Reliable and Cost-Effective Long-Distance Transport in Kenya: A Mobile-Based Technology Carpooling Solution

By

Boniface Muchendu Ngaruiya

079181

Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Mobile Telecommunications and Innovation at Strathmore University

School of Computing and Engineering Sciences

Strathmore University

Nairobi, Kenya

April, 2024

Declaration and Approval

Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

Student's Name: Boniface Muchendu Ngaruiya

Sign: Date: 24 Jan 2023

Approval

The dissertation of Boniface Muchendu Ngaruiya was reviewed and approved for examination by the following:

Dr. Joseph Sevilla Director @IlabAfrica

………………….. Signature 16/02/2023

Abstract

Carpooling is a form of organisation of car use among several individuals that involve their sharing of costs. It reduces their overall transport costs while reducing the number of cars on the roads. The achievement of the latter is the major emphasis of this study. The study aims to develop a mobile application to promote carpooling and hence reduce the overall congestion on Kenyan roads.

Several key objectives will guide the paper, including evaluating the modes of carpooling and their use of technology. Additional objectives include the development of a mobile-based prototype that addresses carpooling and evaluating the effectiveness of the prototype developed as far as carpooling is concerned.

The prototype developed will enable users of the mobile app to share their private cars with others at a fee. Car users will be able to post a request on the system to access carpooling services.

Table of Contents

List of Figures

List of Tables

List of Abbreviation

HGV-	Heavy Goods Vehicles
TUMI-	Transformative Urban Mobility Initiative
NTSA-	National Transport and Safety Authority
MCSR-	Multiple Clients Single Routes
MCMR-	Multiple Clients Multiple Routes
UML-	Unified Modelling Language
NoSQL-	Non-Structure Query Language
MB-	Megabyte
GB-	Gigabyte
CDROM-	Compact Disc Read Only Memory
USB-	Universal Serial Bus
EMCA-	Environmental Management and Coordination Act

Definition of Terms

Carpooling: a privately owned vehicle shared by several individuals to journey over a given distance

Acknowledgements

To my supervisors and my family, thank you.

Dedication

To my daughters

Chapter 1: Introduction

1.1 Background

Kenya has a road network of 160,886 kilometres. Of these roads, over 63,000 kilometres are classified roads, with the rest being unclassified. However, the unclassified roads are deemed to be more than the estimated 86,000 unclassified roads. According to the Kenya roads board, the rural unclassified roads are about 116,000 km. Of the classified roads, 14,000 Kms are considered main roads, including classes A, B, and C. The rest of the roads are secondary and feeder roads. Of the main roads, only 7,000 Kms are paved, whereas only 2,000 Kms of secondary and feeder roads are paved. As such, only 5% of the entire road network in Kenya is paved (Kenya Roads Board, 2013).

Kenya has a lower road density per its population in comparison to Africa and sub-Saharan Africa. On average, in Kenya, there is 2.3 km per 1000 people, whereas, across Africa, there is 3 km of roads per 1000 people. In sub-Saharan Africa, there is an average of 2.9 Kms of roads per 100 people. Countries like South Africa, Namibia, and Botswana, on the other hand, triple the average road in Africa (Kenya Roads Board, 2013).

In Kenya, over 60% of the road network is in rural areas. In the rural areas, the majority of the roads are found in areas with high agricultural capacity. The level of development of these roads has been increasing over time due to the increase in the maintenance of the roads. In the evaluation of the capital needs of Kenyan roads, it is estimated Kenyan roads require an investment of over US$ 1.2 billion to restore the road network to an acceptable condition (Kenya Roads Board, 2013).

Nairobi is one Africa's fastest growing cities. The city grows at a rate of 4% annually. The growth is driven by high birth rates and influx of immigrants who come to Nairobi to seek employment (World Bank, 2019). The growth in the population has not been in tandem with the growth of the transport infrastructure. In major cities across Kenya, urban transport is characterised by inadequate public transport service in addition to a large number of cars and heavy goods vehicles (HGV). The resultant impact has been heavy traffic congestion during peak hours and stiff competition for the limited road space between pedestrians, cyclists, and motorists. These issues are quite exacerbated in the major cities with long queues of slowmoving vehicles and long waiting times (TUMI Initiative, 2019).

Such challenges with the urban infrastructure are a result of the poor planning and investment in transport infrastructure. This includes the lack of reliable and fast train service and the lack of an interconnected road network within the cities. Additionally, the city's road networks are clogged with parking, which takes extra space that could be allocated to the road network. Further, inner-city roads are limited and promote inner-city traffic towards major city road outlets (TUMI Initiative, 2019).

Distances travelled in Kenya by travellers vary dramatically, as do the incentives behind long-distance travel. The long-distance travel market incorporates passengers in different education levels, the workforce, individuals wanting to relocate and people traveling for leisure. The government has prioritised medium and short distance travel solutions that target daily commuting. The infrastructure and budgets are mainly focused on railway systems and intra-city commuting. However, long-distance transportation solutions have not received enough funding and attention to make significant changes. The investment in additional road infrastructure would allow cars to travel on long-range trips to undertake the shorter duration. The smoother road surface and reduced time wastage due to poor road conditions would reduce travel time. However, additional road infrastructure is not the only key to improving road transport on long-distance trips (TUMI Initiative, 2019).

1.2 Problem Statement

There is a growing demand for a comprehensive transport solution for long-distance travel in Kenya. Most Kenyans rely on Matatus that are known for poor service delivery passenger inconvenience based on comfort, time, and drop-off locations.

1.3 General Objective

i. Development of a carpooling application to satisfy the unmet needs of transportation identified.

1.4 Research Objectives

i. To evaluate modes of public transport used in Kenya.

ii. To identify existing carpooling solutions in Kenya

iii. To design, develop and test a mobile based solution.

iv. To validate the prototype as an acceptable working solution in Kenya.

1.5 Research Questions

i. What modes of public transport are used in Kenya?

ii. Are there existing carpooling solutions in Kenya?

iii. How can one design a mobile-based prototype that addresses carpooling?

iv. Is the prototype a valid solution to the problem of carpooling in Kenya?

1.6 Relevance of the Study

Carpooling presents one of the keys that will ease the Nairobi transport quagmire. Carpooling helps to ease a country's dependence on foreign oil by as much as 40%. Given that oil is the largest import product for Kenya, such a decrease in foreign oil needs would rapidly improve currency terms for the nation.

Importantly, carpooling would decrease traffic by 20% if all driving residents carpooled at least once a week. Given the large proportion of the budget spent on fuelling cars for drivers, cutting down on the key expense would significantly improve the financial position of drivers. Further, if four car owners rotate their cars for carpooling, it would reduce the maintenance cost for each car.

One of the key advantages of carpooling is its impact on the reduction of car emissions. If 100 individuals undertake to carpool every day, it will result in the annual reduction of 1320 pounds of carbon monoxide. Additionally, 2.376 pounds of carbon dioxide emissions would be eliminated.

1.7 Scope and Limitations of the Study

The scope of the study is limited to the development of a mobile application that car-poolers in Kenya would use. Further, the study is limited because it uses research from developed nations due to the lack of comparative research in developing nations, particularly Kenya. The location of the study will be limited to Nairobi because of the level of exposure to technology and easy access to the population. The development of the application will be limited to mobile phones using the Android operating system over iOS and websites as it is the most popular operating system in Kenya. Additionally, mobile phones present the element of mobility which compared to website one has to have either a laptop of desktop to fully appreciate its offerings.

Chapter 2: Literature Review

2.1 Introduction

Wastage of resources, congestion, noise and degrading air quality are just a few challenges facing the transportation sector. Still, shifts towards other types of transport apart from cars are not permanently the best answer. For instance, when vehicular occupancy is low then public transportation is not justifiable. Therefore, by improving transportation resources and facilities, carpooling can be a suitable strategy and intervention that should be adopted and recommended by policymakers (de Lira, 2018).

Carpooling allows people to travel in cars to minimise single-occupancy vehicles found on roads. Carpooling offers individuals the flexibility and convenience of using private cars at minimised costs and the possibility of minimising the passengers' carbon footprint and impact on society. The United States Environmental Protection Agency reports show that a worker through carpooling can save on time, reduced costs, socialising outcomes, and improved time value, such as reading or sleeping when in transit. From an employer's perspective, there is a reduced need for space, and they can benefit from less stressed employees. Additionally, minimal public ventures are needed since carpooling uses already existing transport infrastructure. The reason people carpool is based on several factors, including their contexts, situational factors, demographics and attitudes. For changes in society to be effective through technology, changes in policy recommendations should be adjusted to current trends (Shaheen, 2017).

2.2 Brief History of Carpooling

Carpooling as a term grew in popularity due to the oil crisis of the 1970s. However, its origins can be dated back to the first World War, when America was experiencing economic hardships, and car owners started offering transport to people. During this short period carpooling was successful. However, car manufacturers quickly and successfully petitioned for new regulations that resulted in a significant reduction of carpools. The dwindling numbers remained low until World War 2, when citizens were stimulated to carry passengers with the slogan “when you ride alone, you ride with Hitler” (Aguiléra & Pigalle, 2021). Surprisingly, the carpooling campaign was also supported by the oil and car industries (Aguiléra & Pigalle, 2021). Its popularity grew again in the 1st and 2nd oil crisis. In 1990, carpooling popularity decreased from 19.7% to 13.4% (Tafreshian, et al., 2020).

In 2005, the oil prices increased, and the 2008 financial disaster saw an increase in carpooling. Similarly, the growing popularity of the internet saw private companies and enterprising individuals create various ridesharing services (Furuhata et al., 2013). However, he developed algorithms that did not significantly change travellers' carpooling choices, and carpooling again saw a fall. The reason for the fall can be traced back to aspects that make it inexpensive to commute to work by car, such as subsidised parking and the increased convenience of using a personal car. Additionally, the decline was also caused by flexible working hours and telecommuting. Mobile phone applications, smartphones, and internet advancements provide a chance to promote carpooling. Companies such as Uber with UberPool, LyftShare, Zimride, and BlaBlaCar promote and accelerate carpooling (Jaffe, 2015). The simplicity of requesting a ride using a web application or mobile phone application has popularised ridesharing, making it attractive. Platform-based companies have facilitated fast market spread that allows the companies to gain more users matches and facilitate transport (Jaffe, 2015).

There is an opportunity in societal revolution and the increasing importance of the sharing economy in different business sectors, as shown by companies like Uber, Airbnb, and eBay. Consumer revolution has popularised the slogan "sharing is the new buying." The trend has penetrated the transportation sector, making ridesharing and car-sharing trendy in urban areas (Nicoll & Armstrong, 2019).

2.3 Review of Carpooling Applications

Globally, Lyft and Uber have established themselves as the reliable and convenient alternative typical taxi services and public transportation. Through these applications ridesharing and carpooling have grown to become popular. The following is a review of three popular carpooling applications.

2.3.1 UberPool

UberPool is a service offered by Uber where a passenger is matched with other passengers who are headed in a similar direction. Since the passengers are on the same trip the cost is split between the passengers. Drivers are allowed to pick up several passengers during a trip and continue earning as they continuously pickup and drop-off passengers. UberPool uses a version of its matching algorithm to find the best match with other passengers who are going in the same direction to add to a trip. Its matching criteria is based on the pickup and destination points along the same travel path (Uber, 2022).

As a passenger during the ride the driver stops to pick up other passengers before reaching the destination. Since the app allows the driver to pick-up and drop-off passengers time is added to a passenger's trip and the expected time of arrival is indicated in the app before a user accept to use the UberPool service. At times when the demand is low a passenger may ride by themselves. Additionally, the application does not allow one passenger to reserve more than two seats, to guarantee that other passengers have a seat in the UberPool vehicle. UberPool can be found in its biggest markets in North America and if the UberPool option is missing within the Uber application the service is not offered in a particular region (Uber, 2022).

2.3.2 **Zimride**

Zimride is carpooling and ridesharing service located in North America that has over 300,000 users and has serves more than 130 universities, colleges, and corporate campuses. The goal of the service is to offer university students an easy mobility option during the weekends and on holidays. As the application offers student friendly transportation services, drivers can find passengers within communities to share the trip costs and offer some money for fuel. As of 2013 Zimride was acquired by Enterprise Holdings. At the time of acquisition Zimride offered its services to both public and private entities. However, in January 2015, the company announced that it was removing public carpool reservations to focus on its core service of ride matching among business, universities, and government partners (Zimride, 2022).

As a transportation solution, specifically carpooling Zimride offers affordability to commuters. Additionally, the onboarding process is simple, all one must do is create a profile. As a driver one can post a ride by entering the current location and destination and the application will create a list of probable matches ranked by how far a passenger wants to travel along the same route. Passengers can post destinations they want to go in the future, trip scheduling, and receive email alerts when a match is found. The service does not charge for cancellations, distance overages and late rides. Drivers on the application can accept passengers based on their profiles which include information such as interests, music preferences, and feedback. When passengers book a ride, drivers have up to 24 hours to accept the request. After the request is accepted, the passenger can pay for the trip using PayPal unless there is a cancellation from the driver (Zimride, 2022).

2.3.3 **BlaBlaCar**

BlaBlaCar is a carpooling company that was founded by Fréderic Mazzella in 2006. It is currently run by Comuto Company and has over 300 employees and its headquarters are in Paris, France. BlaBlaCar allows drivers to connect with passengers and offer them an empty seat in their car. Through the application an individual can select to be either a driver or rider.

Drivers are able to post upcoming trips and offer rides. Riders are able to search available trips and request a seat booking. After a ride is requested, both the rider and driver can communicate and share details such as drop-off and pickup locations. Payments are done within the application or on the website and are processed once a ride is complete. Drivers are able to leave reviews, which helps create trust and guarantee that all parties are accountable for their actions (BlaBlaCar, 2022).

BlaBlaCar does not take commissions on trip fares instead riders are charged a flat service fee when they are booking. Therefore, after a trip the driver receives the total amount of fare indicated in the app. The pricing model is a win for both parties since the passenger knows the upfront ride charge and the driver knows that the can pocket majority of the ride fares. During price calculation a certain amount of the price set by the rider is taken as the service which can be seen by the passenger before confirming a ride. The refund policy is flexible such that a passenger can cancel a booking if a driver does not approve their booking. When drivers cancel an already confirmed trip, passengers are refunded the total amount including the service fee (BlaBlaCar, 2022).

2.4 Current State of Transport in Kenya

In Kenya, public transport dates to 1930; however, a lot has changed due to increased urbanisation and population growth (TUMI Initiative, 2019). Road transport accounts for more than 80% of passenger and internal freight traffic in Kenya, with the remainder being shared between air and rail. The road network serves both regional and domestic freight and passenger transportation demands. In Kenya, there is no state-operated road passenger public transportation service (Luongo, 2018).

The current state is dominated by privately owned and run transport services which include motorcycles (boda boda), buses, vans, minivans (matatus) and tricycles and bicycles (tuk-tuks). Due to the lack of organisation and regulation in public passenger transportation, alternatives have resulted in the rapid growth of many unconventional means of public transportation (TUMI Initiative, 2019). The current public transport situation can respond to the demand for motorised mobility from most of the population to meet the need to travel that cannot be satisfied by walking. The demand might result from regular daily and seasonal changes or long-term changes arising from competing forms of transportation or changes in mobility patterns (Luongo, 2018).

Currently, nearly 80% of public transportation people are served by matatus. Until 1984 matatus were not required to have a PSV licence (TUMI Initiative, 2019). The introduction of PSV licensing helped streamline the sector, but there was still increased growth. By the year 2000, there were approximately 40,000 operational matatus. Despite the importance of matatus and buses in the Kenyan economy, the workers in the sector regularly complain of poor labour conditions that are characterised by police and county council officer harassment, long working hours, lack of proper payment structures and other issues (Luongo, 2018).

To streamline the transport sector, several policy interventions were implemented. One of the directives issued to streamline the industry was a cashless transaction that would allow easy taxation and help with fluctuated fare regulation (TUMI Initiative, 2019). Ultimately, the initiative failed because of power struggles and structures between the government and the private sector. Commuters in the country with improved roads can travel easily as many routes have been mapped and there is more regulation (Luongo, 2018). The need to provide better services has led to a change in travel experiences for passengers. Aesthetic elements have been added to improve marketability and appeal to attract passengers. Long-distance buses are now fitted with Wi-Fi, interior furnishings, and television screens. The aesthetic is especially common in short distance matatus. The current public transport services share the following features: they blend all travel modes, and typical overloading and overcrowding (TUMI Initiative, 2019). Vehicular congestion due to poor road usage and planning by non-motorised transport, private vehicles, and roadside vendors. Poor road design where the drop-off and pickup points are not correctly designated. There is a lack of standardisation in fares and the manufacture and design of transportation vehicles. Most of the long-distance travelling is done through low occupancy vehicles, typically 10 and 14 seaters and high-capacity buses for the hard-to-reach areas (Luongo, 2018).

The main challenges facing passengers are disorder and chaos. After introducing the Michuki laws, some form of normalcy and order was achieved. However, the situation has since deteriorated as actors do not follow traffic rules, and there is poor enforcement of rules by the police and other regulatory bodies such as NTSA (TUMI Initiative, 2019). Cartels are another challenge. Cartels in the transportation industry collude with transport actors to sometimes steal and harass passengers, and these cartels operate like gangs. The cartels have caused the cost of entry into the transportation business to skyrocket, preventing new entrants from going into the business. They manage travel routes and terminals and protect them from outsiders. In addition to cartels, other significant challenges include abusive and rude crews, overcharging passengers, overloading, reckless driving, high occurrences of unsafe vehicles, blocking roads and lack of adherence to traffic laws (TUMI Initiative, 2019).

2.5 Improving the Uptake of Carpooling

Although the literature on carpooling is rich, it heavily focuses on short-distance and urban area trips, mainly carpooling between the workplace and home of a place of study. This can be seen in publications on companies like Uber, Lyft, etc. In comparison, carpooling for long-distance trips was studied less. However, Blablacar's accomplishments have brought the company to the limelight that is long-distance carpooling, with a primary focus on non-workrelated trips (Müller, 2017).

Whether mobile-based solutions can address or improve carpooling, the uptake of carpooling is genuine: commuter trips are typically longer and regularly made by a car than other trips. The high levels of pollution and resultant health concerns can be attributed to the high number of cars on the roads. The high numbers also result in traffic snarl ups in major cities reducing the economic efficiency of the population (Shaheen, Stocker & Mundler, 2017). Due to this, the development of carpooling services is taken as an instrument that can reduce carbonisation and congestion due to a change in travel behaviour (Olsson, 2019). In contrast, less is known about non-work long distance carpooling. However, there are environmental and social concerns related to long distance carpooling. For instance, recreational trips and daily shopping trips are more common trips made by cars in many nations. Based on social aspects, the development of daily and long-distance carpooling can increase mobility access for individuals from locations with poor public transport or individuals with economic or health problems (Shaheen et al., 2017).

The effectiveness of carpooling practices can be measured through household travel assessments, which are rarely used. There are few figures on long-distance carpooling practices based on modal sharing or frequency. A study conducted in France pointed out that long distance carpooling is prevalent among the population, but it doesn't occur often (Shaheen et al., 2017). The study also showed that carpoolers practice short and long-distance carpooling, which has captured minimal attention in the literature, leading one to conclude that the practice is done in isolation.

It is also important to mention the motivation and profile of long-distance carpool passengers and drivers. There is a lack of comparative literature, however, there is a significant motivational difference and profiles among short distance carpooling and longdistance carpooling. According to a study on French drivers, shorter workplace trips were overrepresented by young people, while those that carpooled for shopping were on average older (Shaheen et al., 2017). In the same study it was shown that the population that carpooled for children-related activities were women. In a different study it was determined that individuals that opted for soft-distance carpools that did not relate to work trips were less urban, older and could be traced back to low income earning groups relative to work related carpools and long-distance carpool trips (Carrese, et al., 2017). Blablacar long-distance carpooling users were studied. It was revealed that relative to the French populace, carpoolers (long-distance) possessed a similar average income but were more knowledgeable; the majority possessed diplomas. The younger demographic of the group (long-distance carpoolers) mainly visited rural municipalities (Setiffi & Lazzer, 2018).

Additionally, the study showed that many carpooling trips were for relaxation. Additionally, mutual help was a recurrent theme for long-distance carpooling, especially in a location with poor public transportation or communities known to be isolated or exist in solidarity. In both short and long-distance travel, carpooling, despite having a social factor, the economic characteristics were highly influential. However, another analysis on Blablacar long-distance carpooling users showed how social values were important in explaining the continual use of the long-distance carpooling service. Undoubtedly, such aspects merit more investigation on long-distance carpooling (Shaheen, Stocker & Mundler, 2017).

2.6 Adopting Carpooling for Long-distance Trips

2.6.1 Carpooling Platforms and Applications

Most ridesharing applications are found on smartphones. Several services are based on accessing real-time data in transportation systems and suggestions on optimal transportation modes and routes. After which the driver and passenger interact on the application as shown in figure 2.1, to show how to use a ride sharing application. Other services provide access to novel forms of sharing trips such as carpooling and ride-sourcing services or vehicles such as self-service bicycles and car-sharing (Tafreshian, Masoud, & Yin, 2020).

Figure 2.1: Typical Carpool/Ride-Sharing Application

The carpooling landscape can attract new agents. Whether it works as dynamic (realtime) or planned services, the applications and platforms now typically focus on a specific mobility element, such as short-distance or long-distance trips. Passengers and drivers are matched based on a standard search engine where the passenger enters the trip times, direction and other trip criteria, with some data being added automatically and the journey as experienced by the passenger is shown in figure 2.2. In other applications, the algorithm determines the optimal driver and passenger matches. Ride sharing platforms and application include quality of life tools such as travel cost sharing, and platform or application commissions payable to the owning company (Tafreshian, Masoud, & Yin, 2020).

Figure 2.2: Journey Map

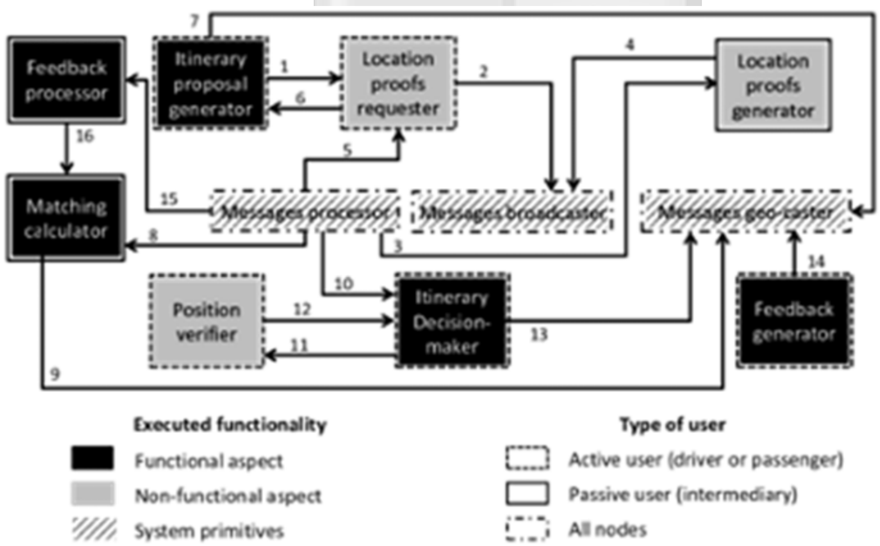

Figure 2.3: Dynamic Carpooling Architecture

These applications present many benefits for both passengers and drivers. They contain several improvements in the probability of satisfying transportation demand and supply in both quality and quantity, including automatic car-matching processes. It is also possible to introduce novel services such as a "last minute service" which combines dynamic and multi-route carpooling services (Aguiléra & Pigalle, 2021), as shown in figure 2.3. Smartphones help organise carpoolers schedules, for instance when a party is running late. Other features that can be added to the platforms and application include transparent access to proposed driver prices which allows passengers to negotiate to a lower price and the implementation of a payment gateways or systems that prevents the need for exchanging cash and last-minute cancellations. Finally, the system has a rating system for passengers and drivers to increase user trust, which is a critical component of car-sharing. Also, several applications assume the responsibility of getting alternatives like taxis when a driver makes last minute cancellation. Many current applications do not offer high-level customisation, making them unrealisable, since they are usually sustained by public companies as application trials which have a short shelf life (Aguiléra & Pigalle, 2021).

2.6.2 Evolution of Carpool Applications

Sonet et al. (2019) developed dynamic ridesharing and carpooling application, SharY, to help people solve Dhaka's public transport overcrowding and timeliness problem. Their main objective was to develop a match-making algorithm where a host can carpool with several passengers from different routes without compromising on distance travelled, fares, fuels, and other basic preferences. The application developed helped satisfy the accessibility, offer and request, and matching functionalities to achieve their objective. After defining the functionalities, the system architecture was designed to follow the following procedure. Hosts and clients can query direction when using the mobile application, supported by the Google Maps API. The host can offer rides, and clients can request rides using the application. Hosts, individuals that offer rides, can view their devices for potential clients that ply their route. Potential clients were then pruned for final selection. The prune module results were then sent to the sequence generator to produce client sequences to create optimal pickup and destination points for clients. The produced sequences were sent to a server, and the server sends the host list to clients. Through the host filer module, the host is set for the client. The host is then sent over to the server, and the host receives the client's response. Finally, the host confirms the client's carpool request. SharY, after testing, offered flexibility to both host and client. The application was also tweaked to use Multiple Clients Single Routes (MCSR) and Multiple Clients Multiple Routes (MCMR) to generate a more robust algorithm output. Sonet et al. (2019) discovered that the application effectively utilised traffic, vehicle, money, and time resources.

Correia & Viegas (2009) simulated carpool systems. The research was designed to find a solution to traffic congestion vehicles density using alternative measures to minimise the number of automobiles travelling as single-occupant vehicles. Their concept was divided into group formation and consistency testing. It was possible to simulate a list of trips for each client through group formation after inputting the geographical data, number of trips needed, and acceptable schedules. The output indicators for the formation of groups were the number of groups formed, the kilometres driven, the number of unmatched participants, and the number of unused vehicles. After creating the group lists, consistency testing was carried out to quantify the groups' endurance with respect to destinations and uncertainty of schedules. The input of the test was the number of days to be simulated found in the schedule and destination variations. Other inputs included searching for an existing group, trip times, acceptable delays, and failure limits. The output indicators of the test include the number of people that did not find an alternative group for near-term trips, total failures, the number of people expelled from groups and the number of groups that did not change. Through testing, the researchers understood the uncertainty of commuter trips, their preferences and characteristics. It was also possible to determine user behaviour when users were travelling daily.

Additionally, it was possible to reduce the frontier effects pertinent to simple carpooling models through the simulation. Through the simulation, it was possible to determine the viability of the carpool systems by identifying a suitable geographic area and developing incentives. It also created a baseline for better-adapted systems that could be tailored for specific demographics (Correia & Viegas, 2009).

2.6.3 Challenges of Long-Distance Carpooling

Long-distance carpooling is faced with several challenges where drivers do not have complete independence since there are more individuals in one car and such schedule constraints need to be considered. Also, there are security issues since passengers do not know each other (Aguiléra & Pigalle, 2021). The latter being the most significant barrier of entry and the one that most people will show concern about, additional challenges include:

1. Flexibility is a concern as it can be challenging to accommodate en-route stops or trip changes on an already rigid travel pattern. Schedule and location limitations and travel inflexibility and among the reasons for the poor adoption of long-distance carpooling.

2. Carpooling with strangers increases security concerns and is a significant obstacle to adopting carpooling for long-distance travel. A common approach to mitigate this risk includes a reputation/rating system that flags problematic passengers and drivers and allows the responsible users to create and build trust. The reputation system increases

the application or website's value because it will offer a degree of assurance to passengers and drivers. Another approach that can be copied from ride-sharing applications requires drivers to consent to a background check and submit a criminal record when they sign up to the platform to ensure that the drivers being onboarded are not criminals (Aguiléra & Pigalle, 2021).

3. Another concern is availability; carpooling requires a lot of people to have a working platform, chances of getting a match for similar or specific long-distance trips are extremely low, and it requires a considerable number of active users. As a solution, the platform and application can be deployed as a niche system. There is a high likelihood to get trip matches when people from a similar geographic region, workplace, or school with a similar amount of people are dispersed all around.

4. Legal constraints can be applied because long-distance carpooling can allow anyone to become a taxi driver, and as the service gains more public attention, more regulations will be applied.

2.7 Summary

Online platforms have revolutionised travel. Despite the unavailability of a universal description of an online platform, it is an interface between categories of users and service providers. For instance, newspapers are platforms between advertisers and readers. A platform's success is quantified by the number of users contributing to the platform. Online platforms have been instrumental in increasing ridesharing, which can be translated to carpooling. It is possible to create algorithms that match demand and supply through them. The greater the provider numbers and consumers on carpool platforms, the better the success metrics of the platform (Aguiléra & Pigalle, 2021).

Additionally, platforms allow trust to develop between the registered users, drivers, and the company. Despite carpooling being an efficient mode of transport to minimise emissions and traffic jams in cities, its adoption and use remain low. Therefore, it can be focused on long-distance travel, long city rides, or urban commuting between employees of a similar company living in the same region. However, technology is advanced enough to support carpooling by allowing users to match rides easier and provide incentives and cost savings (Aguiléra & Pigalle, 2021)..

However, there are challenges in the uptake of carpool applications. The sentiment was confirmed by a study on ridesharing use conducted in Nairobi. From the study, 48% of respondents that had used ridesharing services reported that if the ridesharing service were unavailable, then they would have used public transportation (Weru & Mugo, 2020). More people are abandoning boda bodas and matatus in favour of ridesharing services. With increased consumer power caused by a growing middle class, matatu services adapt quickly to regain consumer confidence. The growing preference for digitally enabled mobility services in place of matatus has been Kenya's transportation backbone since 1960. There is also a case for more government support for public transport and alternative transportation. There is particular interest in investing in better mobility options, with the goal of mass rapid transport systems and the transformation of the current public transportation system. The regulation and policies must be precise on digitally facilitating services in the public transportation domain and how to conduct business and have complementary relationships with public transport. Ultimately, carpooling is an essential service compared to individualbased transportation solutions. Digital applications must be designed to facilitate the improvement of public transportation. The focus must be on improving the current state of public transport and on mechanisms that help understand the country's mobility trends. It will be possible to create a data-driven policy and eventually a sustainable mobility system through this (Weru & Mugo, 2020).

Chapter 3: Research Methodology

3.1 Introduction

This chapter deals with the research design, target population, sample and design, data collection methods, and data analysis. It also explains how the users of this project was implement and test the prototype being developed. There are three core elements to consider when conducting a research inquiry (Tan, 2018).

i. What relevant knowledge does the researcher claim to profess? ii. Is there a predetermined strategy for confirming such claims? iii. How does the researcher intend to collect and analyse the relevant data?

According to Creswell (2003), a researcher can combine the three elements and come up with three distinct approaches to conducting research: quantitative, qualitative, and mixed research approaches. Some practical processes of the research design contain elements of the three research approaches.

3.1.1 Understanding Carpooling

The first step in creating a carpool solution is to comprehensively understand ridesharing and carpooling and its viability as a public transport solution. Carpooling has the potential to alleviate current challenges in long-distance travel. However, there is work to be done to make it feasible. A better understanding of carpooling required an understanding of ridesharing dynamics, which can help application designers, transport planners and policy makers increase carpooling friendliness by designing applications and developing policies that make carpooling attractive (Aguiléra & Pigalle, 2021). It also provided service operators with better tools to optimise services. When researching this element several questions will be asked: is carpooling utilisation stable or does it experience significant changes? Is carpool utilisation dynamic and can it be correlated to traceable factors such as traffic density, types of cars, fuel, and driver and client conditions? Finally, if carpooling is dynamic can predictions be made? How are host cars distributed over different regions? What are the observable patterns emerging from different rides? Such question guided the research to better understand carpooling and passenger behaviour by investigating on studies carried out on popular ride sharing applications, and carpooling applications. Additionally, interviews can be carried out on personalities in ride sharing application companies found locally (Aguiléra & Pigalle, 2021).

3.2 System Analysis and Design

It is important to conduct an in-depth analysis of the requirements for developing a software project successfully. The proposed prototype made it easy for the researcher to make a clear account of the system by allowing system components to show the composition and behaviour of the rest of the system's components. According to Larman (2005), the Unified Modelling Language (UML) is a diagramming notation that is standard for programmers. Its developers used Object Oriented Programming to create it and still use it to develop a uniform system that other software can pick up later to improve their functionality. The UML represents all the actions and users of the system in a more comprehensive manner. Its developer chose several diagrams to represent the UML system: Sequence Diagram, Use Case Diagram, System Sequence Diagram, and Design Class Diagram. The Unified Modelling Language uses diagrams to represent the connection between the tables the system creates in its database only. It does not represent the UML in any way. Additionally, since the database will be based on NoSQL there is no need for entity relationship diagrams (Davis & Yen, 2019).

3.3 System Implementation

The project required several tools to enable the researcher to implement the system's front end and the back end. For the hardware part, the system will require the following items; Pentium (R) Dual-Core CPU processor at 2.00 GHz or faster, minimum of 1GB available disk space for installation, minimum of 512 MB memory, USB port, and CDROM drive. The researcher developed the system's backend using Firebase. It is the most appropriate server because of its capabilities for the researcher's preferred language, side scripting. Its other advantage is that it allows the researcher to use a single database for the system's front and the back end (Davis & Yen, 2019).

The researcher used the flutter, firebase and Kotlin mobile development framework. It will enable the researcher to present and structure the system's content in a user-friendly way. The users can access data via devices of different sizes by use of inbuilt devices adaptability features found in Android mobile system (Späth, 2019). Table 3.1 shows a summary of the software tools that will be used in application development.

Table 3.1: Software Tools

Proposed	Software
Database	Firestore
Web Server	Firebase
Designing of User Interface	Adobe Fireworks CS5
Designing of UML Diagrams	diagrams.net
Designing of System Architecture	diagrams.net
Framework	Flutter, Kotlin and Dart

3.4 System Development Methodology

The systems development methodology adopted will be the agile model and specifically rapid application development. The agile development methodology is especially suited for sophisticated software. It also allows for iterations that help in reducing errors and mistakes that occur often (Davis & Yen, 2019).

Under agile development is the rapid application development (RAD), which will be adopted for this project. The RAD development model prioritises quick feedback and fast prototyping over lengthy development and testing phases. Using this method, it will be possible to make revisions and updates to the application fast without completely developing the application every time. The benefit of this is that the outcome will be focused on quality and aligns itself to the needs of the end user (Davis & Yen, 2019).

3.4.1 System Development Framework

The Rapid Application Development framework was used for the application. The development process has 4 steps as shown in figure 4.2, requirement planning, design, development, and cutover.

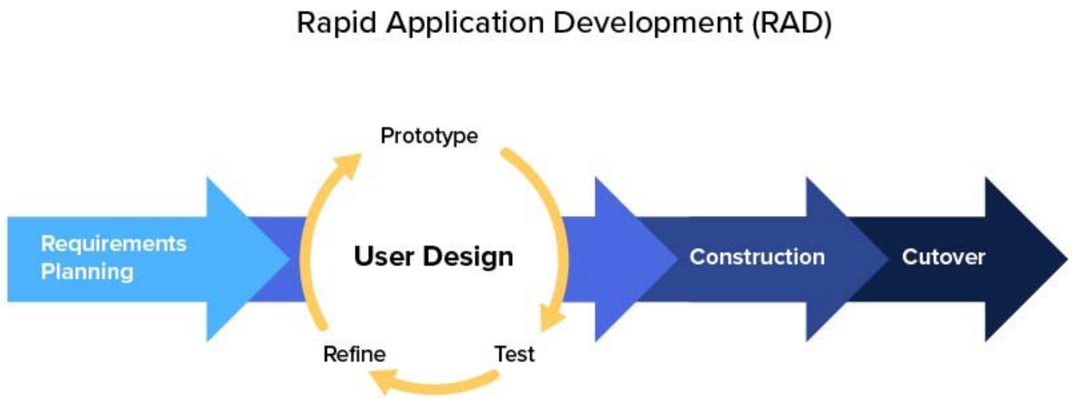

Figure 3.1: Rad Development Process

The first step is requirement planning, where the developer is not required to sit with the end user to obtain a detailed specification list. The step asks for a broad requirement list, which allows the developer to plan on segmenting the requirements as different areas of the development cycle (Davis & Yen, 2019).

The second step is the design where development occurs. Compared to following a specific requirement set, a prototype will be created with features and functions as fast as possible. The prototype will then be sent to users for testing and users can provide feedback. Once feedback is provided on the application updates will be made to refine the application before it is user tested again. Once the application meets the desired standard of functionality the final product will be developed and released (Davis & Yen, 2019).

3.5 Application Testing

The methods used to collect data for this research was quantitative. The sample population comprises a few subjects that facilitated the researcher's ability to answer the formulated research questions developed earlier in this proposal. The researcher issued the user two types of questionnaires. The first questionnaire contained information regarding the user's perception of mobile applications providing cheap transport to Kenyans. The second questionnaire comprised questions that seek to test the mobile application facilitating the supply of cheap transport to Kenyans (Myers et al., 2019).

After the research data is gathered from the questionnaires, the researcher analysed and interpret it. The results of the survey complemented the literature review in the datagathering process. The researcher also reviewed secondary sources of data such as relevant journals and internet articles (Myers et al., 2019).

This research adopted case-study research from private transport operators within the Nairobi town area. The choice of these private transport operators is because the best way to test this application is to test it on transport providers, who take the job as a serious career. The study is an empirical mechanism for studying a theoretical phenomenon within the context of a real-life scenario. The real-life scenario enables the researcher to generate research questions and test them. They are likely to answer the research questions with more honesty because they might be motivated by a mobile application that might upgrade their work, making them an ideal sample (Myers et al., 2019).

3.5.1 Location of the Study

The Nairobi Metropolitan Area formed the case study for this project. Information was collected from the road users of this area. The researcher arrived at the choice of this area due to the high commuter and vehicular traffic.

3.5.2 Target Population

This study targeted private transport operators aged between 18 and 55. They should be above the legal driving age and possess relevant skills in the field. (Tan, 2018)

3.5.3 Sampling Procedures and Sample Size

The expected confidence interval for this project is 7%. The level fell within the recommended bracket of 95% after doing the survey, as shown in table 3.2. The researchers are confident that no matter which subject is chosen from the population, they would choose the same answer as the rest of the respondents (Tan, 2018).

Table 3.2: Sample Size Population

Population	Sample size needed at 95% confidence level		
	+/-3%	+/-5%	+/-7%
5000	880	357	189

The researcher chose 189 private transport operators to test the mobile application. The researchers used the sample size calculator found online and using a predetermined formula (Naing, 2006).

Below is the formula

$$ss = \frac{Z^2 * (p) * (1-p)}{c^2}$$

Where:

Z = Z value (e.g. 1.96 for 95 % confidence level)

p = percentage picking a choice expressed as decimal (.5 used for sample size needed)

c = confidence interval, expressed as decimal (e.g., .04 =+-4)

3.6 Research Instruments and Testing Tools

The main methods of collecting data are pre-test and post-test questionnaires. The pre-test questionnaires gathered information from the respondents concerning their interactions with their Smartphones and their interaction with customers. The post-test questionnaires helped the researcher gain relevant information on testing the mobile phone application through the respondents. All the private transport operators taking part in the study were given a mobile application device, and those with personal devices had the application installed on their devices (Tan, 2018).

3.6.1 Questionnaire Design

The pre and post-test questionnaires were impartial, simple, and understandable. The research used different scales on each questionnaire to facilitate such designs. The researcher's questionnaires consisted of dichotomous as well as Likert scales in their structure (Tan, 2018).

1. Dichotomous scale: Its structure allows the respondents to only make two choices; yes or no, agree or disagree, true or false. The structure makes it easy to analyse each question separately.

2. Likert scale: The scale is diverse and gives the respondents the freedom of exercising varied viewpoints. The data analyst used the different scales used in the Likert scale.

3.7 Data Processing and Analysis

Once the respondents fill the questionnaires, the researchers tabulated the answers to make the analysis simpler. They generated graphs using Microsoft Excel to display the results (Tan, 2018).

3.8 Validation

Validation is the process of finding out whether the proposed solution meets the intended objectives and requirements (Park & Lee, 2014). Validation seeks to answers the question whether the solution solves the problem it is designed to solve. In the project, the researcher used a user questionnaire to find out the validity of the prototype.

Chapter 4: System Analysis and Design

4.1 Introduction

The proposed carpooling solutions was subjected to a thorough system analysis and design. This merited the development of an efficient and valid carpooling solution that meets the needs of the anticipated users. In this section, the researcher commenced with the analysis of the problem and solution using process flow diagrams. The intention is to develop a mobilebased carpooling solution (Davis & Yen, 2019).

4.2 Requirement Analysis

Requirement analysis is a process that involves defining, evaluating, validating and aligning the development goals while accounting for possible conflicts to determine needs and expectations of the mobile application. It was identified that that the end-user for the application are long-distance travellers who need affordable and safe travel, since the application was designed to meet their needs and inputs. Use cases were used to provide a walkthrough of the mobile application from the end-user's perspective. Through this it was possible to visualise how the product actually works. After which a prototype was developed to provide a sample of the sample of what the final product felt. The technique allowed for the identification of issues and potential problems before a final build is developed (Davis & Yen, 2019).

4.2.1 Data Collection Results

The data collected from mainly included user data such as driver phone number, drivers number plate number, type and email and destination. From the client the information collected is the client's phone number, and destination (Tan, 2018).

4.3 System Design

The system was designed using a set of models and technologies to develop a fully-fledged mobile application. During development of the application considerations were made about the application working on smartphones and tablets. The mobile application had several layers as shown in the figure 4.1. The presentation layer comprises of the user interface components and the processing components. The business layer is comprised of the business entities, workflows and components. The data layer is made up of the data utilities, service agents and data access components (Davis & Yen, 2019).

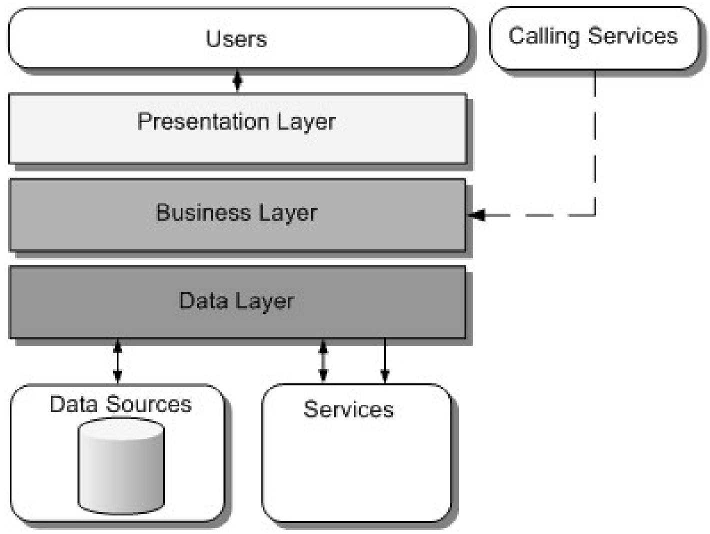

Figure 4.1: Mobile Application Design and Layers

The mobile application was developed using Kotlin and Dart and it was based on the flutter framework. The backend was based on Firebase with a Firestore database. The architecture can be classified as a having a client application (front end) and a server-side application (backend) (Späth, 2019).

4.3.1 Client Application

The client application is mobile application developed using Kotlin and Dart and based on the flutter framework. Kotlin is the Androids official development language. Kotlin helps minimise common coding errors, and its ability to be merged with Java makes it more appealing as a development language. Kotlin was developed as a response to the need for a simpler development language compared to Java (Samuel & Bocutiu, 2017).

Dart is a programming language designed with web applications in mind. However, since its creation in November 2013 it has evolved to be a cross platform development language capable of mobile application development in Android and iOS (Ngo et al., 2022). The Flutter is a framework that allows for the creation of beautiful and natively complied mobile, desktop and web application using the Dart language. Applications are developed using singular programming language and a singular codebase. The framework was originally developed in 2017 by Google and is not managed by the EMCA Standard. Its popularity is attributed to excellent native application experience. Google introduced Flutter as a software development kit to develop mobile applications for Android and iOS. When using Android Studio, Objective C and Java are already integrated (Katz et al., 2021).

4.3.2 Backend (Server-Side) Application

The application backend was supported by Firebase and have a Firestore database. Firebase is a Backend-as-a-Service that allows developers to develop, manage and establish functions. The service is delivered by Google and provides enough services for Unity, Android, and iOS. It also includes cloud storage and allows developers to build secure applications faster. Firebase does not have a programming requirement making it convenient and efficient to use. It also has a NoSQL database to store data. Firebase has several features that increase its usability. These features are cloud messaging, authentication, and limitless reporting. It can maintain application data and sync data in real time (Google Developers, 2021). The database used in Firestore, which is a NoSQL databased developed by Google. The database is designed to provide better development experience and streamline the development process. It is highly effective in data storage, and it is designed to function as a real-time database. The database's data model is flexible and can support hierarchical data structures which store data in documents that is prepared into collections. Here the files can also possess complex nested objects relative to sub-collections. The database can also be used in retrieving and querying single files. The database employs data synchronisation to update data in linked devices. Through this is possible to make the application write, query and focus on the data even when the system or application is offline. When the systems or application comes online, using the cloud the data will synchronise also local modification can be made as shown in figure 4.2 (Google Developers, 2021).

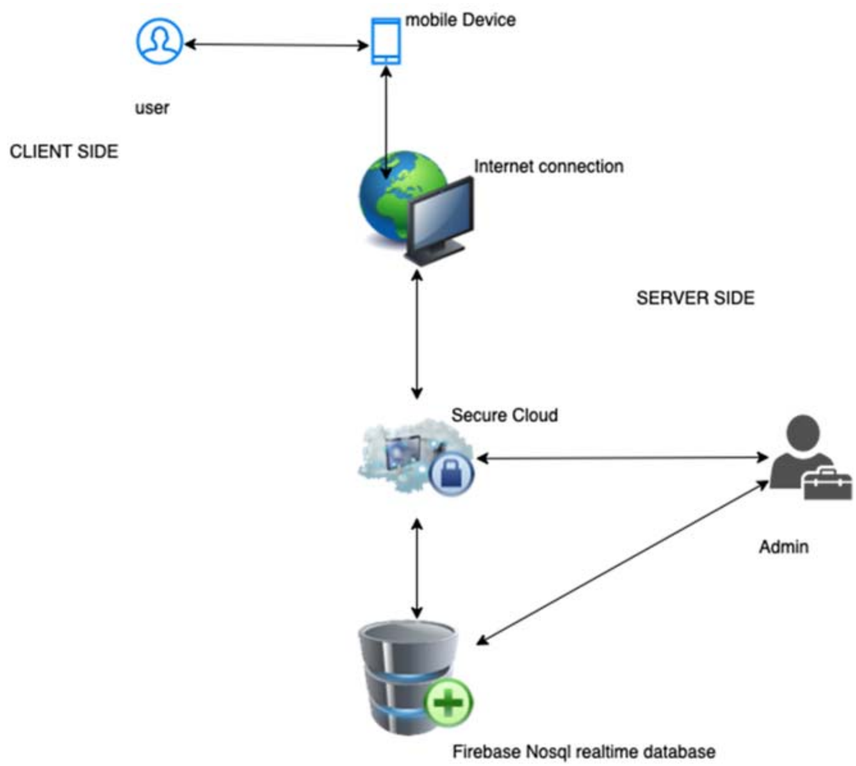

Figure 4.2: Backend (Server-Side) Application

4.4 Use Case Diagrams

When modelling a system, the most critical element to capture is the system's dynamic behaviour. Dynamic behaviour implies the system's behaviour when it is operational. Case diagrams are used to capture the dynamic aspects of the application. However, the definition is highly generic in describing the application purpose, since sequence, activity, state charts and collaboration have similar purpose. Use case diagrams are applied in gathering systems requirements including the external and internal influence. The requirements are mainly design requirements. Therefore, when the system is evaluated to collect its functionalities, use cased are made and the actors identified. Figure 4.3 shows the use case for ordering a ride (Davis & Yen, 2019).

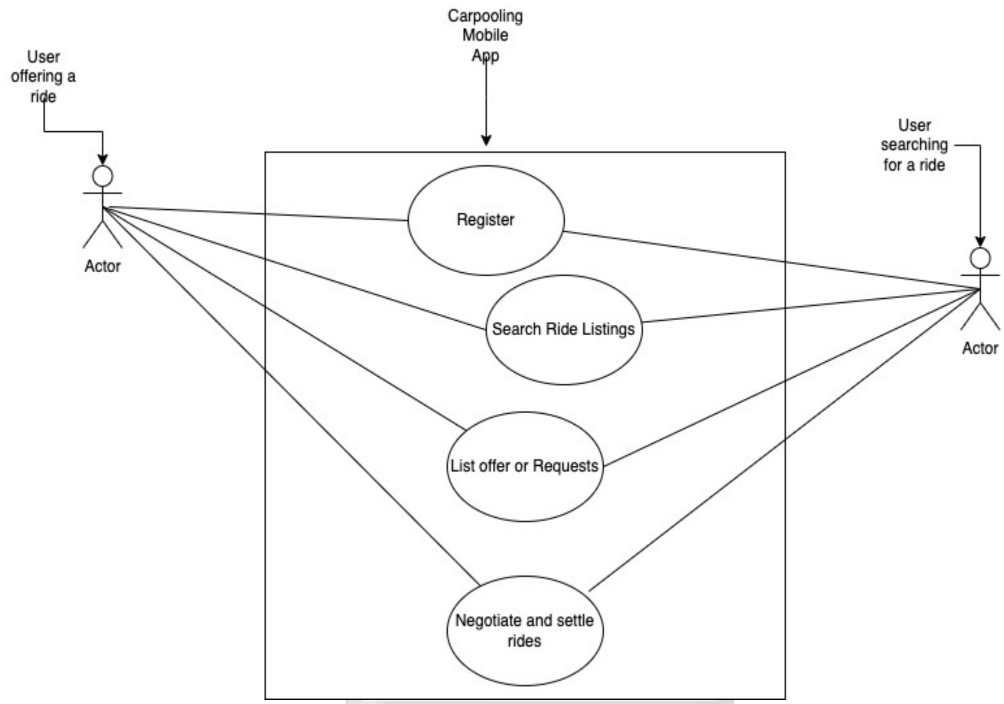

Figure 4.3: Use Case Diagram for Ordering a Ride

4.5 Use Case Description

Use case descriptions are text-based narratives used to describe the functionality of an application based on detail, and interaction between the application and actor (Davis & Yen, 2019). It is used when describing the outcomes of actions taken to achieve a certain objective. The description also details the various paths that can be charted by defining the alternate, primary, and exception flows. The descriptions are written from the actor's perspective while avoiding the internal descriptions. Table 4.1 shows the case where a passenger makes a ride request, while table 4.2 shows the process followed by the driver when posting a trip.

Table 4.1: Use Case Description for Requesting a Ride

Title	**Request for Ride**
Description	Passenger wants to make a long-distance trip.
Stakeholders and Interests • Driver • Passenger	The passenger wants to a trip to a specific destination. The driver wants a passenger to board the car as they share a similar destination.
Primary Actor	Passenger
Pre-condition	The user must be registered.
	A driver must have posted a trip towards their destination.
Success Guarantee (Post-conditions)	The passenger finds a trip to their destination using a suitable driver.
Main Success Scenario	• The passenger can find a trip. • The passenger can find a suitable driver in their preferred route. • The trip is available and at a suitable time for the passenger. • The passenger can confirm and pay for the trip. • The passenger is picked from an agreed location by the driver, and they embark on the trip. • The passenger is dropped off by the driver at their destination.

Table 4.2: Use Case Description for Posting a Ride

Title	**Posting a Ride**
Description:	Driver posts a ride to a certain destination, for instance, Ruiru to Naivasha
Stakeholders and Interests • Driver • Passenger	The driver wants a rider to share the trip with to Naivasha from Ruiru. The passenger wants a trip to Naivasha
Primary Actor	Driver
Pre-conditions	The driver must have installed the application and be registered to be given access to post a trip.
Success Guarantee (Post-conditions)	The driver gets a passenger to share the trip.
Main Success Scenario:	• The driver posts a trip. • An interested passenger finds the trip fitting to their needs.
	• The passenger calls the driver to confirm trip availability, cost, negotiate trip price and confirm booking. • The driver confirms the trip, price and booking. • The driver picks up the passenger at the agreed location and the trip is underway. • The driver drops the passenger at their destination.

4.6 Process Flow Diagram

A process flow diagram is a type of flow chart that shows the step sequences and decisions that are made when performing a process. The steps in the sequence are represented by shapes (Davis & Yen, 2019). The steps are then linked using directional arrows and connecting lines.

Figure 4.4 below shows the process of requesting a ride by the user to finding and booking a ride.

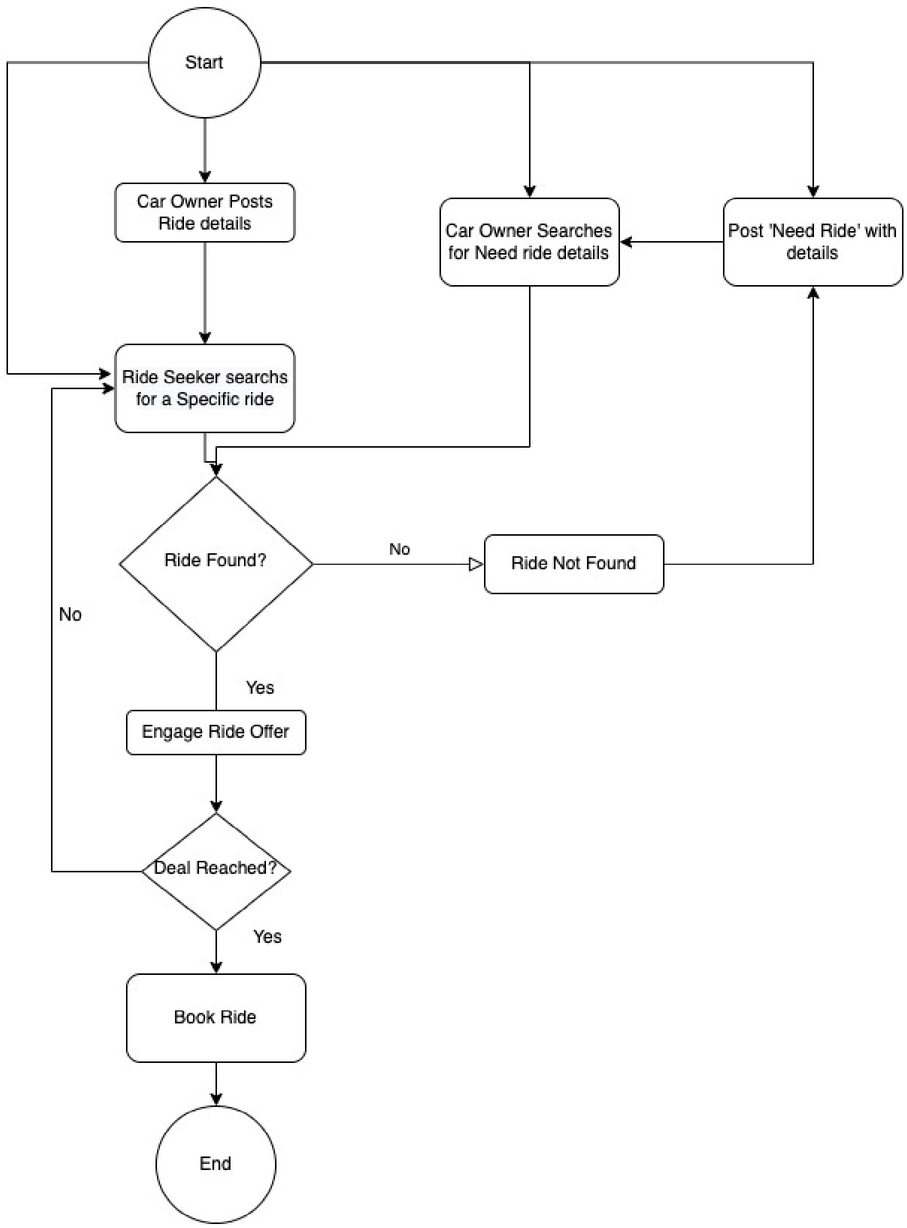

Figure 4.4: Process of Requesting, Finding and Booking a Ride

4.7 System Sequence Diagram

The sequence diagram in figure 4.5 shows the summary of the use cases. The figure shows the add trip and the request ride use cases. The precondition for these cases is that the driver and passenger must be registered and verified on the platform (Davis & Yen, 2019).

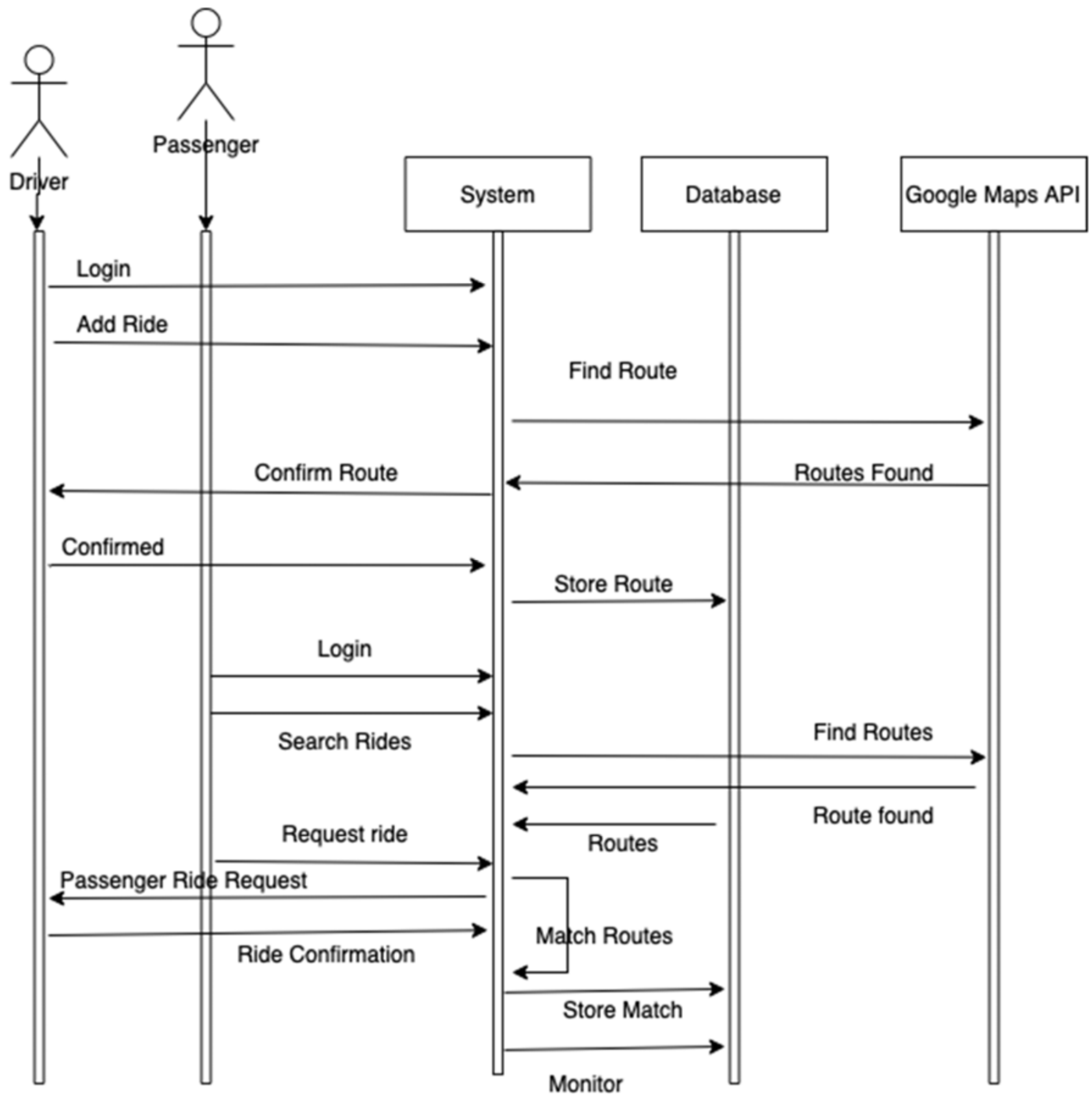

Figure 4.5: System Sequence Diagram

4.8 Collaboration Diagram

Collaboration diagrams are used to depict the relationship between the system's objects. Both the collaboration and sequence diagrams show similar information but in a different manner (Davis & Yen, 2019). Collaboration diagrams show the flow of messages and shows the objects architecture as it sits in the system. Objects are made up of numerous features and in a system the objects are connected. The collaboration diagram, 4.6 shows the object's architecture within the system.

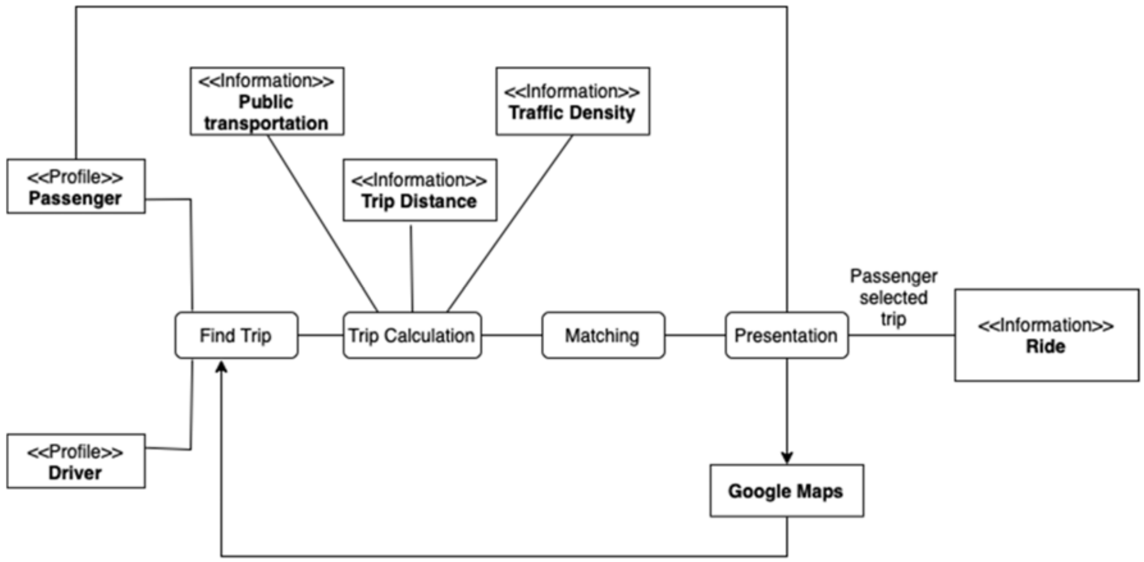

Figure 4.6: Collaboration Diagram

4.9 Client Application Design

The client application, also known as Ride Share, is the client application used to find, request and book trips. Figure 4.7 and 4.8 shows the first page of the application where the user is requested to register using their mobile phone number (Burd, 2020).

Figure 4.7: User Registration

Figure 4.8: User Registration and Verification

After verification the user is requested to enter an OTP code for verification. After verification the user is led to the main page where they see the ShareRide, FindRide and Profile buttons, as shown in figure 4.9.

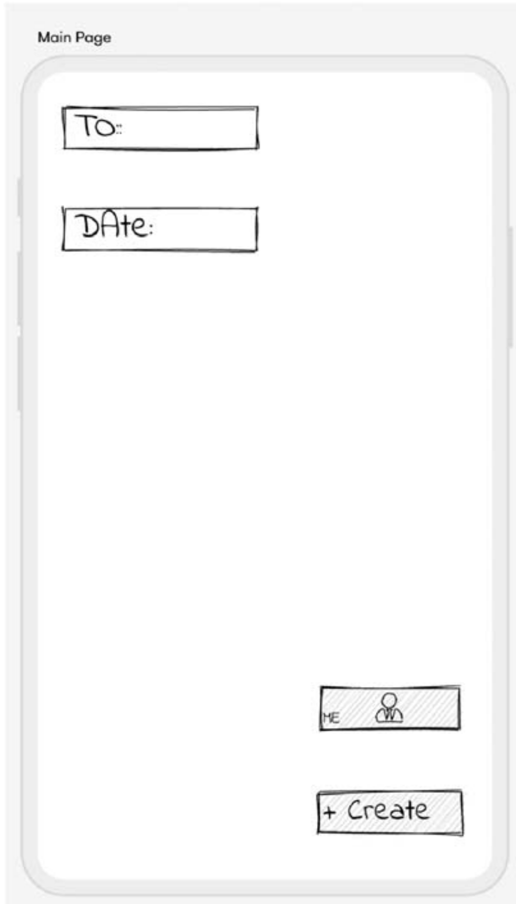

Figure 4.9: Main Page

Once the user clicks the ShareRide button they are prompted to add details about their trip and car, as shown in figure 4.10.

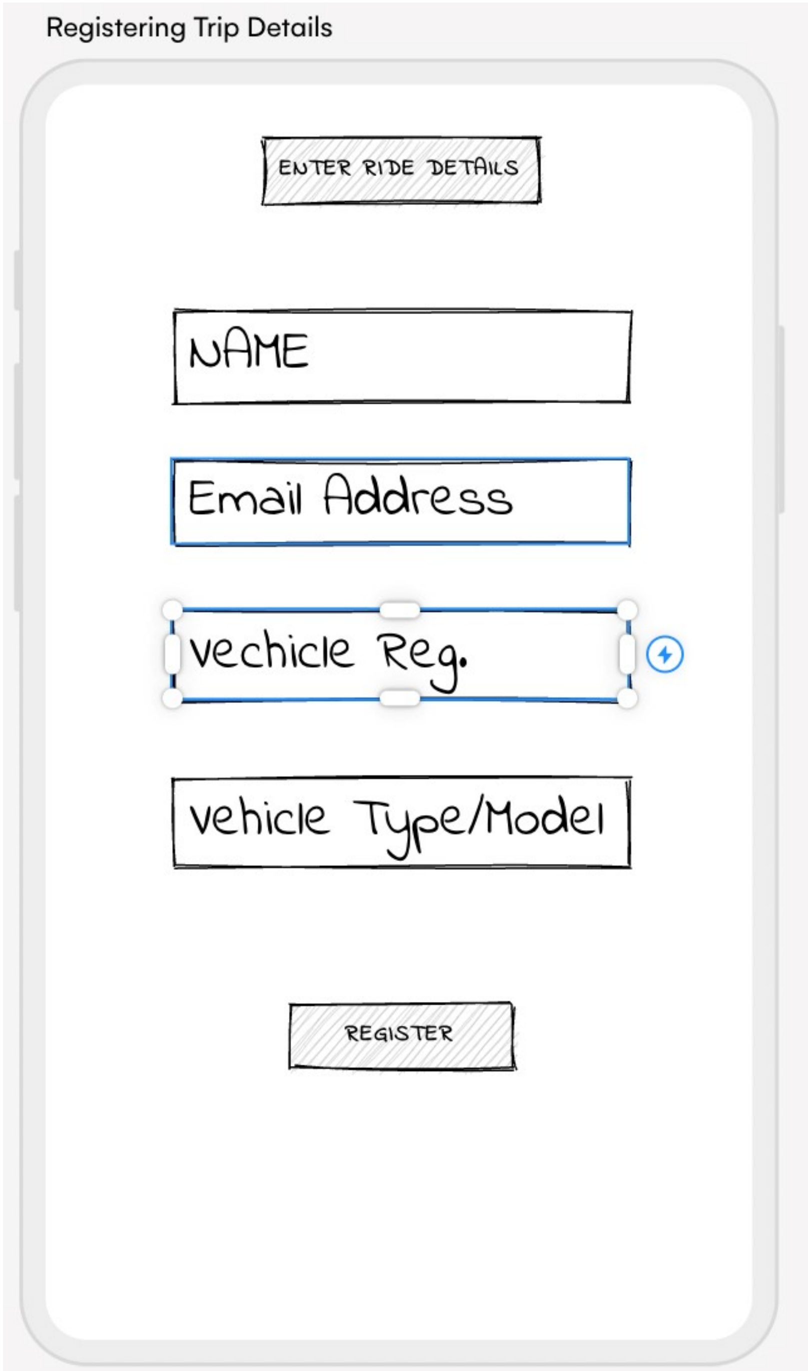

Figure 4.10: Registering Trip Details

After registering as the driver, the user is then prompted to add the trip details as shown in figure 4.11.

Figure 4.11: Adding Trip Details

After adding the trip details a confirmation is issued and the user will await a passenger to request and book the trip, figure 4.12. After which the system will confirm the ride has been shared, figure 4.13.

Figure 4.12: Ride Offering

Figure 4.13: Ride Sharing Confirmation

One the trip is shared the ride is posted on the system for other users and interested parties to see, as shown in figure 4.14.

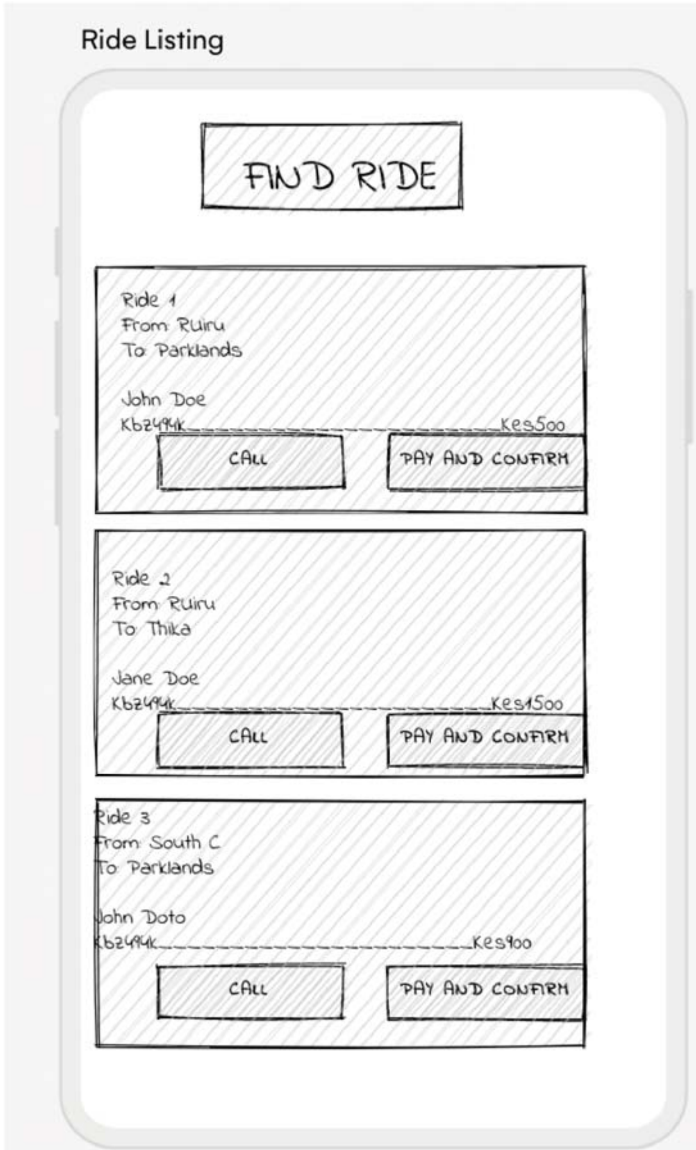

Figure 4.14: List of Rides Offered

Rider can view the posted trips when the press the FindRide button. As show in figure 4.14 the page is populated by the rides available. The user will request for a trip by confirming that the trip is available by calling the driver as shown in figure 4.15. After confirming that the trip is available the rider can pay and confirm the trip. The user has to allow the app to access the phone and payment application in the phone to improve functionality of the application (Burd, 2020).

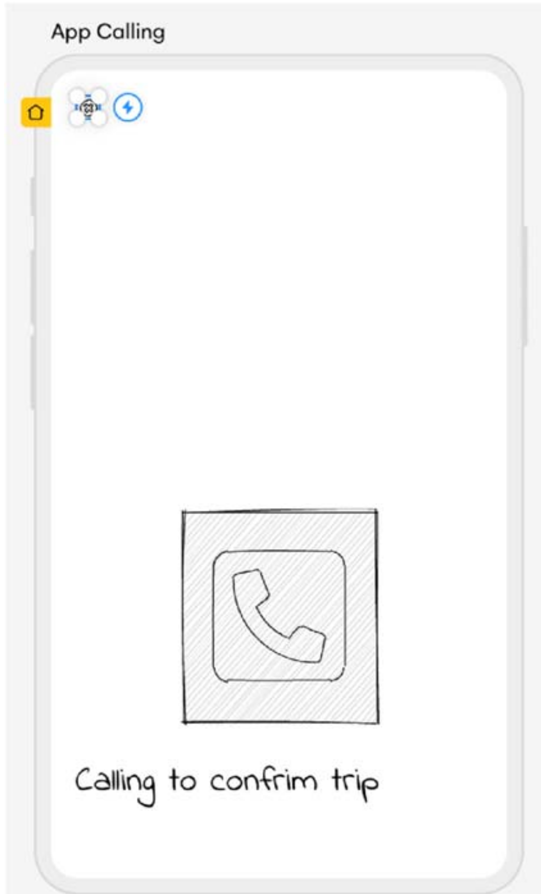

Figure 4.15: Calling to Confirm the Trip

4.10 Server-Side Application

The server-side application is developed using Firebase. It is a backend service that allowed the user to develop, manage and establish functions in the application (Burd, 2020). Figure 4.16 shows the Firebase interface.

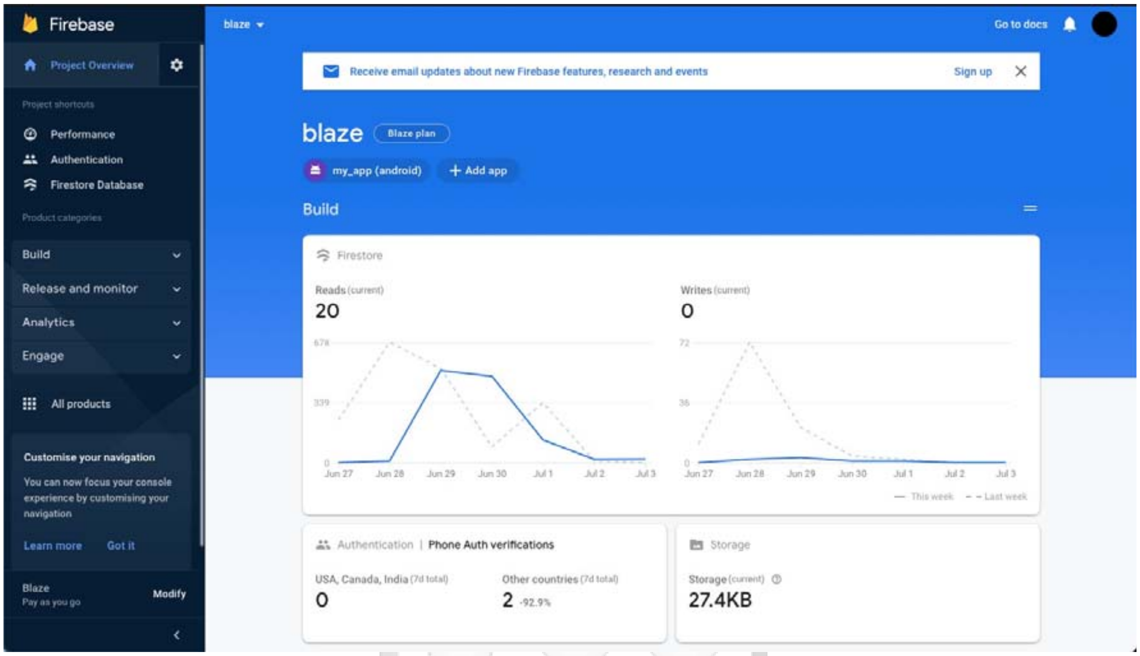

Figure 4.16: Server-Side Application and Platform

Through the backend services such as authentication, application performance, crashes, application extensions, storage and application analytics can all be viewed based on the desired configurations (Burd, 2020).

4.11 Database

The applications data storage is done on the Firestore database as shown in figure 4.17 below. The database stores the user details, locations from the driver and passenger and the trips posted and confirmed by the passenger. The brews section denotes the registered users, the location menu shows the locations entered by the users and the rides tab denotes the rides confirmed on the application (Burd, 2020).

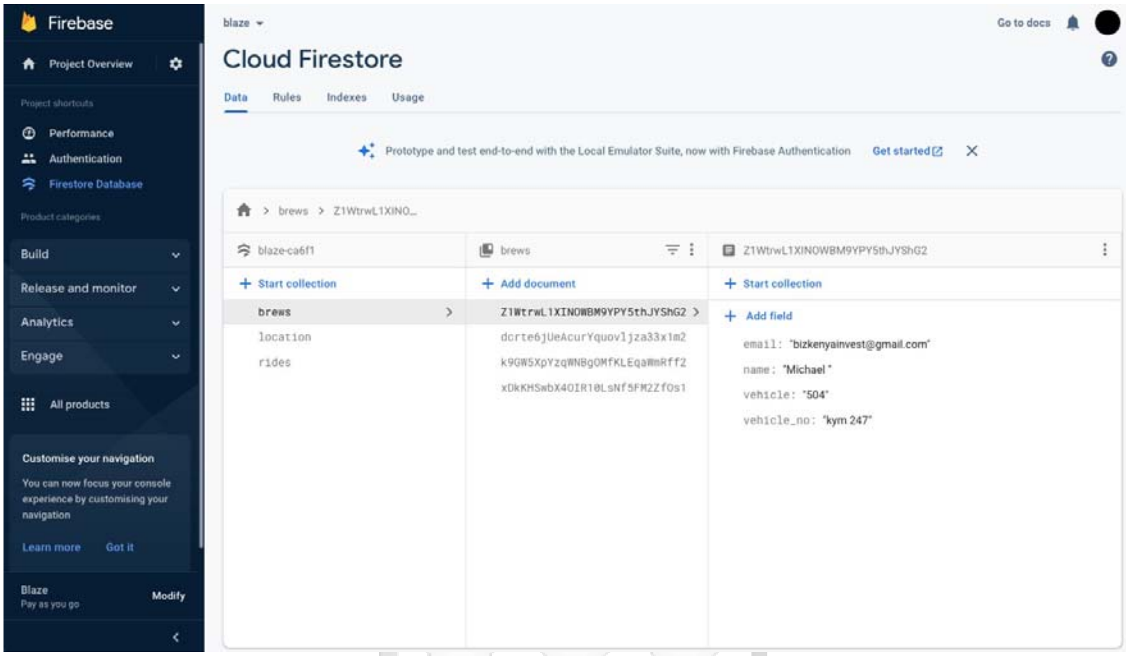

Figure 4.17: Application Database

Chapter 5: System Implementation and Testing

5.1 Introduction

This chapter discusses the development and testing of the application. The mobile application as mentioned in chapter 4 was written using Dart and Koltin programming languages with Flutter being used as the framework. The backed was based on Firebase and the user data was stored in the Firestore database (Burd, 2020).

5.2 System Development Tools

As elaborated in chapter 4 the system is based on a client server model, where the client is the mobile application available to the driver and the rider. The server is where the user data is stored and can be accessed by the system administrator. The tools needed to develop the mobile application are Android Studio. Android Studio is a fully fledge software development tool that is used to develop android applications. The Flutter framework that powers the Dart programming language allows the user to convert the code into either Kotlin (Android) or Objective C (iOS) based on the mobile platform preferences (Burd, 2020).

5.3 System Testing

The prototype mobile application and subsequent updates were sent out to users who also tested the application. Testing was done carried out to obtain feedback on how the application functioned. The functionality test was carried out by sending out the application as an Android Package Kit (apk) to users who would install it in their mobile phones. The tests that were carried out were the functionality, performance, and user acceptance tests (Burd, 2020).

5.3.1 Functionality Testing

Functionality testing is the testing process conducted in the mobile application to test the user interactions and the transaction carried out by the user. The main goal of the functionality test was to ensure application quality, quality of service, ensuring that the application meets the required specification and minimising the errors and risks (Burd, 2020). It was established that all functional and mandatory fields worked as required. The application was required to send an OTP code which was received and input in the text field of the application during registration process as shown in table 5.1. All the text fields in the trip sharing screen including time worked as required as shown in figure 5.1. It was verified that the application works and delivers services as required. During use the application also went into minimised mode when system processes were accessed such as where there was an incoming phone call, as shown in table 5.3. To observe this a second phone was used to call the test phone. The application payment gateway was not validated as a third-party service M-PESA was used as they payment option when passengers confirm the trip. Appropriate error messages were validated to work when a wrong input was fed into the applications and text fields as shown in figure 5.1 (Burd, 2020).

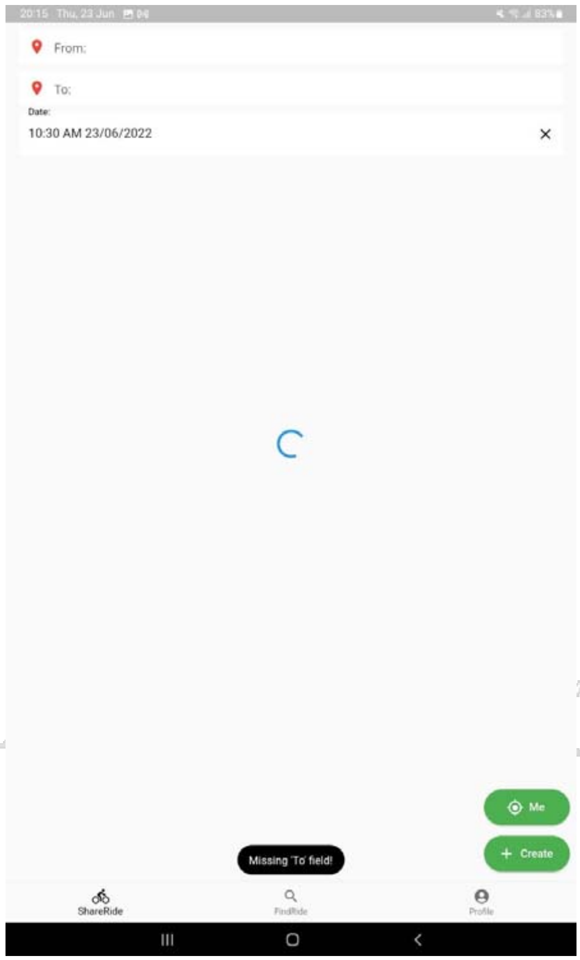

Figure 5.1: Validation of the Error Messages

The maps service was validated to work when determining the driver's location while offering a ride, as shown in table 5.4. The process required the driver to give the application permission to access the device's location as shown in figure 5.2.

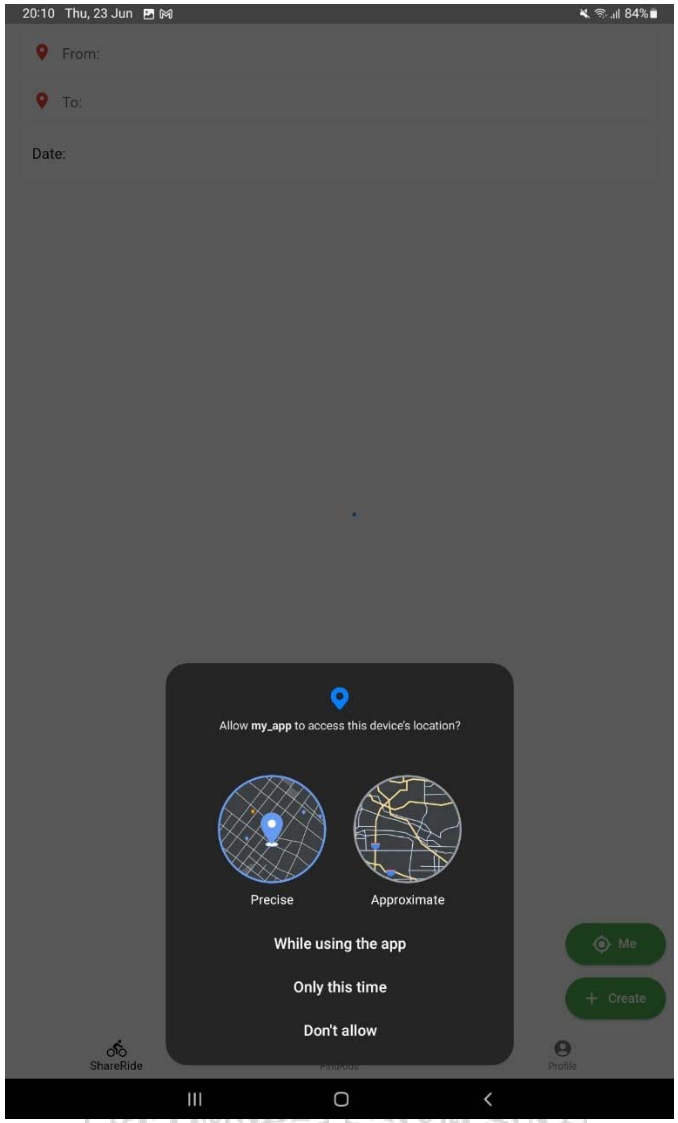

Figure 5.2: Location Verification

Validations were done to ensure that the application allows other application to function satisfactorily, and that the application did not consume the memory available to other applications. This was validated by running other applications after the application was started and the test phone worked within normal parameters, as shown in table 5.5 (Burd, 2020).

Table 5.1: Sending an OTP

Functionality Test Case: Sending OTP		**Test Case Number 1**	
Brief Description: Application should send an OTP verification message			
Pre-condition: A valid phone number should be entered			
Step	**Action**	**Expected Result**	**Pass/Fail**
1.	User enters a valid phone number	User should enter a valid phone number in the text box	Pass
2.	Application should send a verification message	Application sends OTP	Pass
Post Condition: The user has received an OTP message			

Table 5.2: Text and Number Fields

Functionality Test Case: Text and number fields		**Test Case Number 2**	
Brief Description: The application should notify the user when there is a missing entry in a text field.			
Pre-condition: The user should be posting a trip			
Step	**Action**	**Expected Result**	**Pass/Fail**
1.	User enters text in the “from” and “to” fields when posting a trip	The user should be able to add location data in both fields and be notified if there is a missing field	Pass
Post Condition: The user is able to fill in the text boxes and receive error notification when there is a mistake made			

Table 5.3: Minimising the Application

<table>
<tr><td colspan="2">Functionality Test Case: Application minimisation</td><td colspan="2">Test Case Number 3</td></tr>
<tr><td colspan="4">Brief Description: The application should minimise when there is a system function such as a phone call.</td></tr>
<tr><td colspan="4">Pre-condition: The user should have the application running.</td></tr>
<tr><td>Step</td><td>Action</td><td>Expected Result</td><td>Pass/Fail</td></tr>
<tr><td>1.</td><td>User receives a phone call when the application is open.</td><td>The application should minimise and not crash the phone.</td><td>Pass</td></tr>
<tr><td colspan="4">Post Condition: The application is minimised and there are no system or application crashes.</td></tr>
</table>

Table 5.4: Availability of Maps When Posting Trips

<table>
<tr><td colspan="2">Functionality Test Case: Availability of maps when posting trips</td><td colspan="2">Test Case Number 4</td></tr>
<tr><td colspan="4">Brief Description: When the driver is posting trip, they should be able to pin a location on the map when selecting where the trip starts from and where it ends.</td></tr>
<tr><td colspan="4">Pre-condition: The user should be posting a trip.</td></tr>
<tr><td>Step</td><td>Action</td><td>Expected Result</td><td>Pass/Fail</td></tr>
<tr><td>1.</td><td>User selects a location on the map.</td><td>The user is able to place a location pin on the map to select a destination.</td><td>Pass</td></tr>
<tr><td colspan="4">Post Condition: The user placed a location pin on the map and a destination is selected.</td></tr>
</table>

Table 5.5: System Memory Consumption

Functionality Test Case: System memory consumption		**Test Case Number 4**	
Brief Description: The application should hang and lock up resources.			
Pre-condition: The user should be using the application.			
Step	**Action**	**Expected Result**	**Pass/Fail**
1.	User uses the app normally combined with other applications.	The phone should not be hot and there should be not lag when using other application when the application is	Pass
		running in the background.	
Post Condition: The was application lag while using the application and when the application was in the background.			

5.3.2 Performance Testing

The objective of performance testing was to determine that the applications performance was optimum, and that the user had the bets experience. Once the application icon was clicked on the screen the application started after 1-2 seconds. The battery time while using the application was tested and it was determined that the application did not consume too much of the battery and test phone did not heat up significantly. This showed that the application was not resource hungry resulting in a burden on the processor. Memory consumption was also low while using the application. The application was also run on different mobile devices including a tablet where it run smoothly. The application could also be run parallel with other application found on the test phone, which was achieved by switching applications while using the application. When the application was placed in the background and the retrieved it was found to be in the same state and data was not lost (Burd, 2020).

It was also determined that server response times were short based on the data retrieved from the server and the data sent to the server. Network performance was done on different networks and network properties were measured. The application was tested on Safaricom's and Airtel networks and WI-FI while monitoring the apps behaviour. The application's behaviour and performance were not affected by the presence of either Safaricom's and Airtel networks and WI-FI (Burd, 2020).

5.4 Application Testing

The prototype and subsequent updates were sent to users for installation (Burd, 2020). Once installed the application was installed testing began. The first test was onboarding of the user as shown in table 5.6.

Table 5.6: User Onboarding

Test Case: User Onboarding		**Test Case Number 1**	
Brief Description: Application should allow the user to onboard			
Pre-condition: The mobile application should be installed			
Step	**Action**	**Expected Result**	**Pass/Fail**
1.	User enters their phone number	User should enter their phone number in the text box	Pass
2.	Application request verification	Application sends OTP	Pass
Post Condition: The user has been onboarded			

After onboarding the user is prompted to create and share a trip that can be viewed by a rider, as shown in table 5.7.

Table 5.7: Posting a Trip

Test Case: Posting a Trip		**Test Case Number 2**	
Brief Description: User can create and share a trip			
Pre-condition: the User must be onboarded			
Step	**Action**	**Expected Result**	**Pass/Fail**
1.	User enters their name, email, vehicle registration number and vehicle type	System should record the users name, email, vehicle registration number and vehicle type.	Pass
2.	User enters the destination/location details and the date and time of travel	The system records and confirms the destination, date and time of travel has been posted.	Pass
Post Condition: A trip has been created and shared.			

After the trip is posted the rider can find a ride by viewing the FindRide page for available trips, as shown in table 5.8.

Table 5.8: Finding A Trip

Test Case: Finding a Trip		**Test Case Number 3**	
Brief Description: A rider can find and confirm a trip			
Pre-condition: A trip must be posted by a driver.			
Step	**Action**	**Expected Result**	**Pass/Fail**
1.	User will click on the FindRide button	User should be able to view the available rides/trips.	Pass

2.	User can call the rider/driver who has posted the trip and confirm availability of trip and negotiate price and choose to pay for the trip.	User should be able to call the driver and make payments for the trip.	Pass
Post Condition: The trip has been confirmed and payment done.			

5.5 Application Screenshots

The application was developed to offer passengers affordable long-distance trips. Figure 5.3 below shows the main page of the application once a user is onboarded (Burd, 2020). The main page shows the application features of finding a ride, sharing a ride and the users profile page, as shown figure 5.4.

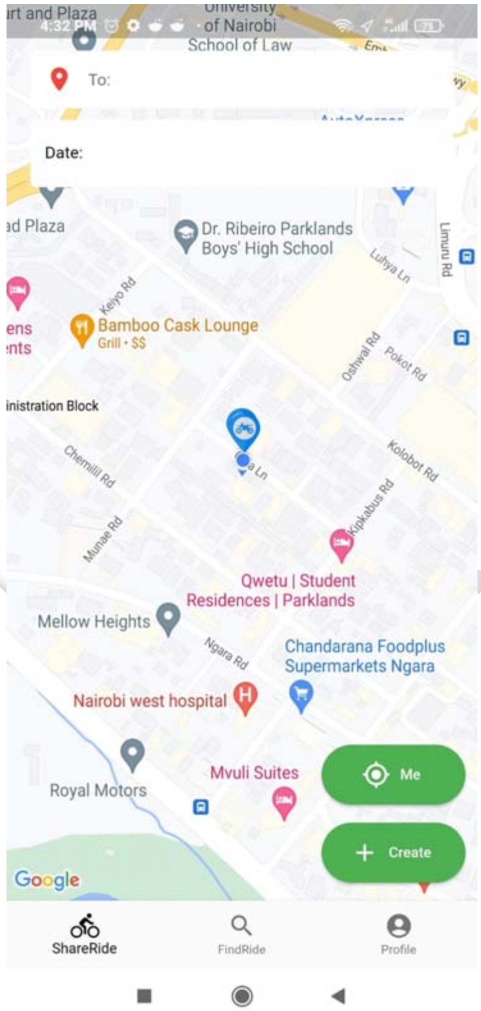

Figure 5.3: Main Application Page

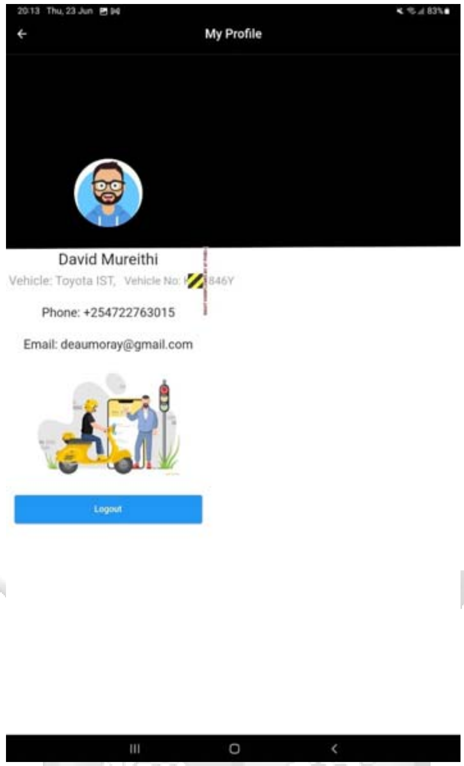

Figure 5.4: Profile Page

Once the user clicks the create button, they can create and share trip after entering their personal data and trip details, as shown in figure 5.5. After creation the user can set the price of the trip and confirm availability, as shown in figure 5.6.

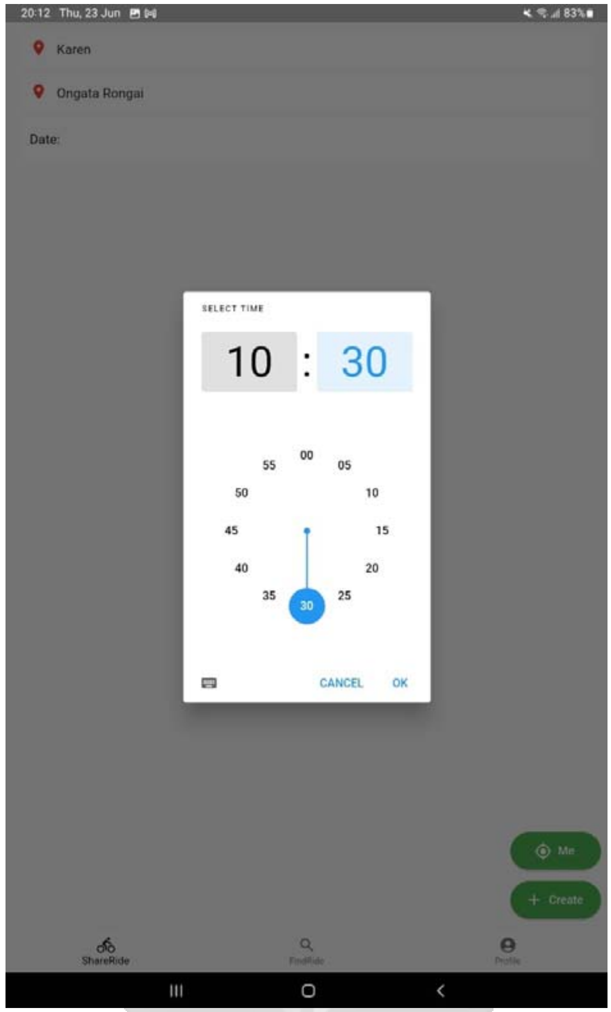

Figure 5.5: Trip Creation

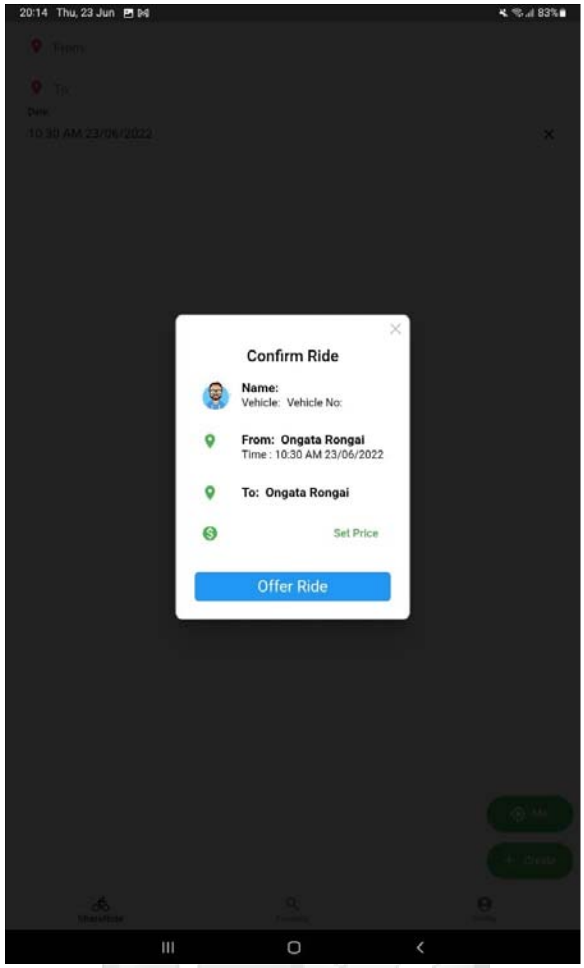

Figure 5.6: Setting the Trip Price and Trip Confirmation

Once the trip has been confirmed by the driver it is posted on the rides available board, where a passenger can view the list and select their preferred trip, as shown in figure 5.7.

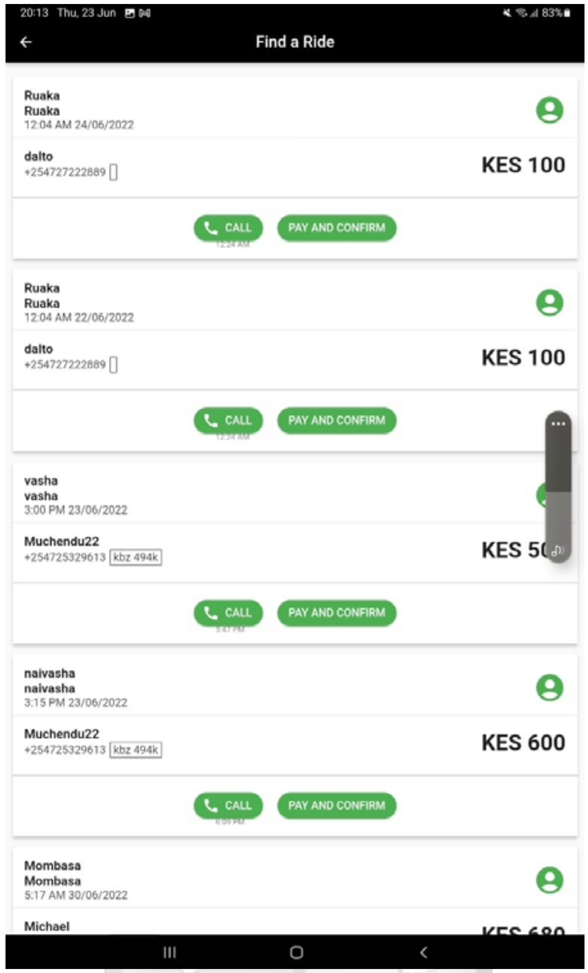

Figure 5.7: List of Available Trips

A passenger on the application can find a preferred trip by clicking the FindRide button (Burd, 2020). As a passenger, trips can be selected from the trips list, as shown in figure 5.8. After selecting a trip, the user can call the driver and confirm availability and choose to pay as shown in figure 5.9.

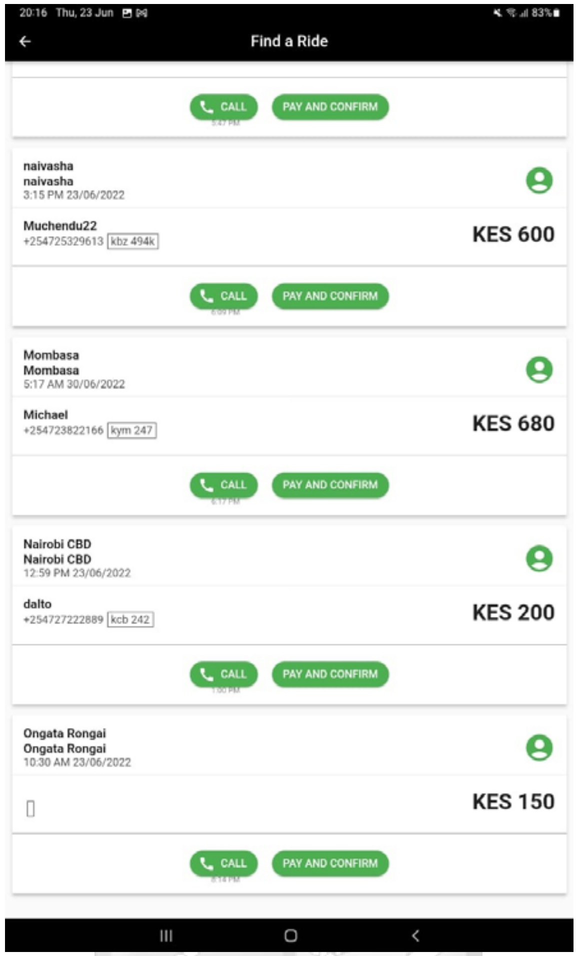

Figure 5.8: Finding a Trip

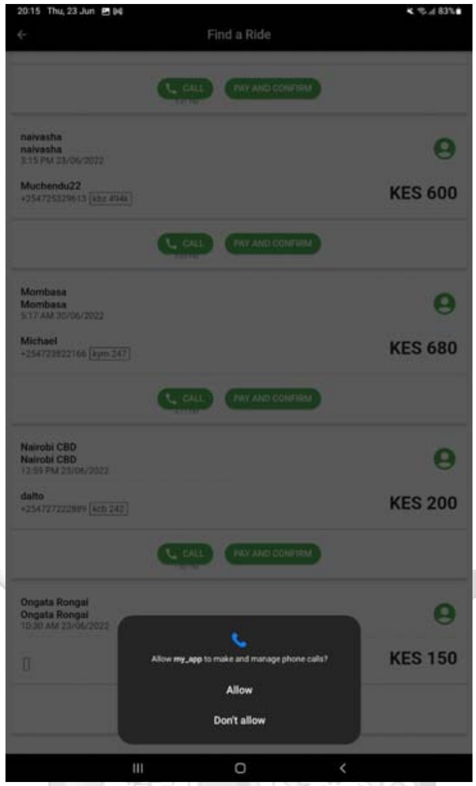

Figure 5.9: Passenger Trip Confirmation

5.6 Validation of Application

Validity was tested using a sample of 189 respondents who were requested to respond to a number of questions (Burd, 2020). The first question was whether the respondent had used carpooling. According to the analysis, a majority of the respondents, with a frequency of 179 (94.7%) had used carpooling, while the minority, with a frequency of 10 (5.3%) had not, as shown in figure 5.10.

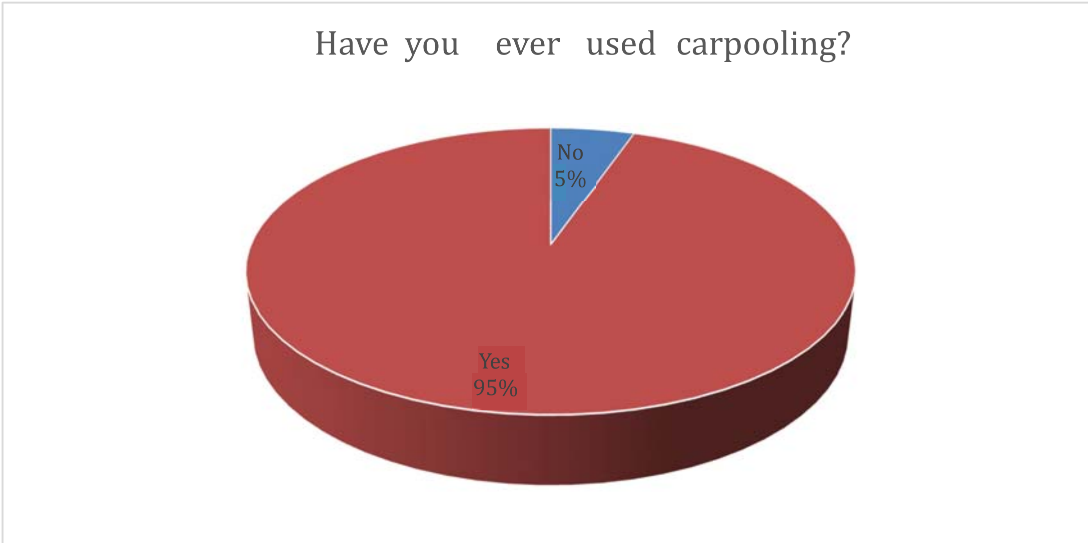

Figure 5.10: Carpool Usage

Secondly, the researcher investigated the experience of the ride share by requesting those who had used carpooling to rate the ride on a scale of 1-5 with 1 being very bad, and 5 very good. According to the analysis, the majority of the respondents argued that the ride was good, with a frequency of 72 (40.2%), as shown in figure 5.11. Another significant proportion of respondents claimed that the ride was very good, with a frequency of 58 (32.4%), as shown in figure 5.11. Other proportions had frequencies equal to 33 (18.4%), 12 (6.7%), and 4 (2.2%) for the neutral, bad and very bad experiences, respectively, as shown in figure 5.11. Hence, the analysis revealed that riding using carpooling offered a good experience to the riders (Burd, 2020).

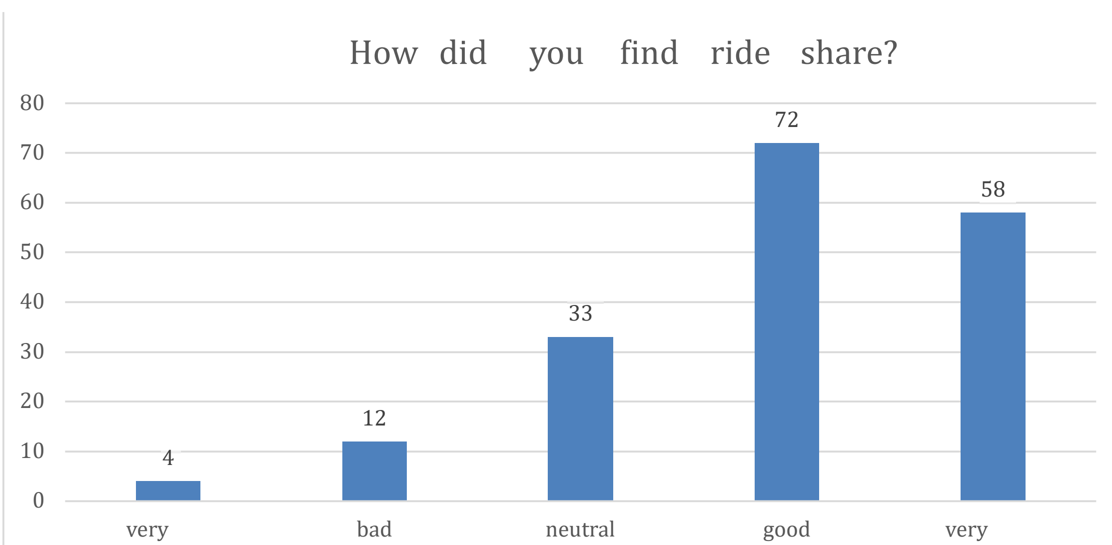

Figure 5.11: Finding Ride Share

The study assessed respondent's satisfaction using their likelihood to recommend carpooling to a friend and to use it again. According to the analysis, a majority of the respondents who had used carpooling, with a frequency of 166 (92.7%), would recommend the app to their friends, as shown in figure 5.12. The minority, with a frequency of 13 (7.3%) would not recommend it to their friends, as shown in figure 5.12. Hence, it can be argued customers were well satisfied with carpooling (Burd, 2020).

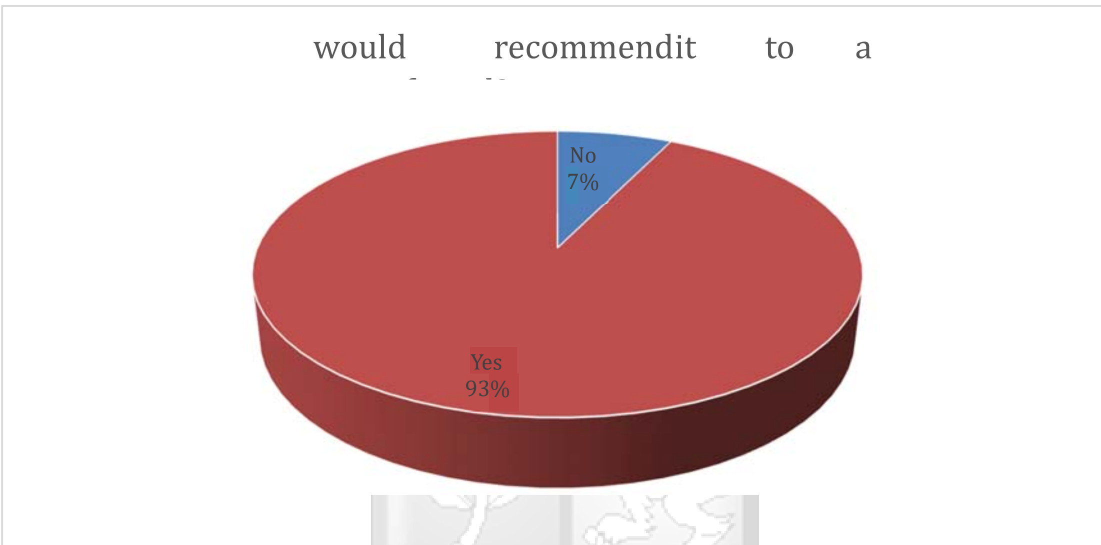

Figure 5.12: User Recommendations

Similarly, a majority of the respondents, with a frequency of 173 (96.6%) would use carpooling again. Besides, a majority, with a frequency of 171 (95.5%), would download the app from Appstore for convenience as shown in figure 5.13.

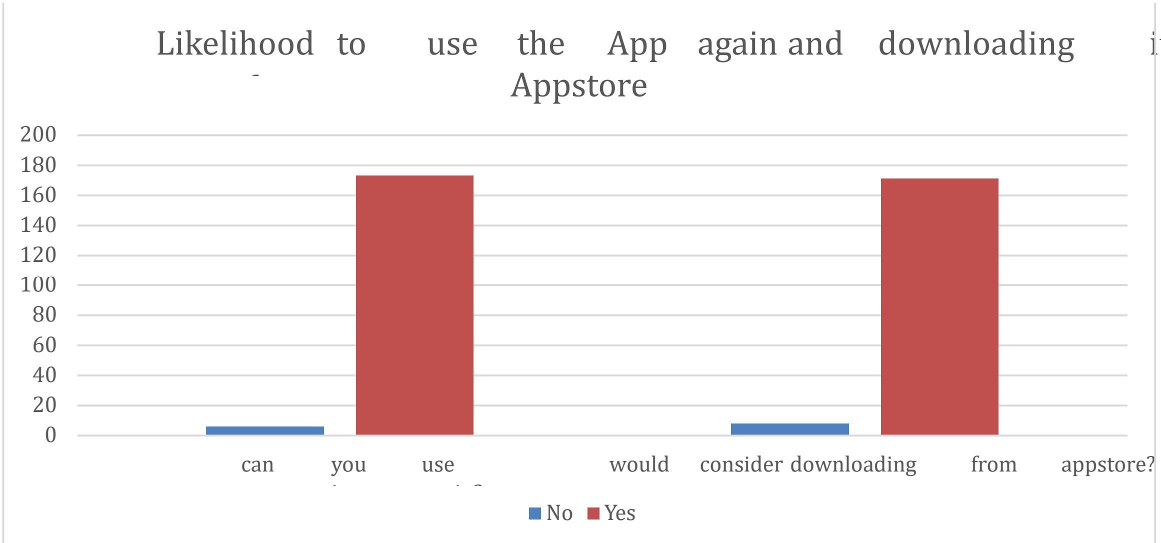

Figure 5.13: Application Usage

The analysis revealed that the respondents were happy with the Application software. Hence, the carpooling app was reliable and valid (Burd, 2020).

Chapter 6: Discussion of Results

With respect to the research objectives the researcher was able to investigate how carpooling can be an affordable solution to long distance travel. It was determined that installation of the application on the user's phone was as simple as clicking on the application package. Once installed the user was onboarded by providing their phone number. After entering their phone number an OTP was sent to verify their phone number. After verification the user was able to get to the main page where they were able to create and share trips. After which a passenger could view the posted trips and choose their preferred trip. Once the user selects a trip, they can call to confirm availability and negotiate for a better fare rate. If an agreement is reached, they can confirm the booking and meet the driver at a specific location on the day of the trip. As a mode of alternative long-distance transport, carpooling presents a solution to the interesting problem that is long distance commuter transport in Kenya. Based on the prototype developed a solution to carpooling was developed. Using the solution, it was shown that carpooling is a viable solution for long-distance travel. It has already been shown that the attitude toward mobility applications and carpooling is positive and that many individuals can consider carpooling as a realistic option is a concrete transportation option is presented (Burd, 2020).

Chapter 7: Conclusions and Recommendations

7.1 Conclusions

The researcher was able to satisfy the research objectives of evaluating carpooling models and the use of related technologies. A mobile base prototype was developed to address carpooling. The effectiveness of the prototype and subsequent application updates was determined with respect to carpooling. It was also determined that as a solution to public transport carpooling was a viable option (Aguiléra & Pigalle, 2021).

7.2 Recommendations

To promote carpooling as a viable option to long-distance travel it is important to promote the any economic, environmental, and social benefits. To make long-distance carpooling a viable alternative to public transportation, the services should offer comfort, accessibility and higher levels of trust that match the use of a private car. Like what short-distance commuter solutions such as Uber, Bolt and other offer and make it competitive with the use of private cars. Therefore, the distance to the meeting points, trip costs such as fuel can be reduced for the driver and passenger (Aguiléra & Pigalle, 2021).

To inspire sustainable behaviour, it is important to determine behavioural barriers. Reports can overwhelm users to numbers and figures on the benefits of carpooling, however not much will change. It is only when individuals are reassured of the key aspects, will behaviour change. It is important for mobility application to alter their approach to effective transport strategies (Aguiléra & Pigalle, 2021).

7.3 Future Work

Mobility technologies such as the one created can be updated to include automatic matching algorithms. It can also be improved to contain several improvements in the probability of satisfying transportation demand and supply in both quality and quantity, including automatic car-matching processes. It is also possible to introduce novel services such as a "last minute service" which combines dynamic and multi-route carpooling services (Aguiléra & Pigalle, 2021). Smartphones help organise carpoolers schedules, for instance when a party is running late. Other features that can be added to the platforms and application include transparent access to proposed driver prices which allows passengers to negotiate to a lower price and the implementation of a payment gateways or systems that prevents the need for exchanging cash and last-minute cancellations. Finally, the system has a rating system for passengers and drivers to increase user trust, which is a critical component of car-sharing. Also, several applications assume the responsibility of getting alternatives like taxis when a driver makes last minute cancellation (Aguiléra & Pigalle, 2021).

References

Aguiléra, A., & Pigalle, E. (2021). The Future and Sustainability of Carpooling Practices. An Identification of Research Challenges. *Sustainability*, *13*(21), 11824.

BlaBlaCar. (2022). *About BlaBlaCar*. Https://Support.blablacar.com/Hc/EnGb/Categories/360002754379-About-BlaBlaCar; BlaBlaCar.

https://support.blablacar.com/hc/en-gb/categories/360002754379-About-BlaBlaCar

Brown, A. E. (2020). Who and where rideshares? Rideshare travel and use in Los Angeles. *Transportation Research Part A: Policy and Practice*, *136*, 120-134.

Burd, B. (2020). *Android programming for dummies all-in-one*. John Wiley & Sons, Inc.

Carrese, S., Giacchetti, T., Patella, S. M., & Petrelli, M. (2017, June). Real time ridesharing: Understanding user behaviour and policies impact: Carpooling service case study in Lazio Region, Italy. In *2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS)* (pp. 721-726). IEEE.

Correia, G., & Viegas, J. M. (2009). A conceptual model for carpooling systems simulation. *Journal of Simulation*, *3*(1), 61-68. https://doi.org/10.1057/jos.2008.4

Cozza, J. (2012, February 7). *The History of Carpooling, from Jitneys to Ridesharing*. Shareable. https://www.shareable.net/the-history-of-carpooling-from-jitneys-toridesharing/

Davis, W. S., & Yen, D. C. (2019). *The Information System Consultant's Handbook* (W. S.

Davis & D. C. Yen, Eds.). CRC Press. https://doi.org/10.1201/9781420049107 de Lira, V. M., Perego, R., Renso, C., Rinzivillo, S., & Times, V. C. (2018). Boosting ride sharing with alternative destinations. *IEEE Transactions on Intelligent Transportation Systems*, *19*(7), 2290-2300.

Delaunay, T. (2021, June 26). *Towards a Ride-hailing Services Dependency in Nairobi? Uses, users and regulation*. https://hal.archives-ouvertes.fr/hal-03237505/document

Ferguson, E. (1997). The rise and fall of the American carpool: 1970–1990. *Transportation*, *24*(4), 349–376. https://doi.org/10.1023/a:1004928012320

Furuhata, M., Dessouky, M., Ordóñez, F., Brunet, M.-E., Wang, X., & Koenig, S. (2013). Ridesharing: The state-of-the-art and future directions. *Transportation Research Part B: Methodological*, *57*, 28–46. https://doi.org/10.1016/j.trb.2013.08.012 Google Developers. (2021). *Firebase Guides*. Firebase. https://firebase.google.com/docs/guides

Huang, H., Bucher, D., Kissling, J., Weibel, R., & Raubal, M. (2018). Multimodal route planning with public transport and carpooling. *IEEE Transactions on Intelligent Transportation Systems*, *20*(9), 3513-3525.

Jaffe, E. (2015, March 17). *Bloomberg - Are you a robot?* Www.bloomberg.com. https://www.bloomberg.com/news/articles/2015-03-17/several-start-ups-are-bettingthat-carpooling-can-make-a-comeback

Katz, M., Moore, K. D., Ngo, V., & Guzzi, V. (2021). *Flutter Apprentice*. Mcgaheysville, Va] Razeware Llc.

Kenya Roads Board. (2013). *KENYA ROADS BOARD ANNUAL PUBLIC ROADS PROGRAMME FY*. http://www.krb.go.ke/wdownloads/APRP1213FY.pdf

Lane, C. (2005). *Phillycarshare: First-Year Social and Mobility Impacts of Car Sharing In Philadelphia*. Paper Presented at Transportation Research Board 84th Annual Meeting, Washington, DC, January 9-13, 2005.

Librino, F., Renda, M. E., Santi, P., Martelli, F., Resta, G., Duarte, F., Ratti, C., & Zhao, J. (2019). Home-work carpooling for social mixing. *Transportation*, *47*(5), 2671–2701. https://doi.org/10.1007/s11116-019-10038-2

Liu, X., Yan, X., Liu, F., Wang, R., & Leng, Y. (2019). A trip-specific model for fuel saving estimation and subsidy policy making of carpooling based on empirical data. *Applied Energy*, *240*, 295-311.

Luongo, K. (2018). [Review of *Matatu: A History of Popular Transport in Nairobi*, by K. Mutongi]. *The International Journal of African Historical Studies*, *51*(1), 181–183. http://www.jstor.org/stable/45176428

Mcgregor, S. & Doya, M. (2014). *Traffic Costs Nairobi $570,000 A Day As No.2 Africa Hub Clogs*. Bloomberg. Online.

Middleton, S., & Zhao, J. (2020). Discriminatory attitudes between ridesharing passengers. *Transportation*, *47*(5), 2391-2414.

Molina, J. A., Giménez-Nadal, J. I., & Velilla, J. (2020). Sustainable Commuting: Results from a Social Approach and International Evidence on Carpooling. *Sustainability*, *12*(22), 9587. https://doi.org/10.3390/su12229587

Montero, J. J. (2018). Regulating Transport Platforms: The Case of Carpooling in Europe. *The Governance of Smart Transportation Systems*, 13–35. https://doi.org/10.1007/978-3-319-96526-0_2

Müller, Nico. (2017). BlaBlaCar-Business Model and Empirical Analysis of Usage Patterns.

Myers, G. J., Badgett, T., & Sandler, C. (2019). *The Art of Software Testing Myers/Art*. Hoboken, Nj, Usa John Wiley & Sons, Inc.

National Association of City Transportation Officials. (2016). *RIDE-HAILING SERVICE ISSUE OVERVIEW*. https://nacto.org/wp-content/uploads/2016/06/Policy-RideHailing-Services-2016.06.pdf

Ngo, V., Sande, J., & Lau, K. (2022). *Data Structures & Algorithms in Dart* (1st ed.). Razeware LLC.

Nicoll, E., & Armstrong, S. (2019). *Ride-sharing: The rise of innovative transportation services - MaRS Discovery District*. MaRS Discovery District. https://www.marsdd.com/news/ride-sharing-the-rise-of-innovative-transportationservices/

Olsson, L. E., Maier, R., & Friman, M. (2019). Why Do They Ride with Others? MetaAnalysis of Factors Influencing Travelers to Carpool. *Sustainability*, *11*(8), 2414. https://doi.org/10.3390/su11082414

Park, Y., Chen, N., & Akar, G. (2018). Who is Interested in Carpooling and Why: The Importance of Individual Characteristics, Role Preferences and Carpool Markets. *Transportation Research Record: Journal of the Transportation Research Board*, *2672*(8), 708–718. https://doi.org/10.1177/0361198118756883

Pinto, G. A., Vieira, K. C., Carvalho, E. G., & Sugano, J. Y. (2019). Applying the lazy user theory to understand the motivations for choosing carpooling over public transport. *Sustainable Production and Consumption*, *20*, 243–252. https://doi.org/10.1016/j.spc.2019.07.002

Qadir, H., Khalid, O., Khan, M. U., Khan, A. U. R., & Nawaz, R. (2018). An optimal ride sharing recommendation framework for carpooling services. *IEEE Access*, *6*, 6229662313.

Rydén, C. & Morin, E. (2005). *MOSES Environmental Assessment Report.*

Samuel, S., & Bocutiu, S. (2017). *Programming Kotlin: familiarize yourself with all Kotlin's features with this in-depth guide*. Packt Publishing.

Schwieger, B. (2004). *International Developments Towards Improved Carsharing Services*. Oxford: Writersworld

Setiffi, Francesca & Lazzer, Gian Paolo. (2018). Riding free-riders? A study of the phenomenon of BlaBlaCar in Italy. In Cruz, I., Ganga, R., Wahlen, S. (Eds.), Contemporary Collaborarive Consumption. London: Springer. 10.1007/978-3-65821346-6_5.

Shaheen, S. A., Chan, N. D., & Gaynor, T. (2016). Casual carpooling in the San Francisco Bay Area: Understanding user characteristics, behaviours, and motivations. *Transport Policy*, *51*, 165-173.

Shaheen, S., Cohen, A., & Bayen, A. (2018). *The Benefits of Carpooling Pooling*. https://doi.org/10.7922/G2DZ06GF

Shaheen, S., Cohen, A., Zohdy, I., & Kock, B. (2016). Shared Mobility: Current Practices and Guiding Principles Brief. *UC Berkeley: Transportation Sustainability Research Center*. Retrieved from https://escholarship.org/uc/item/0gz3b3fx

Shaheen, S., Stocker, A., & Mundler, M. (2017). Online and App-Based Carpooling in France: Analyzing Users and Practices—A Study of BlaBlaCar. *UC Berkeley: Transportation Sustainability Research Center*. http://dx.doi.org/10.7922/G2S46Q4K Retrieved from https://escholarship.org/uc/item/3s40x2x2

Sonet, K. M., Rahman, M. M., Mehedy, S. R., & Rahman, R. M. (2019). SharY: A dynamic ridesharing and carpooling solution using advanced optimised algorithm. *International Journal of Knowledge Engineering and Data Mining*, *6*(1), 1. https://doi.org/10.1504/ijkedm.2019.097355

Späth, P. (2019). *Learn Kotlin for Android development: the next generation language for modern Android apps programming*. New York, Ny Apress.

Tafreshian, A., Masoud, N., & Yin, Y. (2020). Frontiers in service science: Ride matching for peer-to-peer ride sharing: A review and future directions. Service Science, 12(2-3), 44-60.

Tan, W. (2018). *Research methods: a practical guide for students and researchers*. World Scientific.

Transportation Research Board. (2016). *Car-Sharing: Where and How It Succeeds*. Http://Www.ccdcboise.com/Wp-Content/Uploads/2016/02/Document-D1-TCRP-CarSharing-Where-And-How-It-Succeeds.pdf; Transportation Research Board. http://www.ccdcboise.com/wp-content/uploads/2016/02/Document-D1-TCRP-Carsharing-Where-and-How-It-Succeeds.pdf

Tsai, Y. T., Yu, C. H., & Boonprakob, R. (2021). Assessing carpooling drivers and barriers: Evidence from Bangkok, Thailand. *Transportation research part F: traffic psychology and behaviour*, *82*, 84-95.

TUMI Initiative. (2019). *Nairobi, Kenya: Accelerating change in the transport sector*.

https://www.transformative-mobility.org/assets/publications/TUMI-winner_Cityprofile-and-story_Nairobi.pdf

Uber. (2022). *UberPool*. Uber; Uber. https://www.uber.com/au/en/ride/uberpool/

Wayt, T. (2022, June 21). *Uber brings back "Uber Pool" under a new name in NYC and other cities*. New York Post. https://nypost.com/2022/06/21/uber-brings-back-uberpool-as-uberx-share/

Weru, B., & Mugo, J. (2020). *Ride Hailing Survey: Usage of App-Based Mobility Services in Nairobi, Kenya*. https://doi.org/https://www.changing-transport.org/wpcontent/uploads/2020_Ride_Hailing_Survey.pdf

Zimride. (2022). *Zimride by Enterprise | Private Network Ridesharing*. Zimride.com. https://zimride.com

Park, D., & Lee, G. (2014). Validity and reliability of balance assessment software using the Nintendo Wii balance board: usability and validation. Journal Of Neuroengineering and Rehabilitation, 11(1), 99. doi: 10.1186/1743-0003-11-99

Appendix A

First Questionnaire Part A: Demographic Information

1. What is your age?

………………….. (in years)

2. What is your gender?

Gender	Tick appropriately
Male	
Female	

Reliability and Validity related Information

3. Have you ever used carpooling?

Have you ever used carpooling?	Tick appropriately
No	
Yes	

4. How would you find ride share?

How would you find ride share?	Tick appropriately
Very bad	
Bad	
Neutral	
Good	
Very Good	

5. Would you recommend it to a friend?

Would you recommend it to a friend?	Tick appropriately
No	
Yes	

6. Can you use it again?

Can you use it again?	Tick appropriately
No	
Yes	

7. Would you consider downloading from Appstore?

Would you consider downloading from Appstore?	Tick appropriately
No	
Yes	

Appendix B: Revised Questionnaire

Criteria	**Question**	**Answer**			**Description**
Relevance		Yes	No	Cannot Say	*If yes/no kindly describe here*
1	Is the application a relevant solution to long distance travel?				
2	Are there any critical missing features?				
3	Did you find the application easy to use?				
4	Are any relevant outcomes missing?				
5	Describe a situation which the application is the most useful to you?				
Credibility					
1	Does the application provide enough information to find or post a trip?				
2	Does the application resolve of any errors?				
3	Does the application provide notifications of any input errors? For instance, entering a phone number in the location text box.				
4	Would you use the application again?				

5	Would you recommend the application to friends?				

Appendix C: Similarity Report

Final_Dissertation_Boniface_Signed.docx

ORIGINALITY REPORT

10%	9%	3%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	su-plus.strathmore.edu Internet Source	4%
2	Submitted to University of Arizona Student Paper	1%
3	Submitted to October University for Modern Sciences and Arts (MSA) Student Paper	<1%
4	www.mdpi.com Internet Source	<1%
5	docplayer.net Internet Source	<1%
6	Submitted to Strathmore University Student Paper	<1%
7	www.tandfonline.com Internet Source	<1%

Appendix D: Ethical Clearance Exemption Letter

Strathmore UNIVERSITY

21st August 2023

Boniface Muchendu Ngaruiya

Student Number: 079181

boniface.muchnedu@strathmore.edu

Dear Boniface,

RE: Reliable and Cost-Effective Long-Distance Transport in Kenya: A Mobile Based Technology Carpooling Solution

This is to inform you that the Office of Graduate Studies has today received your request on email for exemption from Ethical Clearance for the above Thesis. However, it is noted that the Research Services Office and The Strathmore University Institutional Scientific and Ethical Review Committee (SU-ISERC) cannot review your study since you have already collected data and written the Thesis. The ethics approval process is ONLY done before any collection of primary or secondary data.

The office notes that: On the grounds of not having submitted your research proposal, with reason of ethical approval not being compulsory at the time of your research study in the University. This is a letter for you to proceed with the next steps of your academic requirements.

Please be advised, that in future, all research proposals should be submitted to the SU-ISERC through the RHInnO Ethics platform: https://strathmoreuniversity.rhinno.net/login

Disclaimer: 1) This is not in any way an ethical approval letter. 2) Should there be any legal implications/actions emanating from the research in terms of any ethical violations, you will be personally liable.

Yours sincerely,

Dr. Bernard Shibwabo

Director of Graduate Studies

Ole Sangale Rd, Madaraka Estate. PO Box 59857-00200, Nairobi, Kenya. Tel +254 (0)703 034000
Email admissions@strathmore.edu www.strathmore.edu