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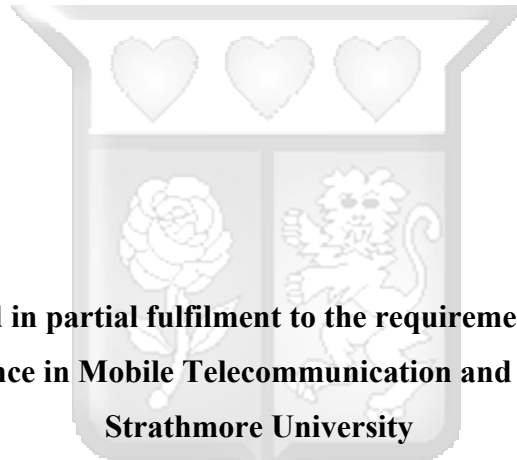
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# **A MOBILE BASED PEER TO PEER CAR SHARING APPLICATION**

**Samson Nzuki Ndambuki**



**Submitted in partial fulfilment to the requirements for the  
Degree of Masters of Science in Mobile Telecommunication and Innovation (MSc. MTI) at  
Strathmore University**

**Faculty of Information Technology  
Strathmore University**

**Nairobi, Kenya**

**April 2020**

## Declaration

I declare that this work has never been previously submitted and approved for the award of a degree by Strathmore University or any other university. To the best of my knowledge and belief, this dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

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Ndambuki, Samson Nzuki  
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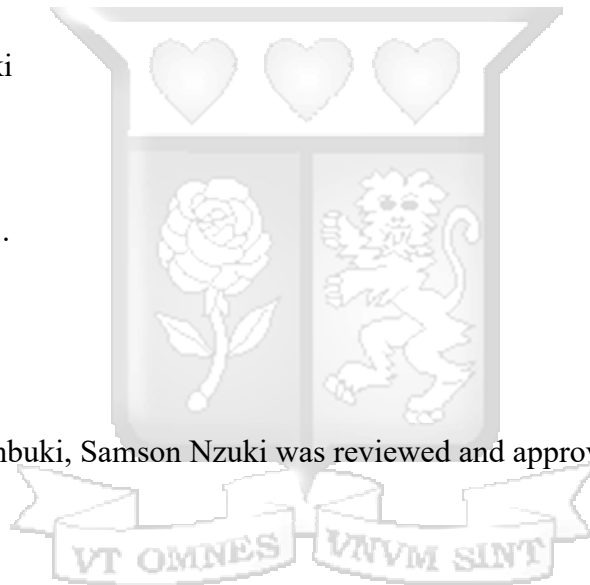
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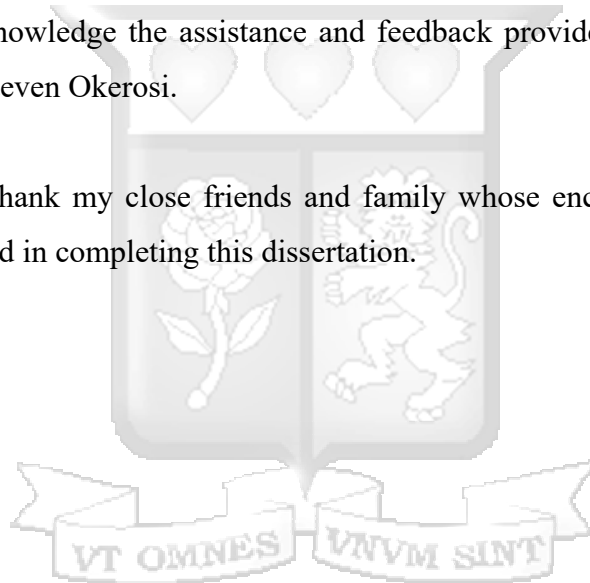
First I would like to thank the Almighty God for His grace and guidance that has enabled me to complete my studies.

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## Abstract

The rate of urbanisation has been increasing over the past few years with the need for mobility leading to an increase in car ownership among the population. Challenges faced by cities due to the increase in private vehicles include environmental degradation due to an increase in emissions and congestion.

Studies indicate that private vehicles are parked around 95% percent of the time which shows that they are underutilised. Residents of cities like Nairobi who do not own a vehicle lack a suitable means of getting access to a vehicle for short trips when the need arises and public transport is not suitable or not available. Vehicle owners on the other hand have no way of sharing their vehicle to generate some extra income when it is not in use.

This study aimed to enable clients to easily find an appropriate rental vehicle for short trips at an affordable price using a mobile application running on the Android platform. Vehicle owners were also provided with a platform to share their vehicles when parked and not in use.

The application was developed using the Agile software development methodology to allow for changes to the requirements with each iteration which ensured the resulting application closely meets the needs of the clients.

### Keywords

Car Sharing, Peer to Peer, Mobility, Internet, Mobile Application

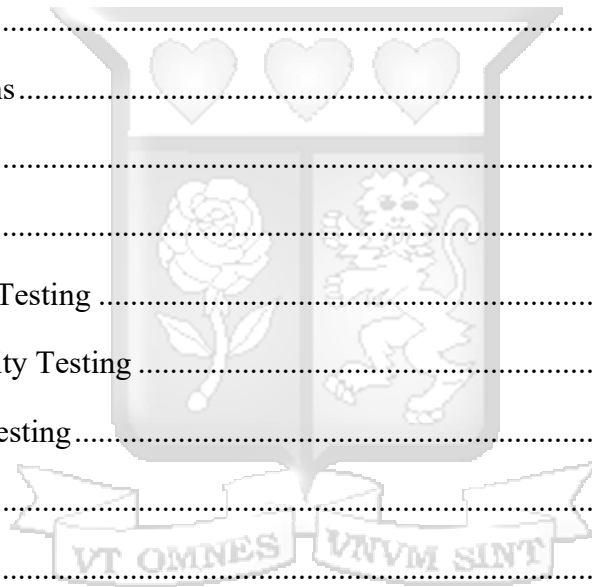
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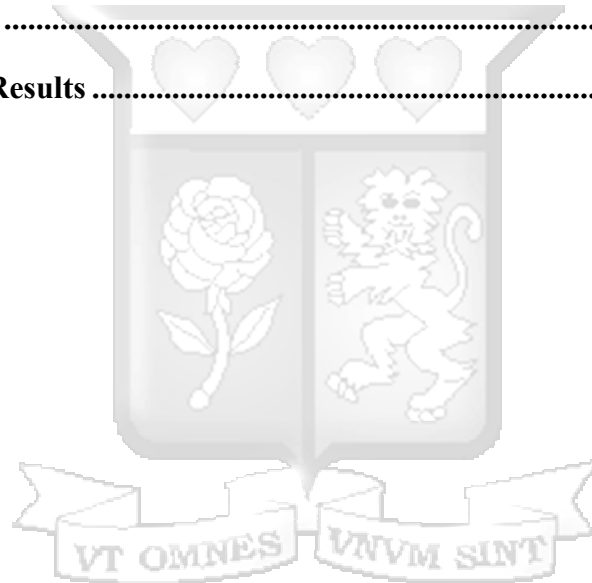
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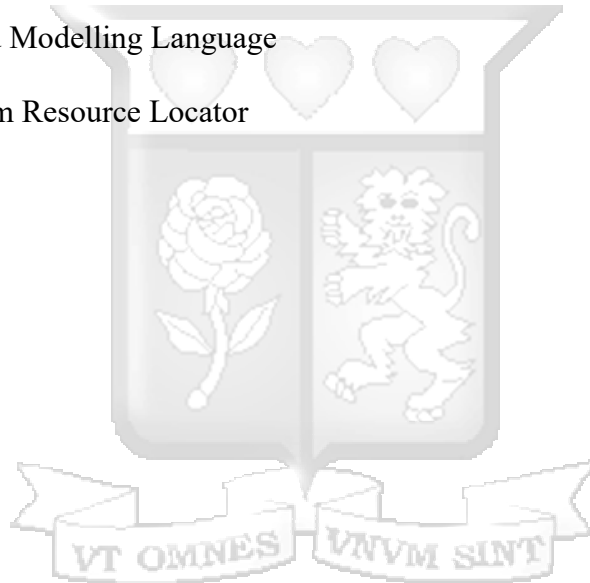


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## List of Abbreviations

<b>CSO</b>	Car Sharing Organisation
<b>DBMS</b>	Database Management System
<b>IDE</b>	Integrated Development Environment
<b>NFC</b>	Near Field Communication
<b>PHP</b>	Hypertext Preprocessor
<b>RFID</b>	Radio Frequency Identification
<b>UML</b>	Unified Modelling Language
<b>URL</b>	Uniform Resource Locator



## Definitions of Terms

Android	A Linux based mobile operating system developed by the company Google (Butler, 2011)
API	Application programming interface refers to an interface that allows a access to a software's services over a communication network (3scale, n.d).
MySQL	An open source database management system (Mysql, n.d)



## **Chapter 1 : Introduction**

### **1.1 Background of the Study**

Urban development has resulted in a greater distance between places of work and residences leading to increased traffic jams and the need for ownership of personal automobiles (Abuhamoud, Rahmat, & Ismail, 2011). In many African cities the increase in private cars has led to many challenges such as inadequate infrastructure, traffic congestion and second hand cars that are not road worthy (Abuhamoud, Rahmat, & Ismail, 2011).

Traffic congestion refers to a situation where demand for road space exceeds supply is a major problem in many cities. It is responsible for the wastage of time, energy and an increase in pollution (Rao & Rao, 2012). The challenge posed by urban congestion has forced some cities to limit the use of private vehicles (NRMA, 2017). Statistics indicate that a total of 297,289 automobiles were registered in 2018 in Kenya which is a 5.2% increase compared to 282,672 in 2017 (Kenya National Bureau of Statistics, 2019). A total of 42.5 million vehicles were in operation in Africa in 2014. This implies that there are about 44 vehicles per 1000 inhabitants which is lower than the global average of 180 vehicles per 1000 inhabitants (Deloitte Africa, 2016). Public transport is a good alternative to owning a personal car however it does not meet some consumer's needs since it involves changing vehicles a number of times before getting to the destination (Kriston, Inzelt & Szabo, 2015). The public transport industry in Kenya has also faced numerous challenges such as corruption and regulatory failures leading to unreliable services for commuters (Leis & Baghudana, 2015).

Current trends indicate that consumers are moving away from owning goods to services that allow them to have access to and experience them for a specified period of time (Bardhi & Eckhardt, 2012). An example of this is ridesharing which refers to the matching of passengers and drivers who offer rides using their own vehicles. This service relies on an online platform to provide the service with examples of ridesharing companies being Uber, Lyft and Taxify (Eisenmeier, 2019). Car sharing offers an alternative to ridesharing by providing access to a network of vehicles by paying members for short durations which is on a self-service basis. Car sharing began in Switzerland in 1987 and later in Germany in 1988. Later on it was introduced in the United States, Canada and Japan in the 1990's. Some of the major car sharing organizations

are ZipCar and Turo which operates in over 100 cities in the United States (Fraigerber & Sundararajan, 2016). Car sharing is able to provide an increase in mobility while reducing the adverse environmental effects of driving (Lane, Zeng, Dhingra, & Carrigan, 2015). There are a number of different modes of car sharing such as peer to peer car, round trip and one way car sharing. Peer to peer is a form of car sharing where the vehicles are owned by individuals and are rented through the use of a website or mobile application (Lane et al., 2015). Introduction and popularity of technologies such smartphones and social media have encouraged the adoption of peer-to-peer car sharing services (Ballús-Armet, Shaheen, Clonts, & Weinzimmer, 2014).

Car sharing services enable individuals to meet their transportation needs better than public transport and reduces the need for purchase of personal cars and their adverse effects (Kriston, Inzelt & Szabo, 2015). It also provides transportation to the consumer while enabling them to avoid the costs of maintenance and storage that they would incur if they owned a vehicle (Ballús-Armet et al., 2014). One of the challenges faced in car sharing is increase in mileage due to car sharing activities. Thus it may negatively impact the resale value of the vehicle and shorten the time taken before a vehicle is scrapped. The owner of an asset such as a car intends to make use of it for a long duration and therefore is more likely to take good care of it (Fraigerber & Sundararajan, 2016).

## **1.2 Problem Statement**

An increase in the population of Nairobi and need for movement of goods has made it very congested as compared to other cities globally (Leis & Baghudana, 2015). Cities have been experiencing an increase in personal automobiles to meet the mobility needs of the residents. This has contributed to the challenges faced by cities such as low road safety and adverse effects to the climate (Lane et al., 2015). Car sharing services have provided city residents who have not yet purchased a personal car with a good alternative and may help delay the purchase of additional cars (Lane et al., 2015). Studies on the usage of personal cars have determined that they are parked about 95% of the time which is a great waste of resources (NRMA, 2017). Most of the costs faced by the owners are fixed and not variable (Martin, Shaheen & Lidicker, 2011). They include insurance, depreciation and loan payments. This makes personal car ownership more expensive if they are not utilised fully. Idle cars need to be more efficiently utilised to avoid the need to purchase more personal cars and generate income for the car owners. Trust is also a challenge

among the users of ride sharing services with some users reluctant to take trips in cars belonging to strangers (Ballús-Armet et al., 2014). Despite the increasing popularity of car sharing organizations there is a disproportionately small number of car sharing members in emerging markets such as Africa.

### **1.3 Research Objectives**

This study aims to develop a mobile application to provide peer to peer car sharing services and provide car owners with a platform to reach out to potential clients.

- i. To study the challenges faced by individuals sharing cars.
- ii. To analyse current systems available for car sharing.
- iii. Design, develop and test a mobile application to aid car owners in sharing their cars and enable renters to access them affordably.
- iv. To validate the developed application.

### **1.4 Research Questions**

- i. What are the challenges faced by individuals sharing cars?
- ii. Which are the current systems available for car sharing?
- iii. How will the mobile application be designed, developed and tested to aid car owners in sharing their cars and enable renters to access them affordably?
- iv. Does the developed mobile application meet the needs of car owners who want to share a car?

### **1.5 Scope and Limitations**

This study focused on people within Nairobi city who own at least one car and were willing to rent it out on occasion. Individuals participating in the study also needed to own a smartphone since a mobile application was developed to allow easy access. The mobile application that was developed was limited to devices running on the Android platform due to the greater number of Android users in the country. The study was limited to Nairobi due to the need for an urban environment where short trips facilitated by car sharing are common.

## 1.6 Justification of the Study

There are various adverse effects of private car ownership such as traffic congestion and increased pollution. Public transport does not meet some consumer's needs since it involves changing vehicles a number of times before getting to the destination (Kriston, Inzelt & Szabo, 2015). In such situations the use of a personal car is desired and thus car sharing provides a good alternative. Car sharing services can enable consumers to avoid the need to purchase private vehicles but also increasing their mobility thereby helping to reduce the congestion of the city (Lane et al., 2015).



## **Chapter 2 : Literature Review**

### **2.1 Introduction**

This chapter will look into the definition of car sharing, the various types of car sharing, current solutions that already exist and security concerns of the clients and owners. It will also highlight the current state of the transport sector in the country.

### **2.2 Transportation in Nairobi**

The increase in the population of urban areas in particular cities has brought with it a number of challenges such as inadequate road infrastructure, congestion and pollution of the environment. The city of Nairobi is one of the most congested cities globally. It loses about \$570,000 per day in lost productivity due to traffic congestion (Leis & Baghudana, 2015). The public transportation system in Kenya has struggled with widespread corruption and regulatory failures. Factors such as private ownership of the vehicles, extortion by illegal gangs, lack of political goodwill are some of the reasons the industry has not been regulated. All this has led to the provision of unreliable and unaffordable transport services to the public (Leis & Baghudana, 2015).

### **2.3 Car Sharing**

Sharing refers to the process of distributing things that belong to us for use by others or receiving and making use of things that belong to others. Through sharing access to objects or networks that are unaffordable to own or that may be undesirable to own due to space constraints or environmental concerns can be made possible (Bardhi & Eckhardt, 2012). Car sharing refers to a service where consumers are able to gain access to a vehicle for a limited time and pay per usage. Members of car sharing organizations are able to make reservations either online or via phone. There are a variety of payment plans available with a majority of members paying a monthly or annual fee in addition to fees per hour or per mile (Martin & Shaheen, 2011). During the past few years' consumers have been moving away from ownership and instead seek to gain access to goods for a limited duration of time and only pay for the service. Car sharing services represent a new type of consumer model in which the access to goods, services and resources is through sharing or pooling using technology and a community (Bardhi & Eckhardt, 2012). It gives individuals the opportunity to have the experience of owning a car without the associated costs of car ownership (Lane et al., 2015). Between 2010 and 2015 the urban population of Kenya grew by 4.4 percent

which is higher as compared to the world average during the same period of 2 percent (Leis & Baghudana, 2015). A good alternative for emerging markets where there is rapid urbanization and increase in motor vehicles is Car sharing which has grown in popularity in North America, Europe and Australia. The car sharing industry is growing rapidly in emerging markets with a total of 9,200 vehicles and 898,000 members in Brazil, China, India, Malaysia, Mexico and South Africa as of 2015. Consumers in emerging markets where rapid motorization and urbanization is a challenge have limited access to this new mobility option (Lane et al., 2015). The populations of Asia, Africa, Latin America and the Caribbean form about 78 percent of the world's urban population but only 20 percent of the members of car sharing organizations come from these countries (Lane et al., 2015).

## 2.4 Types of Car Sharing

### 2.4.1 Round Trip

Round Trip car sharing refers to a situation whereby an organization provides a fleet of cars to registered members for a set duration. The users are required to return the vehicle to the same place they reserved it after the trip. The vehicles are parked in designated areas and the members can gain access to them using technology such as Key Cards that allow remote access after making their reservations online (Ballús-Armet et al., 2014). Figure 2.1 illustrates the various steps in round trip car sharing.

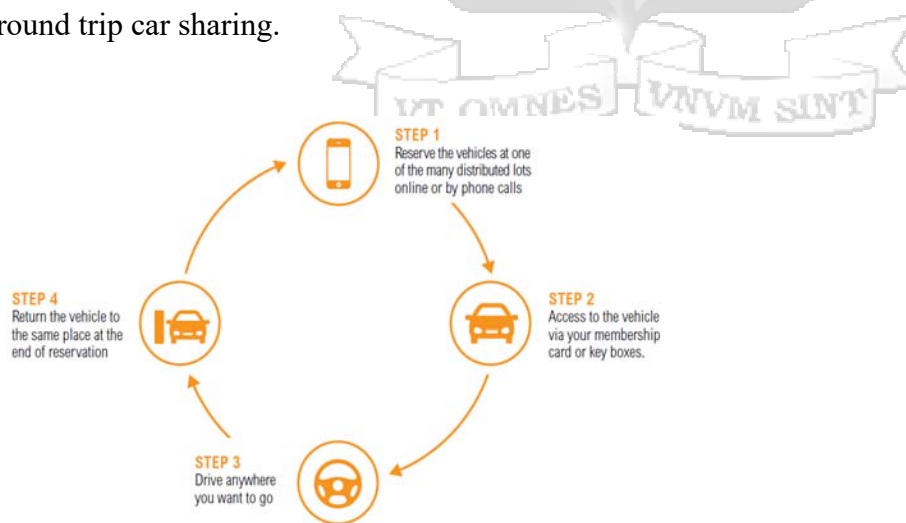


Figure 2.1 Round Trip Car Sharing

(Source: Lane et al., 2015)

### **2.4.2 One Way**

One way car sharing also involves an organization providing access to a fleet of vehicles for registered members but with the added ability to return the vehicle to a different location from where it was reserved (Ballús-Armet et al., 2014). Shared vehicles require a permit that will ensure it doesn't incur parking charges or any time limit on a parking space in the city. This is due to the nature of one way car sharing where the car cannot be returned to a designated parking lot owned by the company (SFMTA, 2017). Other parking regulations such as passenger and commercial loading zones are still applicable to the shared vehicle. An example of one way car sharing organizations operating in numerous U.S, Canadian and European cities is Car2go and ReachNow (SFMTA, 2017).

### **2.4.3 Peer to Peer**

Peer to peer is a type of car sharing where individuals rent out their own personal cars temporarily to members who are close by on an hourly or daily basis. Organizations provide a platform via the Internet to allow for the interaction between their clients and vehicle owners as well as the collection of payments. Fees paid by the renters are shared between the car owners and the car sharing company. As an additional incentive the car sharing companies also provide car insurance cover in case of any damages (Ballús-Armet et al., 2014). The advancements in smartphone technology and social networking have greatly aided in enabling the growth of peer to peer car sharing. A significant advantage of peer to peer car sharing is the reduction of costs for the car sharing companies since they avoid purchasing and maintaining their own fleet of cars. Vehicles available on peer to peer platforms tend to be older as compared to the vehicles in car sharing organizations however there is a greater variety of vehicle types. They are also available in many locations and offer a greater selection of daily and hourly rental prices (Ballús-Armet et al., 2014). Table 2.1 gives a comparison of the defining characteristics of existing car rental modes.

Table 2.1 Defining Characteristics of Existing Car Rental Modes

CATEGORY	DRIVER	WHO OWNS VEHICLE?	RESERVATION	SHARE RIDE WITH STRANGERS?	SERVICE CHARGE
<b>Round-trip carsharing</b>	Customer	CSO	Required; Online/ phone	✗	By hour or hour + distance
<b>Peer-to-peer carsharing (two-way)</b>	Customer	Individual	Required; Online	✗	By hour
<b>One-way carsharing</b>	Customer	CSO	On demand	✗	By minute
<b>Rideshare (carpool)</b>	Owner	Individual	Required; Online	✓	By distance
<b>Taxi<sup>a</sup></b>	Driver /Owner	Fleet management company / individual	On demand; some via booking	✗	By time and distance
<b>Car rental</b>	Customer	Fleet management company	Required; Online/ phone / in person	✗	By day and distance
<b>Chauffeured car rental</b>	Driver	Fleet management company	Required; Online/ phone / in person	✗	By time & distance
<b>Shared taxi</b>	Driver	Fleet management company	On demand	✓	By time and distance

Notes:

a. Taxis include transportation network companies (TNCs) such as Uber and other peer-to-peer taxi companies.

(Source: Lane et al., 2015)

## 2.5 Benefits of Car Sharing

### 2.5.1 Lower Costs

Car sharing provides users with mobility while helping them avoid the maintenance and storage costs of owning a personal car. The lower costs are beneficial in emerging markets where consumers are more price sensitive and few are able to afford owning a personal car (Ballús-Armet et al., 2014). A lot of funds are spent by the public sector on infrastructure such as roads and parking spaces in cities to accommodate increasing vehicles (Martin, Shaheen & Lidicker, 2011). Most of the costs involved in car ownership are fixed as opposed to variable making it more suitable for households where a car is really needed (Martin, Shaheen & Lidicker, 2011). Studies indicate that personal vehicles are underutilized since the vehicles are idle 95% of the time. Car

sharing provides a means of distributing the fixed costs of personal vehicle ownership over many users and thus making more efficient use of the vehicles (Ballús-Armet et al., 2014).

### **2.5.2 Convenience and Availability**

The availability of car sharing services is very convenient and beneficial to those who cannot afford to own a personal car and also those who live in places not easily accessible by public transport. Car sharing can also be used in conjunction with public transport to solve the “last mile” problem to enable someone to travel from the bus stage or train station to their destination (Mobility lab, 2013).

### **2.5.3 Benefits to the Environment**

In recent times there has been a focus on reducing Greenhouse gas emissions and petroleum consumption to reduce the effects of climate change. In the United States transportation activities contribute nearly 30% of greenhouse gas emissions and 70% of petroleum consumption (Martin & Shaheen, 2011). Car sharing has been proven to reduce the amount of greenhouse gas emissions. In addition it also has resulted in an increase in use of alternative means of transport such as biking, walking and public transport. Car sharing fleets are also frequently replaced with newer models and with advancements in technology newer car models have less emissions and are more efficient (Martin & Shaheen, 2011). Reduced strain on the infrastructure such as roads will help to avoid the adverse environment degradation that can be caused by road repair projects (Mobility lab, 2013).

### **2.5.4 Lower Congestion in Cities**

The population of Nairobi has been growing at a high rate with some of the growth being attributed to immigrants who visit from peripheral villages to work in the city. The city is the permanent home of 3.3 million people, and it has a daytime population of 4.1 million. This increase in population has overburdened the existing transport infrastructure (Leis & Baghudana, 2015). Car sharing reduces the number of cars needed to meet the transportation needs of consumers with on average each car in a car sharing fleet replacing three normal cars. Most users of car sharing services also report an increase in walking, biking and use of public transport. With the reduction in the number of cars and their usage there is the potential to reduce traffic congestion and free up much needed parking spaces in the cities (Mobility lab, 2013).

## **2.6 Challenges in Car Sharing**

### **2.6.1 Liability**

Peer to peer car sharing may pose some challenges in regards to insurance policies. The vehicles have personal insurance policies which are generally not valid if the vehicle is being rented to others. In some cases the insurance cover may be cancelled if using one's personal car is used for commercial purposes is against the conditions set by the insurance company. Peer to peer car sharing companies provide a secondary auto insurance policy for the car when it is being shared or rented out. While the car is being used privately the owner is expected to have a personal insurance policy (Ballús-Armet et al., 2014). The owner assumes possible damages and liabilities on behalf of the person renting their vehicle above and beyond the peer-to-peer insurance

### **2.6.2 Trust**

Trust is an important consideration in the sharing economy and has a great effect on its future growth. A number of existing companies involved in sharing such as Airbnb, which is a site that allows individuals to share their homes with others, have implemented a number of measures to increase the level of trust among its users (Ballús-Armet et al., 2014). Among the measures put in place is the use of Social media integration which can be used to establish credibility among users. It also allows users to share with users who are already part of their social networks. In ridesharing users are sometimes concerned about taking a ride in a stranger's car. The companies have limited the ridesharing to environments such as workplaces and universities and implemented rating systems to provide reassurance to their users (Ballús-Armet et al., 2014). Consumer to consumer platforms for sharing have implemented various forms of numerical rating systems. The rating systems however differ in terms of scales, aggregation, granularity, and display (Teubner & Dann , 2018). The creation of socially rich profiles on sharing platforms that are created by the users also aid in building trust. The profiles may include photos and short descriptions such as interests or occupation (Teubner & Dann , 2018). Platforms may seek to verify the user's identities by requiring the provision of documents such as IDs and licenses. Email and phone verification can also be implemented on user registration. Badges and information such as number of successful transactions and average response time also aid in building trust on the various platforms (Teubner & Dann , 2018).

### **2.6.3 Rental Costs**

In the case of automobiles, depreciation comprises about 40% of the lifetime costs of owning a personal car. The increase in mileage due to car sharing activities will negatively impact the resale value of the vehicle and shorten the time taken before a vehicle will be scrapped. The owner of an asset such as a car intends to make use of it for a long duration and therefore is more likely to take good care of it (Fraigerber & Sundararajan, 2016). The care taken cannot be compared to a person who rents an asset for a shorter period. There is a higher risk of damage during use which will increase the costs incurred by the owner of the car. Recent technological advancements have provided systems that can keep track of usage and also there are systems that maintain user reputation but the risk cannot be completely eliminated (Fraigerber & Sundararajan, 2016).

### **2.7 Technologies Used in Car Sharing**

In car sharing organizations there are no employees who are involved issuing the cars to the customers and picking them up at the end of the rental period as is the case with traditional car rental companies. The service is instead based on a self-service model which enables the company to lower costs and offer better rates to its members. The company therefore relies on the members to return cars on time, take care of them and report any mechanical issues or damage. This represents a new form of consumption that differs from traditional rentals by making use of digital technology, tending towards self-service, being more collaborative and not always mediated by the market (Bardhi & Eckhardt, 2012). In the case of ZipCar which is a car sharing company their vehicles are located close to the member's residence or place of work and are meant to be returned to a specific parking space after renting (Bardhi & Eckhardt, 2012). The vehicles are equipped with technologies to allow for remote access so that members can access their reserved vehicles using a keycard or fob issued by the car sharing organization (Ballús-Armet et al., 2014). The popularity and spread of smartphone technology and use of social media sites is a recent change in culture that has had a big effect on the adoption of peer-to-peer car sharing. The vehicles are reserved on an online vehicle reservation system and are located at specific parking spaces within neighborhoods, businesses and college campuses (Ballús-Armet et al., 2014).

### **2.7.1 Vehicle Telematics**

Vehicle Telematics refers to the combination of mobile connectivity, vehicle tracking and vehicle monitoring systems. Telecommunication devices installed in vehicles are able to transmit real time driving data and road and weather conditions (Reifel, Hales, Xu & Lala, 2010). Vehicles need to be connected to the car sharing organizations through in vehicle telematics (Vine, Zolfaghari & Polak, 2014). Some manufacturers such as Suzuki have released some vehicles with factory equipped Radio Frequency Identifiers (RFID) used in user identification and also the capability to communicate with fleet management software used by car sharing organizations (Shaheen & Cohen, 2013). Information collected from On Board Diagnostic (OBD) systems can aid in various operations such as identifying the need for maintenance, keeping track of vehicle Billing and status and as a source of evidence in case on any accidents (Zeng & Lu, 2017) . GPS tracking is important in providing users with the option of parking the vehicle in any free parking space when they have completed the trip as in the case of free floating car sharing organizations. In addition the fuel levels are monitored to alert the employees to refill the vehicles when the fuel is too low (Alli et al., 2012).

### **2.7.2 Keyless Entry**

Most car sharing services provide the user with keyless access which requires in vehicle telematics to operate. In some cases the users can be provided with access to the vehicle via smartcards. The exception is some peer to peer car sharing services which rely on the owner and the user exchanging the car keys (Vine, Zolfaghari & Polak, 2014). After use of the vehicle users can return it to the specific area they picked it from and they will be billed according to their usage based on time or mileage (Richter, 2012).

### **2.7.3 Mobile Applications**

In the case of free floating bike sharing systems in china the bikes have microchips that are used to locate them through the use of a mobile application within the designated bike parking area. The mobile application can also be used to unlock the bike and keep track of what is to be charged. Car sharing operators also make use of mobile phones to provide access to the vehicle as well as enable the users to make reservations through the use of Short Message Services (SMS) (Lan, Ma, Zhu, Mangalagiu & Thornton, 2017). Through the use of geolocation services and smartphones car

sharing users can get real-time information on vehicle availability (Shaheen & Cohen, 2013). Peer to peer car sharing is dependent on mobile and web technologies to provide a platform for linking owners with potential drivers (Cohen & Kietzmann, 2014). QR codes are also used by bike sharing organizations such as Mobike to provide the users with the option of scanning it with their mobile phone to unlock the bike (Lan, Ma, Zhu, Mangalagiu & Thornton, 2017).

#### **2.7.4 RFID**

Radio frequency identification (RFID) is a technology that makes use of radio waves to automatically and accurately identify objects by retrieving identification information from attached electronic tags. Tags which also are referred to as RFID labels have a chip for storage of a unique code used for identification which is communicated to the reader through an antenna. The reader generates an electromagnetic field which causes the tag to relay back the identification information without the need for the reader and tag being within line of sight. A tag can be either active or passive with the difference being that an active tag can be able to use its own power source and transmitter to send the information to the reader while a passive tag can be powered by the electromagnetic fields that originate from the reader (Wu, Ranasinghe, Sheng, Zeadally & Yu, 2011).

#### **2.7.5 NFC**

Near Field Communication is a type of RFID which is limited to bidirectional communication over a short range. The communication distance used in NFC is approximately 5-10 cm and the maximum rate of data transfer is about 424kb/s. It makes use of electromagnetic field induction and ensures secure transfer of data between two devices. There are two forms of NFC namely passive tag and Peer to peer. In the case of passive tag NFC there is one device that is active and is used to read and write from a passive tag. On the other hand Peer to Peer communication NFC involves two devices which are both active. Car sharing provides a good opportunity for the use of both NFC and RFID technologies especially when it comes to providing access to a shared vehicle. The driver of the vehicle makes use of a specific smart card or a key fob that acts as a passive tag to gain access. This is especially useful for car sharing if the reader is installed in such a way that it is accessible from outside the vehicle (Steffen, Preißinger, Schöllermann, Müller & Schnabel, 2018).

## 2.8 Existing Systems for Car Sharing

This section reviews car sharing organisations that exist and discusses how they operate.

### 2.8.1 ZipCar

ZipCar is the world's largest car-sharing company and for a decade it was the sole car-sharing company in the United States. It belongs to the classic round trip category of car sharing and has been an icon in the industry. Since being founded in 2000, ZipCar has experienced over 100% growth annually, and its annual revenue in 2011 was \$241.6 million. ZipCar had grown to 650,000 members and over 8,900 cars in urban areas and college campuses throughout the United States, Canada, and the United Kingdom by the end of 2011 (Bardhi & Eckhardt, 2012). The procedure for making a reservation on ZipCar is as follows; the consumer must be at least 21 years old and become a member after going through a background check which includes driving history. After being approved as a member he/she is issued with a ZipCard, which works as an automatic key used to unlock the door the rented car, this provides members with automated access to any ZipCar they reserve (Bardhi & Eckhardt, 2012). The users can then start the car with the keys which are chained inside the car. An option of gaining access via a smartphone app is also provided to the users (Alli et al., 2012). Reservations for the cars can be made either online or by phone. Members can reserve a ZipCar online or by phone quickly for up to a year in advance. Rates can range from \$6 per hour and \$60 per day, and includes fuel, parking, insurance, and maintenance (Bardhi & Eckhardt, 2012).

### 2.8.2 Turo

Turo founded in 2009 is one of the largest Peer to Peer car sharing companies operating in over 100 cities in the United States (Fraigerber & Sundararajan, 2016). Turo has implemented various measures that make it easy for new users to get on to their platform. Car owners can register their cars with Turo using an application on their smartphone and set the location and the period when the car will be available for rental (Smith, 2016). Renters on the other hand input their travel dates and location details on the mobile application and then browse through a wide variety of vehicles with varying features and luxury levels (Oei & Ring, 2016). An example of the usage of the platform is a vehicle owner who may decide to rent out his/her car after they get to work in the morning since they know it will be parked for a number of hours. A potential client can then pick

up the car and make a short trip then return it before the vehicle owner’s workday ends. Turo has various insurance packages on offer for its participants which provide protection against physical damage on their vehicles up to their actual cash value. This includes collision and most comprehensive causes and also promises that participants will be covered by \$1 million in liability insurance (Smith ,2016). The company has implemented a number of policies that the renters will have to comply with to retain their membership. Charges for tolls and tickets that have not been paid by the renter of the vehicle will be reimbursed to the car owner. There are also a number of fees that punish users for offenses such as smoking fees, pet fees, cleaning fees, gas fees, and late return fees (Oei & Ring, 2016). Figure 2.2 gives an overview of how Turo works.

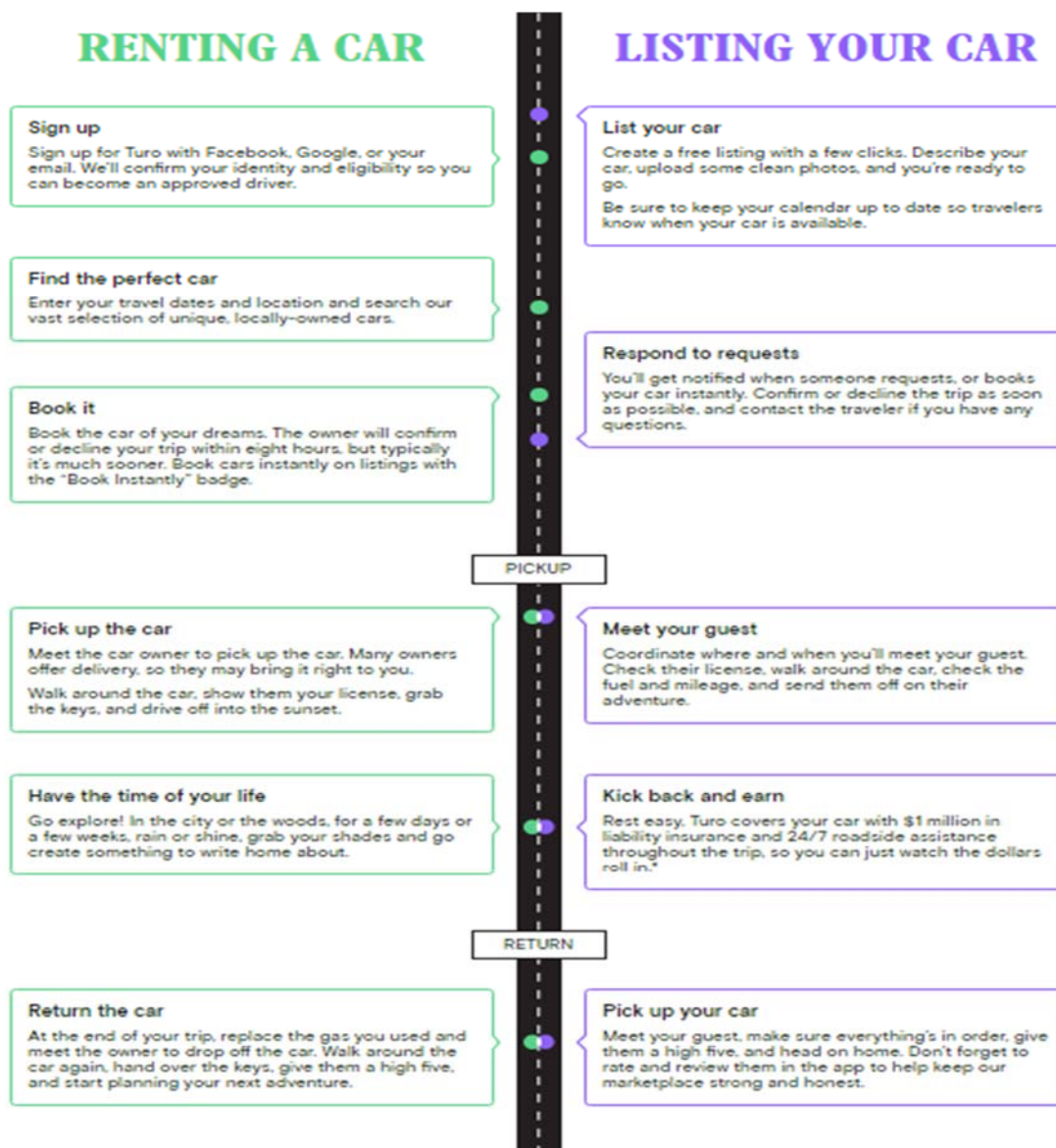


Figure 2.2 How Turo Works

(Source: Turo, n.d)

### 2.8.3 Locomute

Locomute is the first car sharing company on the African continent which was founded in South Africa in June 2015. As of 2015 they served three cities with a fleet size of 26 vehicles (Lane, Zeng, Dhingra, & Carrigan, 2015). They offer one way car sharing which allows their users to leave the rented vehicle at their destination. A mobile application and website provides the users with a convenient way of registering and reserving a vehicle on the system. The vehicles on the company's fleet can be unlocked by users either via a mobile application or a member's card. The vehicle keys are stored in the glove box and the users are expected to leave them in the glove box and then lock the vehicle using the mobile application or member's card at the end of their trip (Locomute, n.d). Figure 2.3 illustrates the user interface of the Locomute mobile application.

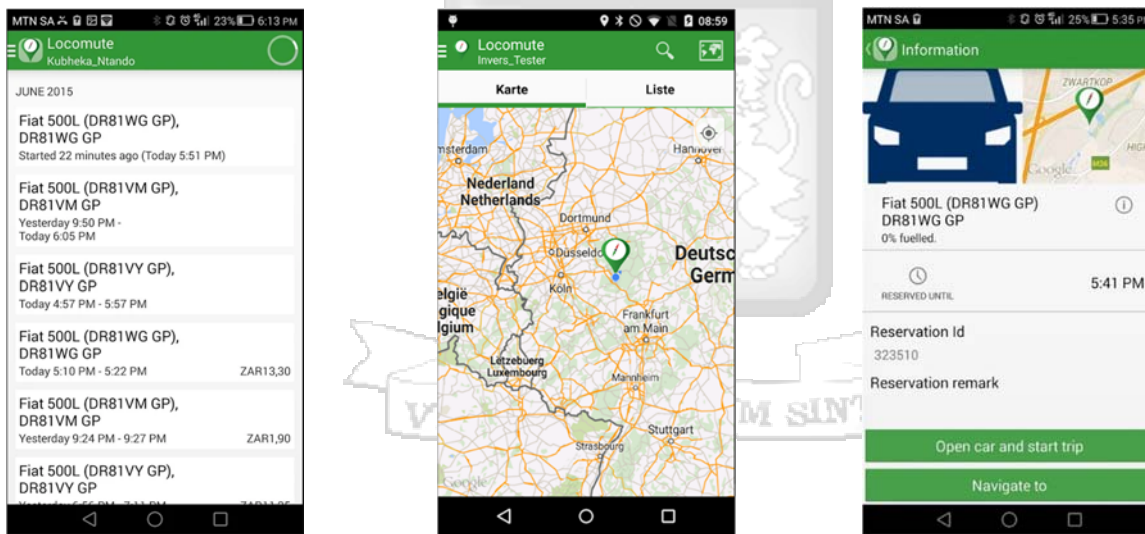


Figure 2.3 Locomute Mobile Application

(Source: Google Play, n.d)

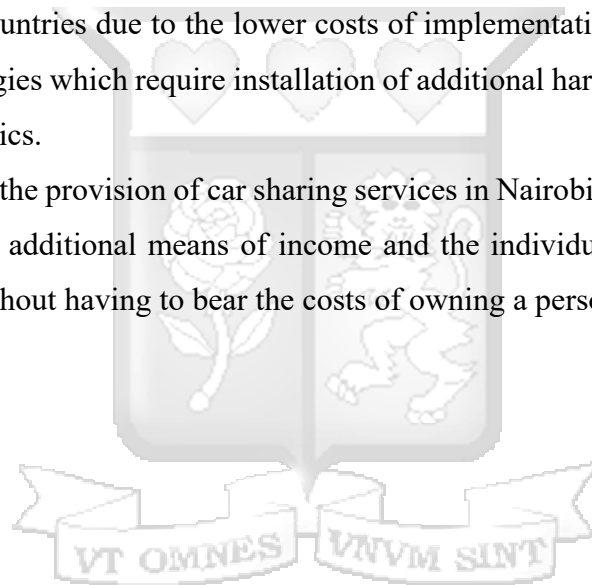
## 2.9 Conclusions

Transportation in major cities such as Nairobi is facing a number of challenges. These include rise in the number of personal vehicles and inadequate infrastructure leading to high congestion on major highways. As a result there is enormous environmental degradation that is fueled by increased pollution and emission of greenhouse gases.

In developed nations the Car sharing phenomenon has been growing in popularity and attracting benefits such as reduced number of personal cars, lower costs and conservation of the environment. There are various car sharing organisations operating worldwide but there is a disproportionately small number of car sharing members in emerging markets such as Africa where there rate of urbanisation is increasing and this provides opportunities for growth.

One way and round trip car sharing models make use of technologies such as vehicle telematics, keyless entry and online reservation. These technologies provide users with convenient access to a vehicle close by without many processes needed when picking up a vehicle from traditional car rental companies. Implementation of these technologies in every vehicle in the fleet however requires a substantial investment on the part of the company. Peer to peer car sharing can be more suitable in developing countries due to the lower costs of implementation. It can operate without the use of some technologies which require installation of additional hardware in vehicles as is the case with vehicle telematics.

Given the above benefits the provision of car sharing services in Nairobi can be beneficial for both the owners of cars as an additional means of income and the individuals who need access to a vehicle for short trips without having to bear the costs of owning a personal vehicle.



## **Chapter 3 : Research Methodology**

### **3.1 Introduction**

Research Methodology refers to systematic procedures through which researchers describe, explain and predict phenomena (Rajasekar, Philominathan & Chinnthambi, 2013). This chapter will aim to discuss the methodologies that were applied to answer the following research questions what are the challenges faced by individuals renting cars? Which are the current systems available for car sharing? How will the mobile application be designed, developed and tested to aid consumers in identifying genuine car owners and find affordable cars to rent? Does the developed mobile application meet the needs of consumers who want to share a car? This chapter will also cover the planning, design, development, testing and validation phases of the Agile methodology.

### **3.2 Software Development Methodology**

The researcher employed Agile Development methodology due to its advantage over other methodologies such as the waterfall software methodology (Altexsoft, 2016). Waterfall software methodologies require a number of phases which are carried out sequentially and are suitable for projects where there are very few changes (Altexsoft, 2016). Agile methods are aimed at an increased speed of software development, when the project has rapidly changing requirements. The development is done in iterative steps and usually there are many releases to the customers. Customers closely collaborate with the development team and changes in requirements are expected and encouraged (Greer & Hamon, 2011). Each iteration in the Agile Development methodology is referred to as a sprint and it includes design, implementation, testing and deployment within a set scope (Altexsoft, 2016). The Agile development cycle is displayed in figure 3.1 below.

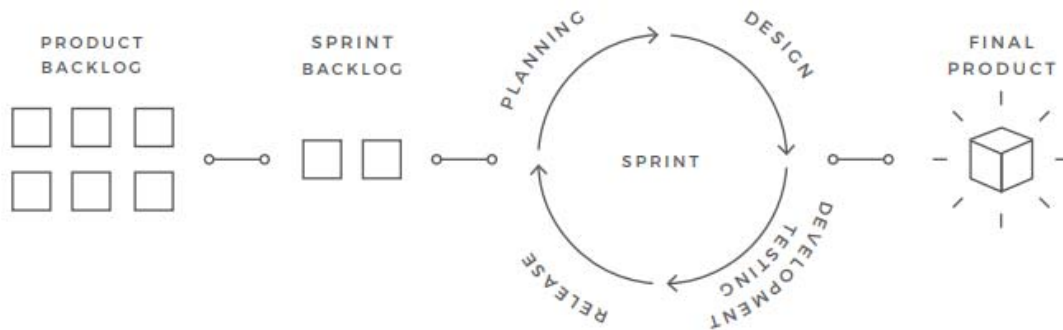


Figure 3.1 Agile Development Cycle

(Source: Altexsoft, 2016)

Scrum framework was chosen because it prioritizes the needs of the customer and delivering the product on time and within the budget (Altexsoft, 2016). Scrum is one of the Agile methodologies which consists of short development cycles that result in a usable product. The sprints typically have duration of less than four weeks (Altexsoft, 2016). In the Scrum framework there are a number of roles such as product owner, scrum master and scrum team. The product owner decides the software requirements needed which form the product backlog and the set budget. At the start of the sprint the team decides which deliverables from the project backlog are to be implemented and this forms the sprint backlog. The scrum master is responsible for resolving the issues faced by the scrum team (Duka, n.d).

### 3.2.1 Planning Phase

This is the first phase of the Agile Software development methodology. The stakeholders of the system were identified and relevant literature on car sharing from journals and other documents was reviewed and analyzed to determine the gaps in the existing systems. A questionnaire was then issued to find out the needs of the Car owners who are the main stakeholders (See Appendix A). Requirements for the system were then formulated using the information gathered. The development environment such as the IDE and other software needed was set up during this phase. The study population consisted of the private vehicle owners in Nairobi who number approximately 495,000 (Leis & Baghudana, 2015). The study was focused on Nairobi due to its proximity to the researcher and also due to the nature of peer to peer car sharing which consists of

short trips that are suitable for urban areas. The formula used for calculating the sample size was recommended by Taro Yamane and is as follows (Singh & Masuku, 2014).

$$n = N / (1 + N (e)^2)$$

n refers to the sample size

N refers to the population size.

e refers to the margin of error.

If we take the population size to be 495,000 and the margin of error to be 10 % the sample size is estimated to be 100.

### **3.2.2 Design Phase**

The requirements gathered were then used to come up with a number of design diagrams to show how the requirements will be implemented. Unified Modeling Language (UML) refers to a standardized language for documenting and visually representing the various components of a software system (Tutorials point, 2017). UML tools were used to come up with design diagrams namely Use case diagrams, Class diagrams, Sequence diagrams and Entity Relationship Diagrams. Use case diagrams represent the functionalities of the system from the point of view of outside agents referred to as actors who interact with the system (Rumbaugh, Jacobson & Booch, 2005). Sequence diagrams are a representation of messages sent among different parts of a system arranged in time sequence (Rumbaugh, Jacobson & Booch, 2005). Class diagrams give the object representation of the system (Tutorials point, 2017). Wireframes were also created to illustrate the layout of the user interface. The diagrams were developed by use of draw.io which can be accessed from (<https://www.draw.io/>).

### **3.2.3 Development Phase**

The various UML diagrams were then used to guide the development process and ensure that the developed system is in line with the requirements gathered from the users. Modules and components of the system were developed using Integrated Development Environment (IDE) software such as Android Studio which can be downloaded from (<https://developer.android.com/studio/>) and Sublime Text 3 which can be downloaded from (<https://www.sublimetext.com/3>). The mobile application was developed on the Android platform

and the backend was developed using the Laravel PHP framework version 5.6 which can be installed from (<https://laravel.com/>). Data storage and access control was taken care of using XAMPP which is a tool combining the MySQL Database Management System (DBMS) and Apache server. The MySQL database was used to store the car sharing system information and the tool can be accessed from (<https://www.apachefriends.org/download.html>). All the above tools were installed and run on the Windows ten operating system which is owned by Microsoft.

### **3.2.4 Testing**

Finally the Testing phase was conducted through functional testing, non-functional and usability testing and the results documented. Tools that were used included a suitable Android device, Postman Client and questionnaires to get the feedback from the users. The questionnaire was presented to 10 respondents and their feedback recorded. A validation was then undertaken to verify that the system managed to address the problem as envisioned. The various phases will be repeated iteratively until the system met the needs of the users.

#### **3.2.4.1 Functional Testing**

Functional testing is used to determine if the components of the developed software are working as expected. This is meant to ensure that the system has met all the user requirements. The functional testing is user oriented and does not take into account the internal structure of the software as the user only interacts with the user interface (Saini & Rai, 2013). The following functionalities were tested against the user requirements.

1. Functionalities for the vehicle owner such as registration and accepting sharing requests.
2. User functionalities such as registration, vehicle selection and submitting sharing requests.
3. Security of the system data.
4. User access controls based on the roles.
5. Compatibility testing was performed on the backend with different browsers.
6. The mobile app was tested on various phones with different versions of the Android Operating System to ensure it functioned correctly.

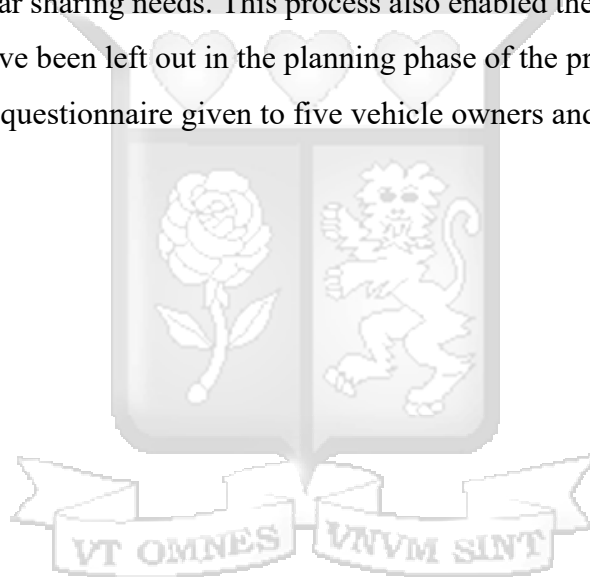
#### **3.2.4.2 Non Functional Testing**

Non Functional testing focuses on the aspects of the developed software such as security that are not part of the user requirements of the software. The developed software was tested in the following areas.

1. The usability of the software in regards to the ease of navigating the menu and searching for a vehicle.
2. The security of the web based backend was tested to ensure it did not have serious vulnerabilities.

### **3.3 System Validation**

System validation testing is used to check if the developed system has met the specifications given by the users (Saini & Rai, 2013). Validation of the system was used to determine if the developed solution is suitable for solving the challenge faced by the users which is the ability to easily and conveniently meet their car sharing needs. This process also enabled the identification of any user requirements that may have been left out in the planning phase of the project. The validation was conducted by means of a questionnaire given to five vehicle owners and the results recorded (See Appendix B).



## Chapter 4 : System Analysis and Design

### 4.1 Introduction

This chapter describes how the car sharing system was designed. The various functionalities of the system will be represented by use of use case diagrams, data flow diagrams, sequence diagrams and data modeling diagrams

### 4.2 Requirements Analysis

The requirements for the car sharing system were identified through the information gathered during the planning and user design phase. The system allows for three types of users namely car owners, car renters and the administrator. Vehicle owners post details of their personal vehicles on the system to get access to potential clients. Renters search for appropriate vehicles on the system and select a suitable vehicle. Administrators on the other hand are responsible for ensuring the users meet the requirements for approval before they can be allowed to login to the system.

#### 4.2.1 Survey Responses

##### Age of Respondents

The data collected showed that many of the respondents are between the ages of 25 – 30. This is usually the age that respondents were able to afford a private vehicle as shown in Figure 4.1.

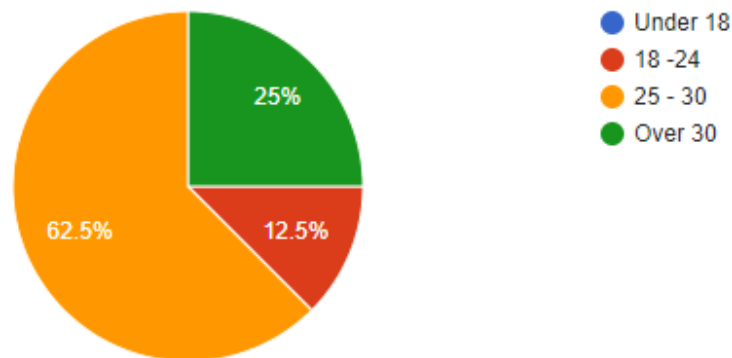


Figure 4.1 Age of respondents

## Vehicle Ownership

The data collected showed that a majority of the respondents own only one vehicle with a few having two. Sharing of the vehicles will have to take into account that the vehicles may be shared for short durations when not in use as shown in Figure 4.2.

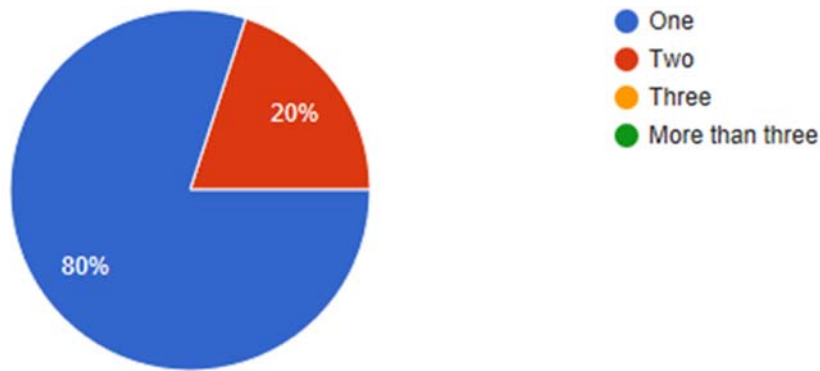


Figure 4.2 Vehicle Ownership

## Sharing of Personal Vehicle

A majority of the respondents had shared their own vehicle with a friend or colleague. This shows that some respondents are willing to share their vehicle with a trusted person as shown in Figure 4.3.

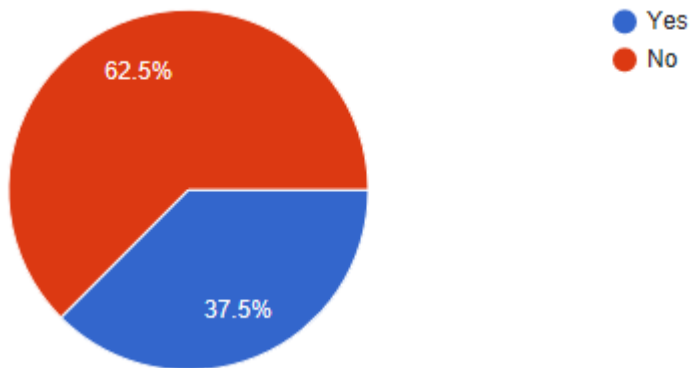


Figure 4.3 Vehicle Sharing

## Duration of Vehicle Sharing

An important consideration when sharing vehicles is for how long the respondents were willing to share their vehicles. Many respondents had shared their vehicles for duration of between one and five days. This shows a preference for sharing their vehicle for a short duration as shown in Figure 4.4.

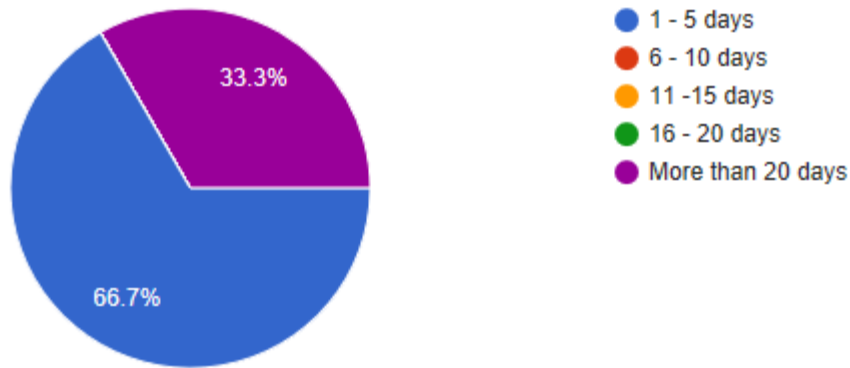


Figure 4.4 Sharing Duration

### Concerns when Sharing a Vehicle

Car sharing has faced a number of challenges mainly due to concerns faced by the vehicle owners than may make them reluctant to participate. The survey sought to determine which the greatest concerns are. The options provided were as follows:

- i. Liability in regards to Insurance
- ii. Trust
- iii. Costs involved e.g. risk of depreciation and damage.
- iv. Convenience
- v. Other

The results are as shown in Figure 4.5

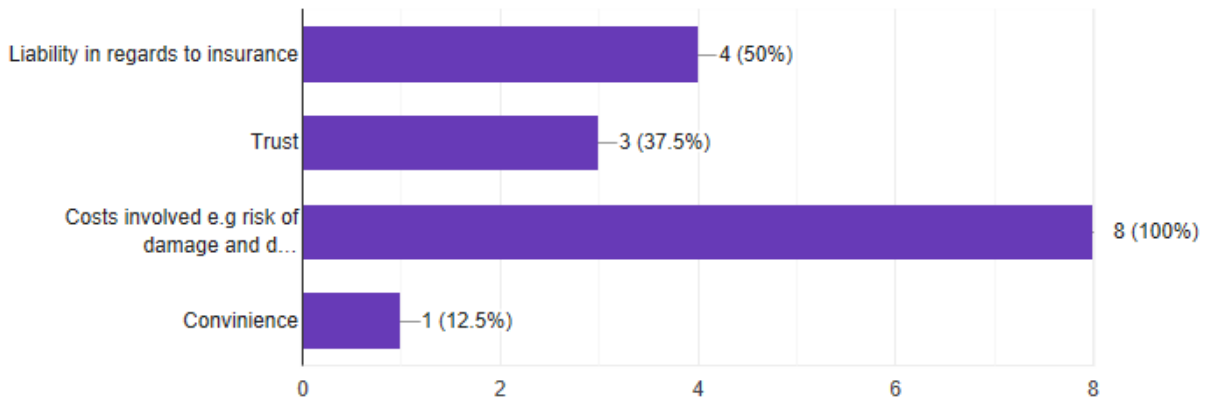


Figure 4.5 Vehicle Sharing Concerns

## Reasons for Renting a Vehicle

The survey sought to find out the main reasons for renting out a vehicle. The options provided were as follows:

- i. Liability in regards to Insurance
- ii. Trust
- iii. Costs involved e.g. risk of depreciation and damage.
- iv. Convenience
- v. Other

The results are as presented in Figure 4.6

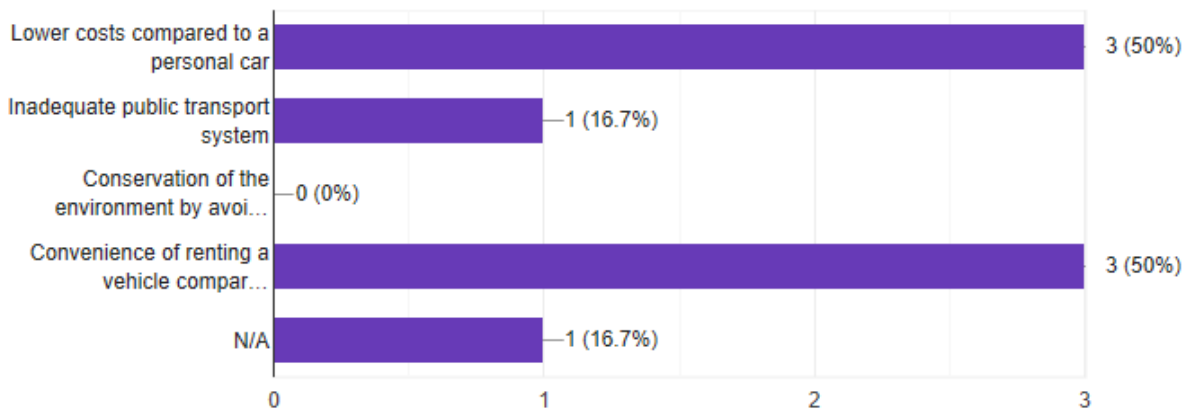


Figure 4.6 Reasons for Sharing

## Kilometers Driven Per Day

The respondents were queried on the average distance they drive per day. The responses are as shown in the figure below. Almost half of the respondents drive a distance that is below 20km as shown in Figure 4.7.

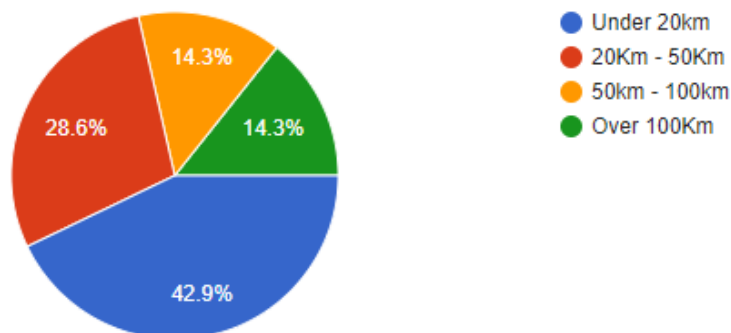


Figure 4.7 Kilometers Driven per Day

## 4.2.2 Requirements Determination

Literature review of existing car sharing systems enabled the researcher to formulate a set of suitable requirements. The analysis of the survey responses ensured the requirements were in line with the needs of the potential users of the system. The following are the functional and non-functional requirements of the system.

### Functional Requirements

- a) User login and registration - the system should allow for the registration of both vehicle owners and car rental clients.
- b) Vehicle registration - the vehicle owner should be able to add a vehicle to the system.
- c) Vehicle search including location - the car sharing client should be able to search for an appropriate vehicle.
- d) Submission of vehicle sharing request – the system should allow for the car sharing client to make a request to rent out a vehicle.
- e) Approval of sharing requests – the vehicle owner should be able to review and approve rental requests.
- f) Mobile money payments – the car sharing clients should be able to make payments after the rental period is over.
- g) User rating – the clients should be rated by the vehicle owners. This will aid in addressing the trust concerns.
- h) Reporting – the administrator should be able to review reports on the activities on the system.

### Non Functional Requirements

- a) Adequate security – the mobile application and web based backend should be developed while taking into account the security best practices.
- b) Good usability - the mobile application and web based backend should be intuitive to aid the users.
- c) Availability – the mobile application and web based backend should be

### 4.3 System Architecture

The system makes use of a client server architecture which splits the system into servers which provide the service and clients which request the service. The AutoShare system consists of an application server to process information and a database server to store data. A mobile based application will be used by both the vehicle owners and car sharing clients to access and submit information to the system. The users can download the application on the Android app store and then proceed to register their details. Communication between the mobile application and the system will be through the Internet which is provided by the user's mobile service providers. The system administrator can access the car sharing application server using a web based backend as shown in Figure 4.8.

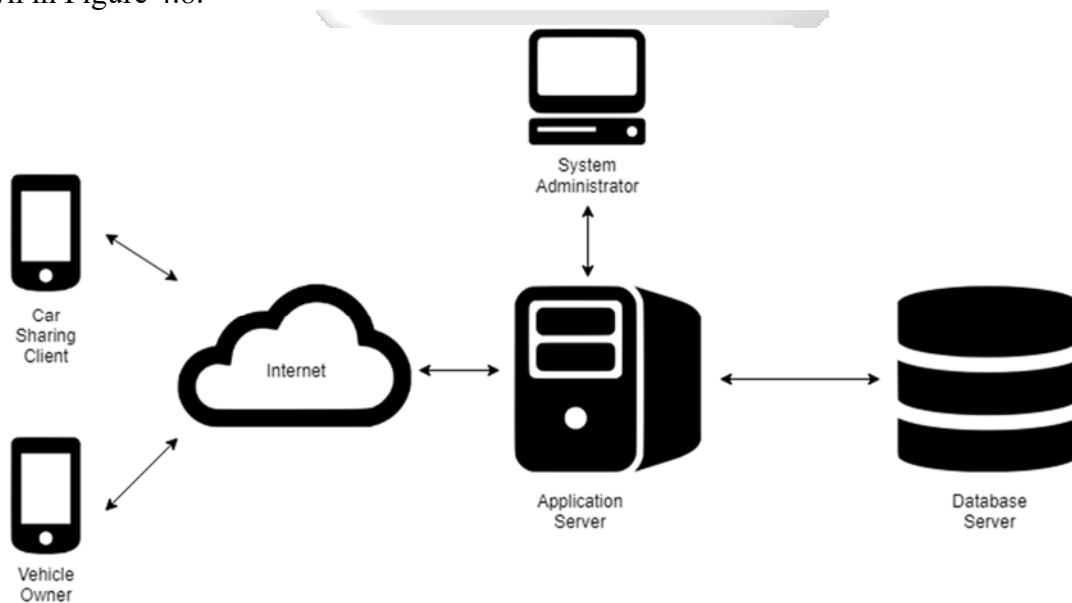


Figure 4.8 AutoShare System Architecture

#### 4.3.1 System Administrator

The system administrator is able to access the system via a web based application to perform various CRUD actions. The administrator can approve users, manage the vehicles available on the system and view various reports on the activities on the system.

#### 4.3.2 Car Sharing Client

The car sharing client refers to the users who are looking for vehicles available for sharing and proceed to make user of them for short trips. The user can place a request to the vehicle owner to

make use of the vehicle. A summary of previous trips and payment history is also available to the client.

### 4.3.3 Vehicle Owner

The vehicle owner can post details about his/her vehicle including the times when it will be available for sharing. Sharing requests are also approved by the vehicle owner. The owner can also access summarized reports on the number of times the vehicle has been shared and the money earned.

## 4.4 Data and Process Modeling

### 4.4.1 Data Flow diagram

The flow of data in the AutoShare system can be shown through the use of a data flow diagram. Figure 4.9 illustrates the context diagram for the proposed system.

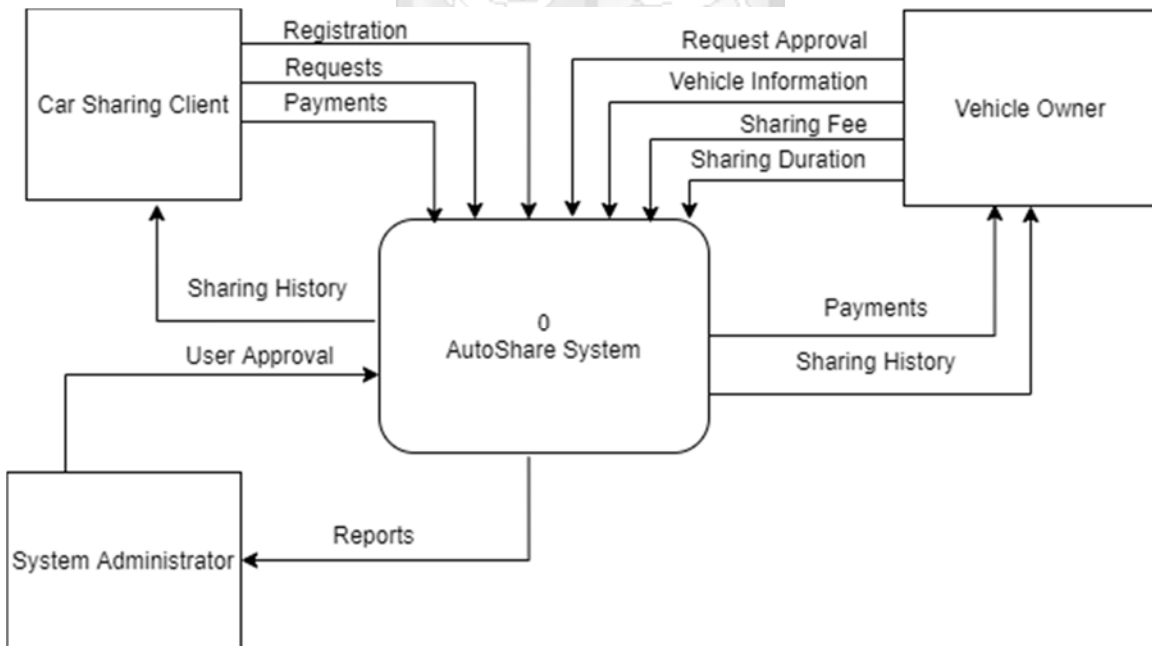


Figure 4.9 AutoShare Context Diagram

#### 4.4.2 Level 1 Data Flow Diagram

The data flow through the various sub processes within the system can be displayed in the level 1 DFD as shown in Figure 4.10.

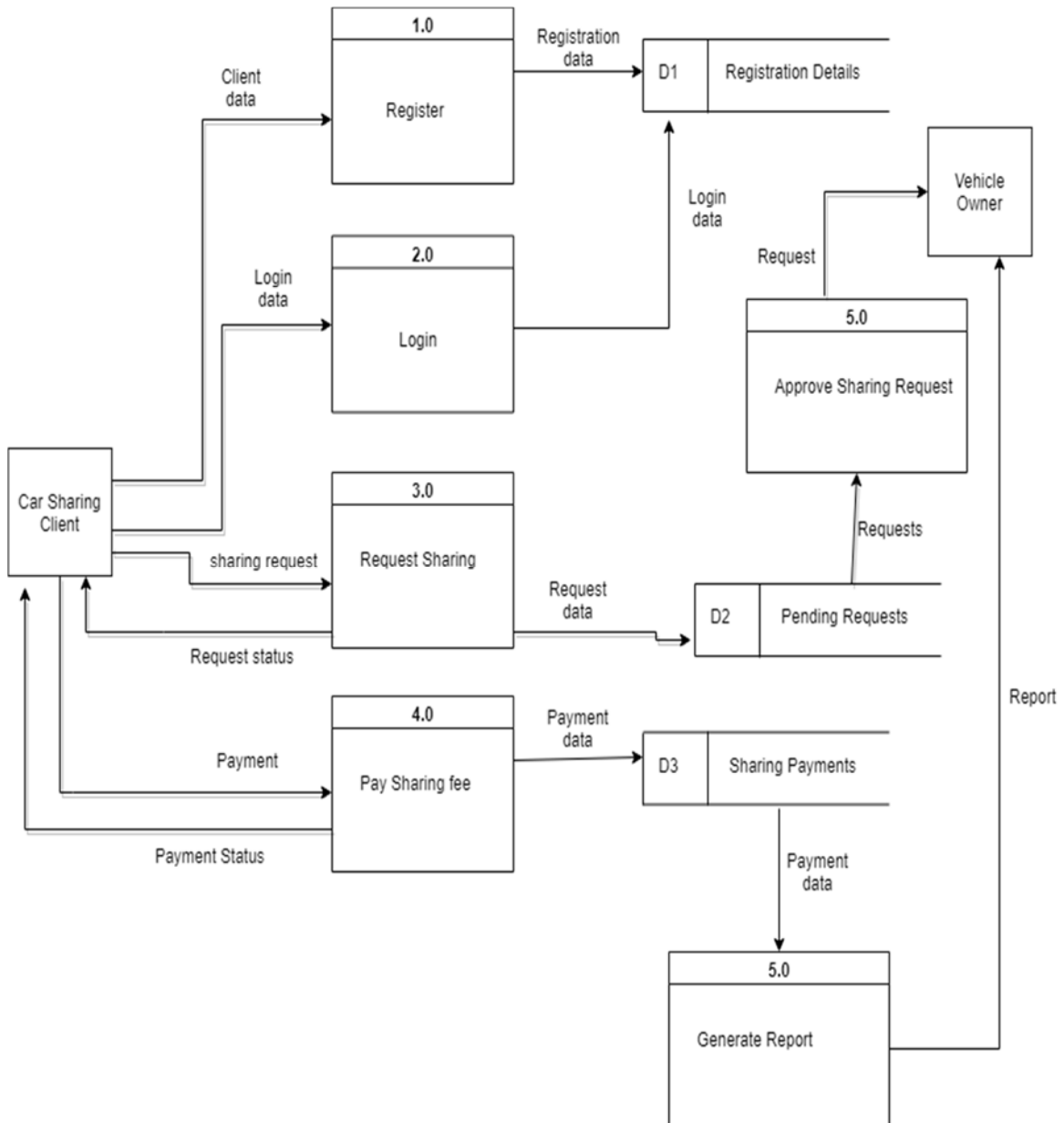


Figure 4.10 AutoShare Level 1 Data Flow Diagram

# 4.5 Systems Design

## 4.5.1 Use Case Diagram

A Use case diagram illustrates the interactions between the external actors and the system. The main actors are the car sharing client, vehicle owner and the system administrator. Figure 4.11 illustrates the use case diagram for the proposed system.

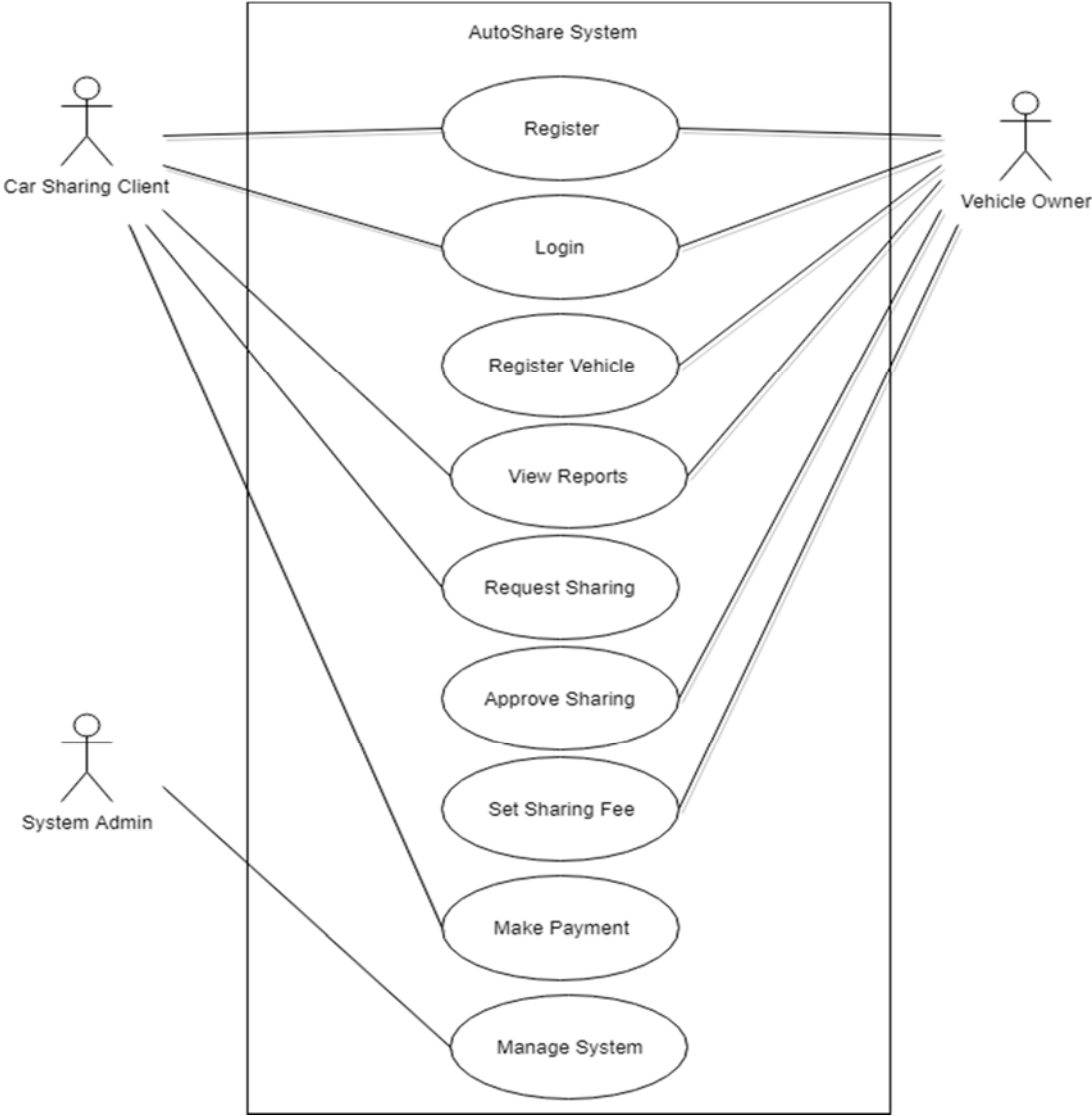


Figure 4.11 AutoShare Use Case Diagram

#### 4.5.1.1 Use Case Descriptions

##### Register

This use case provides details on the procedure for registration on the system by the car sharing client and vehicle owner. They are each provided with different options depending on if they need to rent or share a vehicle as shown in Table 4.1.

Table 4.1 Register Use Case

Use Case Name:	Register
Description:	The user registers on the platform using the mobile application
Primary Actor:	User
Secondary Actor:	None
Preconditions:	Application should be up and running
Post Conditions:	User is registered
Main Flow:	<ol style="list-style-type: none"><li>1. User launches the mobile application</li><li>2. User selects the registration link from the application login</li><li>3. The user then selects if they are a car sharing client or a vehicle owner.</li><li>4. The user is presented with a form to fill in their registration details.</li><li>5. User then fills in their registration details.</li><li>6. The application validates the user input and the details are saved to the database.</li><li>7. The user is presented with the home page of the application.</li></ol>
Alternative Flows:	<p>6a Missing user information</p> <ol style="list-style-type: none"><li>1. System gives error message</li><li>2. Use Case resumes at main flow step 5</li></ol>

##### Login

This use case describes the user login to the system using their email as the username and a password as shown in Table 4.2.

Table 4.2 Login Use Case

Use Case Name:	Login
Description:	The user logs in on the platform using the mobile application
Primary Actor:	User
Secondary Actor:	None
Preconditions:	User needs to have an account on the system
Post Conditions:	User accesses the landing page of the mobile application
Main Flow:	<ol style="list-style-type: none"> <li>1. User launches the mobile application</li> <li>2. User is presented with the login form.</li> <li>3. User enters their email and password into the login form.</li> <li>4. The login credentials are checked to determine if they are valid.</li> <li>5. The mobile application authenticates the user.</li> <li>6. After the application authenticates the user the landing page is displayed.</li> </ol>
Alternative Flows:	<p>4a Invalid email or password</p> <ol style="list-style-type: none"> <li>1. System gives error message.</li> <li>2. Use Case resumes at main flow step 5.</li> </ol>

### Register Vehicle

This use case describes the vehicle registration in the case of a vehicle owner looking to share his/her private vehicle. The details provided will be displayed to any potential car sharing clients looking for a suitable vehicle as shown 4.3.

Table 4.3 Register Vehicle Use Case

Use Case Name:	Register Vehicle
Description:	The user registers a vehicle on the platform to make it available for car sharing.
Primary Actor:	Vehicle Owner
Secondary Actor:	None

Preconditions:	User needs to have registered as a vehicle owner.
Post Conditions:	Vehicle is added to the system.
Main Flow:	<ol style="list-style-type: none"> <li>1. User launches the mobile application</li> <li>2. User selects the add vehicle menu option.</li> <li>3. User fills in the vehicle details in the provided form.</li> <li>4. The vehicle details are validated.</li> <li>5. The vehicle details are saved to the database.</li> </ol>
Alternative Flows:	<p>4a Missing vehicle details</p> <ol style="list-style-type: none"> <li>1. System gives error message.</li> <li>2. Use Case resumes at main flow step 3</li> </ol>

### Request Sharing

This use case describes the process of a car sharing client making a request to rent out a particular vehicle for a set duration which will be forwarded to the vehicle owner for approval as shown in Table 4.4.

Table 4.4 Request Sharing Use Case

Use Case Name:	Request Sharing
Description:	The car sharing client places a request to rent a vehicle to the vehicle owner.
Primary Actor:	Car Sharing Client
Secondary Actor:	None
Preconditions:	User needs to have selected a vehicle.
Post Conditions:	Request is sent to the vehicle owner awaiting approval.
Main Flow:	<ol style="list-style-type: none"> <li>1. User launches the mobile application.</li> <li>2. User enters search criteria for the desired vehicle.</li> <li>3. User is presented with a list of vehicles matching search criteria.</li> <li>4. User views vehicle details and places a request..</li> <li>5. User is notified that the request has been placed.</li> </ol>
Alternative Flows:	<p>4a No Vehicles found matching criteria</p> <ol style="list-style-type: none"> <li>1. System displays no results found notification.</li> </ol>

	2. Use Case resumes at main flow step 2
--	---

### Approve Sharing

This use case describes the process of the vehicle owner viewing the details of sharing requests received from prospective car renters and approving one of them as shown in Table 4.5.

Table 4.5 Approve Sharing Use Case

Use Case Name:	Approve Sharing Request
Description:	The car sharing client places a request to rent a vehicle to the vehicle owner.
Primary Actor:	Vehicle Owner
Secondary Actor:	None
Preconditions:	User needs to have made a sharing request.
Post Conditions:	Request is approved and the user can proceed to start the rental.
Main Flow:	<ol style="list-style-type: none"> <li>1. Vehicle owner launches the mobile application.</li> <li>2. Vehicle owner reviews list of pending requests.</li> <li>3. Vehicle owner approves particular request made.</li> <li>4. User receives notification that the request has been approved.</li> <li>5. The car rental can commence.</li> </ol>
Alternative Flows:	<p>3a Vehicle owner doesn't accept request</p> <ol style="list-style-type: none"> <li>1. Vehicle owner navigates back to list of requests.</li> <li>2. Use Case resumes at main flow step 2.</li> </ol>

### Make Payment

This use case describes the process of a car sharing client making a payment after the end of the rental period as shown in Table 4.6.

Table 4.6 Make Payment Use Case

Use Case Name:	Make Payment.
Description:	The user makes a payment for the car rental.
Primary Actor:	Car Rental Client.

Secondary Actor:	None.
Preconditions:	Car Rental Client needs to have his/her sharing request approved.
Post Conditions:	Car rental charges are paid in full.
Main Flow:	<ol style="list-style-type: none"> <li>1. Vehicle owner ends the rental session.</li> <li>2. Client receives notification to make payment.</li> <li>3. Client enters payment details in the payment page.</li> <li>4. The transaction is processed by the payment gateway.</li> <li>5. Client receives notification if the payment has been successful.</li> </ol>
Alternative Flows:	<p>4a Client gives the wrong payment details.</p> <ol style="list-style-type: none"> <li>1. System gives error message</li> <li>2. Use Case resumes at main flow step 3</li> </ol>

### Approve User

This use case describes the process of the administrator approving a client before they can start using the application as shown in Table 4.7.

Table 4.7 Approve User Use Case

Use Case Name:	Approve User
Description:	The newly registered user is approved by the admin before they start using the application.
Primary Actor:	Administrator.
Secondary Actor:	User.
Preconditions:	User has submitted registration details to the system.
Post Conditions:	User can login to the application.
Main Flow:	<ol style="list-style-type: none"> <li>1. Administrator logs in to the system.</li> <li>2. Administrator reviews list of new users.</li> <li>3. Administrator views all the details of a user.</li> <li>4. Administrator marks the user details as approved.</li> <li>5. User receives notification that his/her account has been approved.</li> </ol>

Alternative Flows:	<p>4a Administrator does not approve the user.</p> <ol style="list-style-type: none"> <li>1. System notifies user that they have not been approved.</li> </ol>
--------------------	--

**4.5.2 Sequence Diagram**

Sequence diagrams are used to illustrate the interactions between objects within a system. Sequence diagrams also take into account the order in which the interactions take place by arranging the messages vertically. Figure 4.12 and Figure 4.13 illustrate the sequence diagrams for the car sharing client and the vehicle owner.

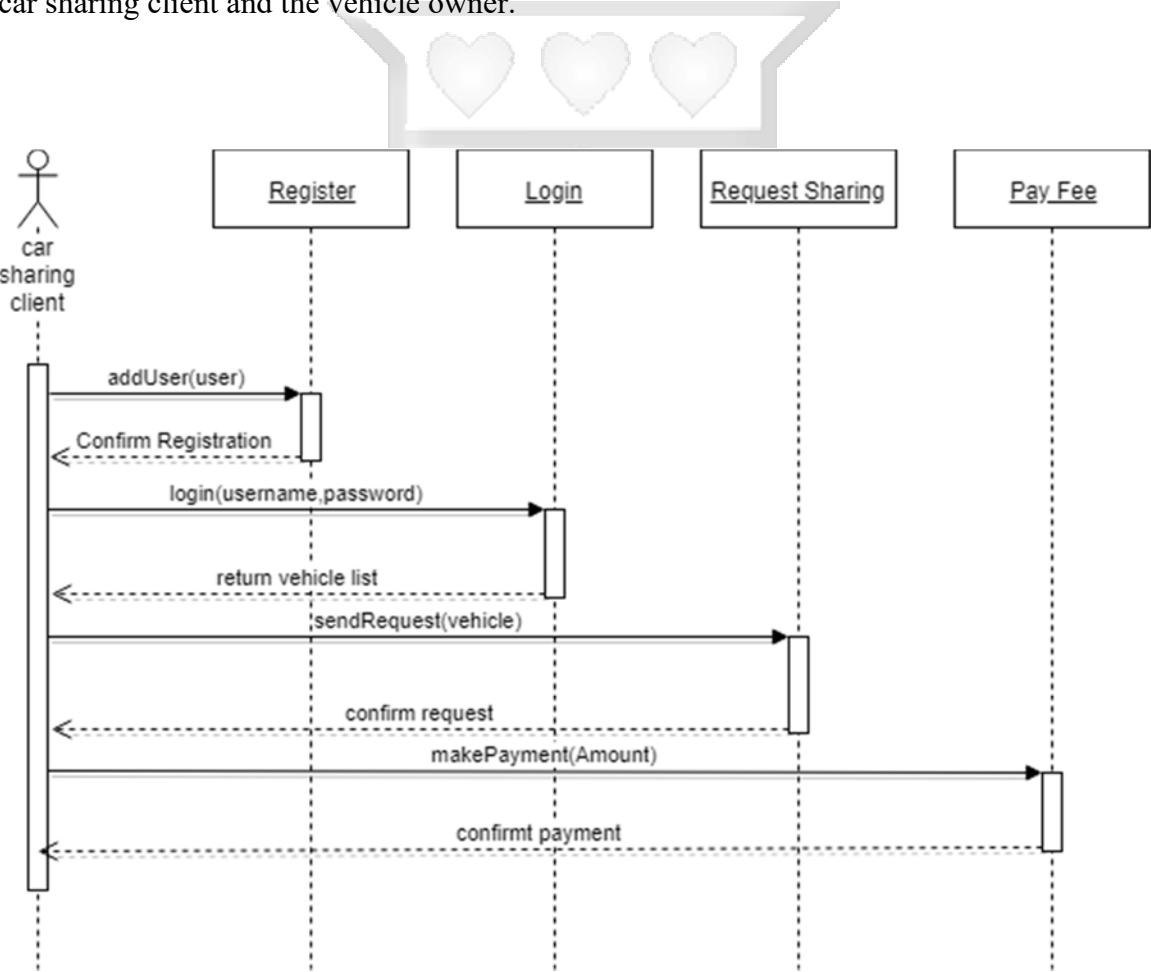


Figure 4.12 Sequence Diagram - Car Sharing Client

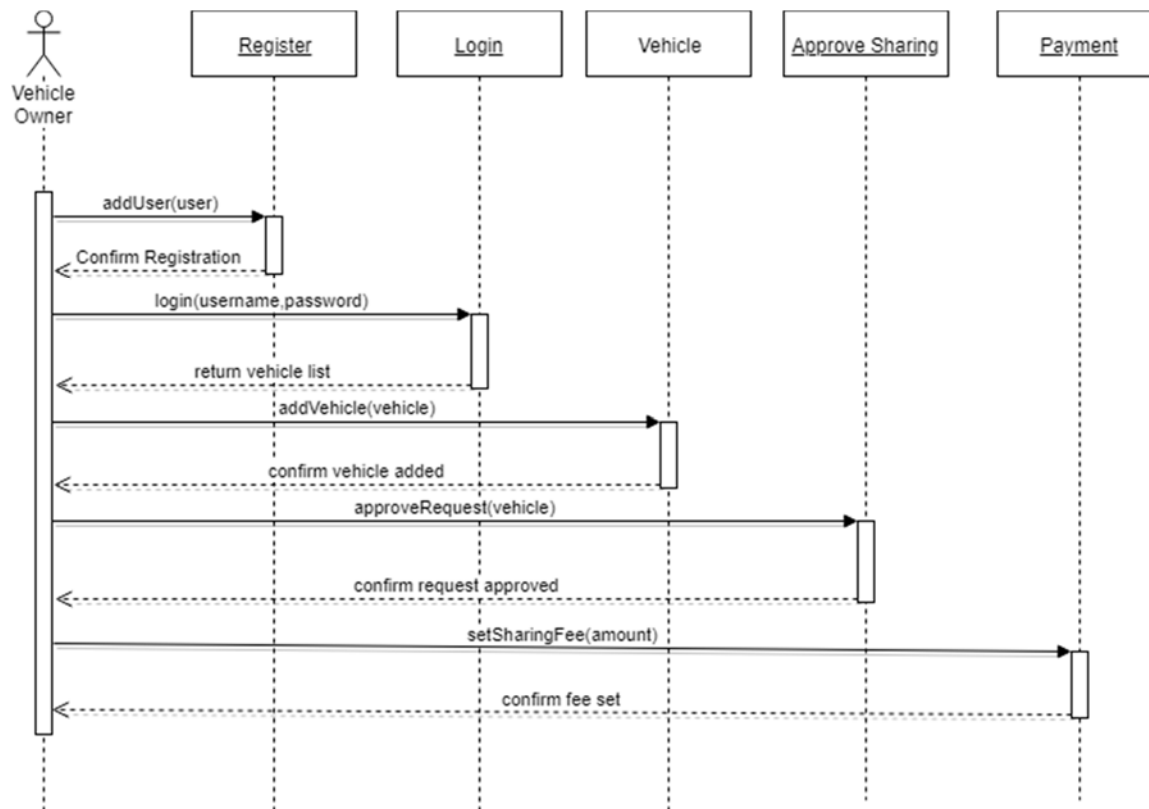


Figure 4.13 Sequence Diagram - Vehicle Owner



### 4.5.3 Database Schema

This section provides a tabular representation of the database tables used in the system including the data types of the columns. The entity relationship diagram displays the relationship between entities in a system which are stored within a database. Figure 4.14 displays the entity relationship diagram for the AutoShare system. In the figure below Primary Key is abbreviated as PK and Foreign Key is abbreviated as FK.

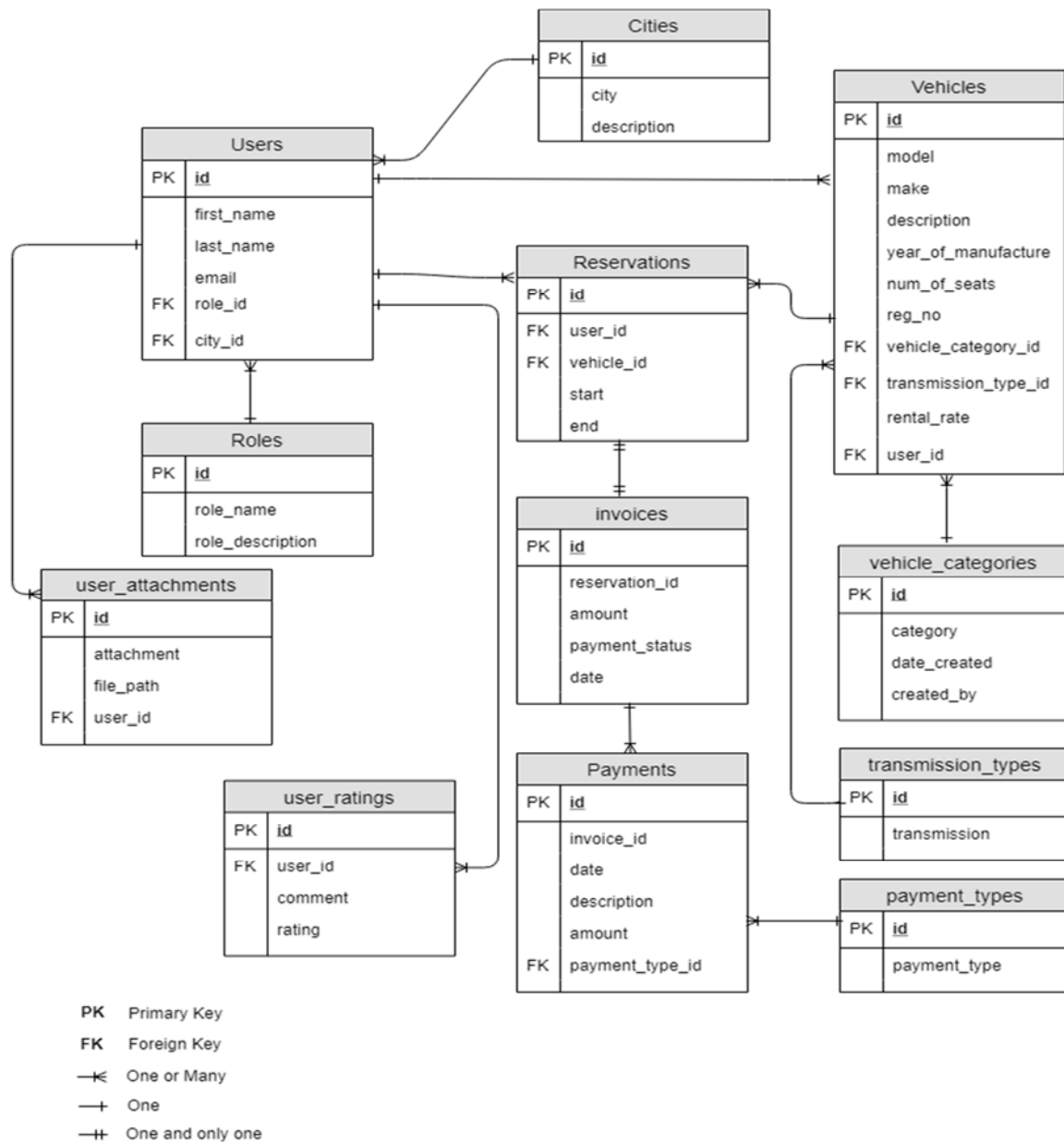


Figure 4.14 Entity Relationship Diagram

In the tables below Primary Key is abbreviated as PK and Foreign Key is abbreviated as FK. Auto increment is abbreviated as AI.

### Users Table

Table 4.8 shows the users table. Users must first be registered on the system before they can access the shared vehicles or post their own.

Table 4.8 Users Table

Field	Data Type	Details	Notes
Id	int	PK,AI	
first_name	varchar		
last_name	varchar		
email	varchar		
username	varchar		
password	varchar		
driving_licence_number	int		
role_id	int	FK	
city_id	int	FK	
status	boolean		

### Roles Table

Table 4.9 displays the roles table. The users on the system are assigned roles so as to manage user access.

Table 4.9 Roles Table

Field	Data Type	Details	Notes
Id	int	PK,AI	
role	varchar		
description	varchar		

### User Attachments Table

Table 4.10 shows the user attachments table. The additional user details such as file paths to scanned copies of important documents uploaded by the user are stored in this table. The documents include driving licenses and ID cards to aid in the approval process.

Table 4.10 Cities Table

Field	Data Type	Details	Notes
Id	int	PK, AI	
city	varchar		

### Vehicles Table

Table 4.11 shows the vehicles table. The vehicles table is used to store the details of the vehicles posted by the vehicle owners looking to share their vehicles.

Table 4.11 Vehicles Table

Field	Data Type	Details	Notes
Id	Int	PK, AI	
model	varchar		
make	varchar		
description	varchar		
year_of_manufacture	Int		
num_of_seats	Int		
reg_no	varchar		
vehicle_category_id	Int	FK	
transmission_type_id	Int	FK	
is_available	boolean		
hire_rate	double		
user_id	Int	FK	

## User Ratings Table

Table 4.12 shows the user ratings table. This table is used to store the ratings and comments given to users by the owners of the vehicles. This helps to build trust in the user renting out the vehicle.

Table 4.12 User Ratings Table

Field	Data Type	Details	Notes
Id	Int	PK, AI	
user_id	Int	FK	
rating	Int		
comment	varchar		

## Vehicle Categories Table

Table 4.13 shows the vehicle categories table. The vehicles are categorized according to body type e.g sedan or pickup. This is to aid the users in finding the appropriate vehicle.

Table 4.13 Vehicle Categories Table

Field	Data Type	Details	Notes
Id	Int	PK, AI	
category	varchar		
description	varchar		

## Reservations Table

Figure 4.14 shows the reservations table. This table is used to store the reservation requests made by the users. After the request is made the vehicle owner is responsible for approving the requests received.

Table 4.14 Reservations Table

Field	Data Type	Details	Notes
Id	Int	PK, AI	
user_id	Int	FK	
vehicle_id	Int	FK	
start	datetime		
end	datetime		

### Invoices Table

Table 4.15 shows the invoices table. This table is used to store the invoices issued to the users containing the charges for the vehicle rental.

Table 4.15 Invoices Table

Field	Data Type	Details	Notes
Id	Int	PK, AI	
reservation_id	Int	FK	
amount	Int		
invoice_date	date		
payment_status	boolean		

### Payments Table

Table 4.16 shows the payments table. This table stores the transaction details of the payments made by the users.

Table 4.16 Payments Table

Field	Data Type	Details	Notes
Id	Int	PK, AI	
invoice_id	Int	FK	
transaction_date	date		
description	varchar		
payment_type_id	Int	FK	
amount	double		

### Cities Table

Table 4.17 shows the cities table. This table stores the city where the user resides.

Table 4.17 Cities Table

Field	Data Type	Details	Notes
Id	Int	PK, AI	
city	varchar		

### Transmission Types Table

Table 4.18 shows the transmission types table. This table stores the various transmission types available for the vehicles. This is to help users pick a vehicle they are comfortable driving.

Table 4.18 Cities Table

Field	Data Type	Details	Notes
Id	Int	PK,AI	
transmission	varchar		

### Payment Types Table

Table 4.19 shows the payment types table. This table stores the various payment channels available for making payments on the system.

Table 4.19 Payment Types Table

Field	Data Type	Details	Notes
Id	Int	PK,AI	
Payment_type	Varchar		

## 4.5.4 Backend Wireframe Diagrams

### Dashboard

Figure 4.15 shows the dashboard page which gives the administrator an overview of the important information in the system. It includes charts to give a better and visual representation of the data.

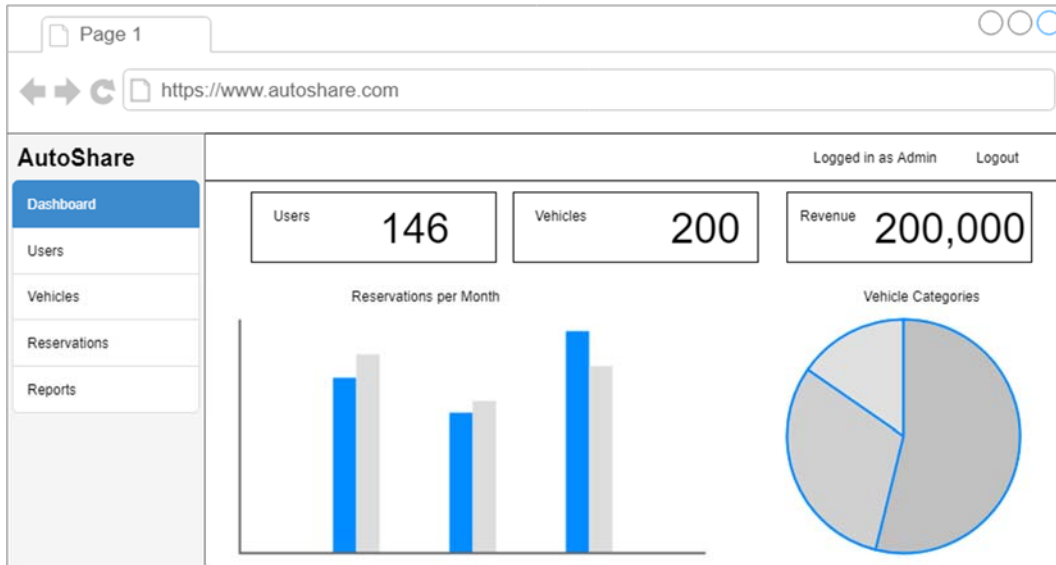


Figure 4.15 Dashboard

## User Management

Figure 4.16 shows the user management page which lists all the users of the system as well as their roles. This page also provides the administrator with the functionality to approve newly registered users before they can begin making use of the mobile application.

The user management page displays the following table:

#	First Name	Last Name	Username	Active
1	John	Boo	johnny81	<input checked="" type="checkbox"/>
2	Mary	Brown	missmary	<input checked="" type="checkbox"/>
3	James	Mooray	jjjames	<input type="checkbox"/>

Figure 4.16 User Management

## Vehicle Management

Figure 4.17 shows the vehicle management page which lists all the vehicles registered in the system.

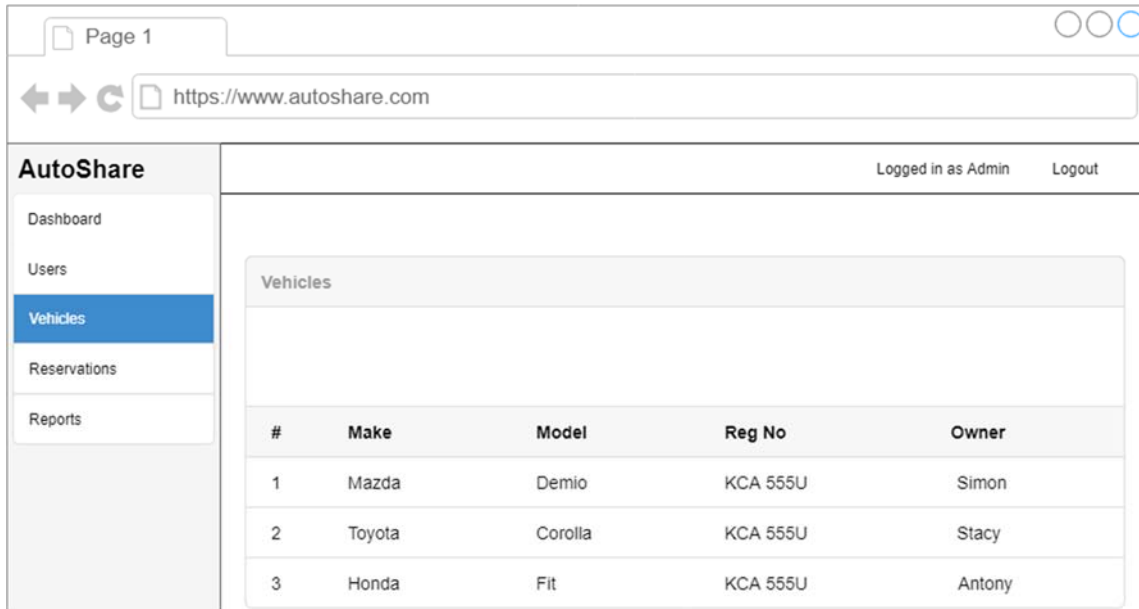


Figure 4.17 Vehicle Management

## Reservations

Figure 4.18 displays the reservations made by the car sharing clients which are subject to approval by the vehicle owner

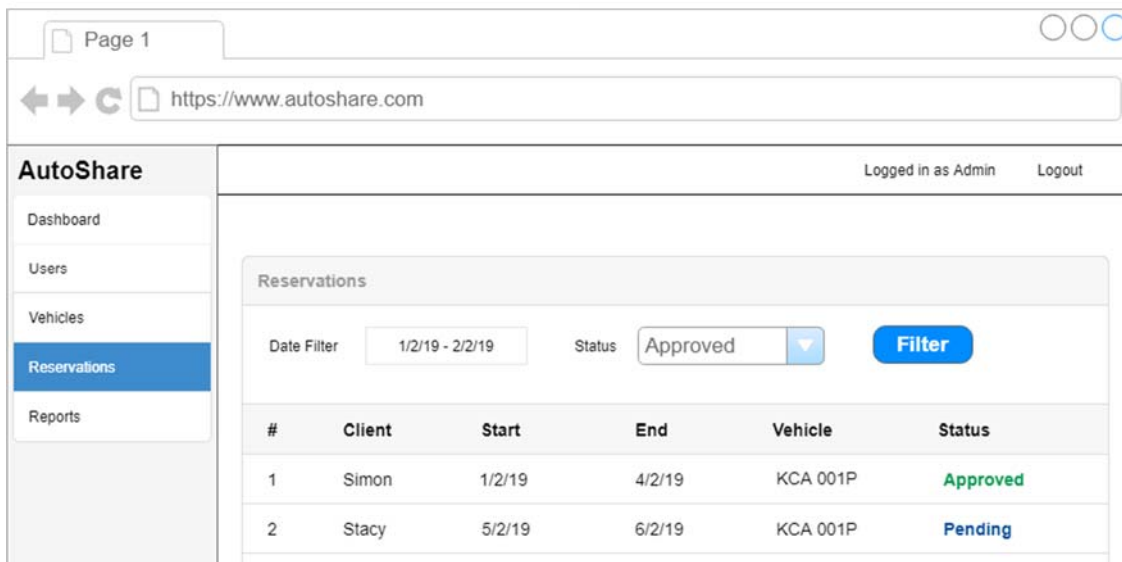


Figure 4.18 Reservations

## Reports Page

Figure 4.19 displays the reports available on the car sharing system including filters to aid in generating appropriate reports.

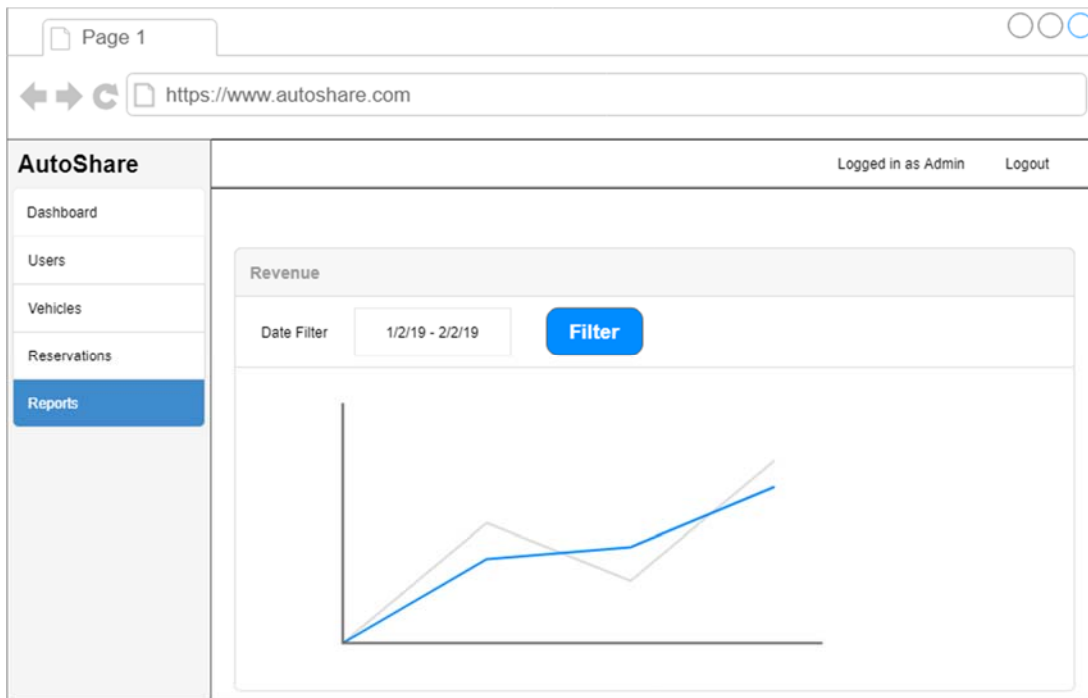


Figure 4.19 Reports Page

## 4.5.5 Mobile Application Wireframes

### Vehicle Search

The vehicle search form allows the car sharing client to enter his/her preferred vehicle details such as transmission type and vehicle type. The client can then get a list that matches his/her search criteria to allow them to choose the best vehicle as seen in Figure 4.20.

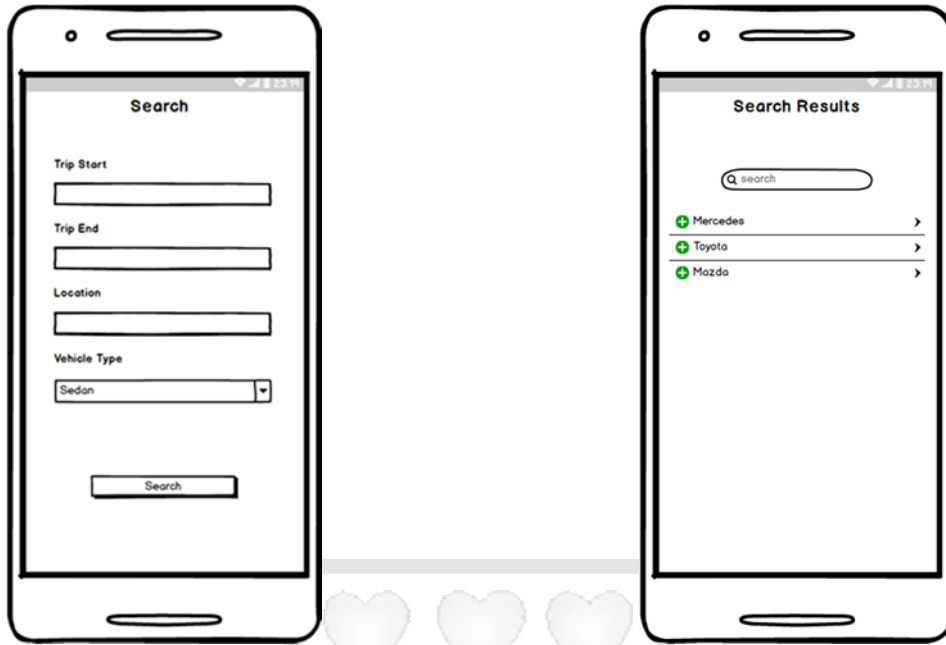


Figure 4.20 Vehicle Search

### Vehicle Request

A vehicle request is placed by the car sharing client after selecting one of the vehicles from the search results. The client can review the additional details concerning the vehicle before clicking on request sharing to send the sharing request to the vehicle owner as shown in Figure 4.21.

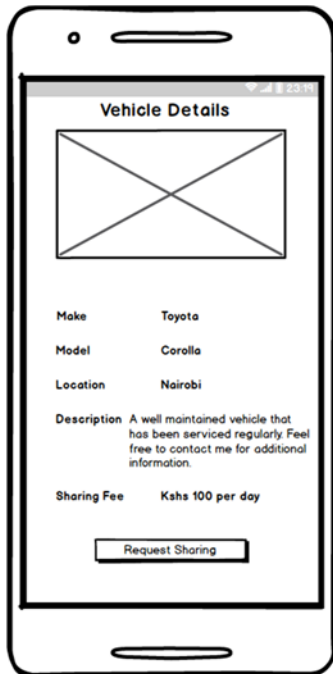


Figure 4.21 Vehicle Details

## Sharing Request Approval

Vehicle owners once logged in the app can get an opportunity to view the sharing requests made for the vehicles they have registered on the system. A list of sharing requests allows them to quickly view with the ability to view extra information about the person making the sharing request as shown in Figure 4.22.

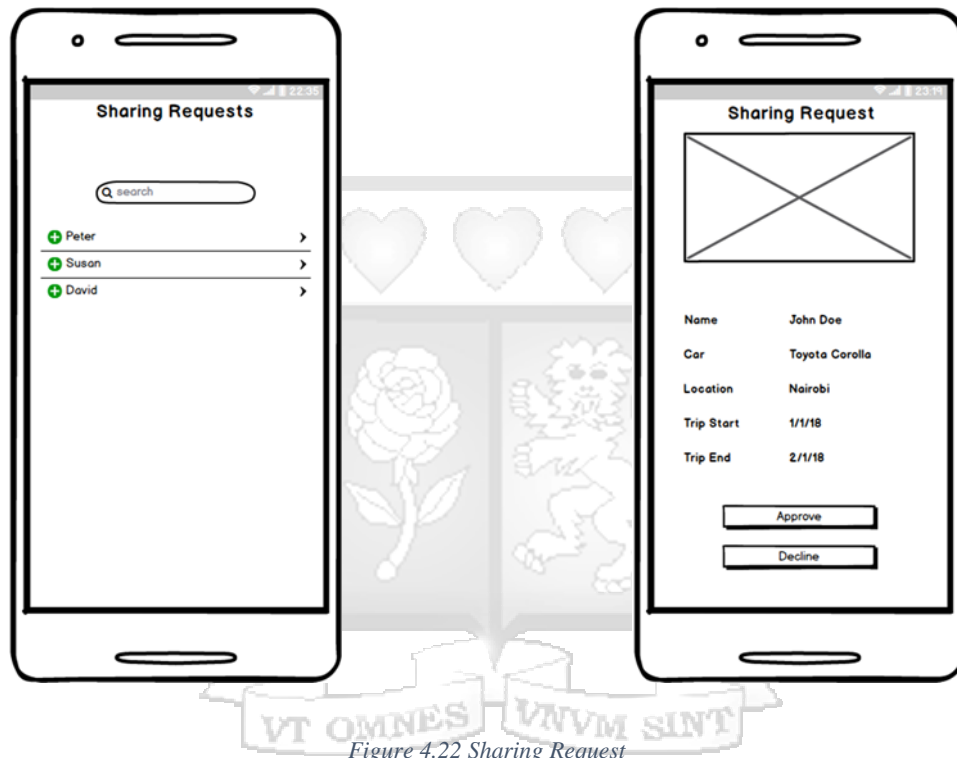


Figure 4.22 Sharing Request

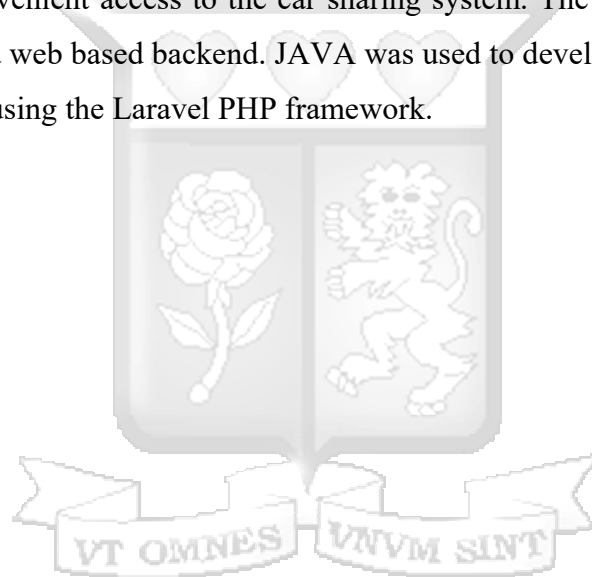
## 4.5.6 Security

The proposed system includes user authentication on both the mobile application and the web based backend using a login form. The login form on the web based backend was developed to include a CAPTCHA so as to prevent numerous login attempts as in the case of an automated brute force attack. Passwords on the system were checked on registration to ensure that they meet the necessary minimum length and also they include a combination of letters, numbers and symbols and they are hashed using SHA1 algorithm before insertion into the database. All forms were designed to only allow a set length of input to prevent a user crashing the system by overloading the forms with large amounts of data. The user input is also sanitized to ensure no malicious code is submitted by the user. Database access was protected through the creation of different database

users with some having limited access levels. Communication between the mobile application and the server is secured using HTTPS to prevent a hacker from intercepting the requests. The Laravel framework used on the application backend has built in support for securing against Cross Site Request Forgery (CSRF) which was enabled on the configuration file. CSRF refers to a situation whereby an attacker causes a user to perform unwanted actions on a trusted site on which the user is currently logged on.

#### **4.5.7 Development**

The proposed solution was developed to work on android devices to allow the car sharing clients and vehicle owner's convenient access to the car sharing system. The system administrator can access the system using a web based backend. JAVA was used to develop the mobile app and the backend was developed using the Laravel PHP framework.



## Chapter 5 : System Implementation and Testing

### 5.1 Introduction

The implementation of the AutoShare car sharing system involved the development of a mobile application and a web based backend. The mobile application was developed to run on the Android platform for devices running version 5.0 and above of the Android operating system. Laravel PHP framework, bootstrap and jQuery were chosen for the implementation of the web based backend. The application data was stored in a MySQL database.

### 5.2 System Development Environment

The following are the hardware and software used in the implementation of the system including the justifications for their use as shown in table 5.1 and 5.2.

Table 5.1 Hardware Environment

Hardware	Justification
HP Elitebook laptop, core i5 processor 4Gb RAM,500Gb hard drive, Windows 10 Operating System	The laptop was used for the development of the system, online research and writing of this dissertation.
Tecno Camon C8	The mobile phone was used to test the Android application.

Table 5.2 Software Environment

Software	Justification
Windows 10	Operating system used in laptop computer
MS Word 2010	Used to write and format the dissertation document.
XAMPP	Used to run the Apache server and Mysql database to test the web application.
Android Studio	Used to create the Android mobile application using the JAVA language.

Sublime Text 3	Used to write the PHP scripts for the backend development.
Postman	Used to the Application Programming Interface (API) used to communicate between the backend and mobile application.

**5.3 Mobile Application Modules**

The developed mobile application has a number of functionalities that are displayed below using screenshots.

**5.3.1 Login and Registration**

The user is authenticated on the login screen using his/her username or email and password. If the user has not been registered on the system they can click on the register link to access the registration form. The application has the capability to handle two types of users namely the car sharing client and the vehicle owner. The user can select the appropriate user type before registration (See Appendix C).

**5.3.2 Main Page**

The main page displays information to the user after successfully login in or registration. The user is presented with a different page depending on the type of user either the car sharing client or vehicle owner. In the case of the car sharing client the user is presented with a search area and a list of vehicles registered on the system is displayed in the case of the vehicle owner. Figure 5.1 shows the search form which requires the user to enter the start date and end date of the duration they need to use the vehicle, choose the location and select the type of vehicle they are looking for.

The image shows a mobile application interface for searching vehicles. At the top, there is a blue header with a hamburger menu icon, the word "Search", and a vertical ellipsis icon. Below the header, there are four input fields: "Start Date", "End Date", "Location", and "Vehicle Type". The "Vehicle Type" field is currently set to "Sedan". At the bottom of the form is a green button with the text "SEARCH". The entire form is overlaid on a large, faint watermark of a coat of arms featuring three hearts at the top, a rose on the left, and a lion on the right, with a banner at the bottom containing the Latin motto "VI OMNIA SVB SVA".

Figure 5.1 Search Form

### 5.3.3 Placing a Sharing Request

When a user has clicked on the search button on the search form they can then choose from a number of vehicles which are near their current location and match the vehicle type they are looking for. Figure 5.2 shows a list of search results where the user can select a vehicle. In Figure 5.3 the user can view the details such as color, transmission and price then place a request for sharing which will be sent to the vehicle owner for review.

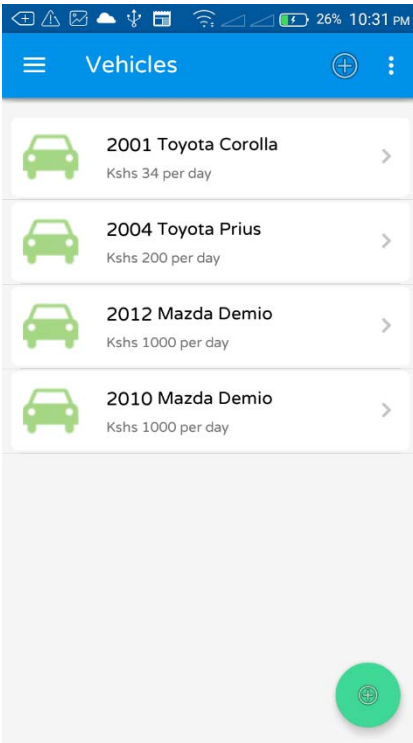


Figure 5.2 Search Results

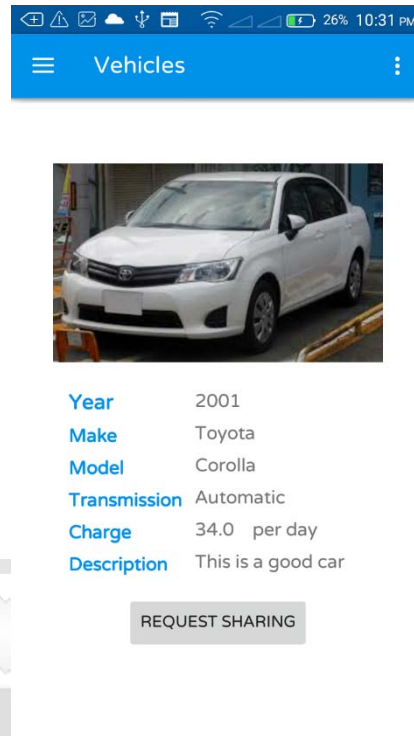


Figure 5.3 Vehicle Details

### 5.3.4 Vehicle Registration

If a user registers as a vehicle owner they have the option of adding a vehicle to their profile. The user clicks on the add button in the navigation bar to launch the vehicle registration form (See Appendix C).

### 5.3.5 Reviewing Sharing Requests

The vehicle owner can review sharing requests made on the system as shown in Figure 5.4 and decide if to approve or decline them based on the dates requested and the user details as shown in Figure 5.5. Once the request has been approved the user who made the request will be notified via the application and they can then contact the car owner to arrange for the vehicle pickup.

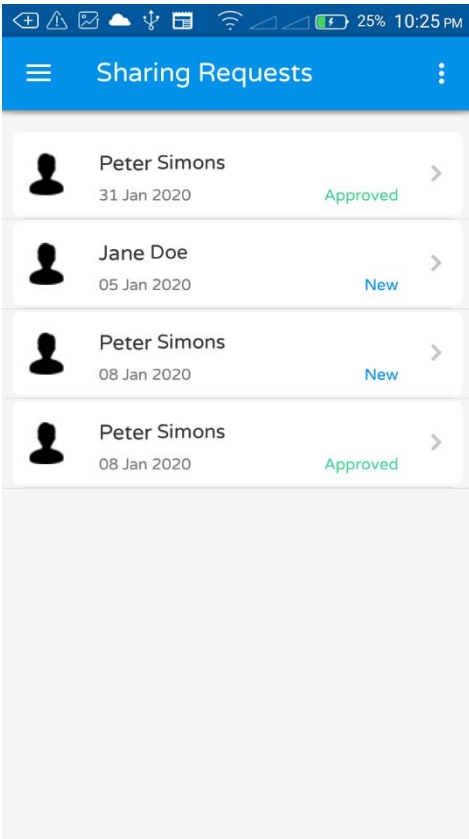


Figure 5.4 Requests List

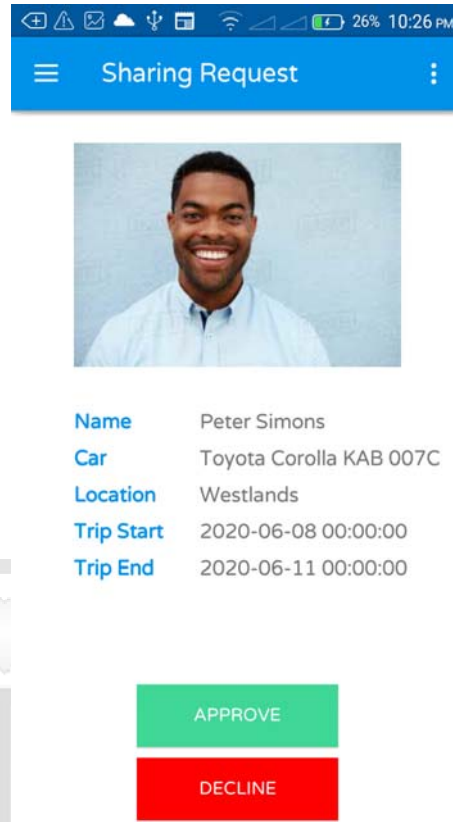


Figure 5.5 Request Details

## 5.4 Web Backend

The web based backend is used by the system administrator to manage the data such as the users, vehicles and view reports on the activities in the system. It can only be accessed by the system administrator to ensure that the application data is secure. The system administrator is also responsible for approving the newly registered car owners before they can start operating so as to review their details.

### 5.4.1 User Authentication

The administrator logs into the system backend by providing his/her username or email and password. The login page ensures that unauthorized users cannot get access to the system (See Appendix D).

## 5.4.2 Dashboard

The system administrator can view a summary of the activities going on in the system on the dashboard which is displayed after logging in. Charts have been implemented to allow for a better representation of the important information needed by the administrator. The page is shown in Figure 5.6.

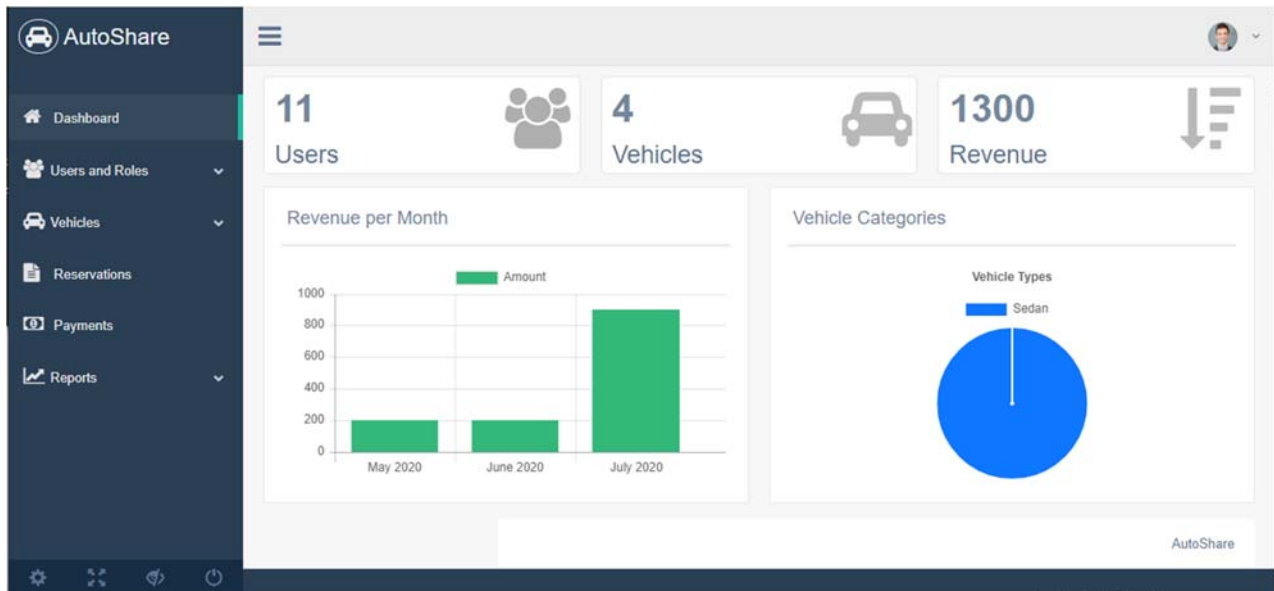


Figure 5.6 Dashboard

## 5.4.3 User Management

The system administrator can view all users on the system and manage their details. New users are approved and the administrator can deactivate users who have been reported by others for offences as shown in (See Appendix D).

## 5.4.4 Payments

Clients can make payments to the system using Mpesa and card payments via the mobile application. The payments made are displayed on the payments page to allow for easy access and assist the administrator in resolving any payment issues that may arise. The page is shown in Figure 5.7.

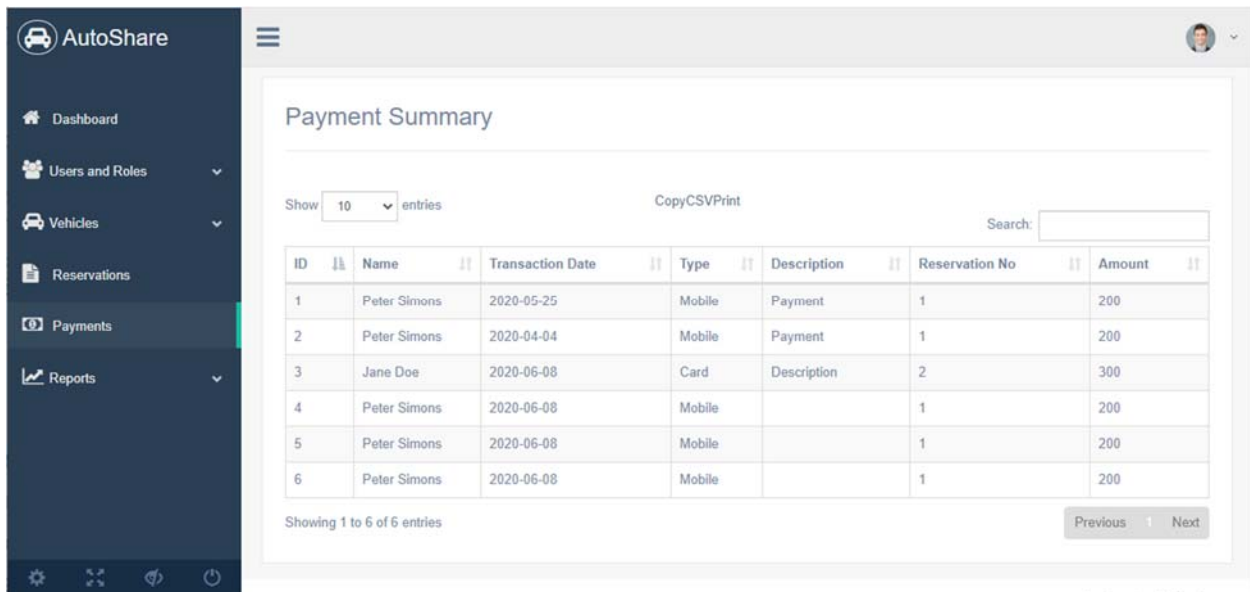


Figure 5.7 Payment Summary

### 5.4.5 Reservations

The system administrator can view the reservations made in the system by the car sharing clients using the mobile application. If there are any changes or cancellations the administrator can be able to modify the reservation on behalf of the client. The page is shown in Figure 5.8.

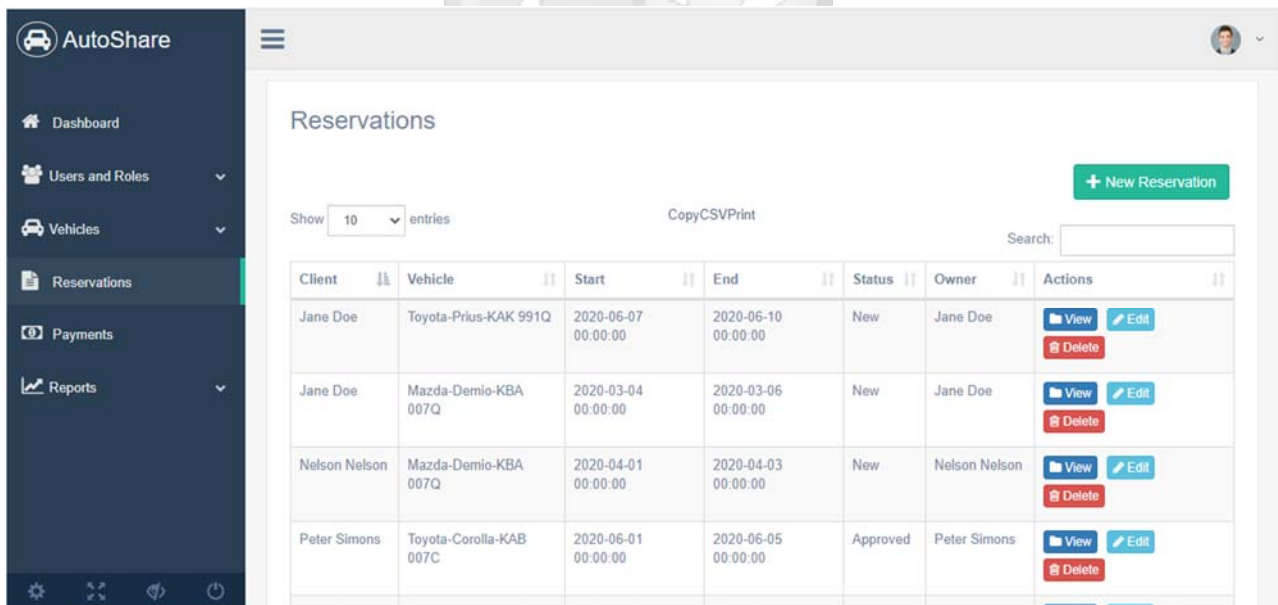


Figure 5.8 Reservations

Figure 5.6 Reservations

## 5.4.6 Reports

The system administrator can view reports on the revenue collected in a particular period with options provided so that they can filter by date if needed. The information is represented as a bar chart to make it easier to interpret it as shown in Figure 5.9.

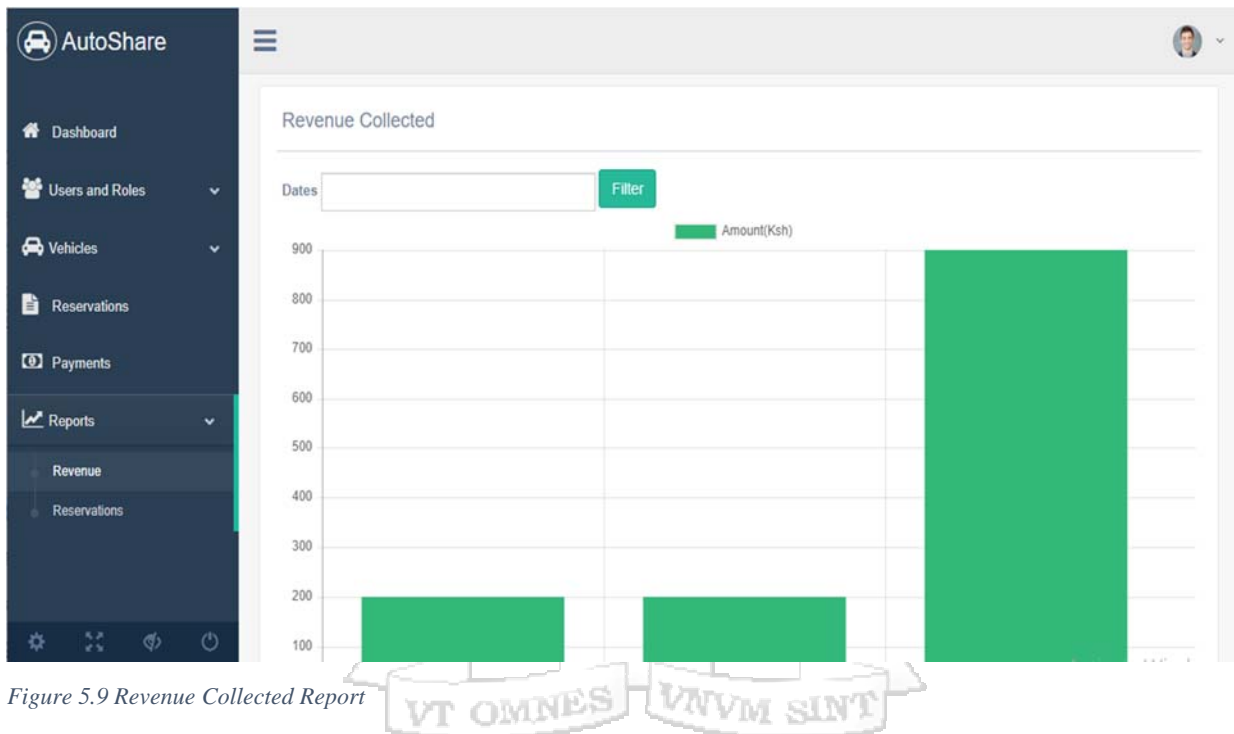


Figure 5.9 Revenue Collected Report

## 5.5 System Testing

This section describes the different tests that were performed on the car sharing system to ensure that it performs as expected. The tests conducted include functional testing, compatibility testing and usability testing. Usability testing was conducted by the selected potential users and the results recorded while the functional and compatibility testing were conducted by the developer.

### 5.5.1 Functional Testing

The system was tested to check if it conforms to functional requirements identified from the potential users. Unit testing as well as integration testing were conducted during the entire

development phase. Test results for user registration are as shown below in Table 5.3. Further test results are in Appendix F.

Table 5.3 User Registration Test

Test Name	User Registration		
Test Description	Testing whether the user can register using the mobile application		
Utilised Use Case	Register		
Steps	User Actions	System Response	Pass/Fail
1	User types in their details and selects save.	Confirmation message displayed after successful registration.	Pass
Comment	User input is validated and appropriate error message displayed.		
Test Pass/Fail	Pass		

## 5.5.2 Compatibility Testing

The mobile application was tested on various mobile phones running different android operating system versions to check if it functions correctly. Various Browsers were also used for testing if the web based backend would be accessible. The test results are shown below in Table 5.3

### Android Operating System Compatibility

The mobile application was tested on a number of phones running different versions of the Android platform. The results are as shown in Table 5.4.

Table 5.4 Android Platform Compatibility

Android Version	Version Name	Compatibility
5.0	Lollipop	Yes
6.0	Marshmallow	Yes
7.0	Nougat	Yes
8.0	Oreo	Yes
9.0	Pie	Yes

### Web Browser Compatibility

The web application was tested to determine if it would function correctly on different browsers. The results of the test are shown below in Table 5.5.

Table 5.5 Browser Compatibility Test

Browser	Versions	Compatibility
Microsoft Internet Explorer	4 and above	Yes
Mozilla Firefox	8.0 and above	Yes
Google Chrome	All versions	Yes

### 5.5.3 Usability Testing

Usability testing was conducted to determine if the system was easy to use. The car sharing system was provided to potential users of the system to test its usability. The user interface, ease of use, functionality and acceptability of the system were tested.

#### User Interface

The users were requested to rate the user interface of the application using a scale of 1 to 5 with 5 representing the system user interface being very good. The results are shown in Figure 5.10 below.

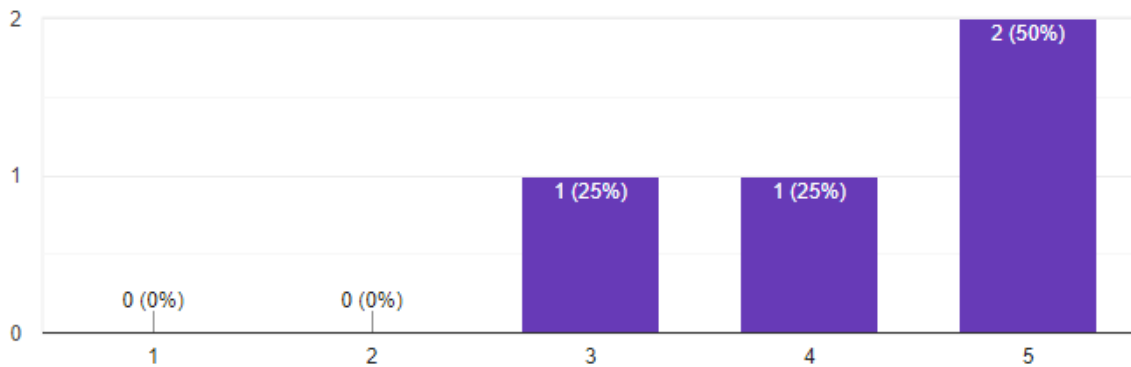


Figure 5.10 User Interface Response

#### Ease of Use

Potential users were requested to give their opinion if the system is easy to use. The options presented were either "Yes" or "No". All the respondents agreed that the system is easy to use as shown in Figure 5.11

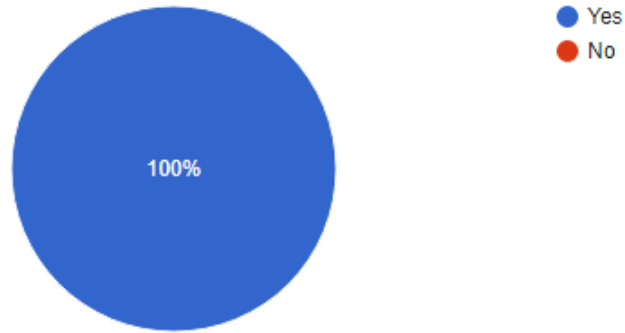


Figure 5.11 Ease of Use Response

### Functionality

The respondents were requested to rate the system on if it had met the functionalities that were indicated in the user requirements. The respondents were presented with a scale of 1 to 5 with five indicating the system had met all the requirements. Results are shown in Figure 5.12 below.

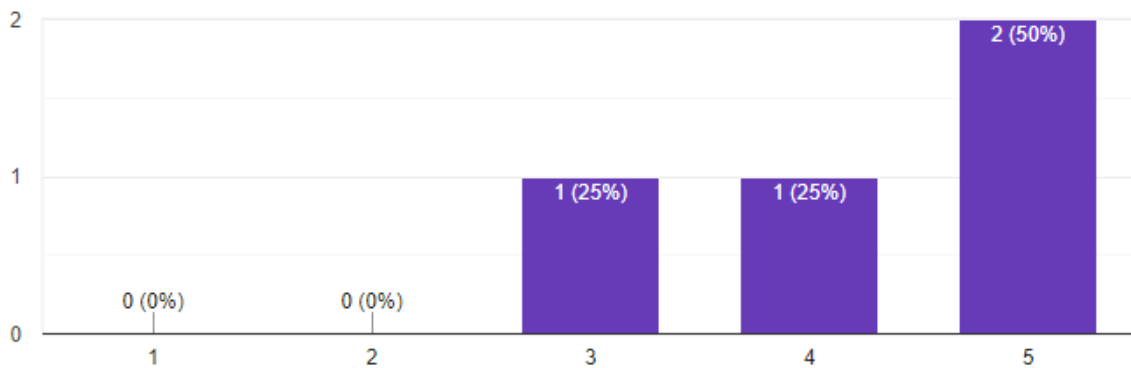


Figure 5.12 Functionality Response

## 5.6 Validation

The system validation was conducted via a survey given to five selected vehicle owners which was combined with the usability questionnaire. The respondents were asked if they think the system would be able to solve the car sharing problem. The options given were "Yes" or "No". All the respondents agreed that the system is capable of solving the car sharing problem as shown in Figure 5.13.

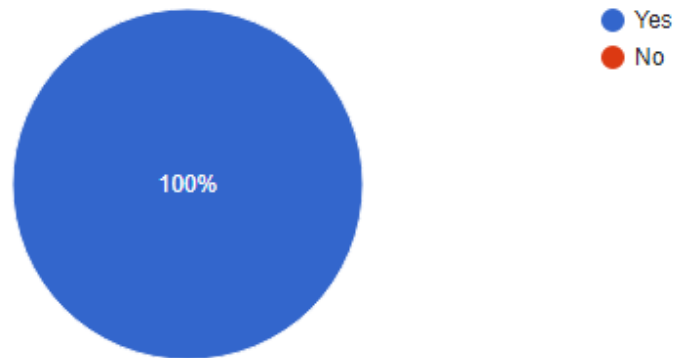
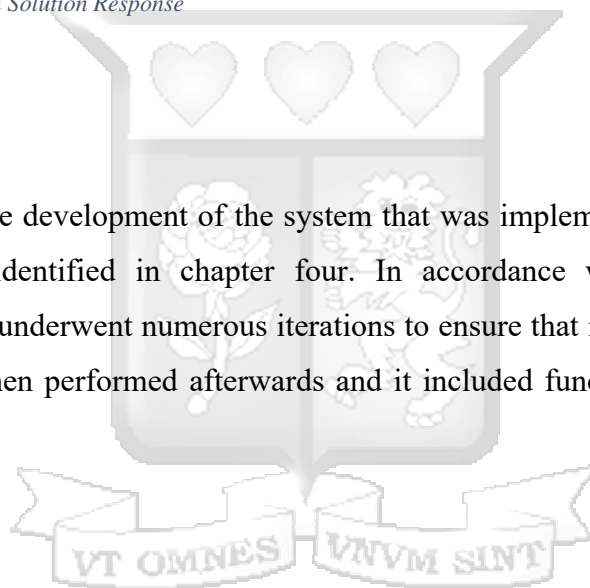


Figure 5.13 Car Sharing Problem Solution Response

## 5.7 Summary

This chapter describes the development of the system that was implemented in accordance with the user requirements identified in chapter four. In accordance with the Agile software methodology the system underwent numerous iterations to ensure that it met the requirements of the users. Testing was then performed afterwards and it included functional, compatibility and usability tests.



## Chapter 6 : Discussions

### 6.1 Review of Research Objectives in Relation to the Developed System

The car sharing system developed consisted of a mobile application and a web based backend. The system was developed in accordance with the research objectives which will be compared to the findings in this chapter.

### 6.2 Objective One

The first objective was to study the challenges faced by individuals sharing cars. The literature review revealed that car sharing has been facing a number of challenges thereby slowing its adoption. The main challenges identified included

- i. Liability in regards to insurance.
- ii. Trust between the users.
- iii. Costs incurred when sharing vehicles e.g. damage.

Sometimes the insurance policies for private vehicles might not cover the sharing of the vehicles and in some cases might lead to cancellation of the policy. This is a great challenge to the private owners who might want to share their vehicles in the case of Peer to Peer car sharing. Some companies have come up with additional policies for the shared vehicles when they are being rented out. A variety of means have been developed to help in providing reassurance and build trust among the users. Examples include social media integration, rating systems and limiting the sharing to environments such as workplaces and university campuses. In addition many companies require users to submit information and provide copies of relevant documents such as Driving licences and Identification numbers. Costs associated with sharing such as increased depreciation of the vehicle due to a higher mileage and risk of damage cannot be entirely eliminated. A system of maintaining user reputation can however help to reduce the risks involved. The survey conducted by the researcher confirmed that Insurance liability and costs incurred are the main concerns faced by the potential users of the system. 100% of the users selected costs as a concern while 50% selected insurance liability.

### 6.3 Objective Two

The second objective was to analyse current systems available for car sharing. This research aimed to identify the various car sharing types as well as the platforms that are available. A variety of

research resources were reviewed including online reports and journals to get the needed information. Three types of car sharing were identified namely Round Trip, One Way and Peer to Peer. One of the largest car sharing companies identified was ZipCar which makes use of the round trip model of car sharing. The research revealed that existing car sharing companies rely on technologies such as NFC, vehicle telematics and mobile apps to provide their services. NFC and RFID cards are used to gain access into the vehicle after which the user can start the car using the car keys which are usually left within the vehicle. Vehicle telematics aid in providing real time data by connecting the vehicle with the car sharing organization. Tasks such as maintenance and vehicle tracking can be aided through vehicle telematics. These technologies provide the car sharing clients with a better user experience by helping them easily find a vehicle and start the trip as fast as possible. A majority of the existing car sharing organizations with the exception of Locomute were found to provide their services in developed nations with very few operating in developing nations.

#### **6.4 Objective Three**

The third objective was to design, develop and test a mobile application to aid car owners in sharing their cars and enable renters to access them affordably. Requirements that were identified from the users were then used to develop the functionalities of the system. Agile software methodology was applied in the development and users participated in testing to check the usability of the system.

#### **6.5 Objective Four**

The final objective was to validate the developed application. Validation was done to ensure that the developed mobile application and web based backend adequately solved the problem outlined in chapter 1. The problem was to provide car sharing services so as to reduce the adverse effects of the increasing number of private vehicles in the cities. Validation was conducted through the use of a survey in which the users reported that the application managed to solve the problem.

## Chapter 7 : Conclusions and Recommendations

### 7.1 Conclusions

This research was aimed at providing a suitable solution for vehicle owners to share their vehicles when not in use as well as provide renters with a vehicle for short trips. Research indicated that private cars were idle for a majority of the time. It also aimed at solving the problems caused by an increase in private vehicles in urban areas by reducing the need to purchase additional vehicles. Information gathered from the potential users led to the formulation of requirements and implementation of a suitable solution. The mobile application and Web based backend was then developed according to the requirements and tested to ensure it worked as expected.

### 7.2 Recommendations

The system is more suitable for urban areas where users need vehicles for short trips. Peer to Peer car sharing aims to make use of vehicles when they are idle which would not allow for longer rental periods. The system should be hosted on a server with a Security Certificate to allow for HTTPS connection to ensure the user data is secure.

### 7.3 Suggestions for Future Work

Additional features for the car sharing system may include inclusion of vehicle tracking, development of a multiplatform mobile application and implementation of keyless access technology in the vehicles.

Vehicle tracking is an important feature that will allow for the vehicle owners to ensure that their vehicles are within the agreed upon area for the rental. This will serve to encourage the vehicle owners to join the system as the tracking will give them assurance that their vehicles are okay. Accurate location data will be important for the car rental company if any incident occurs such as a traffic accident so as to determine what happened. On the other hand vehicle tracking may enhance the usability of the mobile application for the car sharing users. The tracking might allow for the system to display the vehicle that is closest to the user in real time instead of the location provided by the vehicle owner when they registered the vehicle.

A majority of users have devices that run on the Android operating system however there are still a number that use other operating systems such as iOS. The mobile application can be developed as a multiplatform application this will accommodate a greater number of users.

Keyless entry systems make use of NFC or RFID key fobs or cards to allow for the car sharing users to gain access to the vehicle without having to interact directly with the owner. This technology if combined with vehicle tracking will aid to make it easier for a user to locate, access and begin his/her trip using the closest available vehicle. It will also aid in ensuring that the rental does not extend beyond the agreed upon duration as the keyless entry can be disabled automatically.



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## Appendix A: Questionnaire

### Car Sharing Survey

---

Thank you for participating in this questionnaire on car sharing. The responses gathered will be used in a research project.

What is your gender? \*

Female

Male

⋮

How old are you? \*

Under 18

18 -24

25 - 30

Over 30

Do you own a vehicle? \*

Yes

No

---

If you answered yes how many do you own?

- One
- Two
- Three
- More than three

Have you ever shared your vehicle e.g with a friend or colleague? \*

- Yes
- No

If not what would be your main reason for not sharing your vehicle?

Short answer text

---



...

### What are your concerns in regards to sharing/renting out your own vehicle

- Liability in regards to insurance
- Trust
- Costs involved e.g risk of damage and depreciation
- Convenience
- Other...

### Have you ever rented a vehicle for a particular trip? \*

- Yes
- No

### If yes what are your reasons for renting a vehicle?

- Lower costs compared to a personal car
- Inadequate public transport system
- Conservation of the environment by avoiding the purchase of a personal car
- Convenience of renting a vehicle compared to other transport options

**If you have previously shared your vehicle for how long did you share it?**

- 1 - 5 days
- 6 - 10 days
- 11 -15 days
- 16 - 20 days
- More than 20 days

**If you were to share your vehicle would you prefer to lend it to a man or woman?**

- Man
- Woman
- No preference

**Which of the following car sharing companies do you know of?**

- Dingah
- Komboa
- Other...

### How many kilometers do you drive per day?

- Under 20km
- 20Km - 50Km
- 50km - 100km
- Over 100Km

### Additional comments regarding car sharing

Long answer text

---



## Appendix B: Questionnaire

# Car Sharing Survey

Please rate the functionality of the system

1

2

3

4

5

Is it easy to navigate

Yes

No

If the answer above is no please write your reason

Your answer

---

Rate the system user interface

1

2

3

4

5

Does the system solve the problem of car sharing

Yes

No

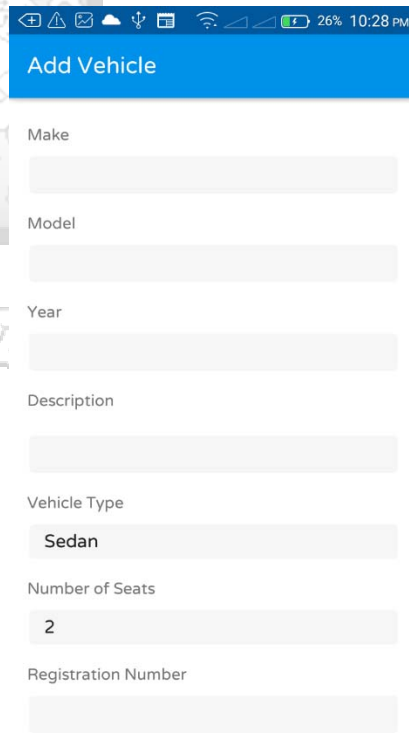
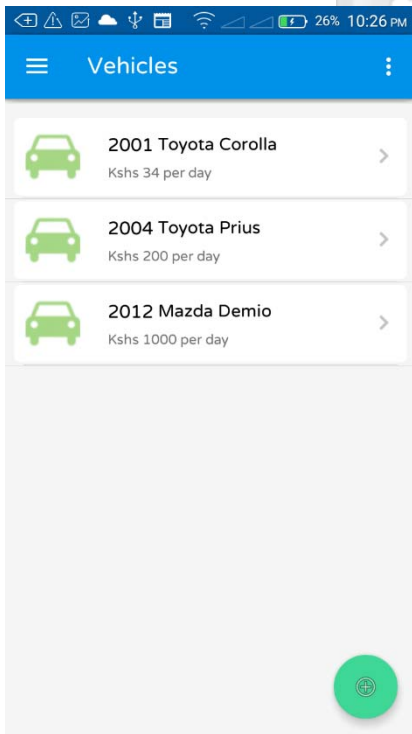
If the answer above is no please write your reason

Your answer

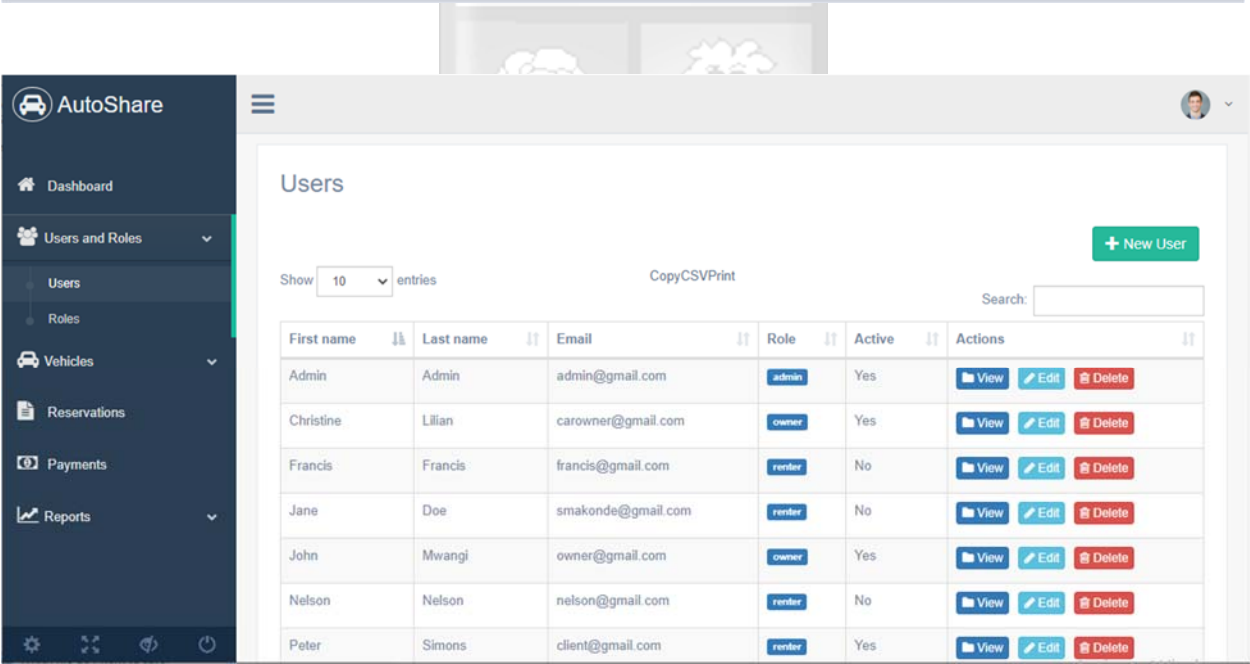
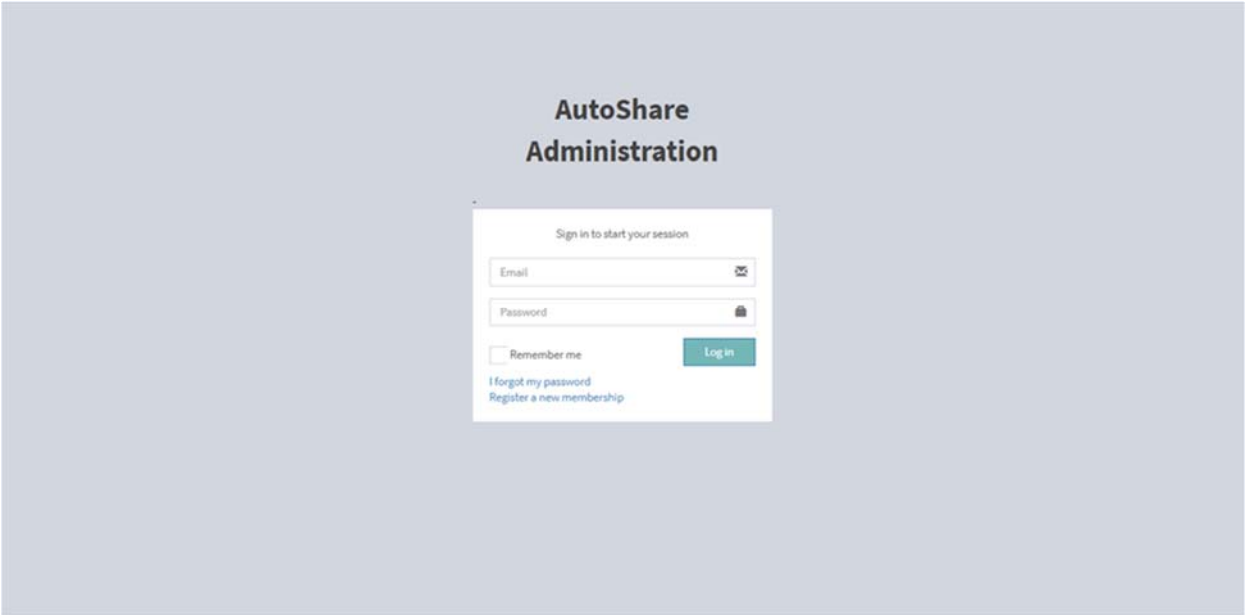
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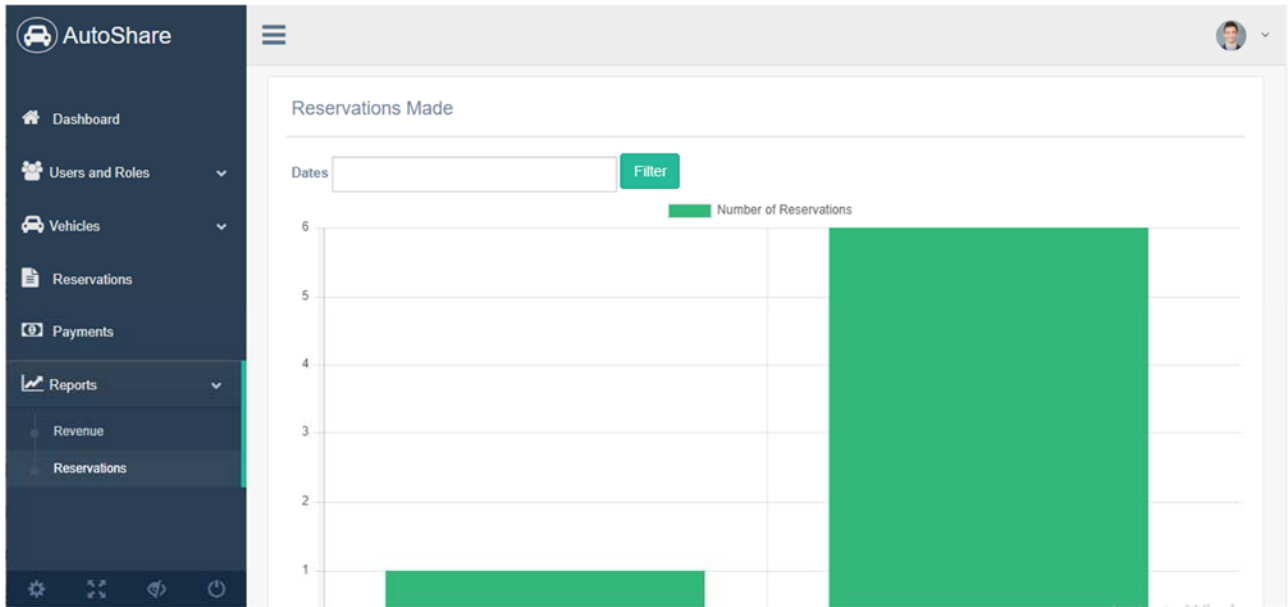


## Appendix C: Mobile Screenshots



# Appendix D: Web Backend Screenshots





## Appendix E: Mobile Application Wireframes



## Appendix F: Test Cases

Test Name	User Login		
Test Description	Testing whether the user can login into the mobile application.		
Utilised Use Case	Login		
Steps	User Actions	System Response	Pass/Fail
1	User types in their username and password and clicks login.	Application main page displayed after successful login.	Pass
Comment	System displays different views for car sharing client and vehicle owner based on their details.		
Test Pass/Fail	Pass		

Test Name	Register Vehicle		
Test Description	Testing whether the vehicle owner can add a vehicle on the system.		
Utilised Use Case	Register Vehicle		
Steps	User Actions	System Response	Pass/Fail
1	User selects vehicles option from the side menu.	A list of registered vehicles is displayed on the application.	Pass
2	User clicks on the add button.	A form is presented with input fields for registering a new vehicle.	Pass
3	User types in the vehicle details.	Confirmation of a new vehicle added.	Pass
Comment	Vehicle is added successfully and the details will be displayed when car sharing client searches for vehicle.		
Test Pass/Fail	Pass		

Test Name	Request Sharing		
Test Description	Testing whether the car sharing client can search for a vehicle, select the appropriate one then place a sharing request		
Utilised Use Case	Request Sharing		
Steps	User Actions	System Response	Pass/Fail
1	User enters search details and clicks on search	A list of vehicles matching the search criteria is displayed to the user	Pass
2	User clicks on one of the vehicles in the vehicle list.	The user is presented with additional details of the selected vehicle	Pass
3	User reviews details and clicks on request sharing.	System notifies user that a sharing request has been placed	Pass

Comment	The vehicle search takes into account the user's location to provide them with the closest vehicles.
Test Pass/Fail	Pass

Test Name	Approve Sharing		
Test Description	Testing whether the vehicle owner can review sharing requests made then approve one of the requests		
Utilised Use Case	Approve Sharing		
Steps	User Actions	System Response	Pass/Fail
1	User selects requests option on the side menu	A list sharing requests is displayed	Pass
2	User clicks on one of the sharing requests	The user is presented with additional details of the sharing request	Pass
3	User reviews details and clicks on approve sharing.	System notifies user sharing request has been approved.	Pass
Comment	The sharing approval only allows one request to be approved per vehicle.		
Test Pass/Fail	Pass		

Test Name	Make Payment		
Test Description	Testing whether the car sharing client can make a payment for the rental after the end of the rental period		
Utilised Use Case	Make Payment		
Steps	User Actions	System Response	Pass/Fail
1	User selects the rentals option on the side menu	A list of past and ongoing rentals is displayed.	Pass
2	User clicks on one of the completed rentals	The user views the details concerning the rental	Pass
3	User clicks on make payment button	System displays confirmation dialog	Pass
4	User approves confirmation	System displays success message	Pass
Comment	The user receives a push request from Mpesa which needs to be approved.		
Test Pass/Fail	Pass		

Test Name	Approve Users		
Test Description	Testing whether the administrator can approve newly registered users so that they can login and start using the mobile application.		
Utilised Use Case	Approve Users		
Steps	User Actions	System Response	Pass/Fail

1	Administrator clicks on the manage user menu option	A table with all the CRUD options is displayed	Pass
2	Administrator clicks on view details button	System displays the user registration details.	
3	Administrator clicks on approve user button	System displays a confirmation dialog	Pass
4	Administrator clicks on yes on the approval dialog	System notifies administrator that user has been approved and changes status to approved in the user table	Pass
Comment	The user approval will also notify the user via email		
Test Pass/Fail	Pass		



## Appendix G: Turnitin Results

Separate groups: MMTI

My Submissions

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Pre-defense Submission    Post-defense Submission

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