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RFID based model for tracking vehicles

Salesio Kinyua Njeru
Faculty of Information Technology (FIT)
Strathmore University

RFID Based Model for Tracking Vehicles

Njeru, Salesio Kinyua
46485

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Declaration

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

Njeru Salesio Kinyua

…………………………………….. Signature

……………………………………... Date

Approval

The thesis of Njeru Salesio Kinyua was reviewed and approved by the following:

Dr. Vitaliz Ozianyi,
Lecturer, Faculty of Information Technology,
Strathmore University.

Dr. Joseph Orero,
Dean, Faculty of Information Technology,
Strathmore University.

Prof. Ruth Kiraka,
Dean, School of Graduate Studies,
Strathmore University.

Dedication

I dedicate this project to God Almighty. He has been the source of my strength throughout this program. I also dedicate this thesis to my family and friends for their continuous encouragement and support, to all my classmates especially "smart farmers" for the support granted throughout the masters' period, the lecturers for their guidance and finally, to my supervisor Dr. Vitaliz Ozianyi, for his advice throughout the research period.

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Abstract

Transport departments in many institutions suffer from logistical delays caused by lack of accurate and timely information among stakeholders. Even though vehicle fueling and maintenance may be a huge percentage of total organizations running costs, existing methods for tracking vehicle movements still depend on human skills. These traditional paper-based data collection methods in these organizations are time and labour-intensive, full of errors, and unreliable due to reluctance of the mandated personnel to monitor and record the correct information.

Even though we have witnessed advances in Automated Vehicle Tracking (AVT) technologies which are technically, economically feasible and viable, organizations have faced challenges in adopting the AVT technologies. This has been because the tracking needs for these organizations are unique due to the nature of work they do. Privacy concerns of the drivers is also another reason why the available AVTs do not fit into these organizations. In order to investigate the challenges of adoption of AVT technologies and to present a solution to the task of tracking organization vehicles, this study provides a useful insight into the AVT technologies adoption barriers within the organizations.

In view of these, a model for integrating the latest innovations in AVT technologies for real-time data collection in transport was proposed. A combination of Radio Frequency Identification (RFID), Global Positioning System (GPS), and Global System for Mobile Communications (GSM) technologies was proposed in this study. The RFID model for tracking vehicles will facilitate extremely low-cost infrastructure solution to uniquely locate and track vehicles and driver behaviour instantaneously. The model aims at eliminating human error associated with data collection process during tracking vehicles in organizations.

Key Words: GPRS, GPS, GSM, RFID, Work Ticket

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List of abbreviations

AVL - Automatic Vehicle Location

AVT – Automatic Vehicle Tracking

API - Application Programming Interface

DFD - Data Flow Diagram

ERD - Entity Relationship Diagram

GIS - Global Information System

GOK - Government of Kenya

GPS - Global Positioning System

GSM - Global System Mobile

GUI – Graphical User Interface

HTTP - Hypertext Transfer protocol

ICT - Information Communication Technology

MMS - Multimedia Message Service

NGO – Non-governmental organizations

NTSA – National Transport and Safety Authority

OOA -Object-oriented Analysis

OOD - Object-oriented design

RFID - Radio Frequency Identification

RSSI - Received Signal Strength Index

SMS - Short Message Service

Definitions of terms

Android - Android is a Linux-based, open-source operating system designed for use on cell phones, e-readers, tablet PCs, and other mobile devices (Educause, 2010).

Microcontroller - A small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals (dharm, 2012).

Chapter 1: Introduction

1.1 Background of the Study

With diminishing finances, it is rarely possible for an organization to have enough vehicles to fulfil their transport needs. What is available is only a portion of what institutions need (Cahill, 2012). Proper utilization of resources is the best way to cope with the ever-increasing challenges: increased transport needs, traffic jams, driving competencies and infrastructure, inflated costs of procuring new vehicles, and staffing needs. However, although these challenges have continued to prevail, companies are in the forefront to find better ways to manage their fleet.

Tracking consists of detecting and monitoring locations of objects, possibly using several types of sensing for example GPS. Tracking has been used in air traffic control, fleet tracking, habitat monitoring, mobile telephony (Techrepublic, 2013). Object tracking is effected with the aim of routing, dispatch, onboard information and security monitoring functions. It also done to encourage a safer, more cost-effective driving among drivers. Other benefits include reduced administration costs associated with wear and tear (Iqbal, Noreen, Sabir, & Afghani, 2014).

Benefits associated with object tracking are almost realized instantly. It is easier to react to situations making it faster to make decision. Tracking also improves security for drivers. (Ting, Wang & Ip, 2012). Tracking in transport management is a way of improving company or institution efficiency. This leads to running a profitable business especially for businesses that own large vehicle fleets (Chen & Hu, 2006). The tracking system enables a company or an individual locate vehicles. This information is used by a manager to make important decisions like rerouting in case of traffic congestion (Obuhuma, & Moturi, 2012)

Studies suggest that GPS technology can provide improved vehicle tracking; however, there are adoption challenges when it comes to organization vehicles due to the uniqueness of their work. (Elshafee, ElMenshawi & Saeed, 2013). Due to privacy concerns institutions cannot track vehicles usage using GPS found in mobile phones of drivers therefore there the need to introduce a unique model for tracking movement of these vehicles (Lin, 2008). In an effort to overcome the challenges posed by the off shelf AVTs this study aims at assessing and developing an RFID and GPS based model for tracking vehicle in such organization.

1.2Problem Statement

Drivers and employees have blamed institutions for not putting enough measures to curb vehicle misuse. For example, there have been several debates in parliament regarding illegal use of institution vehicles (Senate Hansard, 2015). Recently a police vehicle was stolen and the police did not know its whereabouts (Ndunge, 2016). The police had to warn citizens to be vigilant because the vehicle could be used to commit crime. This is an indicator that the current measures put in place to track institution vehicles are ineffective.

Public officers and organization employees use organization vehicles to run personal businesses. The logistics personnel on the other hand has no control of the vehicle once it has been dispatched. This affects service delivery because many delays are realized. Most of the time you will find institutions requesting for more vehicles while they cannot account for the hours in service for the vehicles that they already have (McCormick, 2014). Deploying off shelf AVTs will not provide a solution since the transport managers do not know whether it is the authorized driver driving the vehicle once he leaves the station.

Therefore, it is important to address this subject matter through an RFID and GPS based vehicle-tracking model. This will enable transport managers and logistics personnel to know the whereabouts of a particular vehicle and the driver authorized to drive the vehicle. With this information, they will be able to make transportation decision efficiently.

1.3Research Objectives

The overall objective of carrying out this research is to develop a model for tracking organization vehicles. This will aid the logistics and transport managers in those organizations plan for transport needs. It will also reduce misuse of organization vehicles by drivers and employees. The specific objectives of this study are:

(i) To identify challenges experienced by transport managers in organizations while tracking vehicles.

(ii) To appraise models and architectures that can be used to track vehicles

(iii) To develop a model for tracking organization vehicles

(iv) To test tracking model

1.5 Research Questions

(i) What are challenges experienced by transport managers when tracking movement organization vehicles?

(ii) How can the appraised AVTs be used to develop a model for tracking organization vehicles?

(iii) How can current technology in vehicle tracking be utilized by transport managers in organizations?

(iv) How can the model be tested in the proposed study sample?

1.6Significance of the Study

This research may help establish how effective the introduction of a vehicle tracking model in an organization. The success of this research may guide organizations effectively track movement of their vehicles. The results will help increase accountability amongst drivers, transport managers and other employees.

This research may also be important to scholars as it may add to the existing body of knowledge. It may also complement previous research done on vehicle tracking models for various businesses. It may provide a platform for further research.

1.7Scope of the Study

The study was aimed at assessing and developing a vehicle-tracking model for organizations and institutions. This is because an effective model may go a long way in ensuring accountability and efficiency in use of organization vehicles. This study was conducted in the year 2017.

1.8 Study Limitations

The nature of the study calls for confidential information related to the government operations and police check unit that is mandated by the government to prevent misuse of government vehicles. Semi-Autonomous Government Institutions (SAGAs) and Commissions in State Law Office and Department of Justice were selected as the as representative of the other organizations. Respondents may feel intruded when requested to complete a questionnaire that require them to disclose such information. In order to mitigate these shortcomings, the respondents were assured of confidentiality and ethical handling of the information.

Chapter 2: Literature Review

2.1 Introduction

In order to understand the concept and investigate the research problem, an empirical framework is presented in the form of a review of the challenges currently experienced by transport managers in tracking organization vehicles. Significant publications by accredited scholars and researchers are further reviewed to present a theoretical framework. This is composed of the concept of tracking vehicles using GPS, RFID and GSM technologies. A conceptual framework that aggregates the context is then presented as a culmination of the literature review.

2.1.1 Vehicle Tracking

In the last decade, the research on and the technology for outdoor tracking have seen an explosion of advances. A vehicle tracking device is an outdoor geolocation application in which vehicles can be located using GPS or any other technology while in motion. Initially vehicle tracking systems developed for fleet management were passive. In a passive tracking system, a hardware device installed in the vehicles stored GPS location, speed, heading and trigger event such as key on /off, door open/closed. When a vehicle returned to a specific location, the device would be removed and data would be downloaded to computer (Ganesan, Kumar, & Banu, 2008).

Passive tracking also included auto download type that transfer data through wireless download but it was not real time. Passive systems weren’t useful to track consumer’s vehicle for theft prevention. Real time tracking system was required that can transmit the collected information about the vehicle after regular intervals or at least could transmit the information when required by monitoring station. Active systems were developed that transmit vehicle’s data in real time via cellular or satellite networks to a remote computer or data centre. GPS tracking uses elements of both time and location to provide data points for the user (Kamel, 2015).

Active tracking uses GPS, which is a satellite navigation system that receives data from satellites in space. GPS tracking can be used to track vehicles, equipment, mobile phones, people, animals, and more. The GPS signal is transmitted from a device (either stand alone or a mobile phone) and the time and location data is sent to the satellite. The GPS tracking information is processed and then sent to a data center for storage (Letham, & Letham, 2008).

GPS vehicle tracking can be an important money-saving tool for small, medium, or large sized business. For companies with a fleet of vehicles, GPS tracking may be able to help reduce fleet idle times, improve routing operations, and better customer service. As a result, businesses may be able to lower overhead business costs (Kenya National Assembly Hansard, 2009)

2.1.2 Transport in Organizations

Transport in any organization or institution is complex and dynamic. It involves quite a number of resources that work together with varying activities which include;

i. transport of parcels to other offices, relief items in hunger or conflict stricken areas of the country,
ii. transport of staff coordinating or delivering services, and
iii. Transport of staff and materials related to development programs for example building schools, hospitals, water sanitation (Abdul, Xing, and Hubo, 2012).

The ability to track and exactly locate vehicles and in real time and distribute the information to transport managers is critical to an effective transport management. A model for tracking organization vehicles is desirable (Kenya National Assembly Hansard, 2016). Relying on the current method of capturing important transport data is always a challenge. This is because the information if erroneously reported or the transfer is delayed may make it not possible for transport managers to make correct decisions.

Drivers collude with fuel attendants in filling stations to fill in less fuel and share the remaining money. The transport manager is left to explain why the cost of fueling the vehicles under his watch is so high. Other employees use the vehicles to carry out personal business or driver lend these vehicles to their colleague to run personal errands. All these have led to high transport costs which organizations have been struggling with for a long time.

GPS tracking is the most commonly used method of tracking objects. The problem with GPS is that it cannot be used reliably indoors or underground since it cannot get radio waves from satellites (Nobuhiko, 2016). Another method to track vehicle movement is through closed circuit television (CCTV). (Leung, 2008). But CCTV has its limitations. Aline of sight is required Video cameras require, even so data amount to process is quite huge and camera lenses do not last for long. RFID technology does not capture the movement of an object from one point to another and therefore alone will not be effective to track vehicles in motion. Therefore, there is need to combine technologies to realize tracking of vehicles for organizations.

2.3 Tracking Technologies

2.3.1 Object Tracking and Monitoring using GPS, GSM, GPRS

GPS is a navigation system based on approximately 24 network. The satellites were launched into orbit by the U.S Department of Defense. The configuration is made up of three segments highlighted below:

(i) **Space segment** - There are 24 GPS satellites which orbit the earth. Each GPS satellite transmits a signal to the GPS receiver on the ground. The GPS receiver then calculates the distance to the satellites. Eventually, information such as the coordinates of current location, time and speed can be retrieved from the receiver (Ahmed, 2006).

(ii) **Control segment:** The control segment comprises a master control station which has five ground stations located around the world. They ensure that the satellites are functioning as expected. The main control station (MCS) is located in the United States. GPS satellites use the ground stations to determine, the location of the satellites and the status of atomic clocks among other things (Langley, 2009).

(iii) **User segment:** The user segment comprises GPS receivers that are designed to decode the signals from the satellites in order to determine the position, velocity and time of the receiver. There are two types of service available to GPS users;

a. the civilian (SPS)

b. the military (PPS).

GPS is free to anyone in the world (Ahmed, 2006).

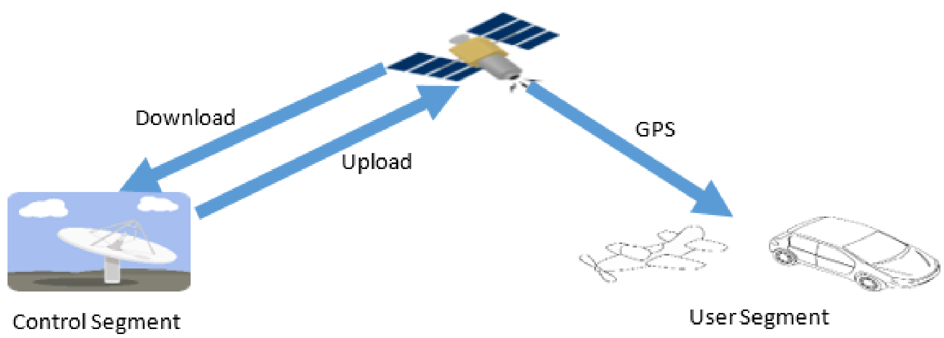

Figure 2.1: Segments of GPS

In the transport industry GPS has seen been used to track assets in transit (Navon, 2008). Some of the challenges of tacking using GPS are:

1. It experiences signal blockage indoors or in built up areas.
2. It creates an incorrect reading when the receiver antenna is placed close to a reflecting surface since the signals hit the surface first before being reflected into the antenna.
3. The signal speed is affected by a variation in earth ionosphere (Majrouhi, 2010).

2.3.1.1 GPS Position Determination

The satellite of GPS will transmit the one-way signal to the GPS receiver equipment on the earth. Every satellite transmits the data that indicates its location and the time they sent out the signal. The timing information plays an important role in determining the users' location on the earth. Thus, GPS satellites are equipped with atomic clock on board to provide an accurate time reference. The distance between the particular satellite and the GPS receiver as shown in figure 2.2 can be determined by calculating the travel time of a signal from the satellite to the receiver, where:

Travel time = signal reception time - signal transmission time

Distance = Travel time x Speed of light

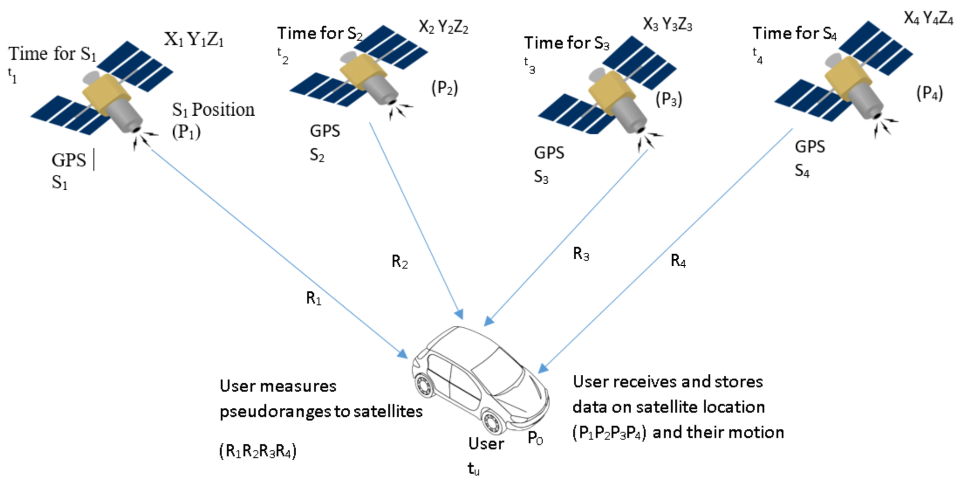

Figure 2.2: GPS Position Determination Technique

2.3.1.2 Global System for Mobile Communication (GSM)

The Global System for Mobile Communication (GSM) is a communication system that originated from Finland, Europe and was developed by using digital technology. GSM is a 2G technology that is implemented globally and is used to transmit voice and low volume digital data service. Examples of low volume digital data are Short Message Service (SMS) and Multimedia Message Service (MMS). Besides that, GSM has four frequency ranges which are 850MHz, 900MHz, 1800MHz and 1900MHz. In Kenya, the GSM standard uses the 900MHz and 1800MHz (Safaricom, 2016).

2.3.1.3 General Packet Radio Service (GPRS)

General Packet Radio Services (GPRS) is an upgrade of the basic features of GSM. GSM and GPRS systems provide inter-working and share the resources between the users. GPRS can be used to track the subscriber's location when connected to the mobile network.

The standard GSM network, to transmit data in packet-switched mode has to be altered to support GPRS. There are several advantages of using this technology, it allows the user to connect to internet all the time and communicate on a worldwide scale.

2.3.1.4 Vehicle tracking using GPS, GSM, GPRS and Google maps

In 2011 Amir massoud developed a fleet tracking system using geographic information system (GIS) technologies, the GPS and GPRS. The system could display the location of moving vehicles with an error less than 50m in real time on the Map. It was expected that the full implementation of the system would ultimately replace the traditional and costly SMS based tracking systems. The system is shown in figure 2.4.

In their research they introduced the means of using GPRS for transmission instead of SMS for low cost tracking.

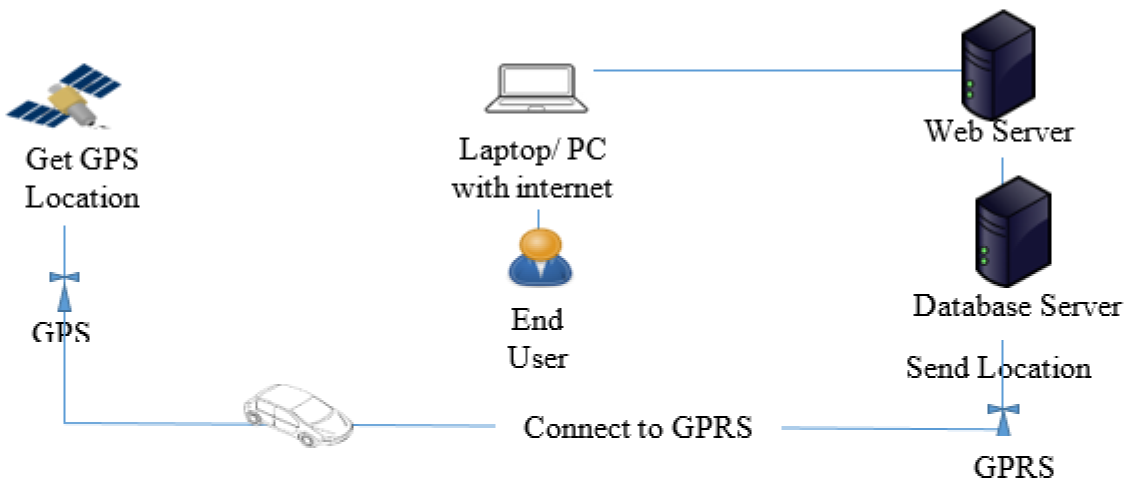

Figure 2.3: Tracking using GPRS instead of SMS

The combination of the GPS and GPRS provides continuous and real time tracking. The cost is much lower compared to SMS based tracking systems. GPRS was used for data transfer instead of the SMS. To reduce the total system cost, a single GSM/GPRS/GPS was used instead of using separate devices. Using free Google map Application Programming Interface (API) and Hypertext Transfer protocol (HTTP), the service cost was reduced dramatically. In their research, they used a single module that consisted of GPS, GPS and GPRS instead of separate devices. The system used GPRS for reducing the costs and using free map services instead of using SMS service.

2.3.3Tracking using Radio Frequency Identification (RFID)

Radio Frequency Identification(RFID) is a wireless sensor technology that comprises of RFID tags and readers that use electromagnetic signal detection to communicate through Radio Frequency (RF) signals within a reasonable range (Ahson, & Ilyas, 2008). A reader detects the existence of tags within the read range by emitting signals to trigger the tag to return back with an identification signal. There are two types of RFID tags, passive and active. The passive tag work without connection to an external battery and depends on the signal from the reader to operate and therefore has lower read range due to weak signals. It is read-only due to its small storage capabilities. It's main advantage over the active tags is that it has unlimited life span (Ahson, & Ilyas, 2008).

Active tags have internal battery and a longer read range. Though they have a limited life span, they have both read/write and a larger data storage capability. RFID Tags could also be categorized based on the frequency of operation (low, high, ultra-high and microwave). 124 KHz, 125 KHz and 136 KHz are low frequency; 13.5MHzis a high frequency and 400MHz to 960MHz an ultra-high frequency (Andoh, Su, & Cai, 2012). A high frequency tag yields a longer read range. The reader can be a handheld or stationary with an inbuilt antenna that transmits signals to the tag. The read range varies from one system to the other.

In the motor vehicle industry, RFID has been applied in many different areas and on different resources. RFID technology has been used in tracking material delivery trucks (Andoh, 2012). This concept established that RFID is a feasible tracking technology in tracking assets if the barriers of implementation are overcome.

2.3.2 How RFID Works

In Figure 4.2 shows how RFID works. Data within an RFID tag's microchip waits to be read. The tag's antenna receives wireless Radio Frequency signals from an RFID reader's antenna, with a message for example, request for information, generated via the host computer. Using power from its internal battery or power harvested from the reader's electromagnetic field, the tag sends a radio wave message back to the reader. The reader then picks up the tag's radio waves and interprets the frequencies as meaningful data. Finally, the reader passes the information, wirelessly or through a docking station, to the host computer for processing and interpretation. The interpretation is done by an intelligent program that uses business rules (Miles, 2008).

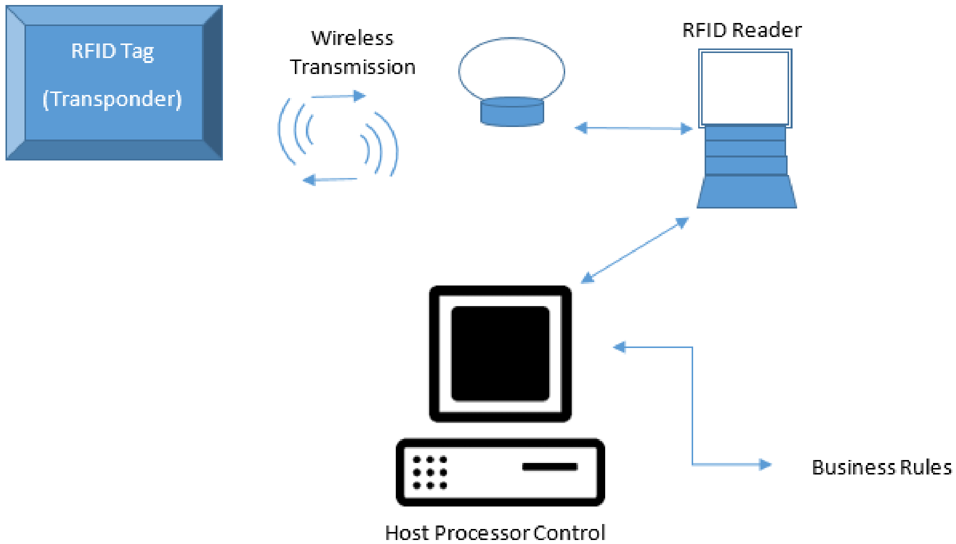

Figure 2.4: How RFID Works

The main challenges of the RFID system are:

(1) signal strength fluctuation due to environmental factors such as metals and atmospheric moisture that affects the transmission.

(2) The reader does not provide the distance, location or direction of the tag but can only detect the existence of a tag within a reasonable range.

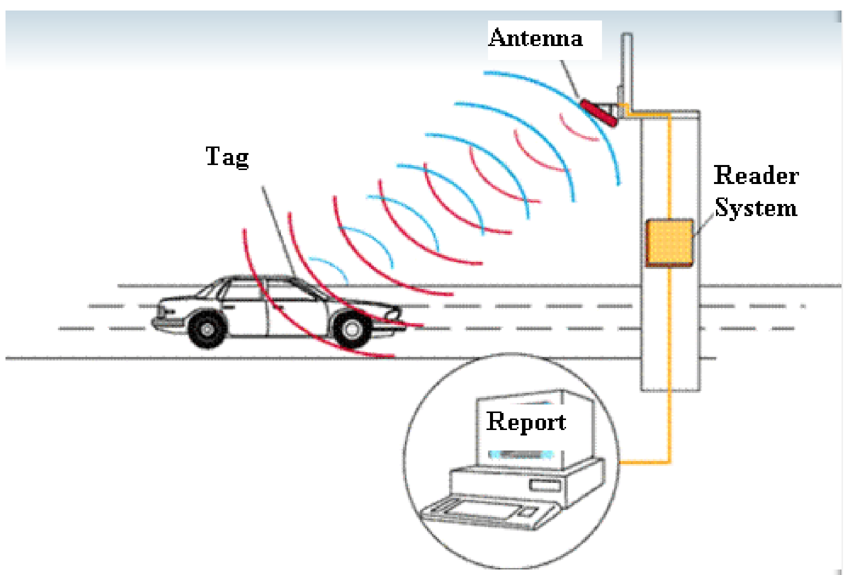

Figure 2.5: Vehicle Tracking Using RFID

2.4 Tracking Methods Comparison

All these methods have some features and limitations which are define in the following table:

Table 1: Tracking Methods Comparison

Method	Method Components	Advantages	Disadvantages
GPS	Satellite GPS Unit Microcontroller (data processing in standalone application)	Ease of navigation and localization. Search based on an area World Wide availability	Obstacles deflect the signal Signal multipath, fading, diffraction
GPS and GSM	Satellite, GPS Unit, Server, GMS Unit, Micro controller	Ability to use repeaters. It provides a stable network. User or Subscriber can switch over network. Roaming type issues is not available.	Fixed maximum cell coverage area. high complexity
RFID	RFID Transceiver, GPS Unit, GSM Unit, Satellite, Server, Antenna, Transponder, RFID Tag	Does not require line of sight to be clear. Easy to perform data update. Human interaction is not required. easy mount anywhere due to its small size and weight	Only 8 frequency band is available. It has no any standard. Difficult for RFID reader to read data from the RFID tags which is in the liquid and metal

2.5 Uber Application

Uber is a technology platform where smartphone apps connect driver-partners and riders. A rider requests for a ride through the rider mobile application. When a nearby driver-partner accepts the request, the rider app displays an estimated time of arrival for the driver-partner heading to your pickup location. The app notifies you when the driver-partner is about to arrive.

The rider app also provides info about the driver-partner with whom they will ride, including first name, vehicle type, and license plate number. This info helps the two of you connect at the pickup location. The rider can enter preferred destination any time before or during the ride. When one arrives at their destination and exit the vehicle, the trip ends. Fare is automatically calculated and charged to the payment method linked to the Uber account. Immediately after a trip ends, the app will ask you to rate the driver from 1 to 5 Stars. Driver-partners are also asked to rate riders. Uber's feedback system is designed to foster a community of respect and accountability for everyone.

2.5.1 How Uber works

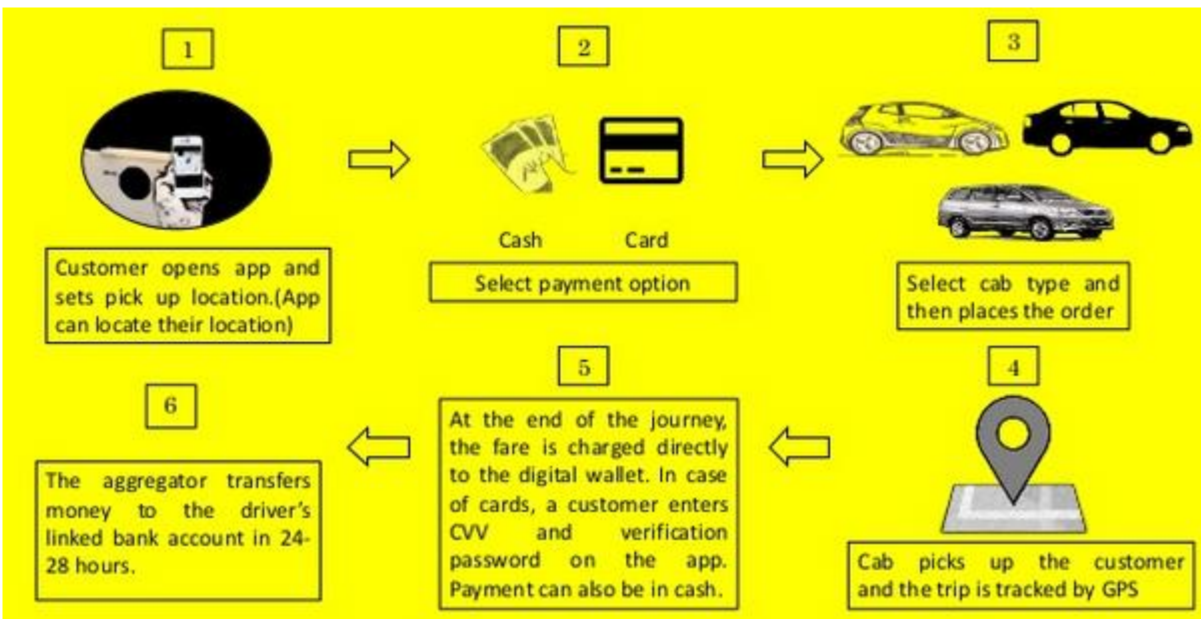

Figure 2.6: How Uber works

2.5.2 Problem with Uber AVT model

Uber being a business supporting app will not work for institutions because the driver can decide to switch off his mobile phone or even logoff from the application. For organizations, is it important that the transport manager is aware of the vehicle and driver whereabouts for proper tracking (Martinez, Stapleton, & Wassenhove, 2011).

2.6A Conceptual Model Architecture

This research presents a conceptual framework that integrates GPS, RFID, and GPRS to track organization vehicles. The model consists of RFID readers and passive tags, GPS receivers communicated to a central server through GPRS. The model operates in four interrelated stages:

(1) Data collection is carried out by using

a. RFID readers in the vehicle dashboard to detect RFID tags that uniquely identify the vehicle and the driver;

b. GPS receiver placed in the vehicle

(2) Modules transfer data to the central server via communication networks;

(3) Server filters the data to estimate the continuous location of targeted vehicle in real-time and the driver who is driving the vehicle.

(4) Application manages the data and graphically displays the locations of vehicles over time

(5) information used to make decisions.

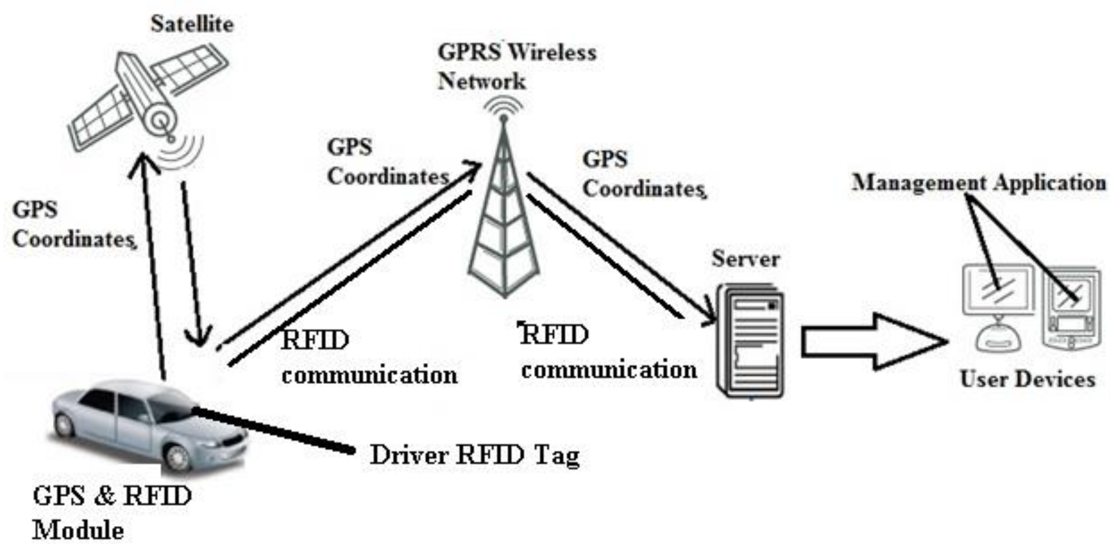

Figure 2.6: Conceptual Framework of the RFID based model for tracking vehicles

Chapter 3: Research Methodology

3.1Introduction

The previous chapters of this research, introduced a research problem, justified investigating it and proposed a framework of research for the investigation. In order to do that, research objectives were defined and finally the proposed framework lead to design of questions to be answered in this thesis. In this chapter the research design will be discussed, that is how the research questions will be answered throughout the research.

Research design defines the general plan for the research whereas research tactics is concerned with details of data gathering and the method of analysis to yield the answers to designed questions (Saunders, Lewis and Thornhill 2007).

3.2 Agile Software Development Methodology

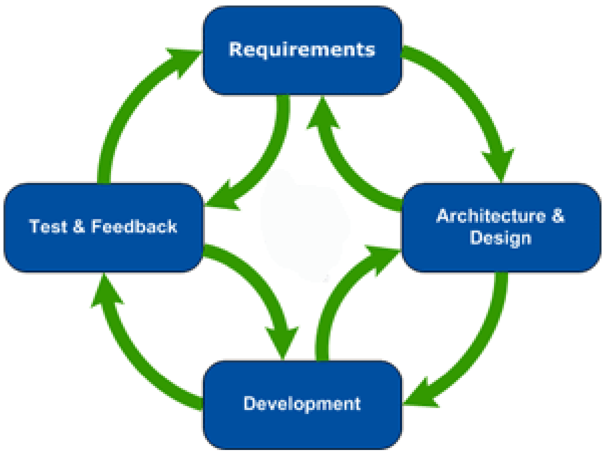

Figure 3.1: Agile software development

Agile software development method allows for faster iteration and more frequent release with subsequent user feedback. Agile processes allow release schedule and user feedback opportunities. This allows faster and more controlled improvements (CPrime, 2014). Figure 3.1 shows the steps followed in the research to achieve the set objectives for this study. the steps are;

1. **requirements** which involves the collection of the intended product specification or features and specifying what it should do or how it should do it.
2. **architecture and design-** includes defining the architecture and design of the model.
3. Development of the model which also involves implementation.
4. **Test and feedback-** allow the product improvement. The developed applications were tested independently during every development iteration. The data flow between the

different components is also tested to ensure complete test coverage. Testing the application will make sure that the needed functionalities are working as required.

3.3 Research Design

This study incorporates qualitative and quantitative methods of research. Qualitative research objective is used to get an enhanced understanding through truthful reporting, firsthand experience, and citations of actual conversations. This was used to understand the current methods used to track and monitor institution vehicles. The quantitative research was used to see the number of people who would like use the new model or think it is a good idea (California State University, 2012).

3.3.1 Model Architecture

The model composed of two major sections; the controller installed in the vehicle installed and the web application.

The controller is composed of Arduino Uno R3, GSM module, GPS module and RFID module. The web application was constructed with PHP and MySQL database management system was used to store application data for web application. MySQL database is open source and provides full compatibility with PHP. The position of a vehicle will be viewed on Google maps using Google Maps API for Map Geocoding embedded into the web application using a JavaScript.

3.3.2 System Analysis

There are 3 approaches in information system development section; data-oriented, process oriented, and object-oriented approaches. The object-oriented method, unlike its two predecessors that lay emphasis either on data or process, combines processes and data into single entities called objects (University of Missouri, 2001).

Object-oriented Analysis (OOA) is the concept used in this research. OOA escalates the understanding of problem domains because it promotes a smooth transition from the analysis phase to the design phase and offers a more ordinary way of establishing specifications.

This study focuses on use-case modeling and class modeling to explore the various approaches that are conducted in the analysis of the model. In the object-oriented development life cycle, use-case modeling is established in the analysis phase. Use-case modeling is done in the initial stages of development to help the developers gain a perfect understanding of the functional requirement without worrying about how those requirements will be applied (University of Missouri, 2001). A use-case model consists of use cases and actors. An actor is an external entity that interacts with the model and a use-case denotes a sequence of interrelated activities initiated by an actor to achieve a precise objective (Hoffer, 2001).

3.3.3 System Design

Object-oriented design (OOD) techniques will be used to refine the object requirements definition identified during model analysis and to define design specific objects. Design class diagram will be used for general conceptual forming of the software systematics. Design class diagram involves comprehensive modeling to translate the models into programming code and for data modeling (Sparks, 2001). The research will adopt design class diagram to embrace classes which comprise the main methods, objects and interactions of the model. Entity Relationship Diagram (ERD) will also be used to demonstrate the relationships between objects and events within a model. It will enable the researcher to outline business procedures and to develop associations between entities and their characteristics in a relational database (TechTarget, 2010).

3.3.4 Model Implementation

PHP was used to develop the server side of the tracking model. MySQL was used as the relational database management system. MySQL was preferred because it is open source and cross platform. PHP was chosen because it is fast and platform independent (Sakshay, 2013). HTML is the markup language that helped to structure and present content in the web backend dashboard.

The vehicle installed controller components were integrated through soldering and pin configuration procedures. The GSM module, GPS module, RFID module, were connected to Arduino Uno R3. Arduino IDE was used to run C++ code in the processor which enabled communication between components. An GPRS to web gateway was implemented as the communication channel between the controller and the web application.

3.3.4 Model Testing

Model testing was divided into two major sections, developer testing and user assessment testing. Developer testing was carried out to ensure that the functionalities were working well. Developer tests included: unit testing, integration testing, compatibility testing and functionality testing. These tests were carried out at different stages of development. User assessment testing aimed at getting the users feedback on the working model (Belatrix, 2015).

3.4 Target Population

The research was carried out in the institutions under the State Law Office and Department of Justice in Kenya (Appendix 2). The target population, transport managers' seeking to track and monitor vehicles under their management, comprises of persons mandated to provide transport and logistics services in the institutions. The target population were interviewed to evaluate the applicability of the proposed model.

3.5 Sample Techniques and Sample Size

A sample is a subset of a population. It is important to consider whether sampling is necessary in a study. Several factors influence the decision of whether to sample or not. These include convenience, representativeness, cost and the nature of data to be collected (Borg & Gall, 2007).

Fostgate (2012) recommends that a formula should be used for calculating the sample size from a population. The choice of the formula depends on the margin of error and the proportion chosen.

Other studies that have used this formula include; Fostgate (2012), Georgiadis, Johnson and Gardner (2005) and Dohoo, Martin and Stryhn (2003). Since the population of staff in the Kenyan SAGAs and Commissions linked in the State Law Office and Department of Justice in Kenya and transport managers in Nairobi is large, the study will adopt the formula below to come up with the sample size to be used in this study. Where:

$n =$ $NZ^2x0.25$ **Equation 3.1 Random Sampling (archive-edu, 2013)**

$[d^2x(N\text{-}1)] + (Z2x0.25)$

n = Sample size

N = Total Population size (known or estimated)

d= Precision level (usually 0.10 or 0.05)

Z = Z statistic for a level of confidence (e.g. 1.96 for 95% confidence level)

Equation 3.1 shows the formulae that was will be used to derive the sample population, this means that each person had an equal probability of being in the sample population.

Table 3.1: Sampling Distribution

Type	**Population**	**Sample Size**	**Percentage**
Estimated Staff in SAGAs and Commissions in the State Law Office and Department of Justice in Kenya	3000	341	100%
Total	3000	341	100%

$n = 3000 \times 1.96^2 \times 0.25$

$[0.1^2 \times (3{,}000 - 1)] + (1.96^2 \times 0.25)$

n = 341

The questionnaire and interviews will be conducted with a sample size of 341 respondents.

3.6 Data Collection Procedure

A wide range of data collection instruments can be adopted in research including but not limited to interviews, questionnaires, observation guides and focus group discussions. This research utilized primary data in order to answer the stated research questions and as such, the study adopted a questionnaire. questionnaires were distributed to each of the institutions offices selected for the sample. An online questionnaire was also sort to supplement the paper questionnaire. Interviews were carried out among drivers and transport managers in the institutions selected. Interviews for expert opinion were also sort. Five interviews were carried out from experts in the fields of logistics and vehicle tracking.

The questionnaire and interview questions are found in Appendix A. The two methods make data analysis easier for it is possible to convert the responses to quantitative form by assigning numerical codes to each response (Upagade & Shende, 2012).

3.7 Data Analysis Procedure

The research data used context analysis to analyze. In validation of study objectives, user and requirements directed content analysis was used. Research objectives and user requirements helped to determine the initial development scheme. As guidance for initial codes, a directed approach analysis begins with relevant research findings or a theory (Hsieh,2005). Information that cannot be categorized are noted and evaluated later to determine if they represent a new category of an existing code. This method was preferred since primary classification will not bias the identification of important application objectives and needs. The methodology also helps focus the questionnaire questions thus making it easier to classify data.

3.8 Research Quality Aspects

Research quality aspects is the degree to which the research was carried out correctly. Validity and reliability were used to test the quality aspects.

3.8.1 Validity

Validity decides whether the study truthfully and accurately processes what it was intended to measure or how truthful the research results are (Golafshani, 2003). Content validity was used to authenticate the research by systematically examining the test content to determine whether it covers a selected sample of the behavior domain to be measured (Anastasi, 1997).

Pilot study that resembled the main study will be used to measure the validity of the research. This will be done by inspecting the preliminary concept, idea and research questions that discerns which data is to be collected and how it is to be grouped and by ensuring that the model implemented was developed in a way that it was as close as possible to an actual application that users tracking and motoring organization vehicles would adopt.

A part from the piloting, survey questions will also be sent to respondents. Responses of the questions given will be analyzed to check whether the new tracking model is of value to the users.

To establish the notch to which the content domain associated with the construct, content validity will be used to find matches in the test content.

3.8.2 Reliability

Reliability is the extent to which there is consistency in results over a specified time and a correct illustration of the aggregate population under research. If the outcomes of a research can be replicated in a comparable approach at that point the research mechanism is considered to be reliable (Golafshani, 2003).

Inter-rater reliability was used in the research to measure the level to which information being gathered is collected in a trustworthy manner (Keyton, 2004). Reliability was attained by giving respondents questionnaires to fill after one week and the correlation between the two checked.

Inter-rater reliability was used because it ensures that the procedures used to gather the information and the data collection instruments are solid enough and that the same results can be obtained repetitively.

3.9 Ethical Considerations

Ethical considerations require that the research should bring no harm to the study stakeholders. For instance, the respondents should not be forced to participate in the study but they should only do so in their own free will. The confidentiality of the study information should also be taken care of. The study information should not be used for any other purpose other than the one stated in the study. To ensure that ethical consideration was taken into consideration, permission to carry out the study was sought both from the school and the study units.

3.10 Summary

This chapter helped to decide on the population from whom data should be collected. Highlights on the various research methodologies and research instruments used to collect data from the target population and describes how the data collected is analyzed and how conclusions are deduced were done in this chapter.

Chapter 4: Presentation of Findings and System Design

4.1 Introduction

Analysis of data collected during the course of the research is presented in this chapter. The analysis was done in an effort to answer the research questions specified in chapter 1. It will also go through the process of designing the desired tracking model based on the research findings analyzed.

4.2 Data Analysis

The research instruments used targeted transport managers and drivers who provide transport services in institutions. Questionnaires handed out to the target groups above were aimed at understanding the current systems adopted in tracking organization vehicles. A total of 300 respondents participated in the research. Pie Charts were used to illustrate the responses and aid in understanding results obtained.

4.3 User Responses

4.3.1 Transport in Institutions

The responses below were obtained using google forms questionnaires and interviews where 62.15% of the sample population thought that vehicles are not used properly. 37.85% thought that they are used efficiently. The responses have been captured in figure 4.1. The outcome shows that organization vehicles need to be tracked to prevent misuse and delay of services.

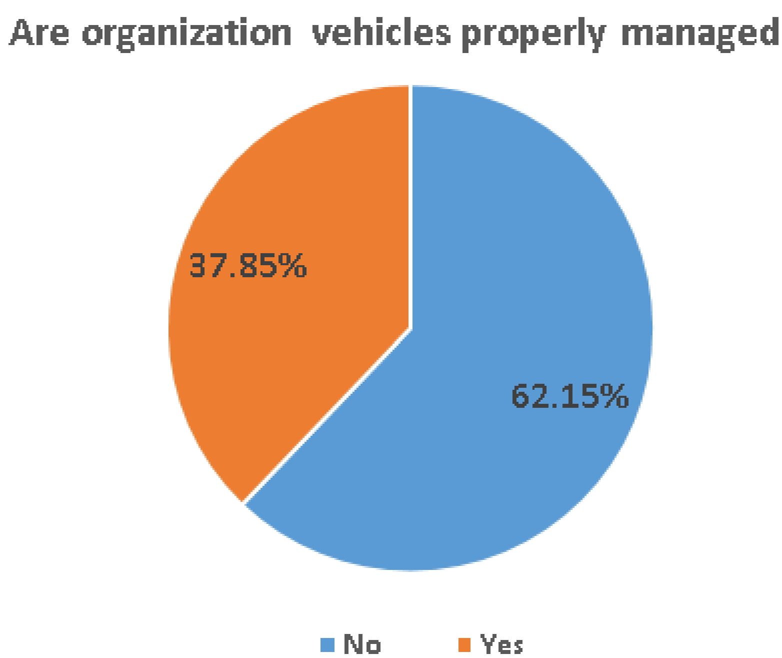

Figure 4.1: Use of organization vehicles

4.3.2 Current Tracking Models in place

An investigation on whether the measures used to curb misuse of vehicles in the various institutions over the past few years have been efficient was carried out. 60.5% of the target population gave a negative response while 39.5 % thought that they were efficient. The outcomes of this investigation shown in Figure 4.2 concludes that a more efficient model is required to be put in place to track institution vehicles.

Does the vehicle work ticket used in tracking movement of vehicles in your organization help curb misuse

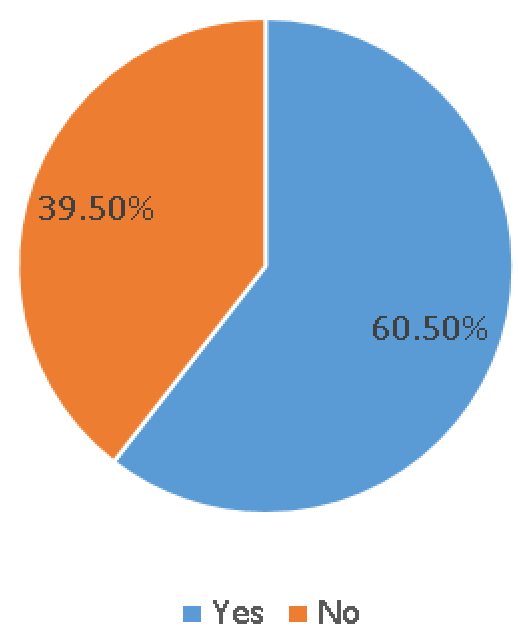

Figure 4.2: Efficiency of current model

4.3.3 Vehicles Regulations

A research on whether drivers in institutions are aware of the transport regulations that control the use of institution vehicles was carried out. 90.5% of the transport managers and drivers involved in the research thought that the drivers are aware of regulations set by the National Transport and Safety Institution (NTSA) as the regulatory body. The figure 4.3 below shows the user response to the question.

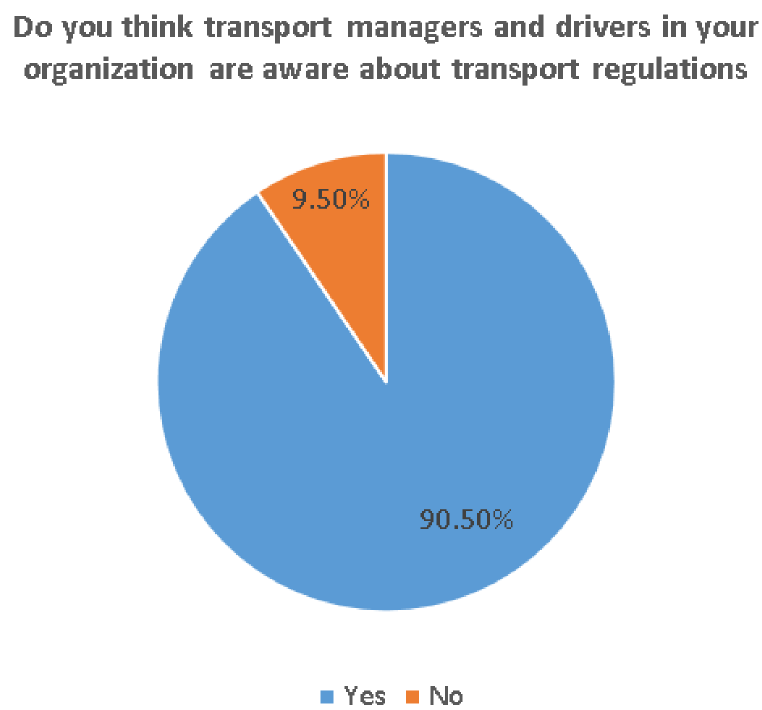

Figure 4.3: Transport Regulations Awareness

4.3.4 Validity of Proposed Model

A validity test sought to find out if the proposed model would help discourage misuse of organization vehicles. 79.5 % thought that a model to track the vehicles would be effective while 21.5% of the sample population gave a negative response. Majority thought that for organizations, the model will be effective compared to other AVTs.

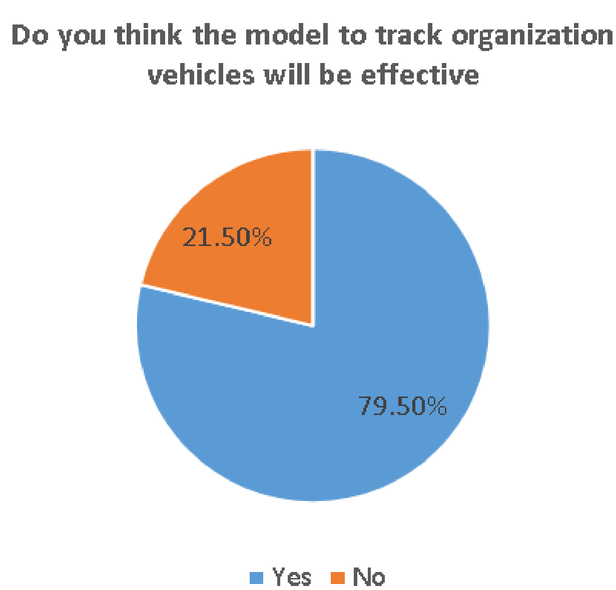

Figure 4.4: Validity of proposed model.

4.3.5 Computer Literacy and Internet Connectivity

Based on the above finding, the researcher went ahead to find out if the transport managers in the institutions are computer literate and whether they have access to internet connectivity at work be it though a desktop PC or a mobile device. Findings showed that computer knowledge was among the requirements for a transport manager position in the institutions. Figure 4.5 shows that 93.7% of the population sampled was computer literate and that 80% had access to internet at work.

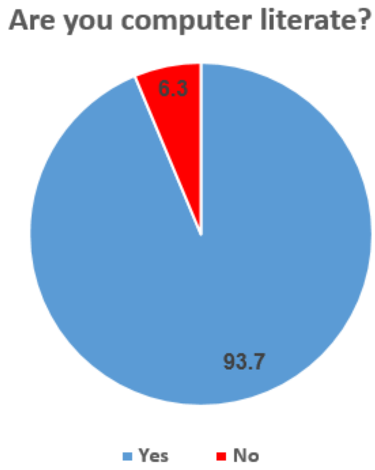

Figure 4.5: Computer Knowledge statistics

4.3.6 Computers and Mobile Devices

The researcher sort to find out which Computers and mobile phones were commonly used by the target population. The researcher found that 100% of the population had mobile phones, 97.8% had access to internet though computers and that 90.2 % of the population used android phones. This helped the researcher to determine the platforms the model should be available on.

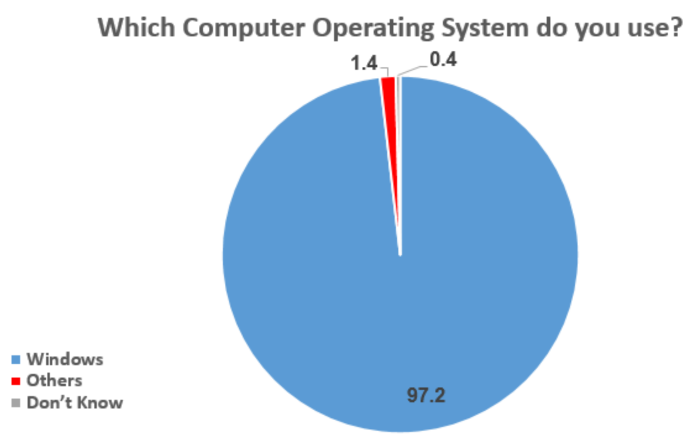

Figure 4.6: Operating system statistics

4.3.7 Willingness for Model Testing

To conclude, a research on whether the transport managers and drivers in the sampled institutions would be willing to test functionalities of the completed model was carried out. It was noted that 91.6% of the target population were willing to test the model while the 9.4% provided a negative response. Figure 4.7 shows response by the institutions.

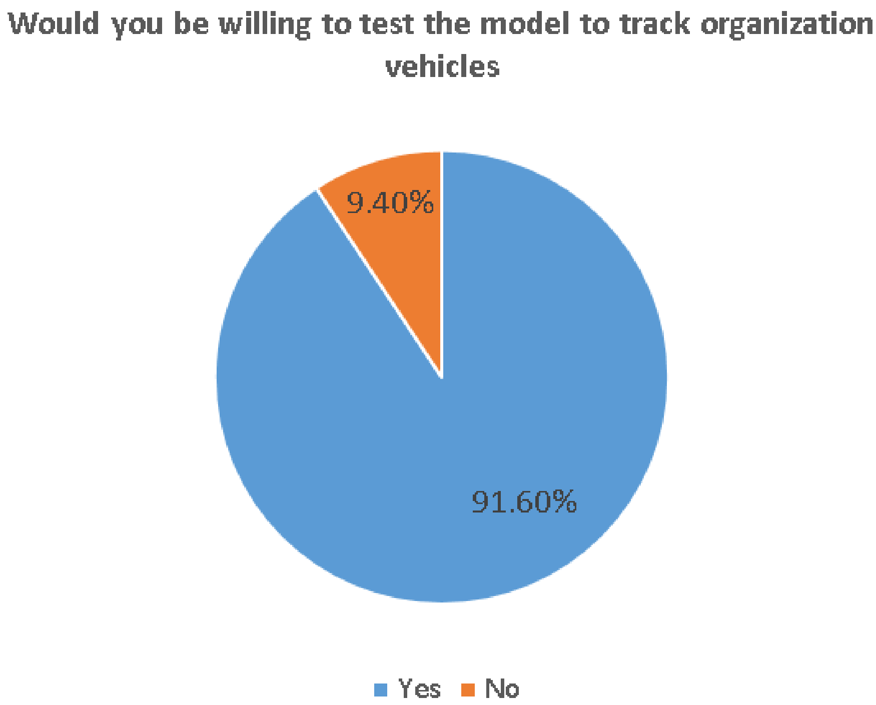

Figure 4.7: willingness for model adoption

4.4 Data Analysis Summary

The responses received helped the researcher in deciding whether or not to implement the model. The researcher was able to decide on some of the functionalities to include in the model which had not been thought of earlier. The conclusions according to the responses were:

Most potential users had the essential technologies for access to the proposed model. Most users had smart phones and were capable of using the model on the go. Transport managers in the organizations had access to internet, hence able to use the web application through their computers or mobile devices. It was clear that the model was to be made available on both computer and mobile devices as the users commonly used operating system among the target population. The research also showed that most drivers are aware about the various regulations set on roads and the model would improve vehicle tracking. The sample population agreed that the model would be highly efficient and effective if implemented for most institutions.

4.5 System Design

System design involves modelling elements to aid in visualization of the intended system. Unified Modelling Language (UML) diagrams such as use cases, data flow diagrams, flow charts among others, were used in various stages of the design process to visualize, specify, construct and document the system.

4.5.1 Model Architecture

For this model, the modelling was done based on the desired functionality. It is composed of a controller which interconnects with an PHP and MySQL application to ensure functionality is achieved. The figure below shows the High level interaction between the main components.

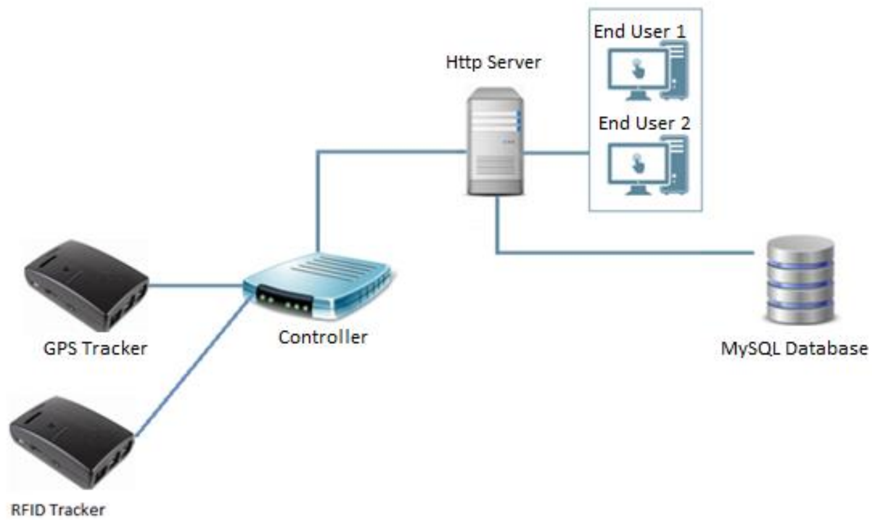

Figure 4.8: Model architecture

Table 4.1: Model Architecture Components

Component	Description
GPS/ RFID Trackers	The GPS and RFID trackers are connected to the Arduino controller which through GPRS send their coordinates to the server
Controller	The Arduino Uno is microcontroller board based on the single-ship. This Arduino has fourteen digital input and output pins, a USB port and a reset button.
HTTP Server	This is web server that processes request through the HTTP network protocol used to spread and share information on the World Wide Web. This server will be responsible for reading the HTTP requests sent by the GPS tracker process them and storing them in a MySQL database.

End User	The end user can either access the application through a WEB interface or through a mobile device.
MySQL Database	This is the most commonly used open-source relational database management system, it uses Structured Query Language SQL.
GSM/GPRS Shield	The GSM/GPRS shield is used to connect an Arduino to the internet using GPRS wireless network.

The Arduino provides control of the whole model. When a vehicle leaves unauthorized, an alert is sent to the transport manager with details, location and vehicle details triggered from the RFID and GSM/GPS module to the server. The driver receives an audio alert that he is driving an unauthorized vehicle.

The GPS module is used to get the exact coordinate location of the vehicle while in motion while RFID module gets the information when the vehicle is at the institution premises.

The data is stored in the database which can be queried by the transport manager and other authorized users through web or mobile device.

The tracking model is consisted of two main parts; Client Side and Server side

i. Client Side

This consists of a web based application and the controller which is fixed in the vehicle. The model is used as a tool to provide information about the location of a vehicle with driver details. The controller consists of a GPS and RFID trackers.

ii. Server Side

This consists of the server where location and identification information is transmitted and stored. The model contains RFID and GPS/GSM modules responsible for sending position coordinates, vehicle registration number and the authorization status to a database which is queried by application users. It is used to receive, analyze and act on data as well as provide information to the Client side.

4.5.2 Data Flow Diagram (DFD)

A data flow diagram shows interactions between external entities and the model. It also shows the various processes that act on the data, as well as data stores where data resides after some form of action by the processes.

i. Context Diagram

A context diagram is high level data flow diagram showing the movement of data in the model. It shows the entire model as a single entity interacting with external entities and the processes that take place between the components. In the model, there are three main external entities whose interactions with the model have been clearly shown.

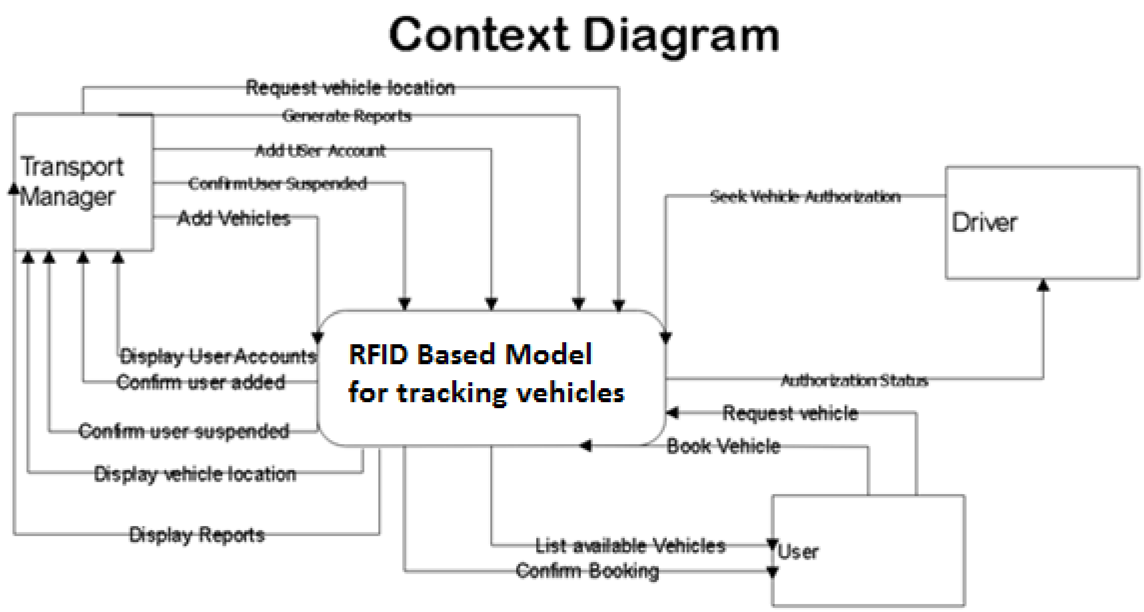

Figure 4.9: Context Diagram

ii. DFD Level 0

Figure shows the flow of data between the various users and the processes in the model. The Level 0 DFD diagram is a more elaborate design of the model as compared to context diagram finally, it shows the data stores available.

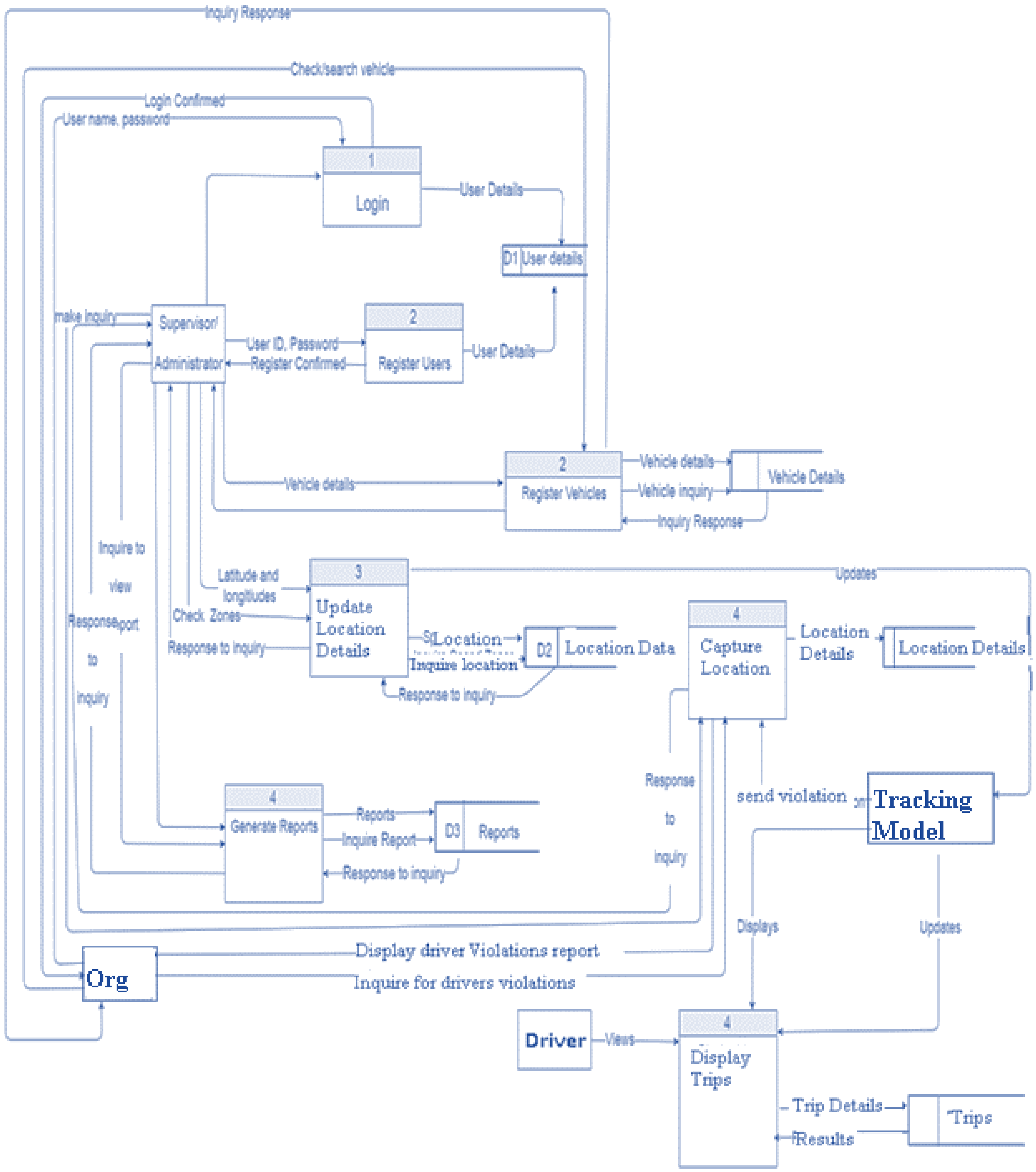

Figure 4.10: DFD Level 0

Figure 4.11 shows a breakdown of the update location use case. This is a main functionality since most processes are dependent on it. RFID and GPS modules are responsible for updating vehicle locations and driver status which can be viewed through a computer or a mobile device.

iii. DFD Level 1

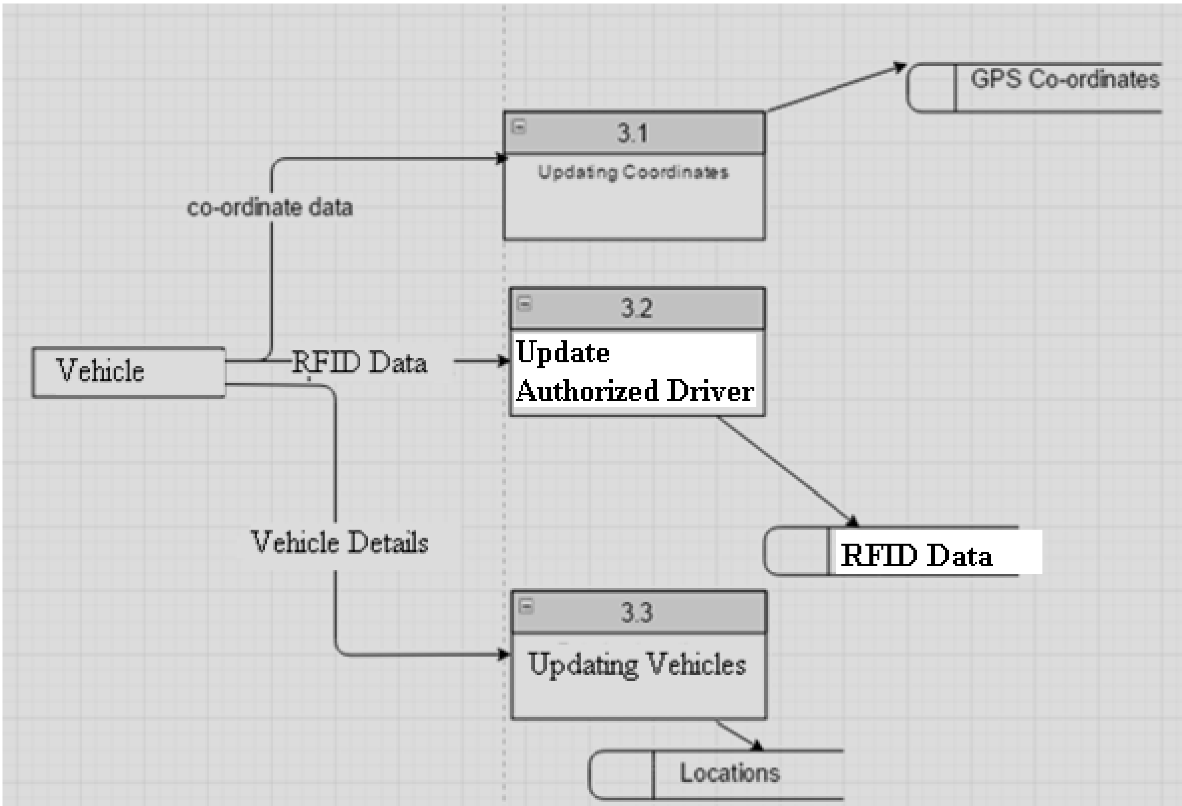

Figure 4.11: Level 1 DFD

4.5.3 Use Case Diagram

A use case is a text based method used to describe complex processes through development of data models. Use case diagrams partition the model into set of actors and use cases. The use cases represent the behavior of the model to an event triggered by the actor while actors represent the roles of the identified users. The main actors are; Transport manager, Driver, as well as the system administrator where the server side resides. Below is the use case diagram showing the relation between actors and events.

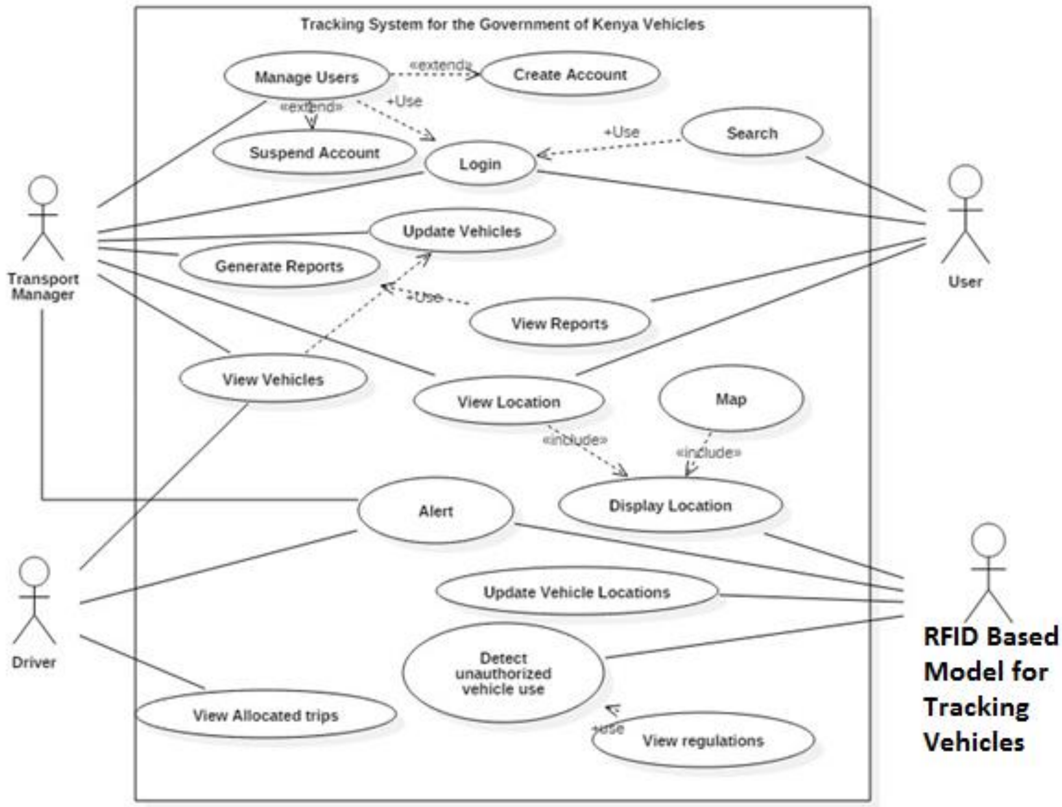

Figure 4.12: Use case Diagram

4.5.4 Use Case Descriptions

i. Manage Users

The transport manager or an administrator is responsible for creating user accounts to be used by the employees who are the primary users. These accounts are created in the web application by specifying the User ID and password. Users are prompted to change password on first logon. The transport manager can also suspend the user accounts in the event that user leaves the institution. The table below shows the step by step process followed by the Transport Manager in managing users.

Table 4.2: Manage Users

Use case Name	Manage Users
Brief Description	Transport Manager creates and suspends account for users
Source	Transport Manager
Major Inputs	User ID, password
Preconditions	The Transport Manager is authenticated and logged in the tracking application.

Post Conditions	
Flow of Events	
Basic Flow	
	This use case starts when the Transport Manager needs to create or suspend user accounts 1 The Transport Manager clicks on “Manage Users” in the homepage. 2 Transport Manager can either create or suspend an account
Case 1	Create Account
	1 Transport Manager Selects Create Account Option. 2 Transport Manager provides User ID and password. 3 verifies that data provided meets requirements specified. 4 User account is created.
Case 2	Suspend Account
	1 Model displays a list of active accounts in the system. 2 Transport Manager selects user account to be suspended. 3 Transport Manager clicks on Suspend account option in the window 4 Confirmation of account suspension.
Alternate Flow	
Title	Description
Incorrect Information during create Account	This alternate flow occurs when the Transport Manager supplies incorrect information during account creation 1 The model displays an error message after Transport Manager submits invalid information. 2 Transport Manager re-enters information and clicks Create.

ii. Update Vehicle Locations

This is a use case detailing the process of updating vehicle locations by the data from RFID and GPS modules. Location data is stored in the server and upon updating, sent through GPRS. This information is then relayed to the transport manager from the server through a graphical user interface (GUI). The step by step scenario of updating map locations is given below.

Table 4.3: Update map locations

Use case Name	Update map locations.
Brief Description	The GPS/ RFID modules can add, locations on the map coordinates.
Actor	Transport Manager.
Major Inputs	GPS location Coordinates, Location names.
Preconditions	Identify the GPS locations to be updated in the model.
Post Conditions	Map locations are updated in the display unit.
Flow of Events	
Basic Flow	
	This use case starts when a Transport Manager accesses the map feature of the model. 1 The tracking model prompts Transport Manager to enter information for a vehicle 2 Transport Manager enters required information and clicks on the Update tab in the window. 3 Model validates the information entered by Transport Manager
Alternate Flow	
In correct information entered	1 The model displays an error message after Transport Manager submits the information and requests the Transport Manager to re-enter the information. 2 Transport Manager re-enters information and clicks submit.
Cancel Update	1 Transport Manager clicks cancel after selecting the feature. 2 Model returns Transport Manager to the administration panel.

iii. Generate Reports

Reports can be generated by either the Systems Administrators or the Transport Managers. The reports generated contain details of a particular vehicle including its location, and authorization status. The details of this use case have been specified in the table below

Table 4.4: Generate Reports

Use case Name	Generate Reports
Brief Description	The Transport Manager and authorized users can generate reports with details about unauthorized use of a vehicle.
Actors	Transport Manager and vehicles.
Preconditions	Authorization status must be available.
Post Conditions	A report is generated.
Flow of Events	
Basic Flow	
	This use case starts when the Transport Manager selects Reports Option in the web application. 1 The Transport Manager enters search criteria in the search text box 2 Transport Manager selects generate option in the web application 3 application generates report.
Alternate Flow	
Search item not found	The application displays an error message.
Cancel Report Generation	The administrator or Transport Manager can choose to cancel

iv. Detect unauthorized driver

This use case is dependent on the functionalities of the RFID sensor and the GSM/GPS module. GPS sensor pin points the location while RFID identifies the driver uniquely. The model compared the recorded information and reports the authorization driver of a vehicle with its location. In the event that the vehicle is in motion and the authorized driver is not reported the transport manager is notified through an alert. This data is stored to the server and can be accessed by Transport Manager or other authorized users.

Table 4.5: Detect unauthorized vehicle

Use case Name	Detect unauthorized Driver
Brief Description	The tracking model detects and transmits unauthorized data which specifies the location, driver and vehicle registration data.
Actor	Tracking Model
Preconditions	Controller modules must detect location of vehicle and the driver authorization status and determine if unauthorized use has occurred.
Post Conditions	
Flow of Events	
Basic Flow	

This use case starts when the vehicle is in motion.

1 The GPS module captures the location of the vehicle
2 The Arduino compares RFID data to confirm authorization status and location.
3 This location captured is compared to the expected location based on authorized trip.
4 In the event that the vehicle is unauthorized an alert is generated and sent to the manager and the driver.
5 Manager can choose to report vehicle to relevant authorities and the police.

v. Display Map

The map is updated remotely through sending GPS and RFID locations through GPRS from the modules to the server from vehicle installed controller.

Table 4.6: Display Location on Map

Use case Name	Display location on map
Brief Description	Transport manager views the map of vehicle locations along their route as well as their location with driver details.
Preconditions	Vehicle have to be installed with the tracking devices
Post Conditions	
Flow of Events	
Basic Flow	

	This use case starts when the Transport Manager queries a particular vehicle. The modules through GPRS send location details to the server Which updates the location and other details of a vehicle which is the
Alternate Flow	
Title	Description
Cancel	

vi. Search

The search option is used by the tracking application user to query database for speeding violations.

Table 4.7: Search

Use case Name	Search	
Brief Description	User can perform search using vehicle registration details	
Type	External	
Major Inputs Vehicle registration	Source Database	Major Result location details
Pre-conditions	None	
Post Conditions	Vehicle unauthorized information is displayed	
Flow of Events		
Basic Flow		
	This use case starts when a user accesses the "Search" feature. 1. The search submission box is displayed in the application 2. User inputs search criteria and submits. 3. Model application displays results 4. Use case ends	
Alternate Flow		
Title	Description	
Cancel 1 2	User selects the "Cancel" option in the application Model returns user to Home page.	

4.5.5 Sequence Diagram

The diagram (Figure 4.13) displays the sequential flow of information in the model. It shows the interaction between the controller installed in the vehicle dashboard and the web portal. The transport manager requests to login into the model through the web portal. The database stores data sent through GPRS.

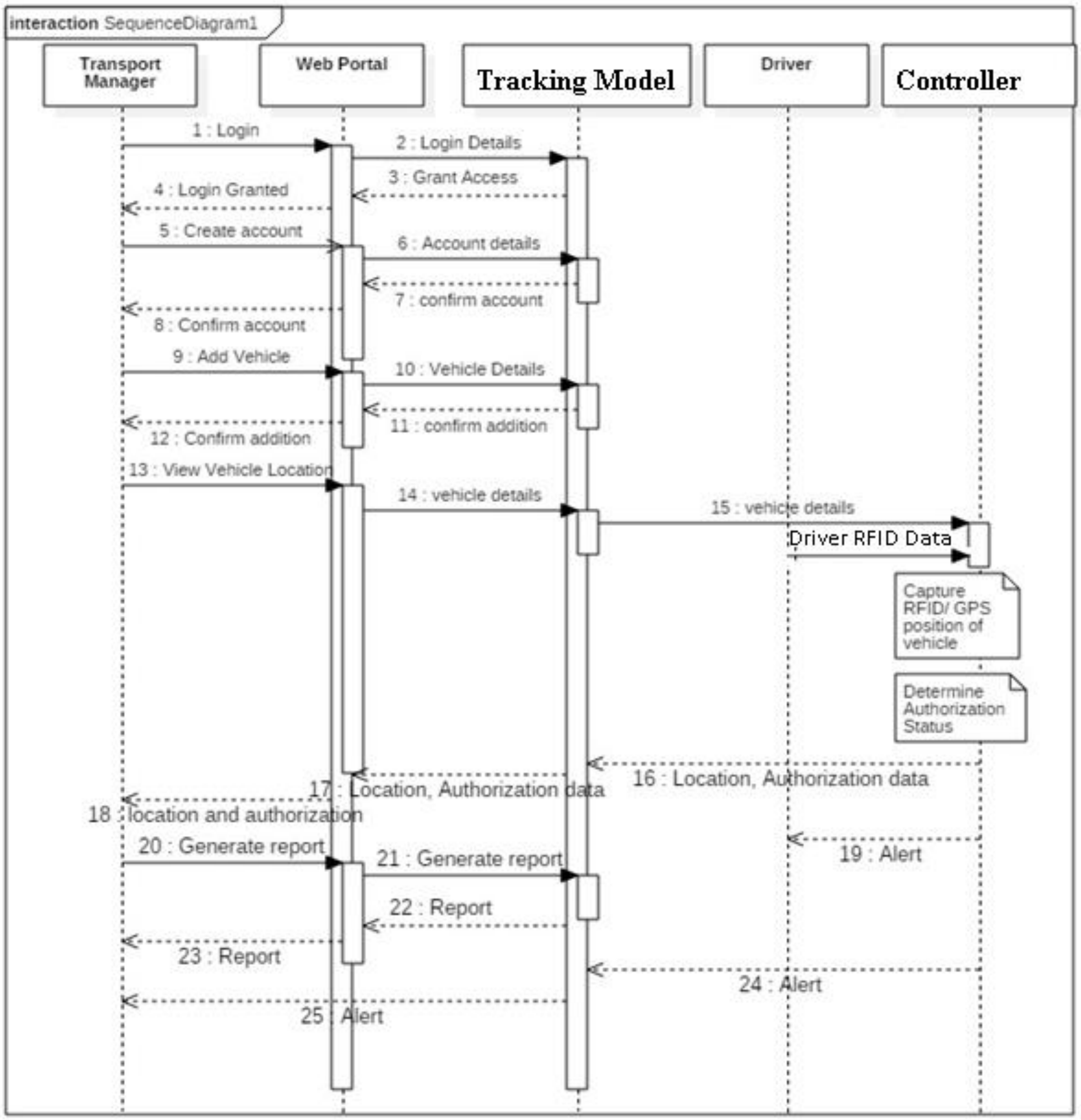

Figure 4.13: Sequence Diagram

4.5.6 Entity Relationship Diagram

The entity relationship diagram is used to show the relationships between the database entities. Figure 4.14 shows the ERD for the proposed tracking model.

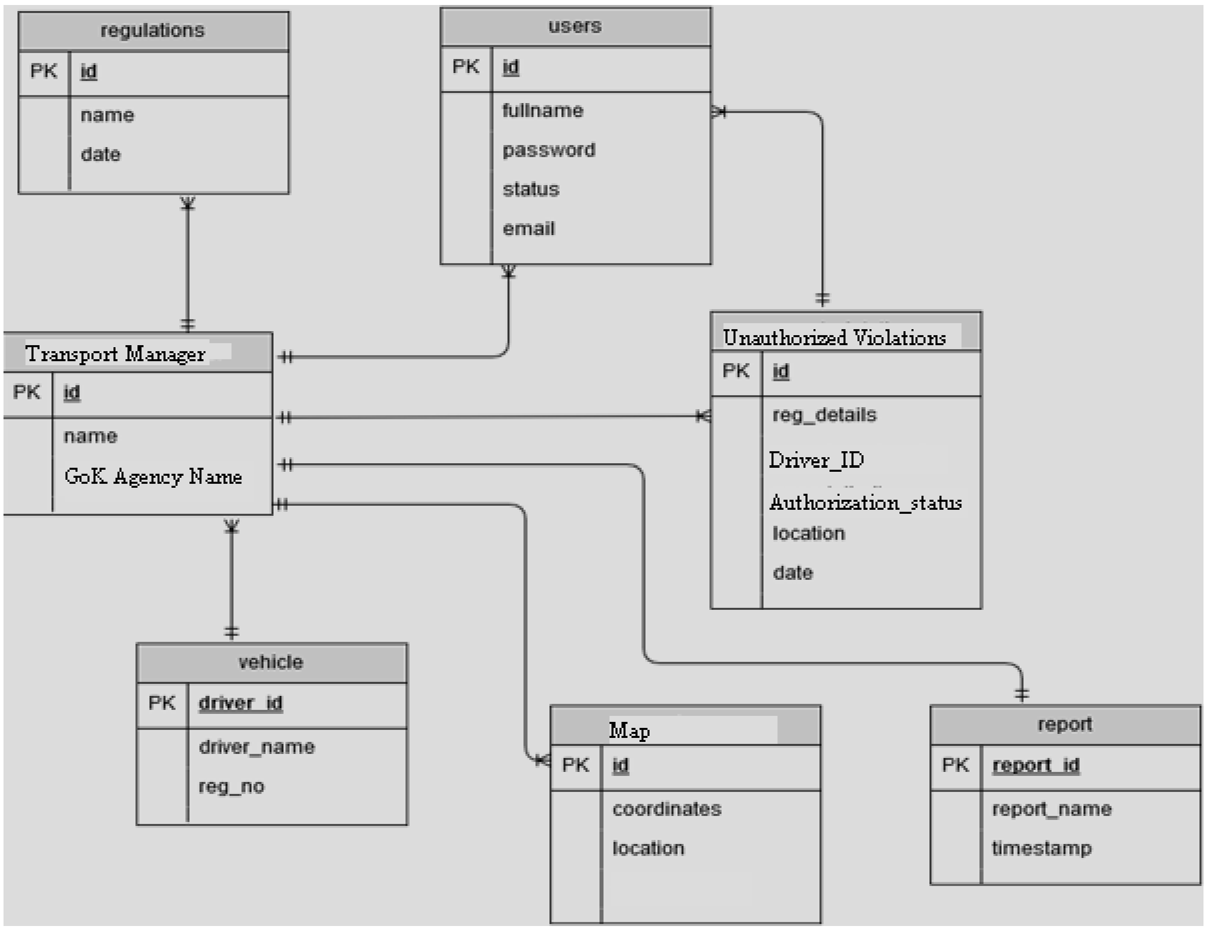

Figure 4.13: ERD diagram

The ERD shows how data is stored for the following information:

(i) Vehicle locations
(ii) Registered drivers
(iii) Location and times for each stop along a route

This information is stored the MySQL database. This is done by acquiring data from the controller. RFID is used to help alleviate privacy issues.

4.5.7 Controller Modules Collaboration Diagrams

A collaboration diagram represents objects that collaborate to ensure functionality of a model. They use the aspect of message passing for realization of a particular behavior. (Dorf, 2006).

Controller

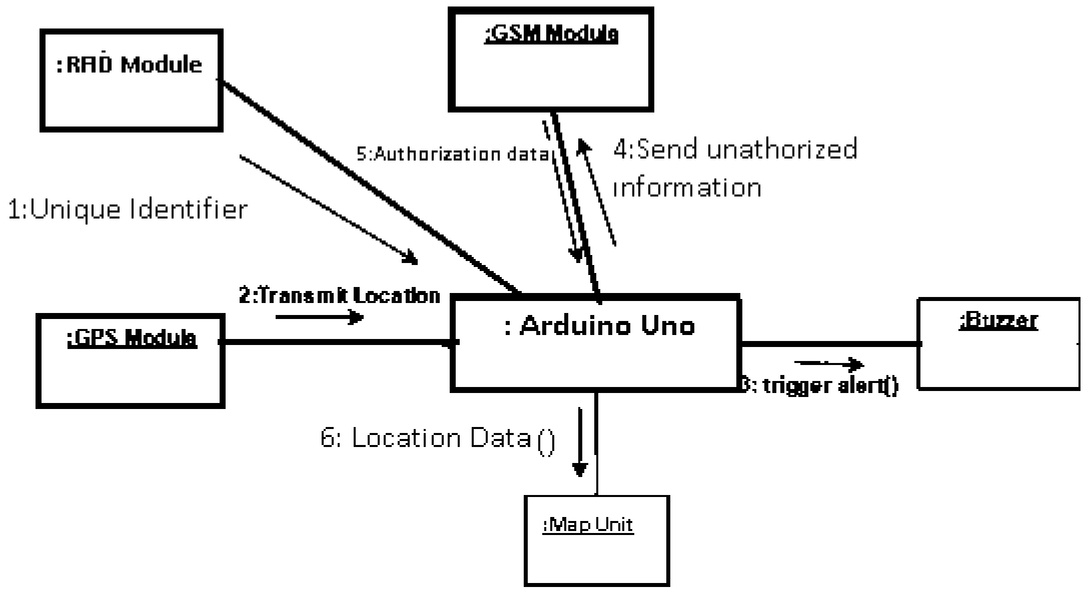

Figure 4.14: Controller Modules collaboration diagram

In figure 4.15 the Arduino Uno is at the Centre of control for the model. RFID module uniquely identifies the driver while GPS reports the location of a vehicle whether in motion or stationary. The GSM Module send the location and identification data to the server. Location data is displayed on the map unit while the buzzer alerts the driver.

4.5.8 Application Design

i. Login

The users are required to change password after first logon. The first logon password is provided by the Transport Manager and has to be changed before user can access the data. After the users' login in they then can view

1 Vehicle location

2 Driver reports.

ii. Home Screen

It specifies the vehicle details, location of vehicle, the time and the driver. It further shows the previous records in relation to particular driver.

4.5.9 Web Application Design

The web application provides the following functionalities to the model.

i. Manage Vehicles

This window allows the transport manager to add other users, details of the various vehicles registered in the organization and drivers. This helps them in keeping track of the fleet and management of the vehicles. The Transport Manager can additionally discontinue and edit vehicle details.

ii. Location

Vehicle information from GPS latitude and longitude and driver details are displayed. These details are sent to the server database through the GPRS and the displayed on the frontend. It enables user to view the specific vehicle location along a particular road/route.

iii. Generate Reports

This allows the transport manager and other users to generate and view reports. These reports contain details of various vehicles as captured and transmitted by the model. Through generation of reports, the behaviour of the driver can be analysed by the institution for decision making purposes.

4.5.10 Model Development Process

The figure 4.16 below shows the development process of the tracking model. The researcher selected the required hardware components to be used. Assembly of this components was done before testing. Source code deployed in the Arduino has to be perfected by carrying out tests before deployment to the hardware. In the event of an error in both software and hardware, the developers reassembled and redesigned the components.

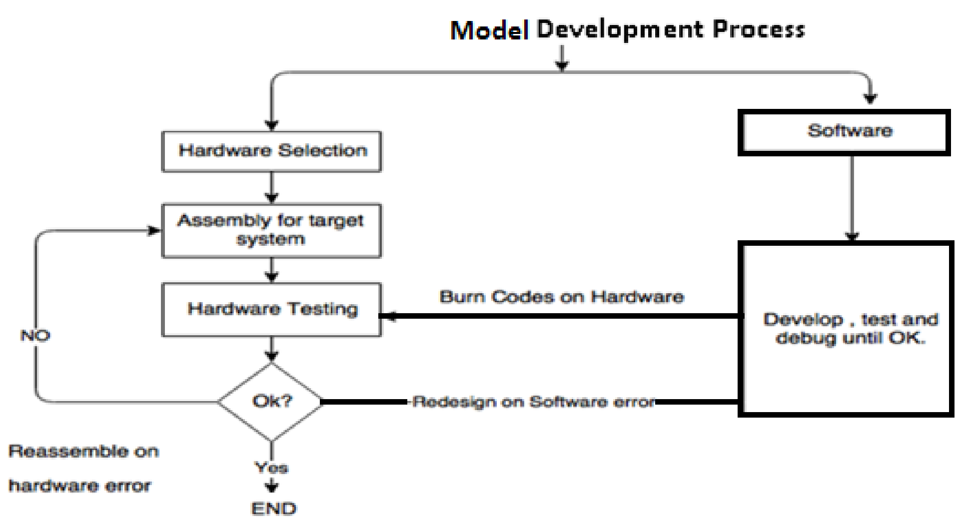

Figure 4.15: Model development process

4.5.10.1 Arduino

The researcher selected Arduino to use as the controller. Arduino Uno was selected due to its advantages over the other Arduinos. The advantages and specifications of this Arduino are specified below.

Figure 4.16: Arduino unit

Advantages of Arduino Uno

1. The Arduino achieves high performance through execution of instructions in a single clock cycle hence achieving a high throughput hence power optimization.
2. Low power consumption
3. Arduino Uno has Four Universal Synchronous/Asynchronous Receiver/Transmitter (USARTs) used to establish a communication channel to the computer using RS-232 serial interface.
4. It uses Serial Interface for communication.
5. Advanced RISC Architecture

4.5.10.2 GSM and GPS module

The researcher selected SIM 908 which is a high performance integrated GSM and GPS module to be used in the controller fixed in the vehicle. Its core functionalities are transmitting and receiving SMS notifications as well as locating position of the vehicle. These features are in line with the requirements of the model proposed. Figure 4.20 shows the SIM908 module.

Figure 4.17: SIM908

The key features considered by the researcher during selection of this module are

i. The module is compliant to GSM 850/900MHz and 1800/1900MHz
ii. The module consumes low power.
iii. It offers point to point mobile originating and mobile terminating point
iv. Can broadcast SMS to multiple destinations
v. The GPS receiver is sensitive hence captures accurate data
vi. Supports both serial and USB interface

4.5.10.2RFID Module

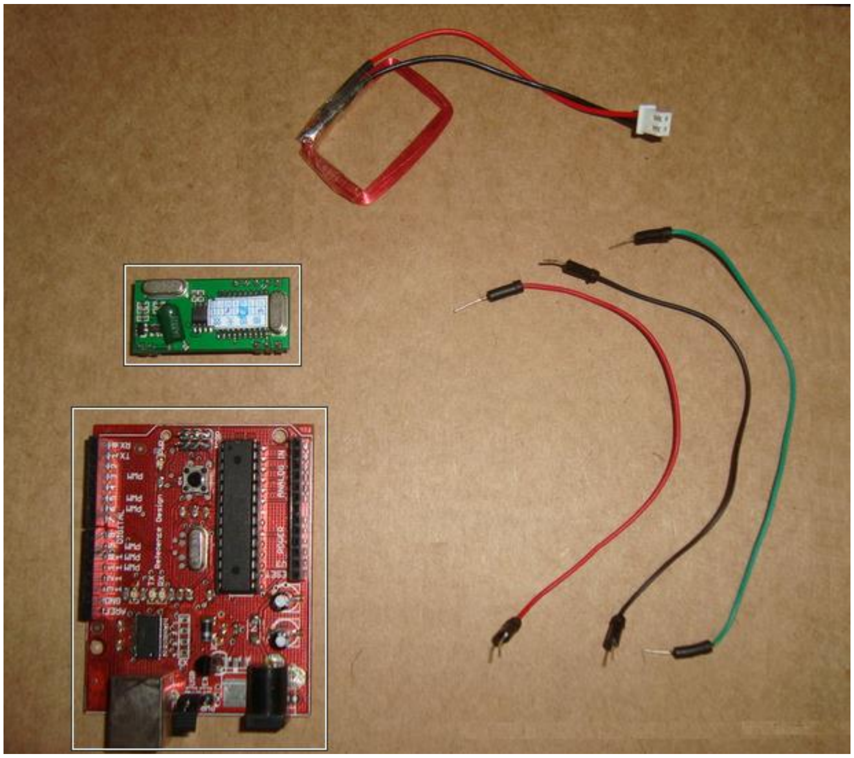

Figure 4.18: RFID

4.5.11 Summary

System analysis and design helps in understanding the model requirements and specifications. UML notation was used to construct the various diagrams and show the flow of data and messages within the model. These diagrams include; use case diagrams, Data flow diagram, sequence diagram, collaboration diagram, class diagram, ERD diagram and the database schema. This chapter has also discussed the various elements of the controller and pointed out their main characteristics, which makes them efficient for use in the model.

Chapter 5: Implementation and Testing

5.1 Introduction

After the tracking model was designed as discussed in Chapter 4, these designs were converted into an operational model and tested to ensure that all functionalities were captured. In line with the design, the model was made up of two parts, namely of the client side and the server side. The client consisted of the web based application and a controller in the vehicle. The server side consisted of a server and was responsible for receiving tracking details as well as providing information to the client side. The output of the model is shown and described in this chapter.

5.2 Client Side

5.2.1 Controller Implementation

The hardware is comprised of the following components; Arduino, GSM/GPS and RFID module. The main function of the controller is to collect data about the location of the vehicle in relation to the particular vehicle and driver then transmit this to the server for processing.

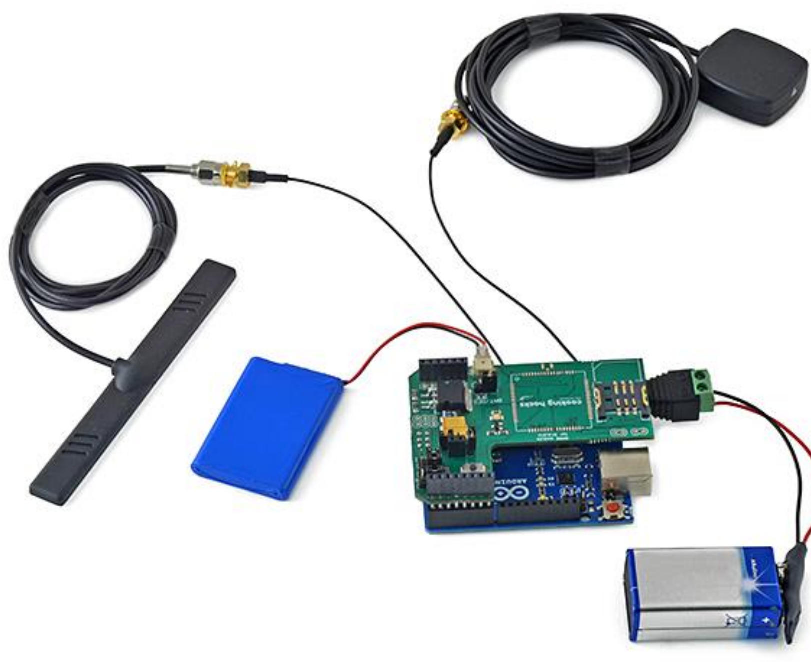

Figure 5.1: Controller Implementation diagram

5.2.2 Tracking Model Implementation

The model was built to run on the PHP MySQL Platform, this is based on the research done which showed that the target population is computer literate and uses both computers and mobile devices. Below are screen shots of the application and their functionalities:

i. Login

For authentication purposes users are requested to key in their user name and password. The users are required to change password on first log on before being allowed to access the homepage. Figure 5.2 below shows the log in screen in the model.

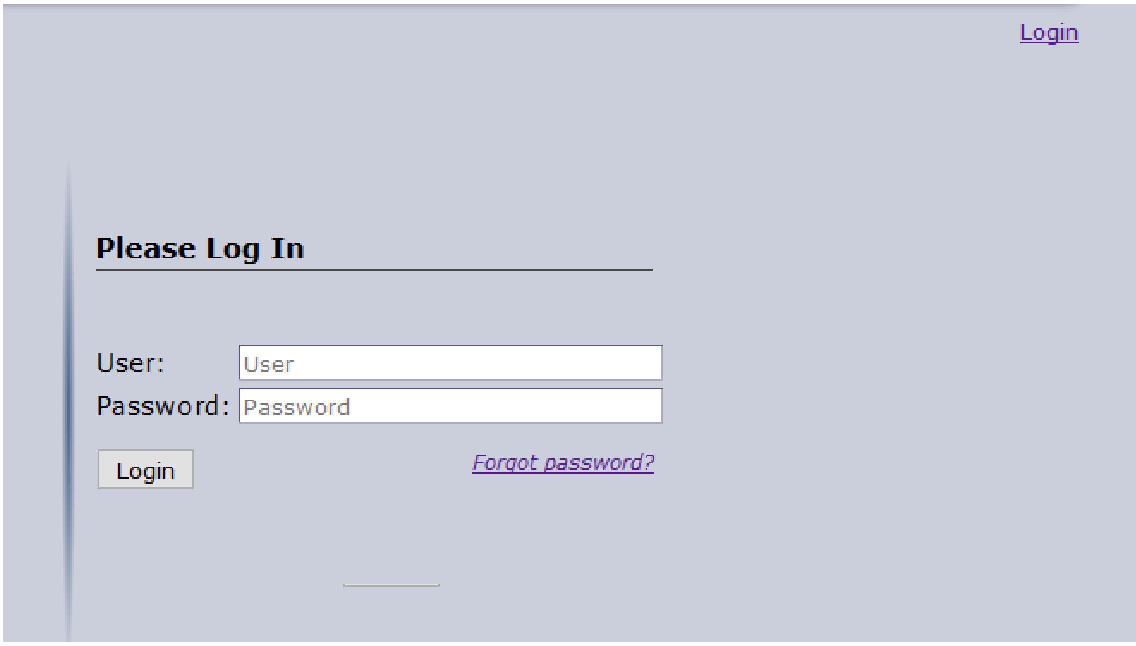

Figure 5.2: Login Screens

ii. Home Page

Upon authentication of the user details, the user is authorized to access the main page. To view more details, the user selects an item in the list from where they are directed to a details page.

Figure 5.3: Home Page

5.3 Server side

5.3.1 Web Application Implementation

The Transport Manager's main role is to manage users, drivers, vehicles and generate reports. To perform these functions, they access the tracking model through the web application where they are required to login with their user ID and password.

The figures 5.4 and 5.5 below show a screenshots of the main functions performed by the Transport Manager.

i. Managing Users

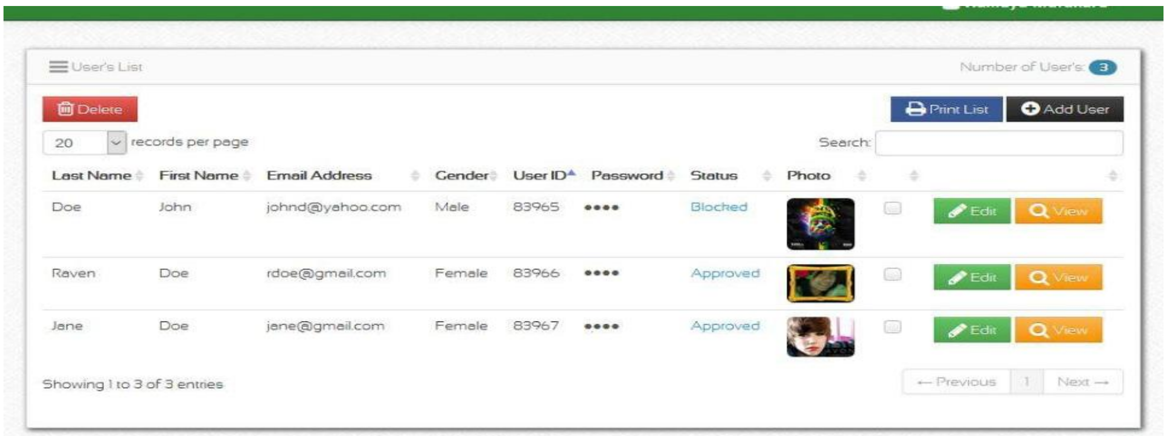

Figure 5.4: Manage users in web application

ii. Monitoring vehicle movement

The Transport Manager/administrator is also responsible for the movement of a vehicle. The screen shot show the interface showing a vehicle movement.

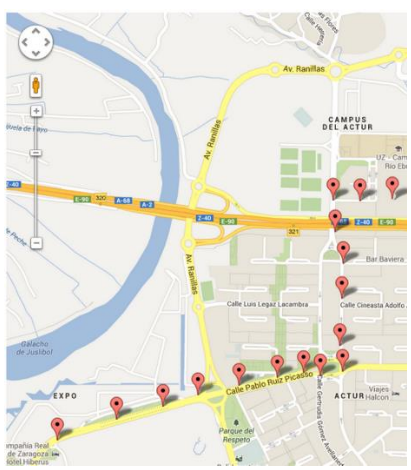

Figure 5.5: Vehicle Movement

5.4 Model Testing

This Section covers testing of the model to ensure that it works as intended. The testing was divided into two sections, developer testing and user Assessment testing. The developer carried out tests to ensure that the various functionalities were working well, the tests included: unit testing, integration testing, compatibility testing, functionality testing and user testing.

i. Nearest vehicle function

This function is sued to show the closes vehicles within an organization to enable managers plan for the next employee transport requests or delivery of parcels and other items.

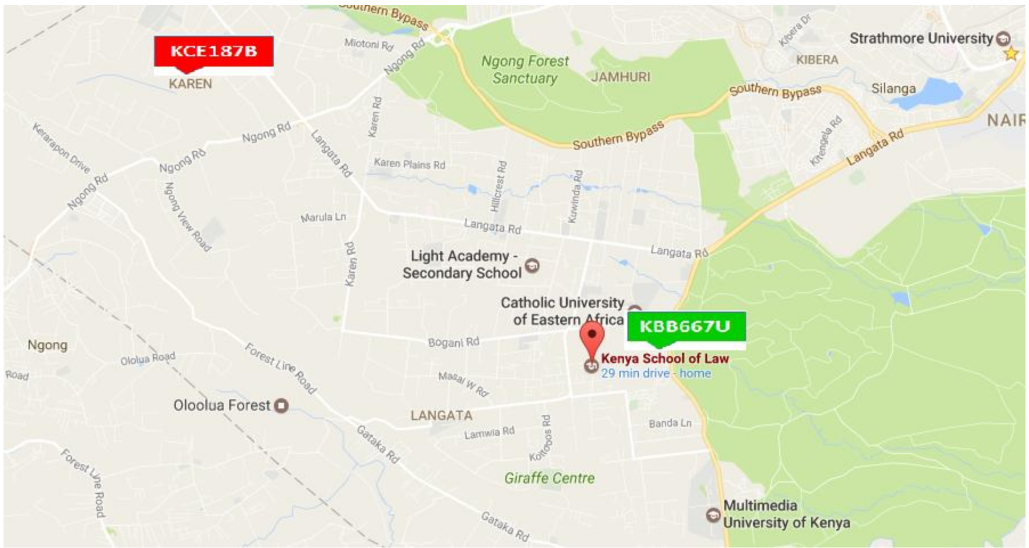

Figure 5.6: Nearest vehicle

ii Automatic driver identification

This function is used to show how close drivers are to the vehicles they are assigned

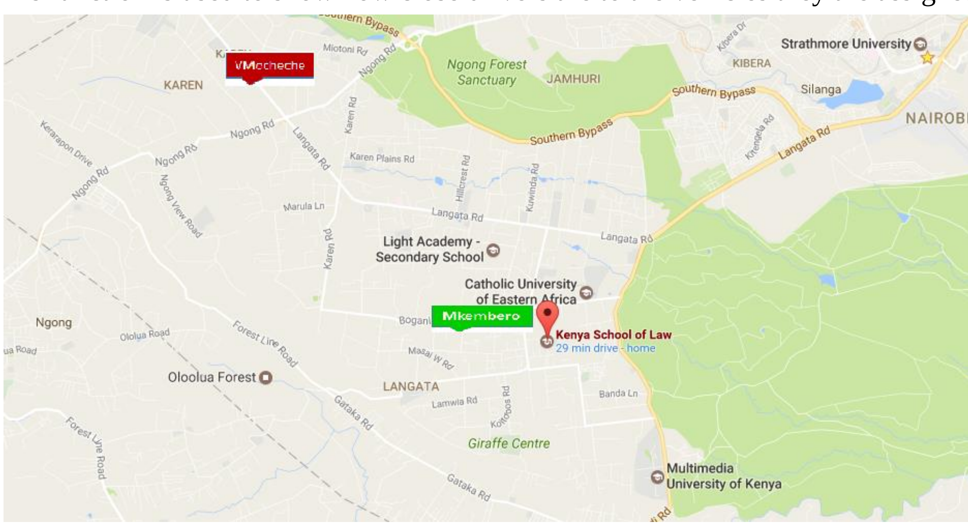

Figure 5.7: Driver Identification

5.4.1 Unit and Integration Testing

In unit testing, the individual units were scrutinized to test for operation. Hardware components were independently tested to ensure that each component perform desired function. The input/output ports for the units were tested using hardware testing IDE. It was also performed to test the source code before deployment to the processor unit. Integration testing was performed after model integration where two or more of the components were integrated and tested for functionality. During this test, the errors realized were corrected.

5.4.2 Compatibility Testing

Compatibility test was done to ensure that the web application was compatible with the available platforms. The model was tested against the available browsers that are commonly used.

5.4.2.1 Software Compatibility

Compatibility testing was done to ensure that the model application was compatible with the available platforms. It ensures that the application runs on all device versions include mobile device browsers.

ii. Web Browser Testing

This test was carried out to determine if the web application developed is compatible with the browser types specified in Table 5.1 below.

Table 5.1: Browser testing

Browser	**Compatibility**
Internet Explorer (versions 8 and above)	Yes
Firefox (version 40.0 and above)	Yes
Google Chrome	Yes

5.4.3 Functionality Testing

Functional tests were carried out to test the features of the model implemented. It based on use cases to determine the success of the implemented model. This section tested both the hardware and software to determine whether all functionalities were achieved. For each use case testing measures were set with results being considered successful or unsuccessful.

5.4.4 User Testing

User testing is performed to seek reaction of the target population to the model. The researcher formulated post questionnaires which were distributed among the sample population to get feedback on the application. Out of the 334 respondents involved in the research, 300 carried out user testing and provided feedback which was used to refine the prototype. The reason why only 300 respondents were involved in the testing process is; they were the only ones who were available in the sample organizations during the testing phase. Users were guided on how to use the model. Credentials to the active test accounts were provided to the sample for testing purposes. User testing was done to achieve the following objectives: ease of use, functionality, aesthetics, acceptability.

i. Ease of use

The ease of use which includes learning and using the model application was tested by the potential users. The results obtained were as follows;

50% of the population indicated that the model was easy to use, 6% indicated that it was very difficult, to use. Figure5.6 below shows a summary of the results.

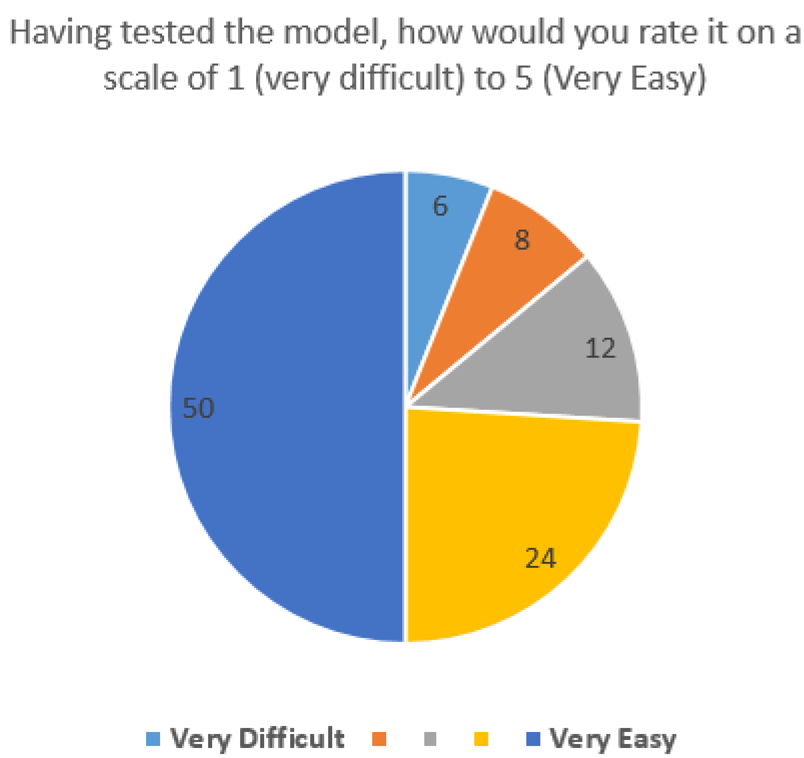

Figure 5.8: Ease of use testing the RFID tracking model

ii. Functionality

The would-be users tested the model against the user specifications to test whether the expected functionalities had been met. 81.4% of them indicated that the specified functionalities had been achieved by the developer.16.2% Indicated that the functionality achieved was not as expected. 2.4 % were undecided. The researcher concluded that some of the requirements had not been realized. The feedback given was used to refine the prototype in an attempt to meet all specifications. Figure 5.8 below shows the summary of results

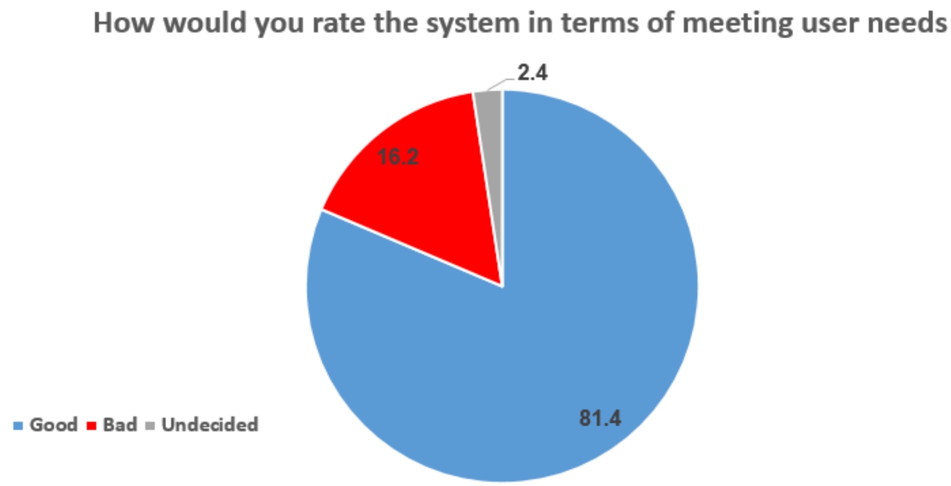

Figure 5.9: Functionality testing

iii. Acceptability

User acceptability testing was done to determine whether the application was a success. 76.2% of the population accepted the application for use in tracking organization vehicles to prevent misuse while23.8 % rejected or were uncomfortable with using the application. Since majority of the target population accepted the application, this test proved to be successful. Figure 5.11 below shows the summary of results

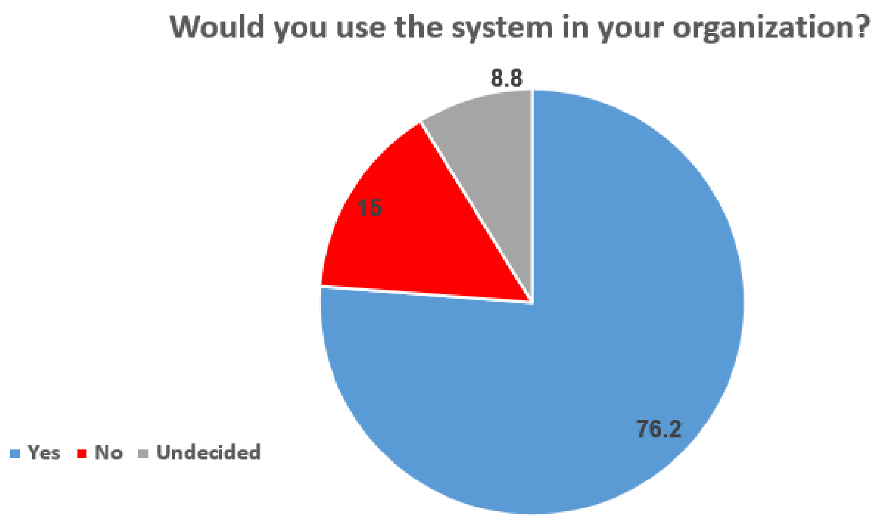

Figure 5.10: Acceptability Testing

5.5 Summary

This chapter describes the process of implementation and testing. The model design in the previous chapter together with the research objectives and research questions were put into consideration to ensure that the model was developed to achieve the set goals. Agile software development and testing was adopted at all stages of implementation. This enabled the researcher to in constant contact with the target users by taking note of their inputs at the different stages of development. It also enabled the researcher to change aspects of the model that could have been overlooked in the analysis stage.

The model was developed using PHP MySQL. The main functionality was to give users ability to track vehicles and drivers in real-time organizations so as to prevent misuse and thus lower the costs associated with fueling and maintaining the vehicles. The application was implemented for administrator management, report generation and tracking of drivers and vehicles. Model testing was conducted by mainly testing functionality to ensure that all requirements were met. Installation testing for both hardware and software was carried out to ensure that a communication channel is established between the two components. Compatibility testing was carried out to determine if the model is compatible with all mobile and computer. Finally, user testing was carried out to ensure that the model is user friendly and easy to understand.

Chapter 6: Discussion, Conclusion and Future Work

6.1 Introduction

The purpose of the research was to investigate the approaches taken to curb misuse of organization vehicles and the limitations of the models in order to identify a model that will help solve the challenges identified. This research aimed at developing a model that can be easily adopted to tracking these vehicles and drivers that drive them so as to ensure they are managed properly. This chapter of the research focuses on the various findings and achievements, how the research objectives were achieved and provides a review of the model in relation to the current models. It also discusses the advantages and future works of the developed model.

6.2 Findings and Achievements

A comprehensive review of previous literature indicated that there are various techniques adopted to maximize the use of vehicles in institutions. The vehicle work ticket and the police check unit for example are among the techniques adopted in ensuring vehicles are used appropriately. There are regulation requiring all institutions vehicles to have a work ticket authorized for every trip. This model of tracking vehicle movement has also been adopted in many other organizations. The police check unit periodically stops all vehicles to check if they comply. With this, the application of the work ticket is impractical since the police do not ensure the vehicle is authorized for a trip at all the times. Institutions do not have a mechanism to track drivers on the roads. Further research shows that a tracking using GPS location and RFID status of the driver would help transport managers in these institutions to efficiently manage their fleet. An audio alert option was also implemented to alert drivers. In the event of a regulations violation, the controller through the GSM/ GPRS module sends the details of the violation to the server for review by the institution transport managers.

6.3 Review of Research Objectives in Relation to the Developed Model.

A tracking model was designed and developed in line with the research objectives. This section describes the various objectives of the research in relation to the findings or results.

The first objective was to investigate the approaches adopted in curbing misuse of institution vehicles in Kenya. This information helped to gain an understanding of the techniques in place as well as identify their strengths and weaknesses in order to select the best approach to be adopted by the researcher. This objective was achieved by reviewing literature, reports and documentation maintained on the current models in the world. Available models include: leasing of vehicles. In Kenya, the work ticket and police check unit are the most common approaches used to track vehicle movements. The model proposed by the researcher helps in locating vehicles and uniquely identifying the driver authorized to drive the vehicle. GPS reports the location while RFID reports proximity of the driver and the vehicle.

The second objective was to identify the best approach to track organization vehicles on roads. This objective was achieved by reviewing literature and accustoming to various technologies which can be applied. From the feedback received during the data collection phase, the researcher identified that the best approach is to develop a controller which was installed in the vehicle to monitor authorization status and the location of the vehicle. A web application through which the Transport Manager can manage vehicles, view violations by drivers, and generate reports was also developed.

The third objective was to design and propose a model for tracking movement of vehicles and driver behaviour on the road. This objective was achieved through carrying out interviews with sample organizations to determine the challenges with the current models. The researcher created a vehicle tracking model suitable for organizations in Kenya and the world.

The fourth objective was to design and develop a web application for Institutions and stakeholders to view vehicle locations. The applicability of the model was evaluated in relation to the sample population. Research showed that organizations depend on transport managers to ensure the drivers and all employees adhere to the regulations. It also showed that the transport personnel would be interested in viewing reports about the vehicles they are supposed to manage. Also, the Transport Managers/administrators in the institution would be able to view the violation details and generate reports.

The last objective of this research was to test the functionalities of the model. The following tests were conducted to prove the validity of the tracking model; Compatibility testing, functionality testing, unit testing, integration testing and user testing. Testing of the model was also done during integration of the components. Testing to ensure a functional communication channel between the controller and the server was also done to ensure data transmission between the two.

It was concluded that the model functioned as required.

6.4 Advantages of the model

Advantages of the model in relation to the current vehicle tracking models in organizations include:

i. The model identifies the authorized driver for a particular vehicle using RFID technology.
ii. An audio alert is generated to inform driver in case of changes while on move.
iii. It provides real time transmission of location and authorization status.
iv. Reports generated provide details about driver behaviour on the road.

v. Location can be reported around the clock.

vi. The model can be used through mobile or computer browsers

6.5 Future Work

The following can be used to further enhance the RFID based tracking model:

i. The model should be developed for a mobile application for ease of use for travelling users.

ii. The alert should be clear in case the driver is in a noisy location.

iii. The model should be integrated to the regulatory like NTSA.

6.6 Conclusion

This research was carried out with the aim of tracking vehicles and driver behaviour for institutions vehicle. Prior to design and development of a prototype, a comprehensive study was carried out to determine the existence of the problem and viability of the research. The data collected from sample population was analysed and helped in designing a relevant model to control the challenge. This model not only reports vehicle locations, but reports unauthorized use of particular vehicles. This provides information to the transport managers, drivers and other users. A model was developed to provide a platform through which vehicle locations can be monitored. It enabled Transport Managers to manage users, manage vehicles, manage drivers and generate reports. Data was transmitted through GPRS from the controller in the vehicle to the server.

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Appendices

Appendix A: Questionnaire

i. Institution Questionnaire

This questionnaire is aimed at collecting relevant information about how transport is managed in an institution. The information you give will be of benefit to the researcher in accomplishing academic goal. Kindly answer the questions to the best of your abilities, your response will be highly appreciated. You are not required to write your name on the form, the information collected is used for academic purposes only.

(Please try and answer all the questions to the best of your abilities)

Tracking System Questionnaire: Institution

1 Are you computer literate?

□ Yes

□ No

2 Do you own a mobile phone?

□ Yes

□ No

3 Which Operating system is installed on your computer?

□ Windows

□ Others

4 Do you have access to internet at work?

□ Yes

□ No

5 Kindly Specify the institution name

6 What Role do you play in this institution?

____

____

7 Who legally owns the vehicles operating in the institution? Institution or Leasing Company

□ Institution

□ Leasing Company

8 Do you have access to a computer with internet connectivity at work?

□ Yes

□ No

9 Are you aware of the regulations on the use of organization vehicles?

□ Yes

□ No

10 As an Institution, do you have regulations to monitor the use of vehicles in the institution?

□ Yes

□ No

11 Do you have access to new regulations about vehicles use as set by the Regulatory body like NTSA?

□ Yes

□ No

12 Have any drivers in your institution been arrested due to flouting rules?

□ Yes

□ No

13 Do you have a system to receive reports about your drivers on the roads?

□ Yes

□ No

14 Do you think that all the drivers in the institution have access to managing organization vehicles information?

□ Yes

□ No

15 Does your institution play any role in ensuring that the drivers are aware of vehicles regulations?

 Yes

 No

16 What techniques do you adopt to ensure that drivers in your institution do not flout rules?

17 Do you think that a map showing vehicle location would reduce vehicle misuse?

 Yes

 No

18 Do you think an alert system to notify drivers when destination changes would help reduce misuse?

 Yes

 No

19 Would you be willing to test a new model implemented to curb misuse of organization vehicles as a resource?

 Yes

 No

ii. Tracking System Questionnaire: General Public

Are you aware of any measures taken to curb misuse of institution vehicles?

□ Yes

□ No

If Yes, Kindly name one measure taken to curb speeding

Do you think the measures adopted to curb misuse of institution vehicles have been efficient over the past years? *

□ Yes

□ No

Do you think a system for tracking movement of institution vehicles help reduce misuse? *

□ Yes

□ No

Appendix B: Interviews

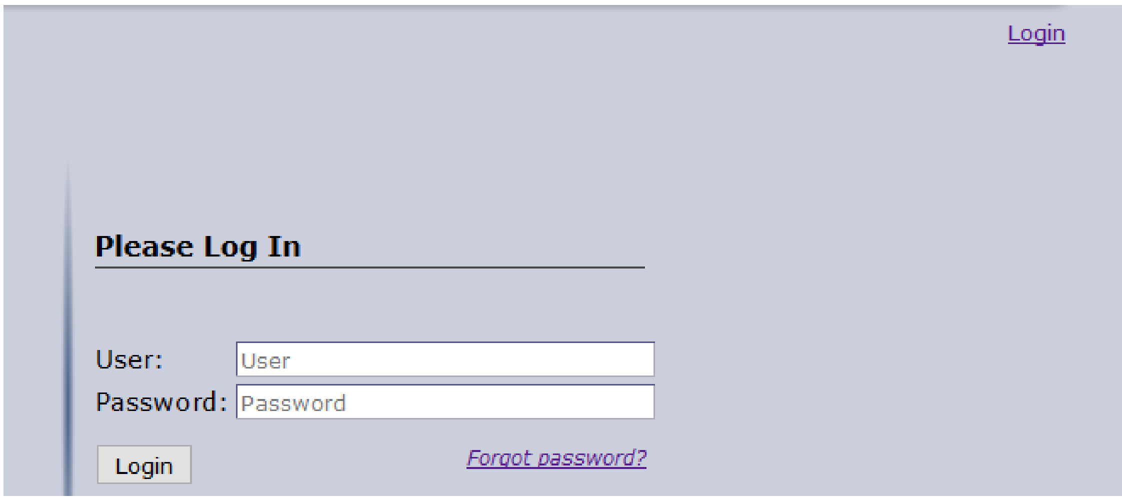
i. Institution Vehicle Drivers

1. Are you aware of regulations that govern the use of your institution vehicles?
2. Have you ever used an institution vehicle for personal jobs?
3. What are the main reasons for using the institution vehicle for personal jobs?
4. Do you think tracking vehicles you drive will prevent misuse?

ii. Institution

1. How many vehicles do you have as an institution?
2. Do you select the specific drivers for your specific vehicles?
3. Do your drivers know about regulations that govern the use of institution vehicles?
4. How do you know if a violation is committed by the driver?
5. Do you think a tracking application to inform you about violations would be relevant?
6. Do you think a tracking application to alert drivers about their next destination would be relevant?
7. Do you think a tracking application to report violations would be useful?
8. What features do you think the application should have?

Appendix C: Application Screenshots



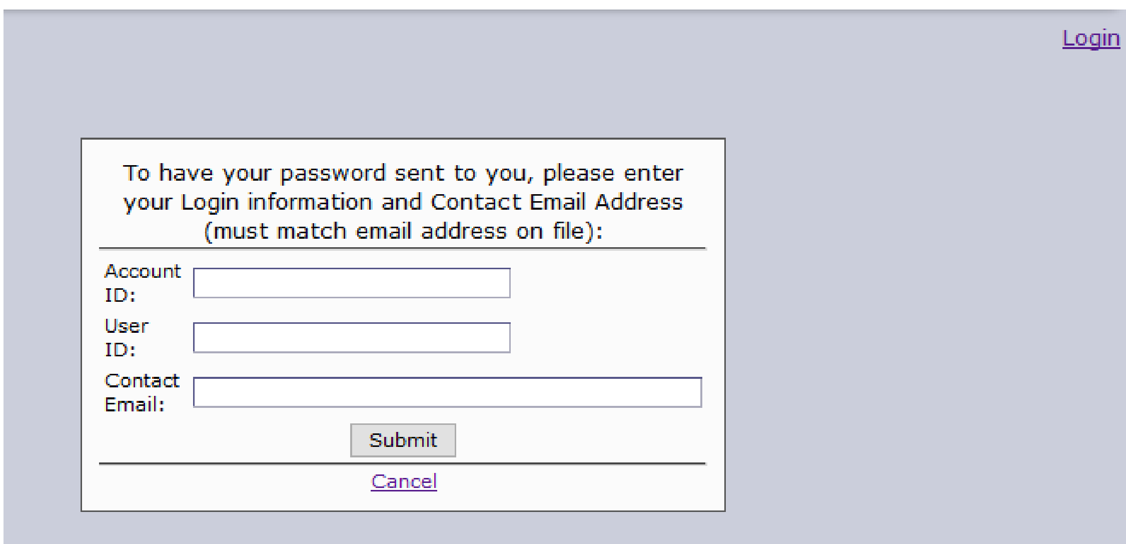
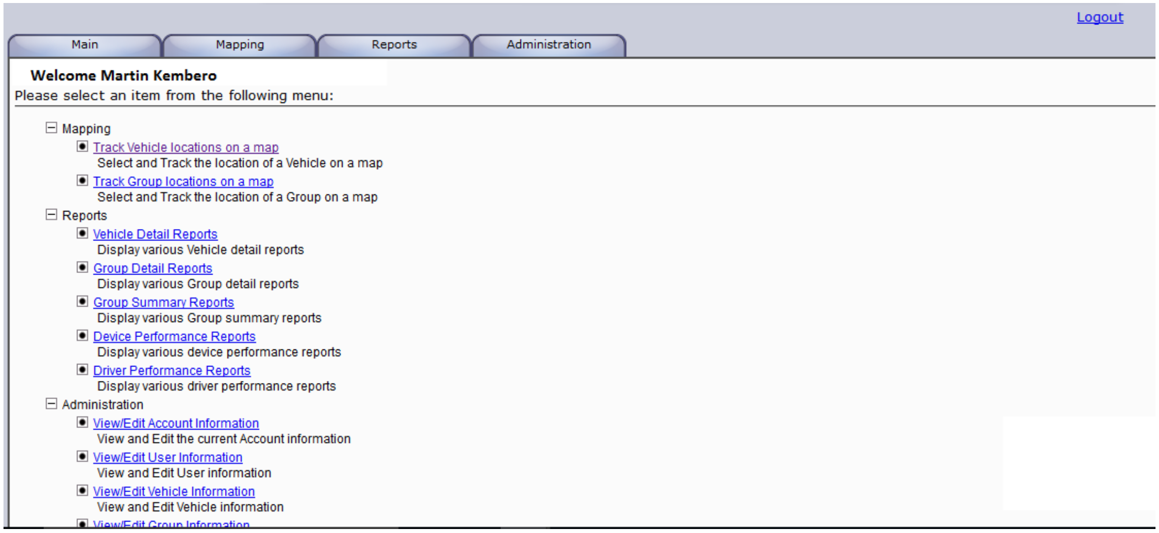


Figure C 1: Authentication function



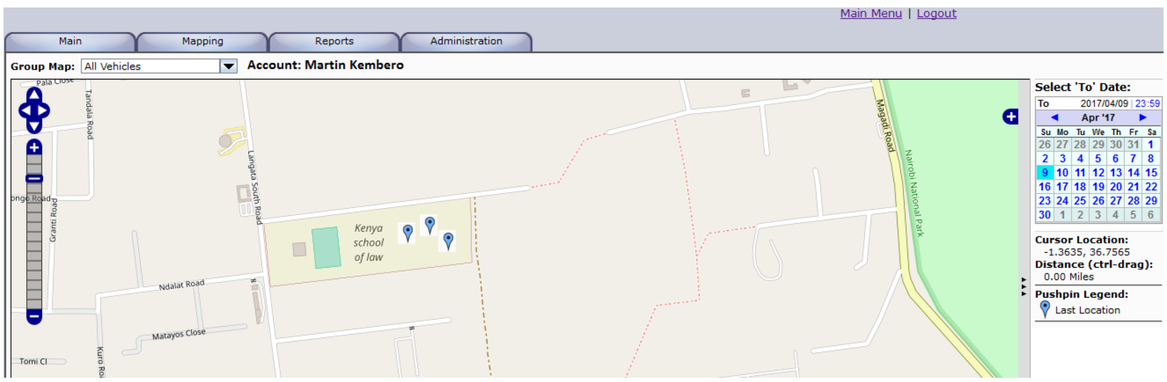


Figure C2: Driver and Vehicle Reports

Appendix D: Turnitin Report

The screen shot below shows the turnitin report.

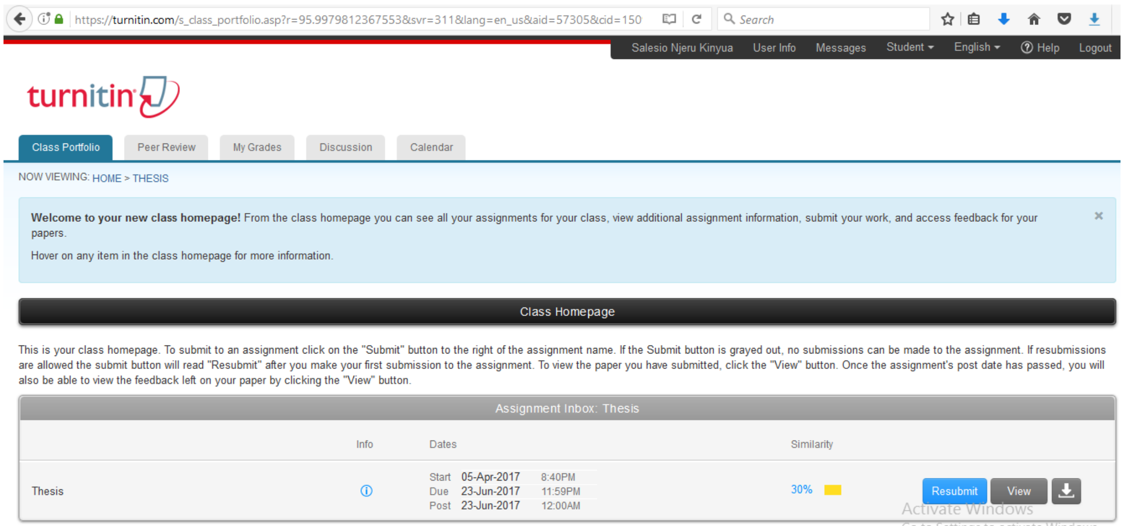


Figure D.1: Turnitin Report