importance are runtime and smart contracts. The runtime is responsible for creating the conditions for the execution of smart contracts. These smart contracts, in turn, offer a reliable and transparent mechanism for automating transaction execution and ensuring contractual obligations are met while also providing high security and resistance to tampering. The integration of these two technologies facilitates the development of decentralised applications that are secure, dependable, and effective within a blockchain network, as stated by Buterin (2014).

2.3.2.6: Governance and DAOs:

The term "governance" in the realm of blockchain pertains to the procedures of establishing rules and making decisions in decentralised systems, as stated by Schwerdt et al. (2019) stated. In conventional centralised systems, governing is commonly carried out by a solitary entity or a limited group of individuals. Conversely, in decentralised systems, the responsibility of governing is dispersed among the network participants.

DAOs represent a novel organisational paradigm that operates exclusively through smart contracts and is underpinned by blockchain technology (Liu & Yu, 2020). Decentralised Autonomous Organisations (DAOs) are characterised by their lack of centralised control, as they are not subject to the authority of any singular entity or group of individuals. Instead, decision-making within a DAO is determined by a consensus of its members. Decentralised Autonomous Organisations (DAOs) possess the capacity to transform how entities are managed, given their transparency, security, and immunity to censorship and manipulation by any singular entity. The utilisation of encoded rules and automated execution enables DAOs to function in a transparent and trustless manner. In a DAO, individuals can suggest modifications to the organisation's structure and participate in the decision-making process through voting. Determining the vote's outcome is based on consensus among the members.

2.4: Research gaps:

Platform	description	weakness
Uber	is A ride-hailing company in many countries worldwide. It uses a centralised system where the company acts as an intermediary between drivers and riders.	1. Uber has faced criticism and legal challenges for its treatment of drivers, safety concerns, and its impact on the taxi industry. 2. Uber has also faced criticism for its surge pricing model during times of high demand. 3. The company has faced regulatory challenges in many cities and countries where it operates. 4. Uber has faced criticism for handling user data and privacy concerns. 5. The company has faced competition from ride-hailing companies in many markets.
La'Zooz	decentralised ride-hailing platform that uses blockchain technology.	1. As a decentralised platform that uses its native crypto tokens called Zooz, La'Zooz may face challenges with user adoption and regulatory compliance. 2. geographical limitation, only available in Israel. 3. Lack of adoption: La'Zooz is a relatively new and experimental platform, and how well the public will adopt it remains to be seen.. 4. The platform's reliance on user participation for "road mining" and other activities may limit its growth and effectiveness.
Arcade City,	A decentralised ride-hailing company run by its drivers who self-organize into peer-to-peer "guilds" and is tokenised via Arcade Token (ARCD).	1. As a decentralised platform run by its drivers, Arcade City may face challenges with scaling and maintaining consistent service quality. 2. Using cryptocurrency may limit the platform's

		accessibility to users unfamiliar with digital currencies. 3. The platform may face challenges with user adoption and regulatory compliance. 4. The platform's reliance on driver participation for "guilds" and other activities may limit its growth and effectiveness. 5. The platform may face competition from other decentralised ride-hailing platforms.

Table 1: Existing models

2.4.1 Business Models.

Implementing blockchain technology in ride-sharing services holds promise for developing novel business models that rely on decentralised, peer-to-peer networks. The proposed models encompass various ownership structures, such as Sacco-style models and decentralised autonomous organisations (DAOs) that rely on smart contracts executed on a blockchain network for governance. The novel models can mitigate challenges linked to conventional ride-hailing platforms, including inadequate driver autonomy and reduced remuneration.

Notably, Community ownership is a nascent concept, and there is a dearth of empirical evidence and instances to illustrate its practical implementation. Nevertheless, the notion is intriguing and has the potential to promote a ride-hailing service that is both fair and environmentally sound.

2.4.2 Token Economics:

The field of tokenomics pertains to the functioning of blockchain-based economies and cryptocurrencies and is a nascent study area. As such, there may be insufficient research on its relevance to the ridesharing sector. Notwithstanding the expeditious expansion of ridesharing platforms, t a scarcity of scholarly inquiry centres on the configuration and efficacy of tokens tailored to the ridesharing milieu. Further investigation is needed to explore the creation of value, utility, and mechanisms governing token models specifically designed for ridesharing ecosystems. According to Chen and Liu's (2021) research, it was found that The investigation of the potential of token-based incentive mechanisms in ridesharing platforms is a promising avenue for academic inquiry. Additional research is required to comprehensively comprehend the effects of token-based incentives and gamification on user conduct and involvement.

2.4.3: Privacy and security

Privacy and security are crucial considerations in ridesharing. With ride-sharing applications like Uber and Lyft gathering user location data to enhance service and efficiency, the exposure of user data has become an increasingly significant concern. Researchers from the JTL Urban Mobility Lab at MIT have investigated the impact of safeguarding user data privacy on ride-sharing applications' efficiency and service quality of ride-sharing applications. Their findings indicate that masking location data to prevent user identification in the event of a security breach can lead to a decline in the quality of service in location-based ride-sharing apps. There exists a trade-off between user privacy and the performance of mobility-sharing applications.

The dy compared various methods for data masking and different levels of location data anonymisation, providing valuable insights into this trade-off. The researchers discovered that as the level of privacy protection for users increased, the percentage of shared miles decreased. For instance, the percentage of shared miles dropped from 10 per cent when minimal privacy preservation measures were implemented to 60 per cent with more stringent privacy preservation policies.

Researchers proposed a distributed and privacy-preserving approach for ridesharing systems in another study. This approach integrated multimodal routing algorithms with secure multiparty computations to balance privacy and utility in these systems.

These studies exemplify ongoing research efforts to enhance ride-sharing privacy and security while maintaining efficiency and service quality. However, substantial work still needs to be done in this domain, given the ongoing challenge of reconciling the trade-off between user privacy and performance.

2.4.4: Decentralisation

Decentralisation within ridesharing is a compelling area of inquiry. A decentralised peer-to-peer (P2P) ridesharing system has been proposed by David Sánchez, Sergio Martínez, and Josep Domingo-Ferrer, which eliminates the need for central matching agencies. The distributed reputation management protocol implemented by the system fosters trust among peers. The system is designed to be self-enforcing and mutually beneficial, relying on the co-utility concept.

The concept of co-utility pertains to a collaborative effort that is mutually advantageous, wherein the enhancement of the utilities of other agents is also the optimal means of augmenting one's utility. The utilisation of ridesharing has the potential to be mutually beneficial as it presents the most advantageous alternative for a majority of individuals regarding both financial and temporal considerations, even for those who prioritise their interests above others.

The system was tested by the researchers, utilising authentic mobility traces of taxis in the San Francisco Bay region. Multiple metrics were employed to measure the extent of ridesharing adoption and the resulting benefits for individuals and society. The findings indicate that the decentralised peer-to-peer (P2P) ridesharing platform can enhance the confidentiality and safety of ridesharing while upholding the effectiveness and excellence of the service. Moreover, the implementation of a decentralised platform has the potential to enhance scalability and flexibility by leveraging decentralised networks and peer-to-peer transactions. A decentralised platform facilitates direct transactions between participants, eliminating the intermediary requirement. This, in turn, reduces both the cost and time associated with the transactions (Chiu et al., 2018). The enhancement can potentially augment the velocity and efficacy of the platform, thereby enabling higher throughput of transactions within a shorter timeframe.

Both Arcade City and La'Zooz are ride-hailing platforms that operate in a decentralised manner. Notwithstanding their decentralised nature, both firms have encountered difficulties achieving broad adoption and expanding their platforms, according to Kshetri's (2018) research.

2.5 Proposed solution

2.5.1 Sacco

A Savings and Credit Cooperative, commonly referred to as a Sacco, is a financial cooperative that offers various financial services to its members, such as savings, loans, and insurance. Credit unions, commonly called Saccos, are typically characterised by member ownership and control, with the members serving as the primary customers. Sacco's primary objective is to facilitate financial inclusion by extending financial services to individuals who may not have access to conventional banking services. Additionally, it aims to promote savings and investment among its members. Savings and Credit Cooperatives (SACCOs) are structured and managed as democratic entities, wherein all members possess an equitable voice in the decision-making process, irrespective of the magnitude of their financial contribution.

2.5.2 Sacco DAO

As per Kshetri's (2018) definition, a Sacco is implemented on a blockchain as a Deeain technology and is administered by smart contracts. Implementing a blockchain-based Sacco entails a shift from the conventional centralised administration to a decentralised governance model facilitated by smart contracts, as posited by Kshetri (2018). The smart contract of Sacco incorporates its regulations, protocols, and decision-making mechanisms and is implemented through the collective agreement of its constituents.

According to Kshetri (2018), using blockchain technology in Sacco operations can provide many advantages compared to conventional Sacco systems. These benefits may include heightened levels of transparency, security, and efficiency. The consensus mechanism of the blockchain enables members of a Sacco based on this technology to exercise their voting rights in the decision-making process about changes within the organisation. The utilisation of a public ledger that is resistant to tampering and easily auditable enhances the transparency of Sacco by documenting all transactions and decisions. In addition, the implementation of a Sacco based on blockchain technology has the potential to eliminate intermediaries, decrease transaction costs, and enhance transaction speed, as suggested by Böhme et al. (2015).

Implementing novel business models is a salient characteristic of a Sacco that operates on a blockchain infrastructure. An instance of a Sacco that is based on blockchain technology has the potential to provide its members with tokenised membership or driver tokens, thereby granting them supplementary benefits and incentives. The Sacco platform enables its members to possess and convey tokens that symbolise their ownership and voting privileges within the Sacco. According to Kshetri (2018), using tokens in a Sacco offers a more fluid mode of ownership for its members, as these tokens can be conveniently exchanged between members and traded on various platforms. This engenders a more dynamic and incentivised platform wherein members possess a heightened stake in the prosperity of the Sacco.

Furthermore, the utilisation of tokens, the capacity to integrate novel business models, and the eradication of intermediaries render a blockchain-oriented Sacco a compelling alternative for individuals seeking to engage in a financial cooperative.

The proposed ride-sharing service will utilise a blockchain-based system and adopt a decentralised autonomous organisation (DAO) model founded on a cooperative approach. This will enable the platform to offer a more equitable and community-driven service.

A decentralised autonomous organisation (DAO) modelled after the Sacco system and implemented on a blockchain platform allows for driver membership and collective decision-making regarding commission rates, payment methods, and other platform policies. This facilitates a community-oriented and democratic method of ride-sharing, wherein drivers are empowered to participate in the decision-making process regarding policies that affect their means of subsistence.

Furthermore, the utilisation of blockchain technology facilitates the execution of pioneering financial frameworks, such as micro-insurance or peer-to-peer lending, to the advantage of constituents of the

Sacco-style decentralised autonomous organisation (DAO). As an illustration, motorists can collectively contribute their monetary resources to obtain shared insurance protection, thereby mitigating the economic strain on individual policyholders. This practice confers advantages not only upon the drivers but also on the riders, who can experience a sense of security knowing that their rides are covered by insurance.

In addition, the integration of smart contracts within a decentralised autonomous organisation (DAO) modelled after a Savings and Credit Cooperative (Sacco) on a blockchain platform enables the automatic processing of decisions and fulfilment of contracts among involved parties, thereby minimising the requirement for intermediaries and enhancing operational effectiveness. Moreover, this measure diminishes the likelihood of fraudulent activities and human mistakes, thus furnishing an additional stratum of protection for all stakeholders concerned.

2.6 Conceptual Model.

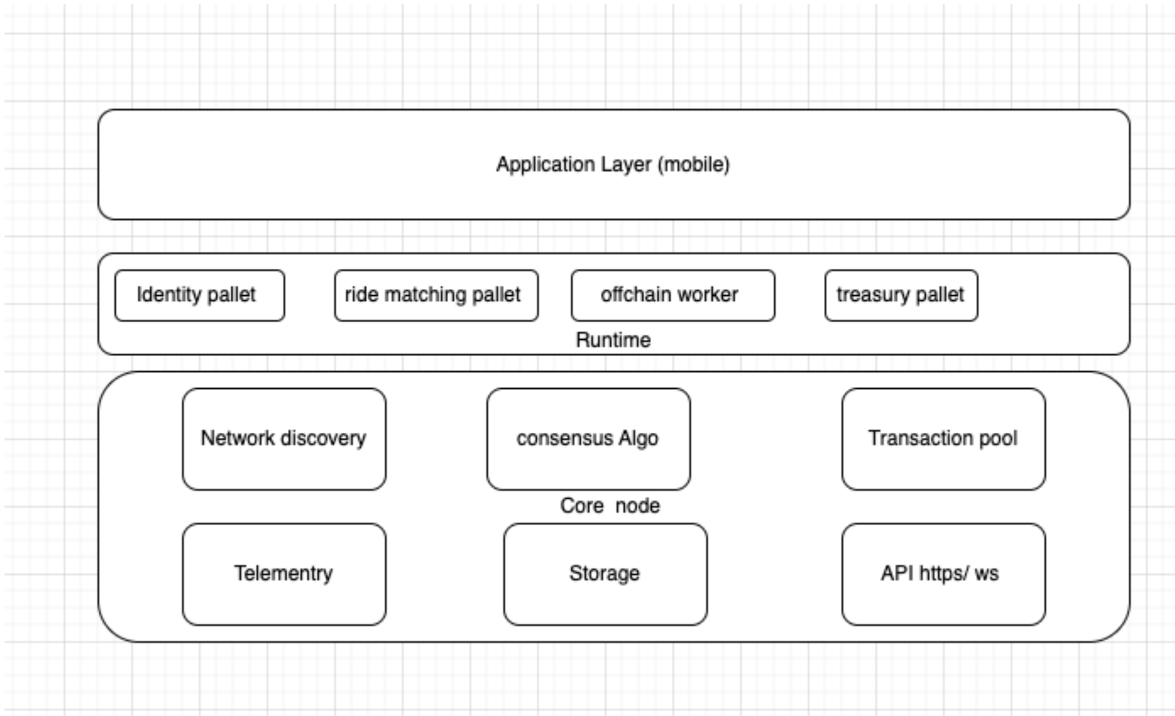


Figure 1: Conceptual model

The system facilitates user interaction via a mobile application interface designed to be user-friendly, catering to drivers and riders. The proposed application would enable users to register an account, define pickup and drop-off locations, and solicit transportation services.

Upon a user's request for a ride, the application transmits a request to the blockchain network to locate suitable available drivers and cater to the user's pickup location and intended destination. The network employs smart contracts and off-chain workers to ascertain the most favourable driver matches and subsequently furnish the outcomes to the user. The user can execute a driver's selection and the ride's confirmation by transmitting a transaction to the blockchain network.

Upon the ride's conclusion, the blockchain network employs smart contracts to compute the fare autonomously and revise the rider and driver's account balances. The application enables users to access their ride history and account balance.

Users would access the blockchain-based ridesharing system through an interface designed to be user-friendly, thereby concealing the underlying blockchain technology and facilitating a smooth ridesharing experience.

CHAPTER THREE:

RESEARCH METHODOLOGY

3.0 Introduction

The research methodology encompasses the systematic design of research work by a researcher to ensure dependable and valid outcomes. As noted by Kumar(2011), research methodology will be a systematic approach to addressing a problem, and its purpose will be to provide a roadmap for the research process. This chapter will discuss how this research was conducted and can be understood by considering the chosen research philosophy, the employed research strategy, and the utilised (and possibly developed) research instruments. These elements were crucial in achieving the research objectives and addressing the research question. In Chapter One, we have presented our research question and research objectives. This chapter aims to

- Elaborate on our research strategy, including the adopted research methodologies in gathering secondary data for review, model design, development, implementation, and evaluation.
- Introduce the research instruments we created and used to pursue our goals.

3.1 Research Philosophy.

Research philosophy refers to beliefs concerning the nature of the reality being investigated. It involves the researcher's assumptions about the best ways to collect, analyse and interpret data(Bryman et al., E. (2019).). It helps researchers establish the epistemological and ontological foundations upon which their research is built. Epistemology, or the study of knowledge, is a branch of research philosophy that deals with actual knowledge (Creswell et al. (2014)). In contrast, ontology deals with beliefs. The goal of science is to turn beliefs into knowledge through inquiry. Within the Western scientific tradition, two main research philosophies have emerged: positivism, which emphasises scientific methods, and interpretivism, which takes an anti-positivist approach and focuses on understanding human behaviour and social phenomena (Galliers, 1991).

From an ontological perspective, this research revolves around the fundamental nature of reality and the understanding of how the blockchain ride-sharing model with decentralised governance operates. The research is grounded in a social constructivist ontological stance, recognising that social interactions and shared interpretations shape reality. It acknowledges that the decentralised governance approach enabled by blockchain technology shifts power dynamics from central authorities to a distributed network of participants. This ontological standpoint allows for exploring stakeholders' subjective experiences, perceptions, and interactions within the blockchain ride-sharing ecosystem.

The epistemological perspective concerns the nature of knowledge and how it can be acquired in studying ride-sharing decentralised governance. Given this subject's complex and evolving nature of this subject, a multi-method approach was considered appropriate, combining both qualitative and quantitative methods. This research recognises the importance of understanding the phenomenon comprehensively through qualitative methods such as interviews, focus groups, and participant observation. These methods provide insights into stakeholders' subjective experiences and perspectives of stakeholders, shedding light on the decentralised ride-sharing ecosystem's social, economic, and governance dynamics within the decentralised ride-sharing ecosystem.

Additionally, quantitative methods, and data analysis of blockchain transactions, can be employed to examine the blockchain ride-sharing model's efficiency, transparency, and economic impact of the blockchain ride-sharing model. This combination of qualitative and quantitative approaches allows for triangulation, enriching the research findings and enhancing the validity and reliability of the study.

The research philosophy underpinning the study of the blockchain ride-sharing model with decentralised governance is grounded in a social constructivist ontological perspective and a multi-method epistemological approach. By adopting a mixed-methods research design and employing qualitative and quantitative data collection methods, this research seeks to uncover the subjective experiences of stakeholders, as well as examine the efficiency and impact of the decentralised governance model. Data analysis would focus on interpreting the meanings and social contexts, providing valuable insights into the potential of blockchain technology in transforming the ride-sharing industry towards a more decentralised and democratic system of governance.

3.2 Research Design

The research design is a plan that guides the researcher in collecting, analysing, and interpreting observations. It serves as the researcher's blueprint for the methods and instruments used to gather and evaluate information in response to the research questions (Eriksson & Kovalainen, 2015). The research design is also defined as a plan for selecting the sources, the type of information, and the overall strategy used to integrate the different components of the study to effectively address the research problem (Ridzuan et al., 2018). It provides a framework for specifying the process to achieve any research objective(s).

The study's methodology was centred around a proof of concept (POC) approach to showcase the viability of the overarching project concept. Various methodologies were employed to accomplish each distinct aim of the investigation. The integrative literature review (ILR) method was employed to elicit weaknesses of the present ride-sharing models, thus addressing the study's first objective. The integrative literature review approach was deemed suitable as it enabled comparing information from various sources while fulfilling the primary objective of substantiating the necessity for a novel ride-sharing model before arriving at a definitive conclusion.The present study employed focus group discussions (FGDs) as a means of gathering comprehensive insights from experts in the fields of Ride-sharing and governance. Focus group discussions were initially employed to assess and analyse the shortcomings of centralised ride-sharing identified through the integrative review procedure.

Secondly, it was used to investigate the proposed blockchain-based model requirements to facilitate the design. This helped gather deeper information about the model's functional requirement and its components, thus achieving objective two. To describe the model users and their potential tasks for the POC, the focus group discussions adopted a scenario-based design to evoke reflection in the model design.

The rapid prototyping approach was used in the model design implementation process. It was employed to demonstrate various aspects of the model functionality and realise the study's third objective. Finally, the developed model was evaluated using functional testing. This was performed using the functional specification provided during the model design and verified the model against the functional requirements. The model was subjected to pilot testing, and user feedback was collected to ascertain the model's quality.

3.3: Proof of Concept (PoC)

Proof of Concept (PoC) was a critical stage in the development of the model. The purpose of a PoC was to demonstrate the feasibility and practical potential of a concept or technology in a real-world scenario. This allowed the developers to evaluate the viability and potential of the technology without incurring excessive costs or resources. As shown (Reed 2017), the proof of concept (POC) or proof of principle (PoP) methodology is widely used in the fields of product design to describe objects, devices, or technologies that demonstrate the feasibility of how a thing may look or function.

The PoC was a prototype or an MVP, Minimum Viable Product. with a minimal feature set. The PoC aimed to demonstrate how the proposed model will support the researcher's goals and requirements and how it will be implemented in a real-world scenario.

The PoC results were used to refine and improve the model and provide valuable insights for future studies and developments in this field.

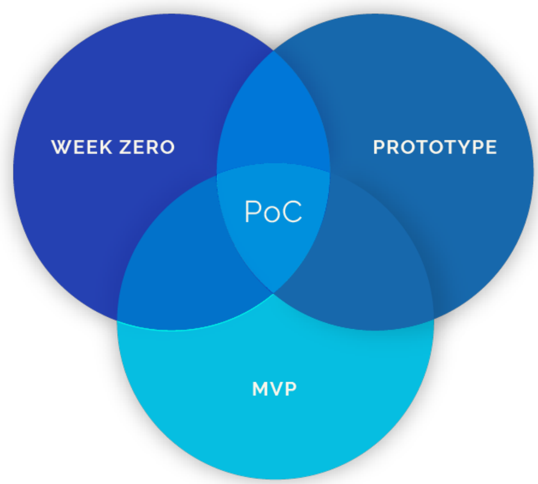


Figure 2: PoC

At the beginning of this research (WEEK ZERO), a comprehensive literature review was conducted to support the need for a blockchain-based solution for the ride-sharing industry, which was described in detail in Chapter 2 and formed a part of the background and justification for this research outlined in Chapter 1. The review revealed the potential benefits of using blockchain smart contracts to improve the manageability and efficiency of the ride-sharing model. It also provided insight into how the objectives and challenges could be mapped to a feasible solution, as demonstrated in Chapter 4. The prototype created during this stage was intentionally kept simple and rudimentary, as the researcher had no intention of reusing it in later stages of development. This stage laid the foundation for the theoretical postulate that was later tested. This research utilised the creation of a prototype to establish the viability and real-world applicability of the proposed concept. This helped the researcher and stakeholders evaluate the best approach for advancing the product towards full production and eventual market launch, as outlined by Segura in 2018 (Segura, 2018).

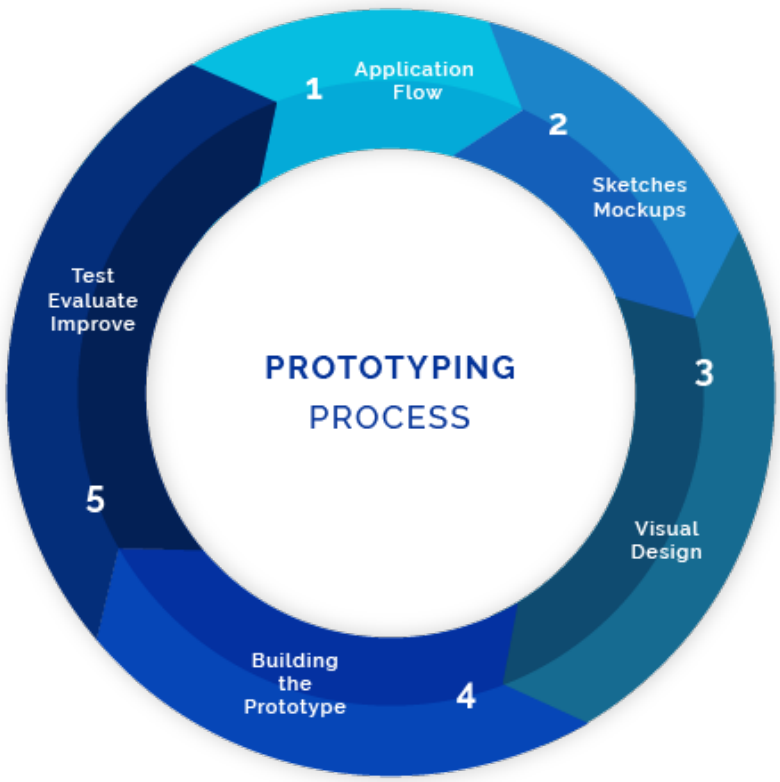


Figure 3:prototyping process

Additionally, the goal of the minimum viable product (MVP) was to verify the feasibility and practicality of the proposed solution as efficiently and effectively as possible. This was achieved by creating a product with a limited set of features sufficient to test the research's core assumptions. The MVP was designed to validate the postulate of the model with minimal resources and to provide insights into the potential impact of the proposed solution in real-world applications.

Chapter 4 of the research provided a comprehensive description of the implementation of the proof of concept (PoC) and the design considerations that were considered. It highlighted the use cases defined for the PoC and described the process of creating and testing the PoC. The results of these tests were used to validate the proposed model and the PoC and to make improvements and modifications where necessary.

It is important to note that the purpose of the MVP and the PoC was not to produce a final, market-ready product but to demonstrate the feasibility and potential of the proposed solution. This information was crucial in helping the researcher and other stakeholders make informed decisions about the development of the final product and ensuring that the solution could be scaled and implemented effectively in real-world applications.

3.2: PDIOI Approach

The Planning, Design, Implementation, Operation, and Improvement (PDIOI) approach was taken when designing the model. This approach, developed by Huawei, is a comprehensive methodology for implementing enterprise engineering projects designed to enhance agility, streamline processes, and address complexities during PoC implementation(Huawei, 2020). The PDIOI lifecycle consists of five interrelated phases and is widely regarded as a best-practice approach for ensuring the successful completion of complex engineering projects.

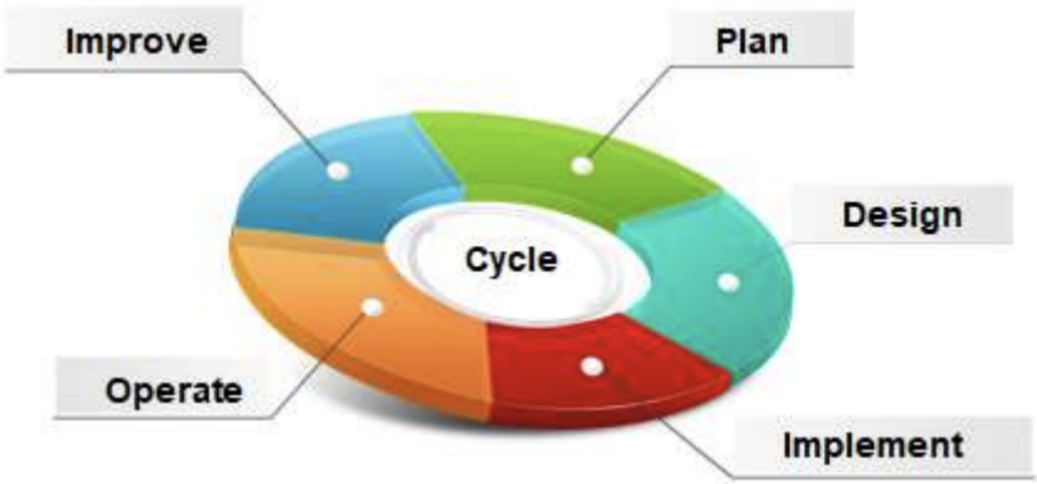


Figure 4: PDIOI phases

Step 1: Planning phase

The planning phase of the PDIOI methodology involved defining the project scope and objectives, identifying the resources and personnel required, creating a project schedule, and determining the project budget. During this phase, the researcher defines the problem and determines the feasibility of the solution. This phase was crucial because it would lay the foundation for the rest of the project and help ensure it remains on track and within scope. The planning phase will also include creating a risk management plan to help mitigate potential risks during the project's execution. During this phase, the researcher also defined the project's success criteria and determined how the results would be measured and evaluated.

Step 2: Design phase

This phase started with defining the requirements and specifications of the system and mapping them to the architecture of the blockchain-based ride-sharing solution. The design considered the various stakeholders involved in the ride-sharing process, such as riders, drivers, and intermediaries, and ensured their needs were met. The design will also consider the security and privacy aspects of the system, as well as the scalability of the solution.

In the design phase of blockchain for ride-sharing, the system's technical specifications will be determined, including data structures, algorithms, and protocols used to implement smart contracts and runtime. This phase will also involve the development of user interface and experience designs and testing and debugging of the system. The design phase must ensure that the solution is technically feasible and meets the stakeholders' needs in the ride-sharing process.

Step 3: Implementation phase.

During this stage, the design and specifications from the previous phase were transformed into a functional product. Blockchain technology, smart contracts, and related infrastructure were established to support the decentralised system. The development team focused on integrating various solutions, such as payment systems, identity management, and data storage, to create a seamless and secure user experience. The development team also tested the system to ensure it meets the requirements and specifications outlined in the design phase. Additionally, the implementation stage involved setting up the environment for real-world deployment of solutions, including deploying nodes and establishing communication protocols. The success of this stage is crucial for the overall success of projects as it sets the foundation for future operation and improvement of blockchain-based ride-sharing solutions.

Step 4: Operation phase.

This phase involved ensuring the smooth and seamless functioning of the system. This included monitoring the system's performance and reliability, addressing issues or bugs, and making necessary updates or improvements to maintain its optimal performance. The focus of the operation phase will be on ensuring the secure and efficient execution of smart contracts, managing the decentralised network of nodes, and monitoring transactions being processed on the blockchain. User support and management of any disputes or conflicts arising within the system will also be key considerations in this phase. Overall, the operation phase aims to maintain n stability and reliability of blockchain-based ride-sharing solutions to ensure a seamless user experience.

Step 5: Improvement phase.

The PDIOI methodology's improvement phase focused on continuously improving the blockchain solution for ride-sharing services developed during previous phases. This phase involved collecting and analysing feedback from users and stakeholders, identifying areas for improvement, and implementing changes to enhance the functionality and performance of the solution. This phase aims to ensure that the solution remains relevant and useful over time while addressing any challenges or limitations that may arise. This will typically be an ongoing process repeated throughout the solution's lifecycle as new technologies and trends emerge, and customer needs and expectations change. The improvement phase is critical for ensuring long-term success and the sustainability of the solution as it allows for continuous optimisation and evolution to meet evolving needs of the ride-sharing market.

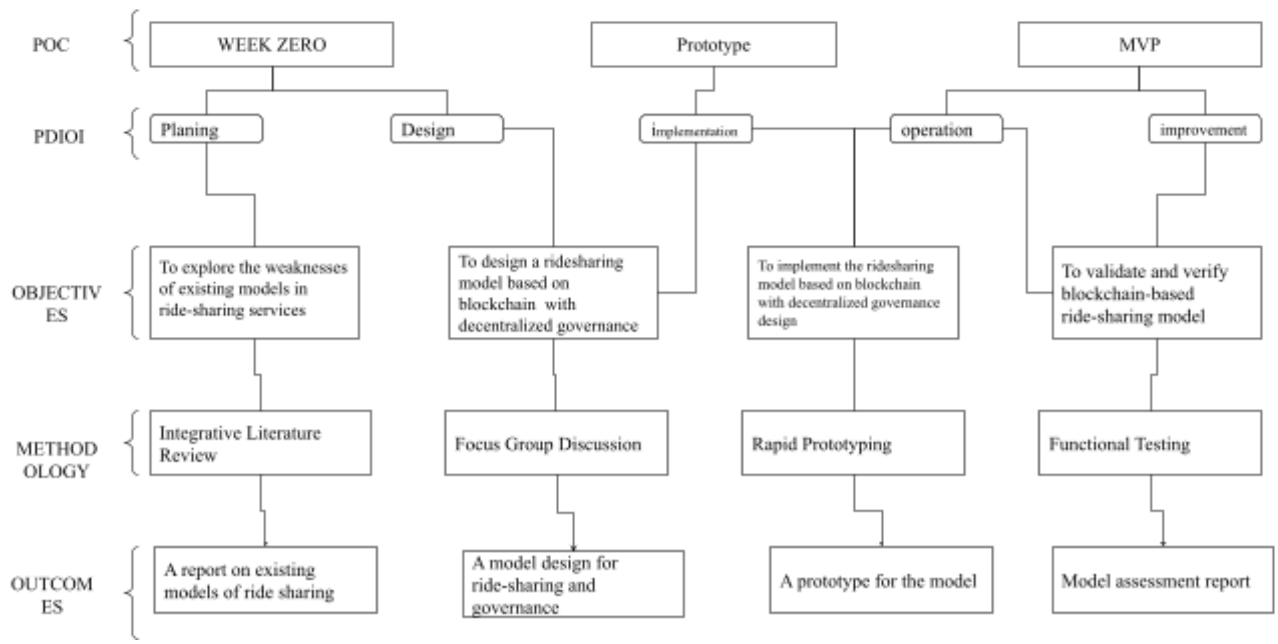


Figure 5: Methodology summary

3.3 Integrative literature review.

The integrative literature review methodology helps synthesise and analyse existing research on specific topics. This methodology aimed to identify and review diverse secondary data sources relevant to the first objective of this study—the first objective aimed to explore the weaknesses of existing models in the ride-sharing services industry. Conducting an Integrative literature review on blockchain ride-sharing with decentralised governance allowed for a comprehensive understanding of the current state of knowledge, identified research gaps, and provided insights for future studies.

The following steps were followed in conducting the integrative literature review on blockchain ride-sharing with decentralised governance:

A. Identification of the research question:

The research question for this integrative literature review is: "What are the key findings and weaknesses of existing centralised ride-sharing models and trends in the application of blockchain technology for ride-sharing platforms with decentralized governance?"

B. Literature search:

A comprehensive search was conducted in electronic databases, such as ACM Digital Library, IEEE Xplore, Google Scholar, and relevant academic journals. The search terms included combinations of keywords such as "blockchain," "ride-sharing," "decentralized governance," "peer-to-peer," and "distributed ledger."

C. Selection criteria:

Studies were included if they focused on blockchain technology's application in the context of ride-sharing platforms with decentralised governance. Only articles published in English from 2015 to date were considered.

D. Data extraction:

Relevant data from selected studies were extracted, including authors, publication year, research objectives, useful method findings, and implications.

E. Data analysis and synthesis:

The extracted data were analysed and synthesised to identify common themes, trends, and patterns. Similar findings were grouped, and overarching conclusions were drawn based on the collective evidence.

F. Critical evaluation:

The selected studies were critically evaluated for their methodological rigour, reliability, and validity. Limitations and gaps in the literature were identified to provide insights for future research.

Key findings can be found in section 4.1

3.4 Focus group Discussion.

Focus group discussions (FGDs) are a qualitative research method involving engaging individuals in a guided discussion to explore their perspectives, experiences, and opinions on a specific topic. In the context of blockchain ride-sharing with decentralised governance, FGDs can provide valuable insights into the perceptions and expectations of stakeholders regarding the implementation and impact of blockchain technology in ride-sharing platforms.

The focus group discussion followed the guidelines established by Krueger and Casey (2000) for conducting FGDs. The following steps were followed:

Participant recruitment:

1. Participants were selected based on their involvement or interest in the ride-sharing industry, blockchain technology, and decentralised governance. A diverse group of stakeholders, including riders, drivers, platform operators, and industry experts, was invited to participate to ensure a range of perspectives.

Development of discussion guide:

2. A discussion guide was developed to facilitate the FGD. The guide included open-ended questions and prompts about participants' perceptions, experiences, and expectations regarding using blockchain technology in ride-sharing platforms with decentralised governance. The questions focused on transparency, trust, peer-to-peer transactions, decentralised decision-making, data privacy, and security.

Conducting the FGD:

3. The FGD was conducted in a neutral and comfortable environment, ensuring all participants could express their opinions. A moderator facilitated the discussion while an observer took notes and monitored the session's flow.

Data analysis:

4. Thematic analysis was conducted to identify recurring patterns, themes, and key insights emerging from the discussions. The data were coded and categorised based on similarities and differences in participants' responses.

3.5 Model Development

During the implementation of the model into action, a rapid prototyping approach similar to the one shown in the following picture was utilised. According to Menold et al. (2017), a prototype is a model of a product or system in part or its entirety. According to Menold et al. (2017), rapid prototyping (RP) produces a low-fidelity item to test a concept. The initially suggested design was turned into a workable prototype with the help of the rapid prototyping approach, shown in the figure below.

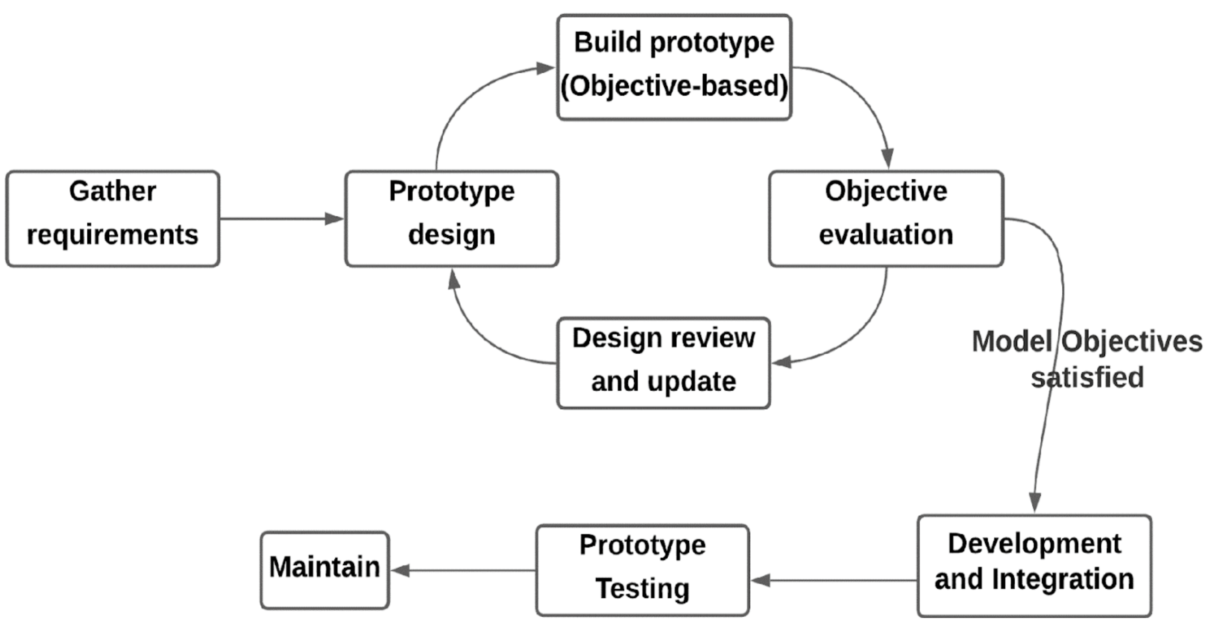


Figure 6: Prototyping process

a) Gather Requirements

Using the results from the first part of the study, this investigation considered the centralisation flaws highlighted in the analysed literature. This part of the RP includes a report to address the shortcomings of the current models, which is based on the findings from the literature study and the input received from the focused groups on the minimal functional requirements for the model. Section 4.2.2 demonstrates the requirements collection process.

b) The Model Prototype Design.

The model prototype design for a blockchain-based ride-sharing platform with decentralised governance presents a blueprint for leveraging blockchain technology to address the limitations of traditional ride-sharing models. By incorporating features such as a robust blockchain infrastructure, smart contracts for governance, user identity and reputation management, decentralised ride allocation, peer-to-peer payment systems, and community voting mechanisms, this design aims to enhance transparency, trust, and fairness in the ride-sharing industry. A hierarchical framework and modular design principles were used during this period

c) Build a prototype.

During the stage of RP implementation, the model was constructed, and the extra components were incorporated according to the design specifications, Supporting infrastructure, and governance.

The prototype consisted of but was not limited to the stages listed below.

A rundown of the many processes involved in setting up an environment

Functional decomposition and implementation

Integration of modules and elements that were independently developed and implemented.

d) prototype testing.

Functional testing, testing of smart contracts/ runtime, testing of integration outcomes, and testing of all the other functional and quality features determined during gathering requirements and planning the prototype were included in the prototype testing process. This required testing both off-chain and post-chain deployment procedures simultaneously. After a transaction procedure (initiation, validation, and storage) was finished and saved within the blockchain network, the prototype's components were evaluated for suitability.

3.6 Model Evaluation

3.6.1 Functional testing

The Software and Systems Modeling (Shas) framework developed in 2018 provides a comprehensive approach to conducting functional testing. The ShaS framework encompasses various stages and techniques that can be applied to validate and verify the model's functionalities. This section outlines the key steps in the functional testing process using the ShaS 2018 framework.

1. Requirement Analysis: The first step in functional testing is to analyse the functional requirements of the blockchain-based ride-sharing model. This involves understanding the desired behaviours and features of the system, as specified in the project documentation or requirements specification. As noted in section 4.2.2.
2. Test Planning: A test plan is developed once the requirements are identified. The test plan outlines the testing objectives, scope, test scenarios, and test cases. It also defines the testing techniques and tools to be used in the functional testing process.
3. Test Design: Test design involves the creation of test scenarios and test cases based on the identified requirements. Test scenarios outline the sequence of steps to be performed to test

functionality. In contrast, test cases specify the inputs, expected outputs, and preconditions for each test scenario.

4. Test Execution: In this step, the test cases are executed to validate the functionalities of the blockchain-based ride-sharing model. The execution process involves providing the inputs specified in the test cases and comparing the actual outputs with the expected results.
5. Test Reporting: Test reporting involves documenting the test results, including any observed defects or deviations from the expected outcomes. This information helps stakeholders in understaunderstand's performance and identify areas that require improvement.
6. Test Evaluation: The test evaluation phase assesses the effectiveness of the functional testing process. It involves analysing the test results, identifying any patterns or trends in the defects, and evaluating the overall quality and reliability of the blockchain-based ride-sharing model.
7. Test Maintenance: Test maintenance refers to updating the test cases and scenarios based on changes in requirements or system updates. As the blockchain-based ride-sharing model evolves, the functional testing process should adapt to ensure continuous system functionalities validation.

3.6.2 Pilot testing:

According to Dellinger et al. (2018), pilot testing is software testing, which a group of end-users carries out before the product is fully deployed. It assists in determining the problems associated with the various parts of a system and evaluates the user experience. In addition to this, it assesses the practicability of the established research project and its efficiency under real-world conditions.

- Purpose: This pilot testing framework outlines the approach and guidelines for pilot testing on the blockchain-based ride-sharing model with decentralised governance.
- Objectives: The objectives of pilot testing are to evaluate the real-world implementation, user acceptance, practicality, and usability of the model.
- Scope: This framework focuses s on pilot testing and does not cover other aspects, such as functional testing or performance evaluation.

2. Participant Recruitment:
    - Selection Criteria: Define the criteria for selecting participants for the pilot testing phase, considering demographics, user roles (drivers and passengers), and willingness to provide feedback.
    - Recruitment Process: Outline the process for recruiting participants, including the channels for reaching out to potential users and the methods for obtaining their consent.
3. Test Environment:
    - Real-World Deployment: Describe the steps involved in deploying the blockchain-based ride-sharing model in a real-world environment, including the configuration of the system and the integration with existing transportation infrastructure.
    - Data Preparation: Specify the process for preparing the necessary data for pilot testing, such as creating sample rides, generating transactions, and simulating user interactions.
4. Pilot Testing Execution:
    - User Guidance: Provide participants with clear instructions and guidance on accessing and using the blockchain-based ride-sharing model. This may include user manuals, tutorials, or onboarding sessions.
    - Data Collection: Define the methods and tools for collecting relevant data during the pilot testing phase, such as ride logs, user feedback forms, and system performance metrics.
    - Duration: Determine the duration of the pilot testing phase, considering the number of participants, the expected workload, and the need for gathering good feedback.
5. User Feedback and Evaluation:
    - Feedback Collection: Specify the mechanisms for collecting participant feedback, such as surveys, interviews, or focus groups. This feedback should cover user experience, satisfaction, and perceived benefits or challenges.

- Feedback Analysis: Outline the process for analysing the collected feedback, identifying common themes, patterns, and areas for improvement. This analysis can help refine the blockchain-based ride-sharing model and address any issues or concerns.

6. Test Reporting and Evaluation:
   - Test Results: Document the findings and observations from the pilot testing phase, including user feedback, system performance data, and any encountered challenges or successes.
   - Evaluation Metrics: Define the metrics and criteria for evaluating the success of the pilot testing phase, such as user adoption rate, satisfaction scores, and system stability.
   - Recommendations: Based on the pilot testing results, provide recommendations for improvements, refinements, or further iterations of the blockchain-based ride-sharing model.
7. Test Closure and Next Steps:
   - Test Closure: Summarize the pilot testing phase, including its duration, participants involved, and key findings. Acknowledge the contributions of the participants and the testing team.
   - Next Steps: Discuss the future steps, considering the pilot testing outcomes. This may include further enhancements, scalability testing, or preparing for full-scale deployment based on the lessons learned.

3.7 Ethical issues/ consideration

Ethical Issues/Considerations for Pilot Testing in the Research Study

1. Informed Consent: Before participating in the pilot testing, all participants were provided with clear and comprehensive information about the research study, its objectives, and the nature of their

involvement. Informed consent was obtained from each participant, ensuring their voluntary participation and understanding of the potential risks and benefits.

2. Privacy and Data Protection: Participants' privacy and the protection of their personal information were paramount. Measures were taken to ensure participant data's secure handling and storage of participant data, adhering to relevant data protection regulations. Data anonymisation techniques were employed to remove personally identifiable information where appropriate.

3. Confidentiality: Confidentiality was maintained throughout the pilot testing process. Participant data and feedback were treated with strict confidentiality, and only aggregated, anonymous data was used for analysis and reporting purposes. The anonymity of participants was preserved unless explicit consent was obtained for disclosure.

4. Voluntary Participation and Withdrawal: Participants could withdraw from the pilot testing without facing any adverse consequences. The voluntary nature of participation was emphasised, and participants were provided with contact information for queries, concerns, or withdrawal requests.

5. Transparency and Open Communication: Participants were informed about the pilot testing's purpose, procedures, and expected outcomes of the pilot testing. Clear communication channels were established to address any queries or concerns raised by participants throughout the testing process.

6. Fairness and Equity: Ensuring fairness and equity among participants was a priority. No discrimination or preferential treatment based on personal characteristics or attributes was permitted. All participants were given equal opportunities to engage with the platform and provide feedback.

7. Consideration of Vulnerable Participants: Special attention was given to the protection and well-being of vulnerable participants, such as minors or individuals with specific needs. Extra care was taken to obtain appropriate consent from legal guardians or ensure the provision of necessary accommodations.

8. Ethical Approval: The research study and its pilot testing phase obtained ethical approval from the relevant institutional review board or ethics committee. Compliance with ethical guidelines and regulations was strictly adhered to throughout the research process.

By addressing these ethical issues and considerations, the pilot testing phase of the research study ensured the ethical treatment of participants and the responsible conduct of research. Upholding ethical princ only protects the rights and well-being of participants and contributes to the credibility and integrity of the research outcomes.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents our comprehensive data analysis on blockchain-based ride-sharing with decentralised governance. Through a rigorous examination of the data, we uncover key insights into the potential benefits and challenges of this innovative approach to transportation. This was achieved by answering the research questions derived from the specific objectives and application of the specified research methodology.

Our analysis focuses on several key areas, including the effectiveness of decentralised governance in promoting transparency, security, and fairness in peer-to-peer transactions. The study's first objective will be addressed through an Integrative Literature Review & data analysis. The first goal was to analyse the existing ridesharing business models to identify those models' problematic aspects. It analyses the current centralised and decentralised models and finds the flaws in each one. As a result, it directs the design and implementation of the projected model.

In analysing the data collected from the focus group, an attempt is made to derive meaning from the participant's responses to the questions in the discussion guide. As a result, it aims to determine the needs of the proposed model and its components to make the design and execution of the model easier. The findings that were determined based on the objectives are discussed in this chapter. The findings were presented in tables, figures, and percentages, and explanations were offered in prose afterwards.

4.1 Weakness of existing models in ride-sharing.

1. Lack of transparency:

One major weakness of centralised ride-sharing models is their lack of transparency. With control held by a single entity, decision-making can be opaque, and users may need to understand how the system operates clearly. This can lead to a lack of trust among users and a perception that the system must operate in their best interests (Mahmoud et al., 2022). In contrast, a decentralised model with distributed governance allows for greater transparency and accountability, as all participants have a say in decision-making (Yuan & Wang, 2016).

2. Limited accountability:

Centralized ride-sharing models can also need more accountability. With control held by a single entity, there may be limited mechanisms for holding decision-makers accountable for their actions(Mahmoud et al., 2022). This can result in decisions not in the best interests of users or drivers, leading to dissatisfaction and reduced trust in the system. A decentralised model with distributed governance offers greater accountability, as all participants have a say in decision-making and can hold each other accountable.

3. Vulnerability to fraud:

Centralized ride-sharing models can be vulnerable. With control held by a single entity, there is a risk that hackers could target the system and gain access to sensitive user data and financial information. This can result in significant financial losses for users and damage the ride-sharing service's reputation. A decentralised model based on blockchain technology offers greater security and reduces the risk of fraud.

4. Security breaches:

Centralized ride-sharing models can also suffer from security breaches. Hackers can target centralised systems and gain access to sensitive user data, resulting in the loss of personal information and financial data. This can result in significant harm to users and damage to the reputation of the ride-sharing service. A decentralised model based on blockchain technology offers greater security and reduces the risk of security breaches.

5. Lack of trust:

A lack of transparency and accountability can lead to a lack of trust among users of centralised ride-sharing models. Users may not clearly understand how the system operates or how decisions are made, reducing confidence in the service. A decentralised model with distributed governance offers greater transparency and accountability, leading to increased user trust.

6. Limited innovation:

With control held by a single entity, there may be little incentives for innovation and improvement in centralised ride-sharing models. This can result in a stagnant service that fails to meet the evolving needs of users. In contrast, a decentralised model with distributed governance can promote innovation by allowing all participants to contribute ideas and suggestions for improvement. This can result in a more dynamic and responsive service that meets users' needs better.

7. Reduced competition:

Centralized control can also lead to reduced competition in the ride-sharing market. With a single entity holding a dominant position, other companies may have little incentive to enter the market and compete. This can result in higher prices and reduced choices for users. A decentralised model with distributed governance can promote greater competition by allowing multiple entities to participate and compete on a level playing field. This can result in lower prices and greater choices for users.

8. Inefficient resource allocation:

Centralized control can result in inefficient allocation of resources, such as vehicles and drivers, in ride-sharing systems. With decision-making held by a single entity, there may be limited ability to allocate resources to meet demand effectively. This can result in longer wait times for rides and reduced user satisfaction. A decentralised model with distributed governance can improve resource allocation by allowing all participants to contribute information and make decisions about resource allocation. This can result in more efficient use of resources and improved user satisfaction.

9. Limited flexibility:

Centralized ride-sharing systems may also lack the flexibility to adapt to changing market conditions or user needs. With control held by a single entity, there may be limited ability to respond quickly to changes in demand or user preferences. This can result in less responsive service to users' needs. A decentralised model with distributed governance offers greater flexibility by allowing all participants to contribute information and decide how the service should adapt to changing conditions. This can result in a more responsive and adaptive service that meets users' needs better.

10. Limited data privacy:

With control held by a single entity, there may be limited protections for user data privacy in centralised ride-sharing models. This can result in the collection and use of user data in ways that users may not be aware of or comfortable with. A decentralised model based on blockchain technology can offer greater data privacy by allowing users to control their data and how it is used.

11. Reduced user control:

Centralized ride-sharing models may also offer limited control for users over their own experiences. With decision-making held by a single entity, users may have limited ability to customise their experiences or provide feedback on the service. A decentralised model with distributed governance can offer greater user control by allowing all participants to contribute information and decide how the service operates.

12. Limited community engagement:

Centralized ride-sharing models may also suffer from limited community engagement. With control held by a single entity, community members may have limited opportunities to provide input or participate in decision-making. A decentralised model with distributed governance can promote greater community engagement by allowing all participants to contribute information and decide how the service operates.

13. Damage to reputation:

Security breaches, fraud, and other issues can damage the reputation of centralised ride-sharing services. When user data is compromised or financial losses occur due to fraud or security breaches, it can harm the reputation of the service and reduce user trust and confidence. A decentralised model based on blockchain technology offers greater security and reduces the risk of reputation-damaging events.

14. Financial losses:

Fraud and security breaches can result in significant financial losses for users of centralised ride-sharing services. When hackers gain access to sensitive financial information or user data is compromised, it can result in financial harm to users. A decentralised model based on blockchain technology offers greater security and reduces the risk of financial losses due to fraud or security breaches.

15. Reduced user satisfaction:

The various weaknesses of centralised ride-sharing models can result in reduced user satisfaction. Issues such as lack of transparency, limited accountability, vulnerability to fraud, and slower response times can all contribute to reduced user satisfaction. A decentralised model with distributed governance offers greater transparency, accountability, security, and efficiency, leading to increased user satisfaction.

16. Perception of unfairness:

Users of centralised ride-sharing models may perceive the system as unfair if they feel they are not treated equitably. This can result in reduced trust and confidence in the service. A decentralised model with distributed governance offers greater fairness, as all participants have an equal say in decision-making.

17. Limited user empowerment:

In a centralised ride-sharing system, users may have limited ability to influence decision-making and shape the direction of the service. This can result in reduced user satisfaction and a perception that the system is not responsive to their needs. A decentralised model with distributed governance offers greater user empowerment, as all participants have a say in decision-making.

Centralised ride-sharing models have several key weaknesses that can limit their effectiveness and user satisfaction. A decentralised model, such as one based on blockchain technology with decentralised governance, has the potential to address many of these issues and offer significant improvements.

4.2 Model Design

This section outlines the findings of the second objective of the research, which aimed to develop a ridesharing model based on blockchain technology and featuring decentralised governance. The design was informed by the results of the initial objective of the investigation, as outlined in section 4.1, as well as the outcomes of the focus group discussions. The initial step involves establishing the design philosophies and objectives that serve as the guiding principles throughout the design process. The functional and system requirements of the model are also outlined.

4.2.1 The Design Philosophy and Objectives:

Ride sharing is closely aligned with the principles of the sharing economy, an economic model based on the sharing of resources and the collaborative consumption of goods and services. The sharing economy promotes the efficient use of resources by allowing individuals to share access to goods and services that would otherwise be underutilised.The model design was then designed around the principles of the sharing economy, which has the potential to address many of these issues and offer significant improvements. By incorporating design philosophies such as decentralised governance, peer-to-peer transactions, and community-driven development, such a system could provide a more transparent, secure, and fair ride-sharing experience.

I. Model design philosophies

1. Decentralised governance: “An effective solution to overcome the problems of the central authority is a decentralised p2p approach for the ride-sharing process” (Sánchez et al., 2016) . Decentralised governance allows all participants to have a say in decision-making, promoting greater transparency, accountability, and fairness. Decision-making power could be distributed among participants through blockchain-based smart contracts and consensus mechanisms.
2. Peer-to-peer transactions: “Blockchain ride-sharing firms are planning to hand control back to the drivers” (Graves, 2020). By facilitating direct peer-to-peer transactions between riders and drivers, the system can reduce the need for intermediaries and lower costs. Transactions could be conducted securely and transparently through the use of blockchain technology.
3. Secure and transparent platform: “This paper proposes a blockchain-based framework from the existing centralised framework for a ride-sharing service” (Nottingham, n.d.2020) . The system can provide a secure and transparent transaction platform by leveraging blockchain technology. All transactions could be recorded on a tamper-proof distributed ledger, providing an immutable record of all activity on the platform.
4. Community-driven: “There is a huge potential not only for a decentralised ride-sharing app or a blockchain-based company but a company who can work more ethically for the betterment of this whole ecosystem” (Sheikh, 2020). A community-driven approach allows users and drivers to collaborate and shape the direction of the service, promoting greater user engagement and satisfaction.
5. Incentive alignment: “We believe when there is a driver who spends 14 to 16 hours behind the wheel, he deserves to take back all the income to his home” (Sheikh, 2020). By designing incentives that align the interests of riders, drivers, and the platform, the system can promote cooperation and collaboration among participants.
6. Sustainability: “Ride-sharing is one of the intelligent transportation systems applications. It achieves popularity in major cities due to its several advantages, such as congestion reduction, It

was maintaining the environment by reducing carbon dioxide emissions and saving users time" (Mahmoud et al., 2022). The system can support sustainability goals by promoting environmentally friendly practices such as carpooling and reduced emissions.

4.2.2 Model function requirements:

The model functional requirement specifies what features must be in the system to support the user's desired action to be supported. It conveys the model's expectation from the standpoint of the user. Focus groups and scenario-based design, discussed in detail in the methodology section, were used to realise the functional requirements.

Central to this design were scenarios developed through focus group discussions. These scenarios depicted a target user attempting to accomplish a particular goal or task within a defined context. Each set of scenarios included both a claim and a narrative. The claim evaluated the potential positive and negative outcomes of key design features, reflecting the implications of these design ideas during and after development. On the other hand, the narrative served as a test case for analytical evaluation, hypothesising usability outcomes for one or more test cases based on the claims.

The table below illustrates the user stories developed based on the functional requirements from the scenarios discussed during the focused group. Subsequently, the tasks and contexts were elaborated upon with precision. The user stories and requirements were streamlined to their essential components while ensuring that the proof of concept (PoC) remained functional and secure.

1. User Stories Defining Functional Requirements.

As a,	I want	
rider,	1. The ability to cryptographically create and manage an account with personal information, 2. The ability to search for and book rides based on location, destination, and desired departure time. 3. The ability to view real-time information about the driver, including their name, photo, vehicle details, and estimated arrival time. 4. The ability to track the ride's progress in real time and receive notifications about any changes or delays. 5. The ability to rate the driver and provide feedback on the ride experience. 6. View a detailed fare breakdown, including any additional fees or charges.	1.1
Driver	1. The ability to cryptographically create and manage a driver account with personal information, vehicle details, and payment information. 2. The ability to view and accept ride requests from nearby riders in real time. 3. The ability to view the rider's pickup location, destination, and desired departure time. 4. Receiving turn-by-turn navigation instructions to the rider's pickup location and destination.	

	5. The ability to view the fare for each ride and track earnings in real-time. 6. The ability to receive ratings and feedback from riders and respond to concerns or issues.	
Riders & Drivers	1. Earn rewards for completing rides or achieving other milestones within the system. 2. view their balance and transaction history within the app. 3. Transfer their rewards to an external wallet or exchange them for other currencies, goods, and services. 4. use their rewards to pay for rides or other services within the app. 5. The system can securely manage and store users' balances. 6. The ability for users to participate in the system's governance through voting on critical decisions and electing leaders. 7. The ability to view information about the system's governance structure and decision-making processes. 8. The ability for users to provide feedback and suggestions on the operation and governance of the system. 9. The system to implement transparent and accountable decision-making processes, with clear rules and procedures for making decisions. 10. The system provides users with regular reports and updates on its performance and governance.	

Table 2: User stories.

2. Description of Model Requirements.

By summarizing the user stories outlined above, we can derive a functional overview of the model for a blockchain-based ride-sharing platform with decentralised governance. This overview is presented as a table, which lists the essential functional requirements for the platform, including the use of rewards and incentives to benefit riders and drivers. The table provides a clear and concise summary of the platform's capabilities to successfully implement a blockchain-based ride-sharing model with decentralised governance. By referring to this table, stakeholders can better understand the platform's key features and functionalities.

Functionality	Description	
Secure Transaction Processing	The platform must securely process transactions between riders and drivers using blockchain technology.	
Decentralised Governance	The platform must have a decentralised governance structure that allows users to participate in decision-making.	
Transparent Pricing Mechanism	The platform must have a transparent pricing mechanism that uses smart contracts to establish fair ride prices.	
Immutable Record Keeping	The platform must keep an immutable record of all ride data on the blockchain.	
Peer-to-Peer Connectivity	The platform must be able to connect riders directly with drivers on a peer-to-peer basis.	
Smart Contract Automation:	The platform must use smart contracts to automate payment and dispute resolution processes.	
Real-Time Information	The platform must provide users with real-time information on ride availability and pricing to users.	
User Empowerment	The platform must empower users by giving them a say in its governance and development.	

Cost Reduction,	The platform must reduce riders' costs and increase earnings for drivers by eliminating intermediaries.	
Rider Rewards	The platform must offer rewards to riders for using the platform regularly, such as loyalty points that can be redeemed for discounts on future rides.	
Driver Incentives	The platform must offer incentives to drivers for providing high-quality service, such as bonuses for achieving high ratings from riders.	
Community Participation Rewards	The platform must reward users who participate in its governance by voting on proposals or contributing to discussions.	

Table 3: Function Requirements.

3. User Interactions

The user interaction design for the blockchain-based ride-sharing platform with decentralised governance outlines the various activities and tasks users can perform using the platform. This design is intended to support identifying and exploring different design alternatives that can meet the requirements revealed through analyses of the opportunity space and context of use. By considering these requirements, the user interaction design can ensure that the platform is user-friendly and meets the needs of its users.

In addition to supporting the identification of design alternatives, the user interaction design also aids in Realising technical requirements and addressing any issues that may arise during the development of the model. By taking these technical considerations into account, the user interaction design can help ensure that the platform is robust, reliable, and able to meet the needs of its users.

The user interaction design is crucial in developing a blockchain-based ride-sharing platform with decentralised governance. By providing a clear overview of the activities and tasks that users can perform while using the platform and by supporting the identification of design alternatives and technical Requirements, the user interaction design helps to ensure that the platform is user-friendly, functional, and able to meet the needs of its users.

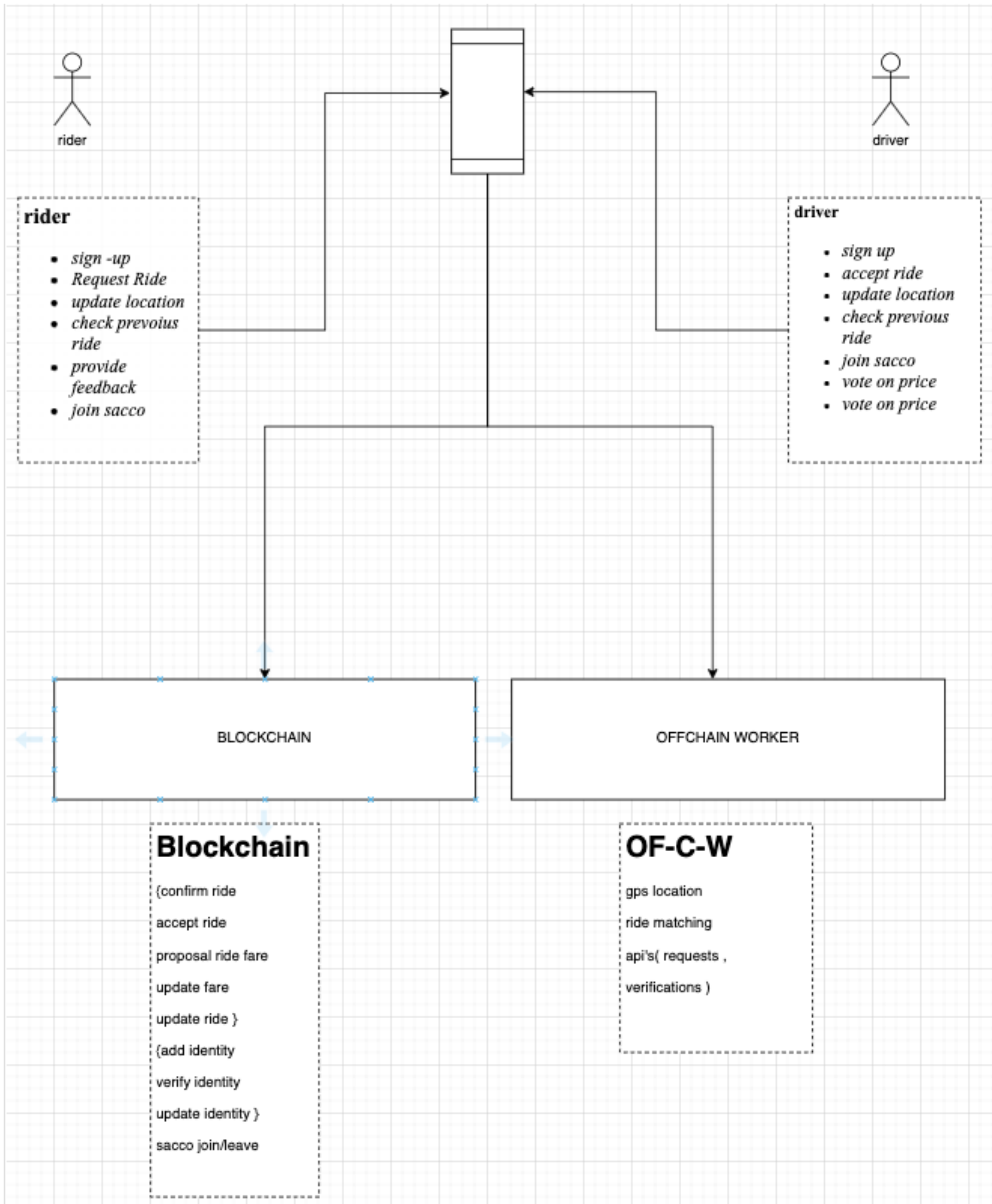


Figure 7: User interaction design

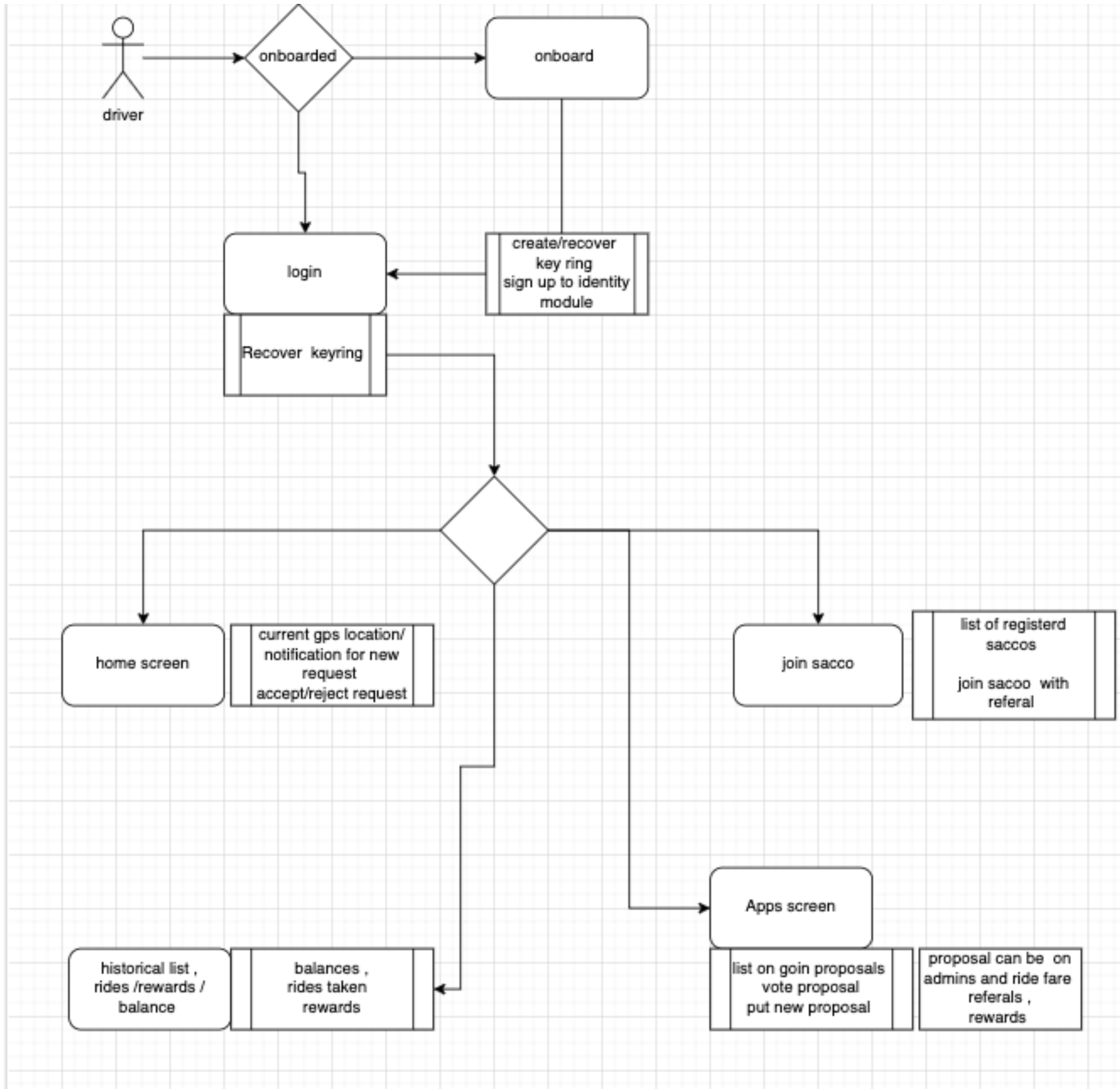


Figure 8: Driver interaction design

4.3 Model Development

This section showcases the successful development of a proof-of-concept (POC) model for a blockchain-based ride-sharing platform with decentralised governance, thereby fulfilling the third research objective of the study. The model provides users with a wide array of services and has boundless potential for future growth and expansion. By utilising blockchain technology and decentralised governance, the platform can deliver value to its users quickly, efficiently, and cost-effectively. A mobile app has been created to address the potential user needs identified during the scenario-based design process. The app has been designed flexibly, allowing for future enhancements and innovations following the design philosophies outlined earlier in the study.

The platform provides various services to its users, with the potential for expansion as adoption grows and new use cases and functionalities emerge. These services are designed to meet the needs of both riders and drivers, offering a seamless and user-friendly experience. Although not all services may be available in the initial POC, the model has unlimited potential to deliver value to users quickly, efficiently, and cost-effectively. One of the key strengths of the blockchain-based ride-sharing platform with decentralised governance is its adaptability and ability to evolve. As new use cases and functionalities are developed, the platform can incorporate these into its service offerings, ensuring it remains relevant and valuable to its users. This illustrates the platform's dynamic nature and ability to meet its users' changing needs.

4.3.1 Secure transaction processing platform

This section presents a prototype blockchain-based ridesharing model with decentralised governance to revolutionise the traditional ridesharing industry.

The power of Parity Substrate, a cutting-edge blockchain development framework, has been leveraged to realise the objective. Parity Substrate provides a robust foundation for building a decentralised ridesharing platform, enabling a secure, scalable, and customisable solution tailored to user needs. The utilisation of the Parity Substrate empowers the design of a blockchain network with built-in governance mechanisms, ensuring that decision-making power is distributed among the platform's stakeholders. A decentralised governance model fosters transparency, accountability, and inclusivity within the ridesharing ecosystem. Parity Substrate's flexible and modular architecture allows various components and functionalities to integrate into the platform seamlessly. This enables the creation of a rich user experience while maintaining necessary performance and security standards. Parity Substrate's extensive tooling and development environment also provides resources and support for rapid iteration and enhancement of the ridesharing model as feedback is received from the community. Through this blockchain-based ridesharing platform, a future is envisioned where riders and drivers have a more significant say in decision-making processes, fare structures, and overall platform governance. A fairer and more equitable ecosystem that benefits all participants is created by eliminating intermediaries and enabling direct peer-to-peer transactions.

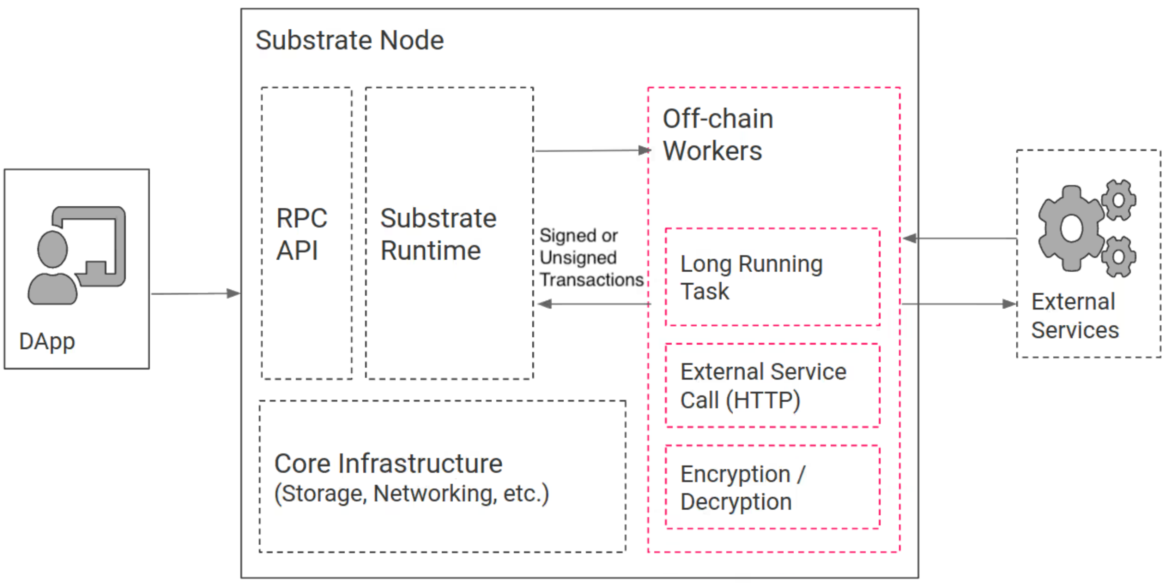


Figure 9: Substrate Node

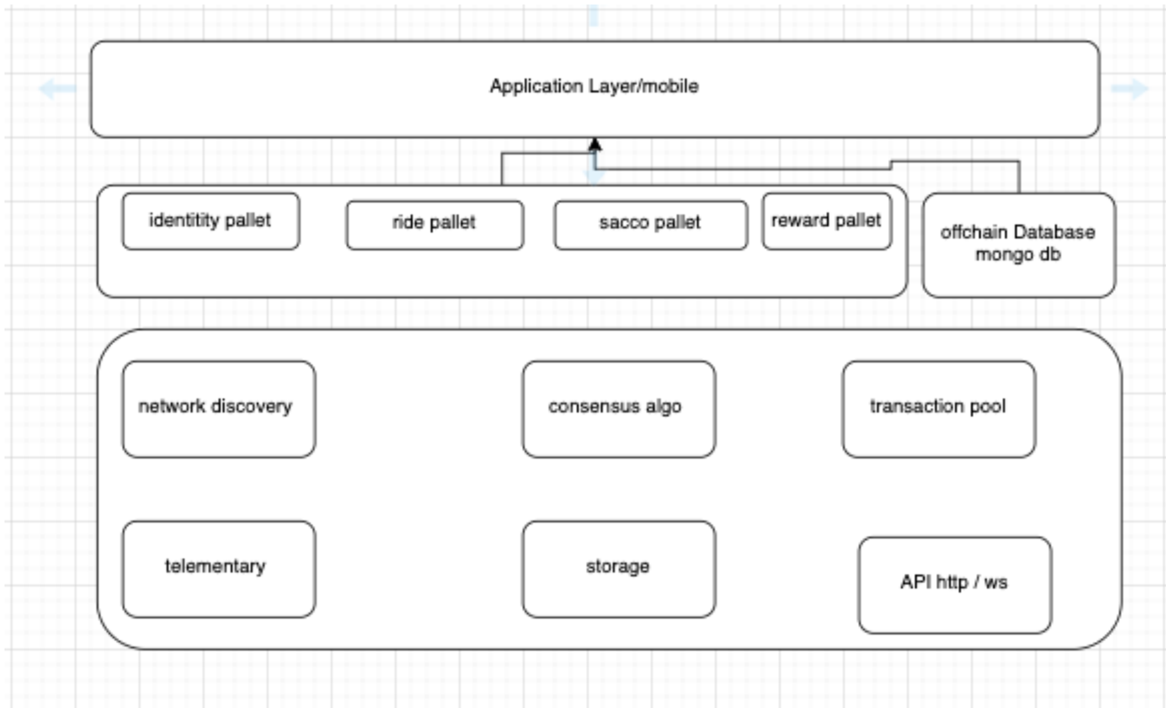


Figure 10: Ride-sharing model node

4.3.2 Pallets

We have developed several vital pallets using Parity Substrate in our blockchain-based ridesharing model with decentralised governance. These pallets facilitate the platform's functionality, including governance, financial operations, user identification, and incentivisation.

```
[workspace]
members = [
    "node",
    "pallets/reward",
    "pallets/ride",
    "pallets/identity",
    "pallets/sacco",
    "runtime",
]
[profile.release]
panic = "unwind"
```

Treasury Pallet:

The Treasury pallet is a vital component that governs the allocation and management of funds within the ridesharing ecosystem. It enables the transparent and decentralised administration of financial resources, ensuring that funds are allocated efficiently based on community-driven proposals and voting mechanisms. The Treasury pallet plays a crucial role in maintaining the sustainability and growth of the platform.

```rust
#[derive(Encode, Decode, Clone, PartialEq, Eq, MaxEncodedLen, RuntimeDebug, TypeInfo)]
pub struct Proposal<AccountId, Balance> {
    /// The account proposing it.
    proposer: AccountId,
    /// The (total) amount that should be paid if the proposal is accepted.
    value: Balance,
    /// The account to whom the payment should be made if the proposal is accepted.
    beneficiary: AccountId,
    /// The amount held on deposit (reserved) for making this proposal.
    bond: Balance,
}

#[frame_support::pallet]
pub mod pallet { ...
}

impl<T: Config<I>, I: 'static> Pallet<T, I> {
    // Add public immutables and private mutables.

    /// The account ID of the treasury pot.
    ///
    /// This actually does computation. If you need to keep using it, then make sure you cache the
    /// value and only call this once.
    pub fn account_id() -> T::AccountId {
        T::PalletId::get().into_account_truncating()
    }

    /// The needed bond for a proposal whose spend is `value`.
    fn calculate_bond(value: BalanceOf<T, I>) -> BalanceOf<T, I> {
        let mut r = T::ProposalBondMinimum::get().max(T::ProposalBond::get() * value);
        if let Some(m) = T::ProposalBondMaximum::get() {
            r = r.min(m);
        }
        r
    }

    /// Spend some money! returns number of approvals before spend.
    pub fn spend_funds() -> Weight { ...
    }

    /// Return the amount of money in the pot.
    // The existential deposit is not part of the pot so treasury account never gets deleted.
    pub fn pot() -> BalanceOf<T, I> {
        T::Currency::free_balance(&Self::account_id())
            // Must never be less than 0 but better be safe.
            .saturating_sub(T::Currency::minimum_balance())
    }
}

impl<T: Config<I>, I: 'static> OnUnbalanced<NegativeImbalanceOf<T, I>> for Pallet<T, I> {
    fn on_nonzero_unbalanced(amount: NegativeImbalanceOf<T, I>) {
        let numeric_amount = amount.peek();

        // Must resolve into existing but better to be safe.
        let _ = T::Currency::resolve_creating(&Self::account_id(), amount);

        Self::deposit_event(Event::Deposit { value: numeric_amount });
    }
}
```

SACCO Pallet:

The SACCO (Savings and Credit Cooperative) pallet facilitates the formation of cooperative groups among ridesharing participants. It lets users pool their resources and collectively manage financial services like savings, loans, and investments. By implementing the SACCO pallet, we aim to empower ridesharing community members with financial inclusivity, cooperative decision-making, and improved economic opportunities.

```rust
#[pallet::storage]
#[pallet::getter(fn reward_amount)]
pub type Rewards<T> = StorageValue<_, u32, ValueQuery>;

#[pallet::storage]
#[pallet::getter(fn cost_per_mile)]
pub type CostPerMile<T> = StorageValue<_, u32, ValueQuery>;

#[pallet::storage]
#[pallet::getter(fn cost_per_minute)]
pub type CostPerMinute<T> = StorageValue<_, u32, ValueQuery>;

#[pallet::storage]
#[pallet::getter(fn completed_rides)]
pub type PassedProposals<T: Config> = StorageValue<_, Vec<Proposal>, ValueQuery>;

#[pallet::storage]
#[pallet::getter(fn get_members)]
pub type Members<T: Config> = StorageValue<_, Vec<T::AccountId>, ValueQuery>;


#[pallet::event]
#[pallet::generate_deposit(pub(super) fn deposit_event)]
pub enum Event<T:Config> {
    MemberAdded(T::AccountId),
    MemberRemoved(T::AccountId),
    REWARDAMOUNTSET(u32)
}

// #[pallet::error]

#[pallet::call]
impl <T:Config> Pallet<T> {

    #[pallet::call_index(0)]
    #[pallet::weight(0)]
    pub fn accept_ride(
        origin: OriginFor<T>,
        //ride Id
    ) -> DispatchResultWithPostInfo {
        let _signer: <T as Config>::AccountId = ensure_signed(origin)?;

        Ok(Pays::No.into())
    }


    #[pallet::call_index(1)]
    #[pallet::weight(0)]
    pub fn set_proposal(…
    ) -> DispatchResultWithPostInfo {
        let _signer: <T as Config>::AccountId = ensure_signed(origin)?;
        let member_count: u32 = Members::<T>::get().len() as u32;
        let  threshold: u32 = member_count/2;

        let proposal:Proposal = Proposal {
            base_fare,
            cost_per_mile,
            cost_per_minute,
            on:true,
            votecount:0,
            yee:0,
            threshold,
        };


    }     pallet_sacco
          mod pallet
    #[    The module that hosts all the FRAME types needed to add this pallet to a runtime.
    #[pallet::weight(0)]
    pub fn add_member(…
    ) -> DispatchResultWithPostInfo {
        let new_member: <T as Config>::AccountId = ensure_signed(origin)?;
        Members::<T>::mutate(|members| members.push(new_member.clone()));
        // do something with the calculated fare

        Self::deposit_event(Event::<T>::MemberAdded(new_member));
        Ok(Pays::No.into())
    }
    #[pallet::call_index(3)]
    #[pallet::weight(0)]
    pub fn leave_membership(…
```

Ride Pallet:

The Ride pallet serves as the backbone of the ridesharing platform, handling ride-related functionalities such as ride requests, matching riders with drivers, fare calculations, and tracking. It ensures the seamless execution of ride transactions within the blockchain network, enabling secure and transparent ride experiences for all participants.

```rust
use scale_info::TypeInfo;
use pallet_reward::RewardInterface;
use pallet_identity;

#[pallet::pallet]
#[pallet::without_storage_info]
pub struct  Pallet<T>(_);

#[pallet::config]
pub trait Config: frame_system::Config + pallet_identity::Config {
    type RuntimeEvent: From<Event<Self>> + IsType<<Self as frame_system::Config>::RuntimeEvent>;

    #[pallet::constant]
    type MaxIdLengthBytes: Get<u32>;

    type RewardCoin:RewardInterface<Self::AccountId,Self::Balance>;


    type Balance: Member + Parameter + AtLeast32BitUnsigned + Default + Copy;
}

pub type Name<T> = BoundedVec<u8,<T as Config>::MaxIdLengthBytes >;
pub type PhoneNumber<T> = BoundedVec<u8,<T as Config>::MaxIdLengthBytes >;

#[derive(Encode, Decode, Clone, PartialEq, Eq,TypeInfo, RuntimeDebug)]
pub struct UberRide<AccountId> {
    pub rider: AccountId,
    pub distance: u32,
    pub duration: u32,
    pub fare: u32,
}

#[pallet::storage]
#[pallet::getter(fn ride_count)]
pub(super) type UserRides<T: Config> = StorageMap<_, Blake2_128Concat, T::AccountId, u32, OptionQuery>;


#[pallet::event]
#[pallet::generate_deposit(pub(super) fn deposit_event)]
pub enum Event<T:Config> {
    Request(T::AccountId, T::AccountId, u32),
}

#[pallet::error]
pub enum Error<T> {
    /// The cab index specified does not exist
    InvalidIndex,

    /// Caller is not the owner
    InvalidOwner,

    ///Driver not availble
    DriverNotAvailable,

    ///no count
    NoCount
}

#[pallet::call]
impl <T:Config> Pallet<T> {

    #[pallet::call_index(0)]
    #[pallet::weight(0)]
    pub fn accept_ride(…
    ) -> DispatchResultWithPostInfo {…


    #[pallet::call_index(1)]
    #[pallet::weight(0)]
    pub fn request_ride(
        origin: OriginFor<T>,
        driver:T::AccountId,
        //ride Id
    ) -> DispatchResultWithPostInfo {…

    #[pallet::call_index(2)]
    #[pallet::weight(0)]
    pub fn calculate_ride_fare(
        origin: OriginFor<T>,
        distance: u32,
        duration: u32,
    ) -> DispatchResultWithPostInfo {…

    // set  base fare
```

Reward Coin Pallet:

The Reward Coin pallet introduces a native cryptocurrency within the ridesharing ecosystem, serving as a medium of exchange and incentivising active participation. Users can earn these reward coins by providing rides, referring new users, or engaging in other platform activities. The Reward Coin pallet facilitates fair distribution, tracks reward balances, and enables seamless peer-to-peer transactions within the platform.

```rust
    #[pallet::pallet]
    #[pallet::without_storage_info]
    #[pallet::storage_version(STORAGE_VERSION)]
    pub struct Pallet<T, I=()>(PhantomData<(T, I)>);


    #[pallet::config]
    pub trait Config<I: 'static = ()>: frame_system::Config {
        type RuntimeEvent: From<Event<Self,I>> + IsType<<Self as frame_system::Config>::RuntimeEvent>;

        type Balance: Member + Parameter + AtLeast32BitUnsigned + Default + Copy;

    }
    #[derive(Clone, Encode, Decode, Eq, PartialEq,TypeInfo, RuntimeDebug)]
    #[scale_info(skip_type_params(T))]
    pub struct MetaData<AccountId, Balance> {
        issuance:Balance,
        minter: AccountId,
        burner:AccountId,
    }



    #[pallet::storage]
    #[pallet::getter(fn meta_data)]
    pub type MetaDataStore<T: Config<I>, I: 'static = ()> = StorageValue<_,MetaData<T::AccountId,T::Balance> ,OptionQuery>;


    #[pallet::storage]
    #[pallet::getter(fn account_balance)]
    pub(super) type Accounts<T: Config<I>, I: 'static = ()> = StorageMap<_, Blake2_128Concat, T::AccountId, T::Balance, ValueQuery>;


    // Declare `admin` as type `T::AccountId`.
    #[pallet::genesis_config]
    #[derive(frame_support::DefaultNoBound)]
    pub struct GenesisConfig<T: Config<I>, I: 'static = ()>{
        pub phantom: PhantomData<I>,
        pub admin: Option<T::AccountId>
    }


    #[pallet::genesis_build]
    impl<T: Config<I>, I: 'static> GenesisBuild<T, I> for GenesisConfig<T, I> {
        fn build(&self) {
            if let Some(ref admin: &<T as Config>::AccountId) = self.admin {
                MetaDataStore::<T,I>::put(MetaData{
                    issuance:Zero::zero(),
                    minter: admin.clone(),
                    burner:admin.clone(),
                });
        }}
    }


    #[pallet::event]
    #[pallet::generate_deposit(pub(super) fn deposit_event)]
    pub enum Event<T: Config<I>, I: 'static = ()> {
        Transfered(T::AccountId, T::AccountId, T::Balance),
    }

    #[pallet::error]
    pub enum Error<T, I = ()> {
        /// An account would go below the minimum balance if the operation were executed.
        BelowMinBalance,
        // The origin account does not have the required permission for the operation.
        NoPermission,
        /// An operation would lead to an overflow.
        Overflow,
        /// An operation would lead to an underflow.
        Underflow,
        /// Cannot burn the balance of a non-existent account.
        CannotBurnEmpty,
        /// There is not enough balance in the sender's account for the transfer.
        InsufficientBalance,
    }

    #[pallet::call]
    impl<T: Config<I>, I: 'static> Pallet<T, I> {…


    impl<T: Config<I>, I: 'static> Pallet<T, I> {
        fn mint_into(who: &T::AccountId, amount: T::Balance)->bool {
            Accounts::<T,I>::mutate(&who, |bal: &mut <T as Config<I>>::Balance| {
                let created: bool = bal == &Zero::zero();
```

Identity Pallet:

The Identity pallet is crucial for establishing trust and verifying the identity of ridesharing participants within the blockchain network. It ensures that each user's identity is securely stored and authenticated, enabling a trustworthy

```rust
pub enum Error<T> {
    /// The cab index specified does not exist
    InvalidIndex,

    /// Caller is not the owner
    InvalidOwner
}


#[pallet::storage]
#[pallet::getter(fn get_user)]
pub(super) type Identity<T :Config>  = StorageMap<_, Blake2_128Concat, T::AccountId, User<T>, OptionQuery>;

#[pallet::storage]
#[pallet::getter(fn get_driver)]
pub(super) type Drivers<T :Config>  = StorageMap<_, Blake2_128Concat, T::AccountId, Driver<T>, OptionQuery>;

#[pallet::storage]
#[pallet::getter(fn cab_count)]
pub(super) type CabCount<T> = StorageValue<_, u32, ValueQuery>;



#[pallet::storage]
#[pallet::getter(fn get_cab)]
pub(super) type CabDetails<T :Config>  = StorageMap<_, Blake2_128Concat, u32, Cab<T>, OptionQuery>;



#[pallet::call]
impl <T:Config> Pallet<T> {

    #[pallet::call_index(0)]
    #[pallet::weight(0)]
    pub fn add_usr(
        origin: OriginFor<T>,
        phone_number:PhoneNumber<T>,
        name:Name<T>

    ) -> DispatchResultWithPostInfo {
        let signer: <T as Config>::AccountId = ensure_signed(origin)?;
        let verified:bool = false;
        let rating:u32 = 0;
        let role: String  =  String::from("rider");
        let usr_to_store: User<T> = User::<T> {
            name,
            verified,
            phone_number,
            rating
        };

        <Identity<T>>::insert(&signer,usr_to_store);
        // make a offchain call
        Self::deposit_event(Event::<T>::AccountCreated {who:signer,role});
        Ok(Pays::No.into())
    }

    #[pallet::call_index(1)]
    #[pallet::weight(0)]
    pub fn add_cab(
        origin : OriginFor<T>,
        plate:Name<T>,
        manufacture_year:u16,
        model:Name<T>,
        driver:T::AccountId,
    ) -> DispatchResultWithPostInfo{
        let owner: <T as Config>::AccountId = ensure_signed(origin)?;
        let count: u32 = Self::cab_count();
        let g: <T as Config>::AccountId = owner.clone();

        // let mut  cab = Self::get_cab(count).ok_or(Error::<T>::InvalidIndex)?;
        <CabDetails::<T>>::insert(count+1,Cab{
            plate,
            manufacture_year,
            model,
            owner,
            driver,
            verified:false,
            rating:Zero::zero(),
        });

        <CabCount<T>>::put(count+1);
        Self::deposit_event(Event::<T>::CabAdded{who:g,count:count+1});
        Ok(Pays::No.into())
    }
```

Request textDocument/completion failed.

Source: rust-analyzer (Extension)　Go to output

Utilisation of Offchain Workers:

Besides the pallets, as mentioned above, we employ chain workers to enhance the scalability and efficiency of our decentralised ridesharing platform. Offchain workers enable computationally expensive or time-sensitive tasks to be executed off the main blockchain, reducing congestion and improving overall system performance. Off-chain workers can efficiently handle data processing, complex algorithms, and external integrations while the blockchain's critical consensus and governance functions remain on the blockchain. This approach ensures a seamless and responsive user experience while maintaining the security and decentralisation benefits of the blockchain. environment for peer-to-peer interactions. The Identity pallet also enables the integration of external identity verification systems while maintaining user privacy and data security.

4.3.3 Mobile Application

Besides developing the pallets mentioned above, we built a user-friendly and intuitive mobile application to complement our blockchain-based ridesharing platform. The mobile application is the primary interface for riders and drivers to access and interact with the platform's features and functionalities. It provides a seamless and convenient user experience, allowing users to easily request rides, track their driver's location, view ride history, and manage payment preferences.

The mobile application is designed with a user-centric approach, focusing on simplicity, ease of use, and intuitive navigation. Riders can effortlessly input their pickup and drop-off locations, select their preferred vehicle type, and review estimated fares before confirming their ride requests. The application also provides real-time updates on driver availability and estimated arrival times, ensuring a smooth and efficient ride experience for riders.

The mobile application offers drivers a comprehensive dashboard with important information such as ride requests, earnings, and ratings. Drivers can accept or decline ride requests based on availability and preferences, view navigation directions to the rider's location, and communicate with riders through an in-app messaging system. The application also facilitates the seamless processing of payments, including options for cashless transactions through integrated digital wallets or cryptocurrencies.

Functionalities

1. User Registration and Authentication:

   The application allows users to easily sign up and create their accounts. Users can verify their identities and gain access to the ridesharing platform through a secure authentication process. This ensures that only authorised individuals can utilise the services offered by the platform.

2. Ride Requests:

   Riders can easily request a ride through the mobile application by entering their pickup and drop-off locations. The application utilises the blockchain's ride pallet to match the rider with an available driver based on proximity and other relevant factors.

3. Real-Time Tracking:

   Once a ride is confirmed, riders can track their driver's location in real-time through the mobile application. This feature provides transparency and reassurance to riders, ensuring they have full visibility of the driver's progress.

4. Fare Calculation:

   The mobile application utilises the ride pallet's smart contract functionality to calculate fares based on predefined algorithms and parameters. Riders can see the estimated fare upfront and receive the final fare at the end of the ride. This transparency eliminates any ambiguity or disputes regarding pricing.

5. Ratings and Reviews:

Riders and drivers can provide ratings and reviews through the mobile application after completing a ride. This feedback mechanism helps maintain the quality of the platform and allows users to make informed decisions based on the experiences of others.

6. Notifications and Alerts:

   The mobile application updates users with real-time notifications and alerts regarding ride confirmations, driver arrivals, and other important information. This ensures smooth communication and a seamless experience for both riders and drivers.

7. Driver and Rider Profiles:

   The mobile application enables users to create and manage their profiles, providing relevant information such as profile pictures, vehicle details (for drivers), and preferred ride settings. Users can also view the profiles of other participants, fostering a sense of trust and familiarity within the ridesharing community.

8. Voting Governance:

   Through the mobile application, users can submit proposals for platform improvements, policy changes, or new features. These proposals are open for discussion and debate within the community, fostering collaborative decision-making. Once discussions are complete, users can cast their votes securely and transparently using blockchain technology.

4.4 Model Evaluation

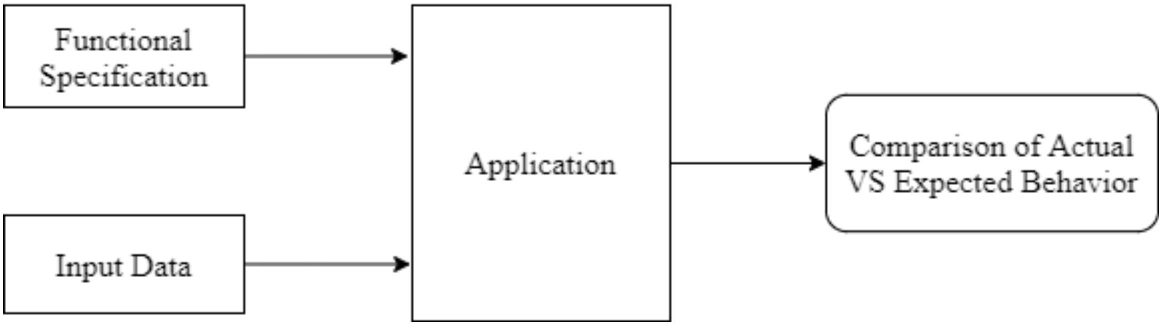
In this section, we present the results of our evaluation of the implemented model. Our analysis focuses on assessing the effectiveness and performance of the model in meeting its intended objectives. To achieve this, we conducted thorough testing and analysis, simulating various usage scenarios and assessing the model's scalability, security, and reliability.

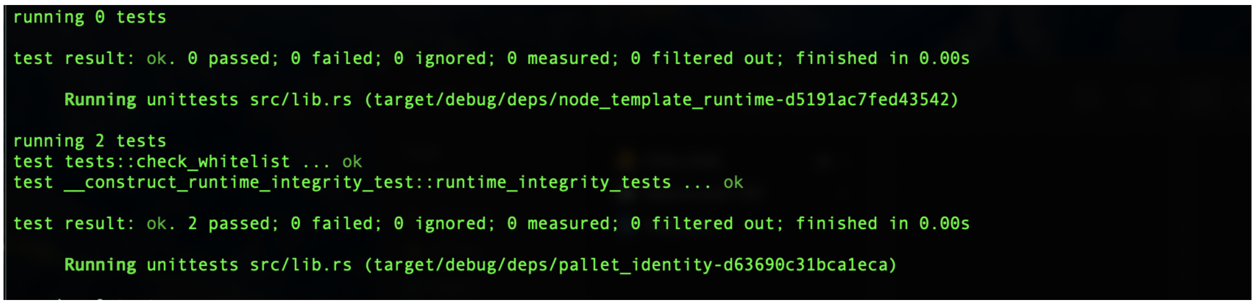
Our results are presented clearly and concisely, highlighting key findings. We also provide in-depth data analysis, identifying patterns and relationships that provide insight into the model's performance. Overall, this section aims to provide a comprehensive and objective analysis of the model's effectiveness, based on both functional and pilot testing, to inform future development and decision-making

4.4.1 Functional testing

As mentioned earlier, the objective of this methodology was to assess the developed model against its functional requirements and specifications. Each functional requirement in the model's minimum viable product was evaluated by providing valid input and comparing the resulting output to the stated functional requirements, as illustrated below.

Functional testing for the blockchain-based ride-sharing platform with decentralised governance was conducted through the execution of unit tests. These unit tests were designed to assess the functionality and behaviour of individual components and features within the platform. By running these tests, the research study validated that each component, such as the Treasury, Ride, Identity, and Sacco pallets, performed as intended and met the defined requirements. This thorough functional testing ensured the platform operated correctly and consistently, providing a solid foundation for the overall system's performance and effectiveness.





```
running 0 tests

test result: ok. 0 passed; 0 failed; 0 ignored; 0 measured; 0 filtered out; finished in 0.00s

     Running unittests src/lib.rs (target/debug/deps/node_template_runtime-d5191ac7fed43542)

running 2 tests
test tests::check_whitelist ... ok
test __construct_runtime_integrity_test::runtime_integrity_tests ... ok

test result: ok. 2 passed; 0 failed; 0 ignored; 0 measured; 0 filtered out; finished in 0.00s

     Running unittests src/lib.rs (target/debug/deps/pallet_identity-d63690c31bca1eca)
```

```
   Compiling thousands v0.2.0
   Compiling sc-basic-authorship v0.10.0-dev (https://github.com/paritytech/substrate.git?branch=polkadot-v0.9.40#ba87188c)
   Compiling frame-benchmarking-cli v4.0.0-dev (https://github.com/paritytech/substrate.git?branch=polkadot-v0.9.40#ba87188c)
   Compiling sc-consensus-grandpa v0.10.0-dev (https://github.com/paritytech/substrate.git?branch=polkadot-v0.9.40#ba87188c)
   Compiling sc-consensus-aura v0.10.0-dev (https://github.com/paritytech/substrate.git?branch=polkadot-v0.9.40#ba87188c)
   Compiling substrate-frame-rpc-system v4.0.0-dev (https://github.com/paritytech/substrate.git?branch=polkadot-v0.9.40#ba87188c)
   Compiling pallet-transaction-payment-rpc v4.0.0-dev (https://github.com/paritytech/substrate.git?branch=polkadot-v0.9.40#ba87188c)
   Compiling node-template v4.0.0-dev (/Volumes/COLLINS/project/radicle-node/node)
warning: `pallet-ride` (lib test) generated 4 warnings (4 duplicates)
warning: `pallet-reward` (lib test) generated 1 warning (1 duplicate)
warning: `pallet-identity` (lib test) generated 2 warnings (2 duplicates)
    Finished test [unoptimized + debuginfo] target(s) in 13m 07s
     Running unittests src/lib.rs (target/debug/deps/node_template-152bfcdd9f80431b)
```

```rust
fn spend_origin_works() {
}

#[test]
fn minting_works() {
    new_test_ext().execute_with(|| {
        // Check that accumulate works when we have Some value in Dummy already.
        Balances::make_free_balance_be(&Treasury::account_id(), 101);
        assert_eq!(Treasury::pot(), 100);
    });
}

#[test]
fn spend_proposal_takes_min_deposit() {
    new_test_ext().execute_with(|| {
        assert_ok!(Treasury::propose_spend(RuntimeOrigin::signed(0), 1, 3));
        assert_eq!(Balances::free_balance(0), 99);
        assert_eq!(Balances::reserved_balance(0), 1);
    });
}

#[test]
fn spend_proposal_takes_proportional_deposit() {
    new_test_ext().execute_with(|| {
        assert_ok!(Treasury::propose_spend(RuntimeOrigin::signed(0), 100, 3));
        assert_eq!(Balances::free_balance(0), 95);
        assert_eq!(Balances::reserved_balance(0), 5);
    });
}

#[test]
fn spend_proposal_fails_when_proposer_poor() {
    new_test_ext().execute_with(|| {
        assert_noop!(
            Treasury::propose_spend(RuntimeOrigin::signed(2), 100, 3),
            Error::<Test, _>::InsufficientProposersBalance,
        );
    });
}

#[test]
fn accepted_spend_proposal_ignored_outside_spend_period() {
    new_test_ext().execute_with(|| {
        Balances::make_free_balance_be(&Treasury::account_id(), 101);

        assert_ok!(Treasury::propose_spend(RuntimeOrigin::signed(0), 100, 3));
        assert_ok!(Treasury::approve_proposal(RuntimeOrigin::root(), 0));

        <Treasury as OnInitialize<u64>>::on_initialize(1);
        assert_eq!(Balances::free_balance(3), 0);
        assert_eq!(Treasury::pot(), 100);
    });
}

#[test]
fn unused_pot_should_diminish() {
    new_test_ext().execute_with(|| {
        let init_total_issuance = Balances::total_issuance();
```

4.4.2 Pilot Testing

The pilot testing aimed to evaluate the implemented platform's performance, functionality, and user experience of the implemented platform. Through this testing, we sought to gather feedback and validate the platform's effectiveness in addressing the limitations of traditional ride-sharing models. The pilot testing was conducted with participants, including riders and drivers.

The pilot testing was conducted by recruiting participants representing diverse user groups, including riders and drivers. These participants were given access to the blockchain-based ride-sharing platform and specific tasks, such as registering, requesting rides, and providing feedback. The testing period spanned two weeks, allowing participants to engage with the platform and provide comprehensive feedback on their experiences.

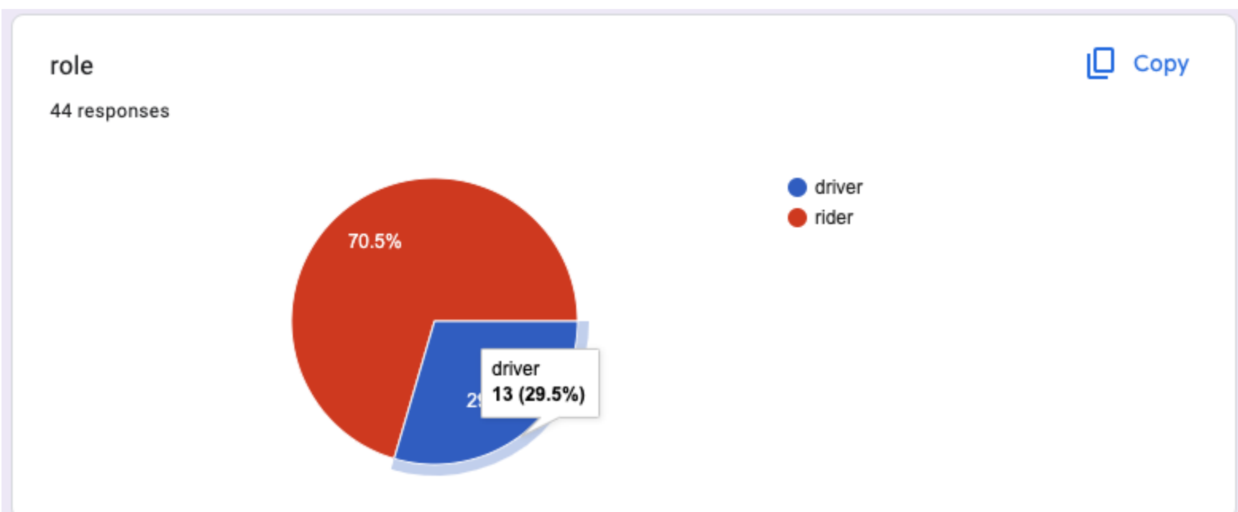
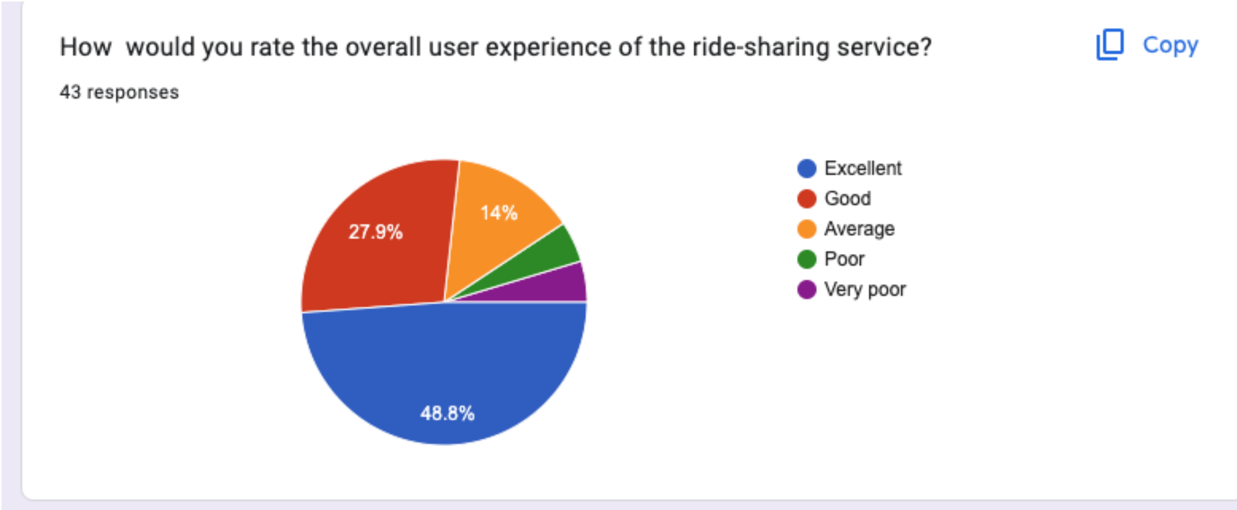


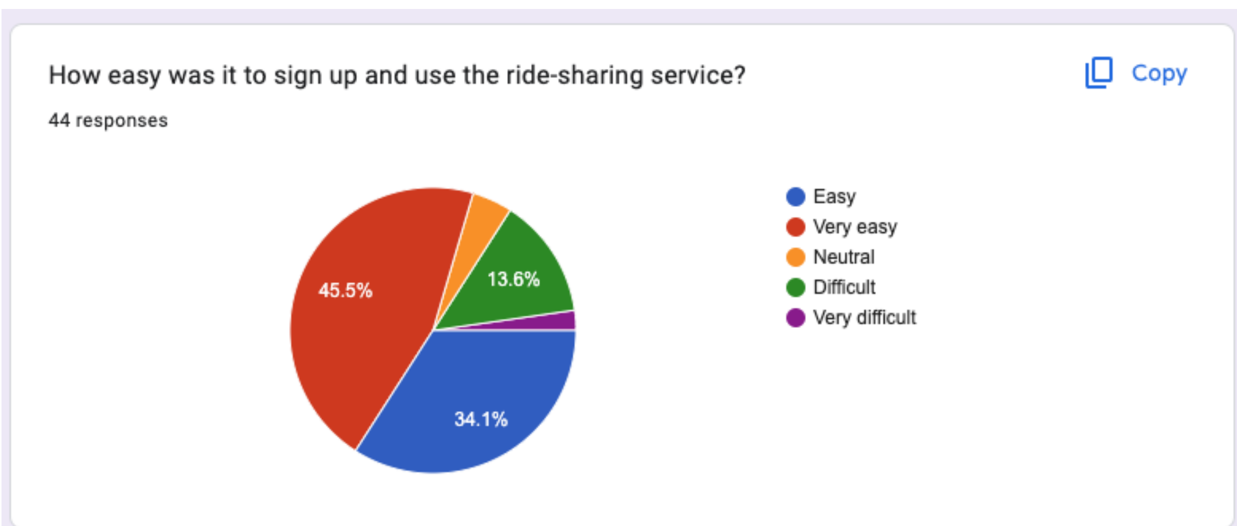
Figure 10: Demographic of responses

Key finding

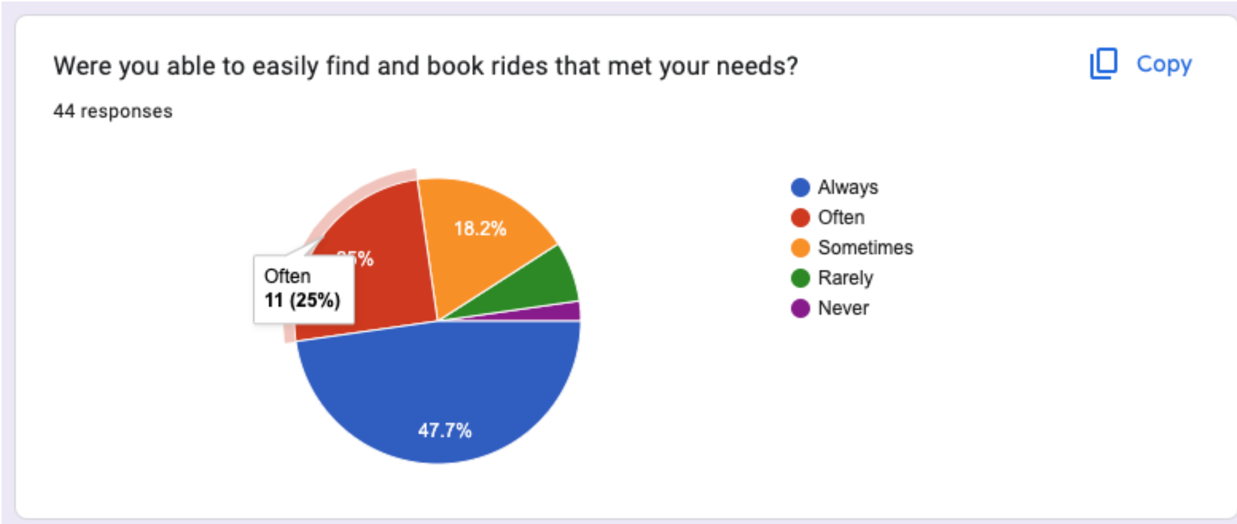
1. User Experience: Most participants reported a positive user experience, noting the intuitive interface and ease of use. They found the platform user-friendly and appreciated the transparency and real-time information provided during the ride.



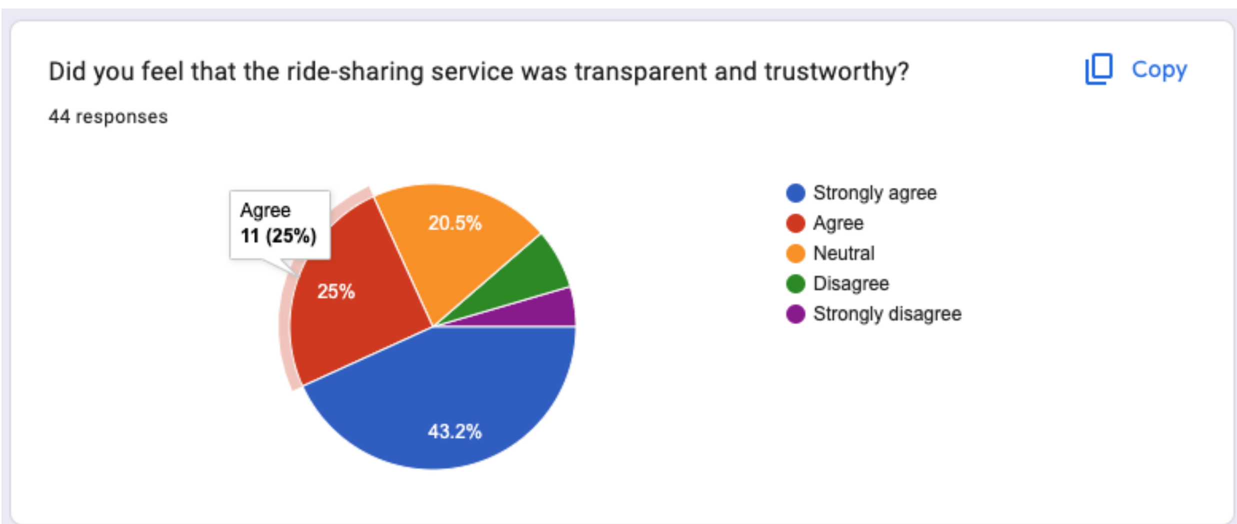
2. Registration and Identity Verification: Participants found the registration and identity verification process straightforward and secure. The integration of blockchain technology enhanced the security of their personal information and provided a sense of trust.



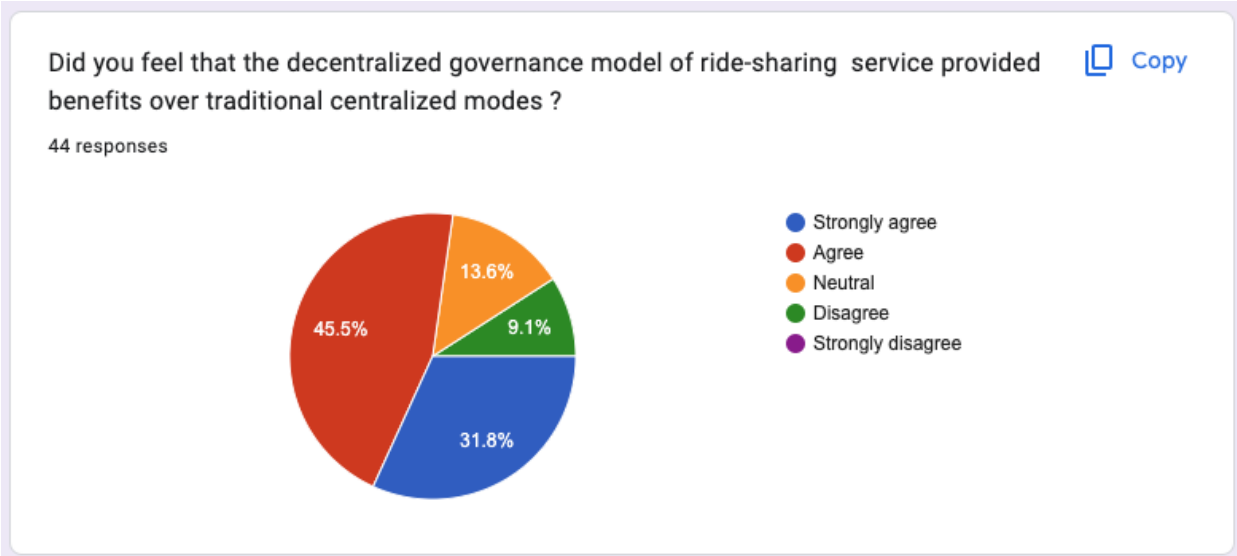
3. Ride Request and Matching: Participants reported that the ride request and matching functionalities worked efficiently. They could find available drivers and book rides without any significant difficulties.



4. Transparency and Accountability: The participants expressed satisfaction with the transparency and accountability features of the platform. They appreciated the visibility of driver information, trip costs, and the ability to track the ride in real-time.



5. Decentralized Governance: The participants recognised the value of decentralised governance, allowing user participation in decision-making processes. They felt empowered and appreciated the platform's efforts to include their input in shaping policies and rules.



4.5 Conclusion and Recommendations

Based on the pilot testing results, the blockchain-based ride-sharing platform with decentralised governance demonstrated its functionality, performance, and potential to address the limitations of traditional ride-sharing models. The positive feedback received from participants highlights the platform's effectiveness in providing transparent, secure, and user-centric ride-sharing experiences.

The following recommendations are proposed to enhance the platform's capabilities further:

- Continuously monitor and address any technical issues or system errors to ensure ongoing stability and reliability.
- Provide comprehensive user training and resources to facilitate seamless adoption and utilisation of the platform.
- Enhance user engagement and participation in the decentralised governance processes to foster a stronger sense of community ownership.
- Conduct regular user feedback sessions and iterate on the platform's features and functionalities based on user input.

Overall, the pilot testing validated the effectiveness of the blockchain-based ride-sharing platform with decentralised governance, supporting its potential as a viable alternative to traditional ride-sharing models. The findings from the pilot testing phase serve as a valuable foundation for further development and future deployment of the platform.

CHAPTER 5

CONCLUSIONS

5.0 Introduction

This chapter summarises our research's essential findings and insights from our research on a blockchain-based ridesharing model with decentralised governance. We have explored the potential of blockchain technology to transform the ridesharing industry by enabling a decentralised and transparent platform. This study aimed to achieve four objectives and answer four research questions, all of which were successfully addressed through the ideas presented in the paper, the design of the application, and the rationale behind it. This section summarises the responses to each of these objectives & questions.

5.1 Summary of the findings.

This report will summarise our findings on the feasibility and potential benefits of implementing a blockchain-based ridesharing model. We will also present our conclusions and recommendations for further research and development.

Our analysis suggests that a blockchain-based ridesharing model with decentralised governance could provide significant advantages over traditional centralised models. These advantages include improved trust and accountability, reduced costs, and increased flexibility for riders and drivers.

5.1.1: What are the disadvantages of the existing models used in ride-sharing services?

Several researchers have explored this topic in the context of blockchain-based ride-sharing models with decentralised governance to investigate the shortcomings of existing models used in ride-sharing services. Their studies have shed light on the challenges faced by traditional platforms, providing valuable insights and justifications for the need to explore alternative solutions.

One of the weaknesses identified in traditional ride-sharing models is the issue of high fees. Goudarzi and Mozafari (2019) stated that centralised platforms often charge excessive fees from passengers and drivers, reducing the overall benefits for both parties. This financial burden hampers the growth and adoption of ride-sharing services as users seek more cost-effective alternatives.

Another area for improvement lies in the need for more transparency and accountability within centralised platforms. In their research, Stavroulaki et al. (2020) argue that the opacity of traditional ride-sharing models makes it difficult to verify transactions, assess the fairness of pricing mechanisms, and address disputes. This lack of transparency erodes trust and undermines the user experience, potentially deterring users from engaging with ride-sharing platforms.

Furthermore, centralised control over decision-making processes poses a significant area for improvement. Xu et al. (2019) noted that centralised platforms can impose rules and regulations without meaningful input from users and drivers. This lack of user empowerment limits the flexibility and customisation of services and diminishes the sense of ownership and involvement in shaping the platform's policies and operations.

These weaknesses highlight the need for alternative models to address centralised ride-sharing platforms' shortcomings. With its decentralised and transparent nature, blockchain technology has been identified as a potential solution. As Goudarzi and Mozafari (2019) state, blockchain can facilitate peer-to-peer transactions, reduce transaction costs, and eliminate the need for intermediaries, thereby addressing the issue of high fees. Blockchain technology enhances trust and accountability within the ride-sharing ecosystem by providing a transparent and immutable ledger.

Decentralised governance is another crucial aspect that can address the weaknesses of traditional ride-sharing models. According to Stavroulaki et al. (2020), decentralised governance empowers users and drivers to participate in decision-making, ensuring that rules and regulations are collectively determined and transparently enforced. This user-centric approach fosters a sense of ownership, trust, and fairness, addressing the shortcomings of centralised control.

As highlighted by various researchers, the weaknesses of existing models used in ride-sharing services revolve around high fees, lack of transparency, and centralised control. The introduction of blockchain technology and decentralised governance in the context of ride-sharing models offers potential solutions to these weaknesses. The studies referenced justify the need to explore blockchain-based ride-sharing models with decentralised governance to overcome these challenges and improve the ride-sharing experience.

5.1.2: How can a ridesharing model based on blockchain with decentralised governance be designed?

This research study aimed to design a ridesharing model based on blockchain technology with decentralised governance. By utilising the Parity Substrate framework and incorporating various pallets such as Treasury, Ride, Identity, and Sacco, the aim was to create a robust and efficient system. The design process involved engaging a focus group to gather requirements and ensure that the resulting model addresses the needs of users and stakeholders.

The design of a blockchain-based ridesharing model with decentralised governance began with selecting the Parity Substrate framework. This framework provides a flexible and modular architecture that allows for the development of customised blockchain solutions. By utilising Parity Substrate, the research sought to leverage its capabilities to create a ridesharing ecosystem that promotes transparency, security, and user empowerment.

A focus group was engaged to define the specific functionalities and features of the ridesharing model. The involvement of the focus group allowed for the collection of diverse perspectives and insights from industry experts, drivers, and riders. Their input was crucial in determining the requirements for the Parity Substrate design, ensuring that the resulting model aligns with the needs and expectations of the target audience.

The design of the ridesharing model encompassed the incorporation of various pallets within the Parity Substrate framework. These pallets included Treasury, which manages the financial aspects of the ecosystem; Ride, which handles ride requests and matching functionalities, Identity, which ensures secure and verified user identities; and Sacco, which facilitates the governance and decision-making processes within the ridesharing community.

By leveraging these pallets and customising their functionalities, the research study aimed to design a comprehensive blockchain-based ridesharing model. This model would address the weaknesses of traditional ride-sharing platforms, such as high fees, lack of transparency, and centralised control, by providing cost-efficient transactions, transparent and accountable governance, and user empowerment.

5.1.3: How can a ride-sharing model design based on blockchain with decentralised governance be implemented?

Objective 3 of this research study focused on implementing the ridesharing model based on blockchain technology with decentralised governance following the design phase. The goal was to bring the designed model to life by utilising the Parity Substrate framework and integrating the identified pallets, such as

Treasury, Ride, Identity, and Sacco. The implementation process involved translating the design into functional code, ensuring the model's integrity, and testing its performance.

Implementing the blockchain-based ridesharing model commenced by translating the design specifications into actual code. The Parity Substrate framework was the foundation for building the model, leveraging its modular architecture and development tools. The implementation aimed to achieve the desired functionalities and ensure the model's efficiency, security, and transparency by utilising smart contracts and blockchain protocols.

Throughout the implementation process, emphasis was placed on maintaining the integrity of the model's decentralised governance. This involved integrating mechanisms that enable user participation, decision-making, and accountability within the ridesharing ecosystem. By adhering to the principles of decentralised governance, the implementation sought to empower users, foster transparency, and establish a fair and inclusive environment for all participants. Comprehensive testing and evaluation were undertaken to assess the implemented model's effectiveness and performance. This encompassed simulating diverse Usage scenarios, analysing the system's responses, and evaluating the model's scalability, security, and reliability. Subjecting the model to rigorous testing could identify and address any potential issues or vulnerabilities could be identified and addressed, ensuring a robust and resilient ridesharing platform.

5.1.4: How can a blockchain-based ride-sharing model prototype be validated and verified?

The final goal of this research study aimed to validate and verify the effectiveness and functionality of the blockchain-based ride-sharing model. The validation process involved conducting functional and pilot testing to ensure that the implemented model meets the requirements and objectives outlined in the earlier stages of the research. This objective sought to provide empirical evidence and validate the proposed model's capabilities and potential to address traditional ride-sharing platforms' limitations.

During the validation process, functional testing was conducted to assess the individual components and features of the blockchain-based ride-sharing model. This testing aimed to verify that each element, such as the Treasury, Ride, Identity, and Sacco pallets, functioned correctly and interacted seamlessly. Any bugs, errors, or inconsistencies were identified and addressed by conducting functional testing, ensuring the model's reliability and performance.

Once the individual components were validated, pilot testing was conducted to evaluate the blockchain-based ride-sharing model's overall performance and user experience of the blockchain-based ride-sharing model. Pilot testing involved engaging a limited number of users, including riders and drivers, to interact with the model in a real-world scenario. This allowed for collecting valuable feedback, identifying usability issues, and assessing the model's effectiveness in addressing the challenges faced by traditional ride-sharing platforms.

During pilot testing, key performance indicators (KPIs) were defined and measured to evaluate various aspects of the model, such as transaction speed, cost efficiency, user satisfaction, and overall system stability. The feedback and data collected from the pilot testing phase were carefully analysed to identify any areas for improvement and refine the model further.

The validation and verification process also involved comparing the performance and outcomes of the blockchain-based ride-sharing model with those of traditional ride-sharing platforms. This comparative analysis objectively assessed the model's strengths, weaknesses, and overall impact on the ride-sharing ecosystem. By completing the validation and verification process, the research study provided empirical evidence of the effectiveness and functionality of the blockchain-based ride-sharing model. Based on functional and pilot testing, the validation results demonstrated the model's ability to address the weaknesses of traditional platforms, including high fees, lack of transparency, and centralised control. The findings also highlighted the model's potential to enhance user experience, foster trust, and promote decentralised governance within the ride-sharing industry—the final objective of validating and verifying the blockchain-based ride-sharing model involved functional and pilot testing. The model's functionality, performance, and user experience were evaluated through this rigorous testing process. The validation and verification outcomes provided empirical evidence of the model's capabilities and its potential to revolutionise the ride-sharing industry. The findings from this objective served as a solid foundation for the conclusions and recommendations of the research study, highlighting the benefits and implications of implementing blockchain-based ride-sharing models with decentralised governance.

5.2 Conclusion

This research study has explored the potential of blockchain-based ride-sharing models with decentralised governance as a solution to the challenges faced by traditional platforms. The research objectives were successfully achieved, providing valuable insights into the weaknesses of existing ride-sharing models, the design and implementation of a blockchain-based model, and the validation of its effectiveness through pilot testing. The findings have demonstrated the benefits of blockchain technology, including increased transparency, security, and user empowerment. At the same time, decentralised governance mechanisms have enhanced fairness, accountability, and user participation within the ride-sharing ecosystem

5.2.1: New Business Models:

Incorporating a SACCO DAO introduces a novel and democratic approach to platform governance, granting equal participation rights to all stakeholders. This decentralised governance model empowers drivers and riders by allowing them to collectively make decisions, propose platform updates, and vote on crucial matters. Moreover, tokenomics is pivotal in incentivising active participation and excellent performance. The platform fosters a positive and motivating environment that benefits all participants by rewarding drivers and riders with tokens based on factors such as ride quality, positive feedback, and community engagement.

5.2.2 Decentralisation:

The adoption of a decentralised approach offers several notable advantages. Eliminating a central authority minimises the risk of single points of failure, reducing vulnerability to hacking and data breaches. Decentralisation also ensures transparency and immutability, providing riders and drivers with a trustworthy and auditable history of transactions and platform operations. Furthermore, decentralised governance mitigates monopolies' influence and enhances decision-making inclusivity, ensuring the platform evolves according to its users' collective needs and interests.

5.2.3 Privacy:

Integrating zero-knowledge proofs is a pioneering solution to address privacy concerns in the ride-sharing industry. Zero-knowledge proofs allow riders and drivers to verify the authenticity of their data without disclosing sensitive information. This advanced cryptographic technique ensures that personal details, trip histories, and financial transactions remain private and secure. By preserving users' privacy while maintaining the platform's integrity, the model significantly enhances trust and encourages wider adoption of the blockchain-based ride-sharing service.

5.3 Recommendations:

Based on the research findings, the following recommendations are proposed:

1. Adoption of Zero-Knowledge Proofs: Zero-knowledge proofs, a cryptographic technique that allows verification of information without revealing the underlying data, should be considered for further enhancement of privacy and security within the blockchain-based ride-sharing model. Zero-knowledge proofs can protect user privacy, validate identities, and ensure data integrity while maintaining the blockchain's trust and transparency.

2. Education and Awareness: Educating users, drivers, and policymakers about the benefits and potential of blockchain technology and decentralised governance in the ride-sharing industry is essential. Raising awareness about these models' increased transparency, security, and user empowerment offered by these models can drive acceptance and encourage stakeholders to adopt and support these innovative solutions.

3. Regulatory Frameworks: Policymakers should engage with the ride-sharing industry to develop regulatory frameworks supporting blockchain technology and decentralised governance adoption. These frameworks should balance innovation with consumer protection, privacy, and data security, enabling the growth of blockchain-based ride-sharing models while addressing regulatory concerns.

4. Continued Research and Development: Further research and development are necessary to improve the functionalities and capabilities of blockchain-based ride-sharing models. This includes exploring emerging technologies, such as artificial intelligence and IoT (IoT), to enhance safety, optimise routing, and improve user experience within the ride-sharing ecosystem.

By implementing these recommendations, the ride-sharing industry can embrace the potential of blockchain technology and decentralised governance, leading to a more transparent, secure, and user-centric ecosystem. The adoption of zero-knowledge proofs can further enhance privacy and security, ensuring the protection of user data. With collaborative efforts, education, and regulatory support, blockchain-based ride-sharing models can transform the industry, revolutionising how people access transportation services while prioritising fairness, trust, and user empowerment.

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ANNEX

Focus Group Discussion Paper.

Welcome, participants, to this focus group discussion on blockchain-based ride-sharing platforms. Today, we gather here to engage in a collaborative and insightful conversation about the implications and potential benefits of integrating blockchain technology into the ride-sharing industry. This discussion aims to explore various perspectives and ideas regarding adopting blockchain in ride-sharing platforms and gain a deeper understanding of its opportunities and challenges.

Originally introduced as the underlying technology for cryptocurrencies like Bitcoin, blockchain technology has since emerged as a powerful tool with diverse applications across multiple industries. Its decentralised and transparent nature has the potential to address many of the existing challenges faced by traditional ride-sharing platforms, such as trust issues, data security, and governance concerns.

Through this focus group discussion, we aim to tap into the collective knowledge and experiences of the participants, who come from diverse backgrounds and possess a range of insights into the ride-sharing industry. Our discussion will involve open-ended questions to encourage meaningful conversations and promote exchanging ideas.

By exploring topics such as transparency, trust, data security, privacy, governance, payment systems, and the overall impact on riders and drivers, we seek to understand blockchain-based ride-sharing platforms' potential benefits and limitations of blockchain-based ride-sharing platforms. The insights generated from this discussion will contribute to a deeper understanding of the implications of this technology and its potential to transform the ride-sharing landscape.

It is important to note that this focus group discussion aims to create an inclusive and respectful environment where all participants feel comfortable expressing their thoughts and opinions. We encourage active participation and open dialogue, allowing for a rich exchange of ideas and perspectives.

Your contributions to this discussion are valuable, as they will provide a foundation for further research, policy development, and industry advancements in blockchain-based ride-sharing. We thank you for your willingness to participate and look forward to an engaging and insightful discussion.

Please note that this discussion will be documented for research purposes, and all data collected will be treated confidentially and analysed in an aggregated and anonymised manner. Your privacy and anonymity will be respected throughout the process.

Let us begin this focus group discussion on blockchain-based ride-sharing platforms and, together, explore the potential future of the ride-sharing industry.

Discussion Questions:

1. How familiar are you with blockchain technology, and what are your initial thoughts on its potential applications in the ride-sharing industry?
2. In your opinion, what are the main challenges traditional ride-sharing platforms face that could be addressed through blockchain-based solutions?
3. Transparency and trust are often cited as significant concerns in ride-sharing. How does blockchain technology improve transparency and build trust among riders and drivers?
4. Data security and privacy have been prominent issues in the ride-sharing industry. How can blockchain help protect user data and ensure privacy in a blockchain-based ride-sharing platform?
5. What are the potential benefits and drawbacks of decentralised blockchain technology d governance in blockchain-based ride-sharing platforms? How might this impact the overall user experience?

6. How do you think implementing blockchain and smart contracts can simplify and streamline payment processes in ride-sharing? It could lead to lower transaction costs and greater financial empowerment for drivers.
7. Are there any potential challenges or barriers to adopting blockchain-based ride-sharing platforms? What are your concerns regarding integrating blockchain technology into the existing ride-sharing ecosystem?
8. Can blockchain-based ride-sharing platforms promote fairer pricing models and empower drivers to have more control over their earnings? What mechanisms or features would you like to see in such platforms to support driver empowerment?
9. How do you envision the future of the ride-sharing industry with the integration of blockchain technology? What changes or improvements do you anticipate for riders, drivers, and the overall industry?

Source code.

https://github.com/grandmullah/radicle-node.git

https://github.com/grandmullah/radicle-driver-app.git

https://github.com/grandmullah/radicle-rider-app.git