2020

Centralized public parking management - case study of county government of Nairobi

Kang'ethe, Evans Mungai
Faculty of Information Technology
Strathmore University

CENTRALIZED PUBLIC PARKING MANAGEMENT

CASE STUDY OF COUNTY GOVERNMENT OF NAIROBI

EVANS KANG'ETHE

090662

Submitted in partial fulfilment of the requirements for the Degree of Master of Science in Computer Based Information Systems (MSc. CIS) at Strathmore University

Faculty of Information Technology Strathmore University Nairobi, Kenya

September 2020

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.

Name: Evans Kang'ethe

Signature ……  ……

Date ……11.11.2020……

Approval

The thesis of Evans Mungai Kang'ethe was reviewed and approved by the following;

1. Dr. Omwenga – Chair
2. Dr. Ozianyi – Internal Examiner
3. Prof. Katsriku – External Examiner

Table of Contents

Abstract

Commuting in Nairobi is part of life for anyone living within the city. This has seen the exponential growth of vehicles that operate within the county. The county government is in charge of controlling parking spaces which are limited. The methods used are mostly manual and several automated parking which also has limitations and is highly inefficient. Manual processes are lengthy with low accuracy of actual operations and accountability. This involves lots of manpower, which is costly, inconsistent, and inefficient. This has an effect on productivity of the economy since time and revenue are lost. This research will be aimed at evaluating the current system and finding ways to make it effective, efficient and convenient to both the county citizens and government. Information will be collected on the existing method used to parking management, analyzed to establish current gaps and a recommendation of the best approach will be presented. There is need for a holistic approach to managing parking in the count of Nairobi. A system that aggregates all parking slots centrally and identifies each uniquely. The system will be accessible from anywhere using a web based enabled interface. The drivers in the county will be able to log in and preserve slots at a defined time on a first come first serve basis. This will coordinate traffic flow in a more efficient way since the system is able to predict estimated number of vehicles expected in the city per unit of time apart from those that will be in transit and not stopping. It will improve the approach used to coordinate parking, people involved with the efforts required and the technology that is currently being used. Administration of the system will be centralized and accountability methods stringent.

Acknowledgements

I am highly grateful to my support system i.e. God, family and friends for all His love, kindness, guidance, knowledge and wisdom.

My supervisor too for the thoroughness and patience accorded to this project. He has played a very focal role of guiding me tirelessly through the process. Thank you for your invaluable advice, guidance and patience throughout my proposal writing.

List of Abbreviations and Acronyms

CPF - Car Parking Framework

GIS - Geographical Information System

IoT - Internet of Things

LAN - Local Area Network

MCU - Micro Controller Unit

RFID - Radio Frequency Identification

SDLC - Software Development Life Cycle

SPS - Street Parking Framework

RPO - Recovery Point Objective

RTO - Recovery Time Objective

VMS - Variable Message Screen

WLAN - Wireless Local Area Network

WSN - Wire Sensor Network

Definition of Terms

County Government - Units of a devolved system of governance (County, 2020).

Geographic Information Systems - a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data (Gunawardena, 2014)

Internet - is the wider network that allows computer networks around the world run by companies, governments, universities and other organizations to talk to one another (Waweru, 2015).

Operating System - the low-level software that supports a computer's basic functions, such as scheduling tasks and controlling peripherals (Wikipidea, 2020).

Recovery Point Objective - is the age of files that must be recovered from backup storage for normal operations to resume if a computer, system, or network goes down as a result of a hardware, program, or communications failure (Gurkok).

Recovery Time Objective - is the duration of time and a service level within which a business process must be restored after a disaster in order to avoid unacceptable consequences associated with a break in continuity (Gurkok).

Server - a computer or computer program which manages access to a centralized resource or service in a network (Direct, 2005).

Software Development Life Cycle - is a process used by the software industry to design, develop and test high quality software (Bedir Tekinerdogan, 2016).

System - a set of principles or procedures according to which something is done; an organized scheme or method (Cambridge, 2020).

User - a person who uses or operates something (Cambridge, 2020).

Web Server - is a computer that stores web server software and a website's component files (Cambridge, 2020) .

Wireless Local Area Network - is a wireless distribution method for two or more devices that use high-frequency radio waves and often include an access point to the Internet (Cambridge, 2020).

List of Figures

List of Tables

List of Equations

Chapter 1: Introduction

1.1 Background

Nairobi is the capital city of Kenya. According to the last census in 2009, the population was at 3.1 million. It has over time grown, well over 4 million to date, with the metro area having resident population of around 6.5 million. The city has a history dating 1899 and has had a consistent growth as rural-urban migration is an on an ever upward trajectory, with citizens seeking employment and opportunities to make a living (Africanmodern, 2017). As the rural-to urban migration is on the rise, commuting in Nairobi is part of life for anyone living within it. This creates an immediate need for mobility and has seen the exponential growth of vehicles that operate within the county. Nairobi is notably the largest city in Kenya by population.

Nairobi's growth is consistent and sits on a surface area of around 696 square kilometers. This plus the the residents' total count, ,maps the population density per square kilometer at 4850 or in other words 12,600 persons living with a square mile (Africanmodern, 2017). The increase in number of automobiles is directly proportional to the population growth is demand equally rises to respond to commuting needs.

30% of traffic pileup is caused by drivers actively searching for parking spots within the city .Economic activity stakeholders such as enterprises, city councils, municipalities and real estate developers have in the past tried to match the growing parking demands. Overtime it has been established that creating more parking spaces partly addresses the issue and congestion. And new methods of management such as parking systems seem to have a between and balanced way that manages demand and supply of parking. The county government is in charge of controlling traffic flow, in and out of the city and this includes parking spaces which are limited. The methods used to manage parking in Nairobi are mostly manual and several automated parking spots that use standalone systems. These has limitations and is a highly inefficient service.

Manual processes are lengthy since they involve lots of human intervention to complete. This creates room for errors since financial transactions are recorded by hand and receipts issued, unnecessary time loss from the back and forth in the processes, lack of transparency and accountability as records can be altered and be predetermined, with low accuracy of actual

operations and accountability. Manpower, which is costly, inconsistent and inefficient. There is need for a holistic approach to managing this parking as there is still much congestion within the city and in turn loss of revenue to the county through gaps in the processes. This has an effect on productivity of the economy since time and revenue are lost. Review of this management system has potentially great impact on the productivity of the county economy, convenience to service consumers

This research will be aimed at evaluating the current system and finding ways to make it effective, efficient and convenient to both the county citizens and government. It will address the systems used to coordinate parking, people involved with the efforts required and the technology that is currently being used. This in turn will advise on how best the county should approach parking management and the best practice which can also be emulated by other counties within Kenya.

1.2 Problem Statement

According to (Taniguchi, 2014), in 2010 the urban population globally was 3.5 billion according to a United Nation's survey which was to see a 60% increase by the year 2030 .Freight transports are now rated a critical in supporting and enabling better life fo both environment and the people in there in urban areas . Cars only drive on average for one hour a day, and the remaining 23 hours they are parked somewhere (Patrick Auwerx, 2019) .

Commuting in Nairobi is part of life for anyone living within it. This has seen the exponential growth of vehicles that operate within the county. The number of vehicles added to the traffic within Nairobi annually are increasing at an alarming rate. The county government predicts an increase of vehicles to 1.35m by the rear 2030 , according to the new vehicle registration trends . The vehicle registration arm, National Transport and Service Authority (NTSA) , adds to its registers and average 7,000 vehicles every month and almost 90,000 annually . This, with time builds traffic outbursts if not managed properly since also the public service vehicles are also increasing and add onto the traffic management problem and causing congestion. Private vehicles and taxis contribute to the high traffic congestion in the city. Private vehicles are a headache when it comes to parking since they are not in a transitional state rather

most are more stationary as owners could park for more than eight hours as they work and go about their business. Some however have short parking hours as those of the public service vehicles, taxis included.

The county government is in charge of controlling parking spaces which are limited. The methods used are mostly manual and several automated parking which also has limitations and is highly inefficient. Manual processes are lengthy with low accuracy of actual operations and accountability. This involves lots of manpower, which is costly, inconsistent and inefficient. According to the county integrated development plan for Nairobi (Nairobi, 2018), the remedy to parking problems is to increase the number of parking spots available and also increase pricing to manage demand. This research is aimed at evaluating the current system and finding ways to make it effective, efficient and convenient to both the county citizens and government. It will address the systems used to coordinate parking, people involved with the efforts required and the technology that is currently being used.

1.3 Aim

The aim of this research is to critically assess the current parking management approach and establish strengths and weaknesses to create a better parking management system. It will review processes and then recommend the best system functionalities to improve its efficiency in service to citizens.

1.4 Specific Objectives

i) To identify the factors that influence parking management in the county of Nairobi .
ii) To investigate the feasibility of implementing a centralized parking management system across the county .
iii) To review the current parking system implemented.
iv) To develop a parking system whose architecture is web based .
v) To analyse how cities in other countries manage their parking systems .

1.5 Research Questions

i) What are the factors that influence parking management in the county of Nairobi?
ii) How feasible is a centralized parking management system in the county?
iii) What is the current system being used by the county?

iv) How will a web-based system architecture be achieved ?

v) How are other cities around the world managing public parking?

1.6 Justification

With the current number of vehicles accessing the Nairobi county per day on the rise, parking efficiency is really low and has had a negative impact when it comes to time, decrease in the county's (Gross Domestic Product) GDP , convenience and accountability . The trend is expected to get worse since the numbers are growing exponentially and the county hasn't had an optimal solution to the management of parking system. This means that more time will be lost, GDP gains are bound to be foregone and civilians will be more inconvenienced to access the city. With this in mind, there is need to have some organization that systemizes the whole approach to parking management. This research is aimed at understanding the current approach to parking management, reviewing it and making the best recommendations to improve the access to the service by county citizens.

1.7 Scope and Limitation

The study will focus on the Nairobi county parking management process. This implies that the data collected will inform decisions to be made that do not necessarily apply to other counties that have different challenges. However, over time, if the implementation is successful within Nairobi county, other counties can customize the process based on their need. The study will also be focussed on available parking spaces that are within the control of the county government since the data will produce more accurate data that can be used to make informed decisions during recommendations. The study will also seek to develop an automated system that streamlines all the process with checks and balances with respect to parking management.

Chapter 2: Literature Review

2.1 Introduction

While evaluating the methods and practises of parking management solutions, this chapter assesses substantial amounts of data from archives accumulated over time on this subject. This knowledge archives are developed by various researchers who have overtime developed working concepts around the world around the subject matter. In that case this chapter identifies previous studies that are relevant to improving the current parking management gaps in the context of the Nairobi county giving findings that address the research question s and problem plus the overall objectives specified in the first chapter of this study

2.2 Background on Parking Management Overview

2.2.1 Parking Management Overview

Cities around the world are the hub of economic activities. Industries, corporate organization's offices, financial institution, logistic service providers, hospitals, government offices, schools, hotels and restaurants, are emblems of a major city activities. Citizens need to access this institution everyday within the allowed operating hours to access varied. services. This leads to densely populated cities during operating hours. With citizens seeking to access the city within certain time windows, comes congestion of people, automobiles, security challenges and pollution. There is a demand for management of automobiles in and out of this city. Management would mean convenient, affordable and available parking when needed.

Parking cost and availability are factors that drive consumer decisions, on whether to go to a certain place and sometimes even decide whether to own a car or not . There is a likelihood of lower car ownership in urban cities sometimes, despite the wealth and purchasing power, influenced by parking spot availability. Sometimes these urban cities provide better public transport means (Tom Rye, 2015).

2.2.2 Parking Management Challenge

Continues increase of motor vehicles in urban areas has made the management of parking complex by the day . County governments and police find it also a very expensive exercise to

track offenders e.g people that don't pay parking . The parking slots available are distributed across the city with no standards of identification. This leaves the authorities disadvantaged with loss of revenue since there is no method to account for parking spot usage. This exposes the city initiatives gaps.

Initiatives could have different dependencies that influence how successful they are. These factors could be management and organization issues in the city for effective and efficient goal planning. Technology factors come into play as the world evolves to adopt smart capability where services and infrastructure are automated through systems. Governance issues contribute to uptake and effectiveness of this issues and not necessarily issues to do with communication and leadership. Governance has to do with processes of implementation with constituents who sharing information in a guided framework.

Contextualizing policies leads to a smother understanding of how to use information systems in appropriate ways . Its characterized by urban issues, mainly institutional and creates conditions that enable urban development, thus making it an influencing issue. People and communities are a factor as initiatives creates room for their participation in governance and management as active members. When they are key players, they can the hve a better hand in influencing initiatives' successes or failures .

2.2.3 Concept of Parking management

Parking management concept was proposed to address the challenges of parking . Parking management is a major component of the county economy directly affecting productivity. It is a component of performance, productivity and profitability strategically. Literature dealing with is subject of strategy and effective management . Similarly, over the years' efforts have been made to address the problems of parking management across the globe.

2.3 County Government of Nairobi Traffic and Transport Management

Since 1980, there has been deterioration of the quality of services in public transport and traffic . this is a s a result of by inadequate public transport means for the large population, rapid vehicles' number increase, laxity in enforcement of regulations and lack of discipline for drivers and pedestrians. Time is lost while commuting and vehicles consume more fuel in snull ups translating to economic losses .

Road construction projects for superhighways, bypasses are aimed at reducing this congestion in the county . Other strategies planned to ease congestion are elimination of the round-a-bouts and alternative parking for motorists away from the CBD (Naiirobi County Government, 2014).

A survey on the parking issue by IBM in the year 2011 found that motorists use approximately 32 minutes looking for a parking spot . The CBD, Nairobi, has over 9500 parking slots under the county council. This parking spots are on a Car park on Taifa Rd, Sunken car park, (243 slots), law courts park (220 slots) and on street parking with above 10,000 vehicles accessing on a normal peek day (Winnie Mitullah, 2008). Each of this two off street county car parks have a daily turnover of approximately 700 cars which is a very small capacity compared to the number of vehicles. City drivers lament extra payments of additional Kshs 20 to Kshs 50 for parking boys every day for security , since there is a caveat by the county government disclaimer is park at your own risk (Winnie Mitullah, 2008).

Table 2.1 shows a list of some of the car parks in Nairobi central business District with their capacity.

Table 2.1: List of some car parks in Nairobi

Location	**Capacity**	**Authority in Charge**
Sunken Car Park	243	County government
Nairobi Law Courts	220	County Government of Nairobi
Gichamu Lane	80	Private
KICC Grounds	300	Private
Kenyatta Avenue Near laico Regency	180	Private
Utalii Street	70	Private
Intercontinental Hotel open air parking	70	Private

2.4 Efforts to Improve Parking Management

2.4.1 County government parking guidelines

The county government of Nairobi doesn't have a clear management system for parking. However, it has set out some guidelines that are sometimes overlooked by users and hence affect efficiency and smooth flow of traffic in the urban areas especially on peak hours when the central business district has high rates of activity. The following ate the listed guidelines for parking (Nairobi County Government, 2019).

i. A person shall not park a motor vehicle n any other area other than a designated area.

ii. Unless legally permitted, a person shall not stop or parka a vehicle –

a) At an intersection nearer than ten meters to the projection of the curb line immediately ahead or immediately to the rear;

b) Within ten meters on the approach to a stop sign or give way sign;

c) Within five meters of any fire hydrant, or when hydrant is not located at the curb within five meters of the point on the edge of the roadway nearest to the hydrant;

d) Within ten metres of the approach to pedestrian crossing;

e) On a foot way;

f) Facing oncoming traffic;

g) on any bridge or approach to any bridge;

h) in a passenger loading or unloading space posted as such by a traffic control device except when taking or discharging passengers;

i) on any portion of a public rod posted with the sign 'No parking';

j) on any space posted as a fire lane except for emergency vehicles;

k) on any space posted for disabled persons parking unless such vehicle is designated as a disabled person's vehicle;

l) in such a manner so as to obstruct an emergency exit;

Parking on private property is also prohibited unless permission granted by owner of the property or a person having lawful possession or control. Trailers are also prohibited to park on a public road unless attached to a vehicle by which it may be propelled or drawn.

2.5 Key aspects of urban logistics

2.5.1 Urbanization

Global urbanization trends are leading to unique challenges to the transport system in urban areas and especially since population growth is projected to happen in urban areas mostly .This growth is majorly happening in developing countries and that translates to world least advantaged places are likely to experience greatest urban population expansion (UNHABITAT, 2013). 48% of this cities are in Asia and only a minor in Europe and North America. Africa accounts for an even lesser percentage ranging between 12 and 15 percent). Projections depict that large cities count will be 506 by 2020 up from 388 in 2010 and an additional 22 megacities. This growth will mostly be in Africa and Asia and supposedly Africa will have larger cities and megacities compared to Europe by 2020 .

2.5.2 Urban logistics market segments

At the core of cites are places of production, distribution and consumption of goods and service .Activities ensuring that that all material based demands are met is where urban logistics fits and includes transfer of goods necessary for the economy to be productive. This maybe needs by local enterprises such as supplies, parts consumable etc (Deblanc Laetitia, 2011) /.Cities are a hub of many different economic verticals/sectors . This brings about a multitude of supply chains that make the urban logistics complex and diverse by nature. Therefore every activity in the economy can be mapped to a freight generation effect that's constant across cities (Deblanc Laetitia, 2011), however have different variables such as culture, size , geographical conditions, political environment and culture . There are different categories of urban logistics as in the next scenarios elaborated.

Retail category is where several retail facilities are hosted within an urban area and they are the source of the bulk delivery logistics. There are two types of retails using different supply

systems. First is the chain retailing that has a centralized supply system . This stores, by mega retail chains are normally managed by a central system for distribution , making consolidated deliveries using larger vehicles using schedules , reducing the delivery frequencies . Second to the chain retailing is the independent medium sized stores. The have a very different logistic approach and their supply is managed from the supplier desk , using their own vehicles and as a result the frequency of deliveries is high with three to ten in a week (Deblanc Laetitia, 2011)), hat use the centralized distribution system (Cherrett et al., 2012). Therefore the larges freight traffic generators are independent stores . (Deblanc Laetitia, 2011)

Consumers making shopping trips are also a source of traffic. Consumers need to purchase and deliver goods in this stores on their own account . They use cars, public service vehicles or waling and cycling . This trips to this stores to do the purchasing and the trip back, have a significant effect on freight energy in the stores depending transport mode and the quantity and distance moved during shopping . (Michael Browne, 2010).

Couriers, Express and Parcel (CEP) are the other category and they are rated one of the fastest growing enterprise concepts . The deal with transport of light parcels and documents and parcel services move up to 30kgs of luggage . Operators in the CEP have a network of docking terminals for shipment used for delivery in urban areas by small vehicles and mid-sized trucks . A segment of the business caters for home deliveries, while for retail include deliveries centralized from a distribution centre with consumers taking a single trip to the retail outlet and returning home . Online shopping has gained market share with 5% and 8% of all retailing for Europe and the US respectively (Behrends, 2015) .

Hotel, Restaurants and Catering also known as HoReCa are the other category. Significant freight traffic is generated from food deliveries. This industry is in the business of preparing and delivering for, bars, restaurants, hotels and canteens who move large masses of food and beverages. The nature of this orders is that they are small , unpredictable and are on JIT (Just in Time) basis which increases the frequency (Behrends, 2015) .

Construction activities are another category. The scope included roads, urban structures, residential properties, retail and office spaces that are constantly being built or renovated. This material depend on raw materials that must be supplied and delivered regularly at a specific time

place. Construction sites are about 30% of the total tonnage carried in cities (Deblanc Laetitia, 2011).Waste delivery is another category that generates freight traffic. This is because activities in the urban areas generate large amounts of waste that must be collected and moved to sites of disposal and recycling plants and this requires specialized type of vehicles and well-coordinated and scheduled pick-ups. Recycling requires specialized vehicles and dedicated pick-up tours (Behrends, 2015)

2.6 Conceptual Frameworks

There are vexatious technologies used in managing parking in the modern urban setting across the globe. We will be looking at the models, frameworks, and architectures currently existing to inform the solution development.

2.6.1 NTES Parking Framework

This is a framework adopted in China to manage traffic flow as well and manage congestion due to increase in vehicles and people. The architecture is centralized with integrations that interact to enable smooth vehicle inflow and outflow. It's very reliable apart from being complex and non-interoperability which limits is duplication and re-use.

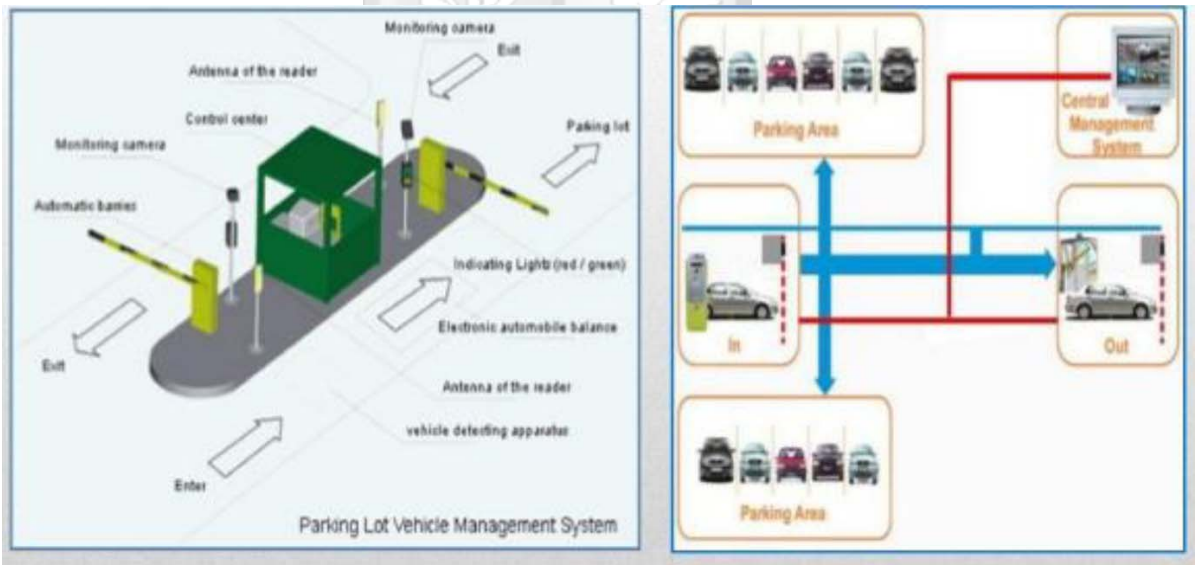

Figure 2.1: Parking lot Management System

2.6.2 Car Parking Framework

The car parking framework is an integration of WSN and RFID technologies that provides some advanced type of features for vehicle parking management. On each vehicle there are active RFID tags . A customer can have tag for a long time after subscription. for private parking or also be dynamically allocated to customers on need basis at the entrance . Parking spots have sensors installed that can wirelessly communicate mote which manages several sensors connected to it . This is efficient since a mote can be used to manage several spots opposed to having a mote for each spot (Elmouatez Billah Karbab, 2015) .

2.6.2.1 *Patterns of Parking Lever Managers*

Parking spot manager in the floor's identifier seen as single component as in the diagram below .

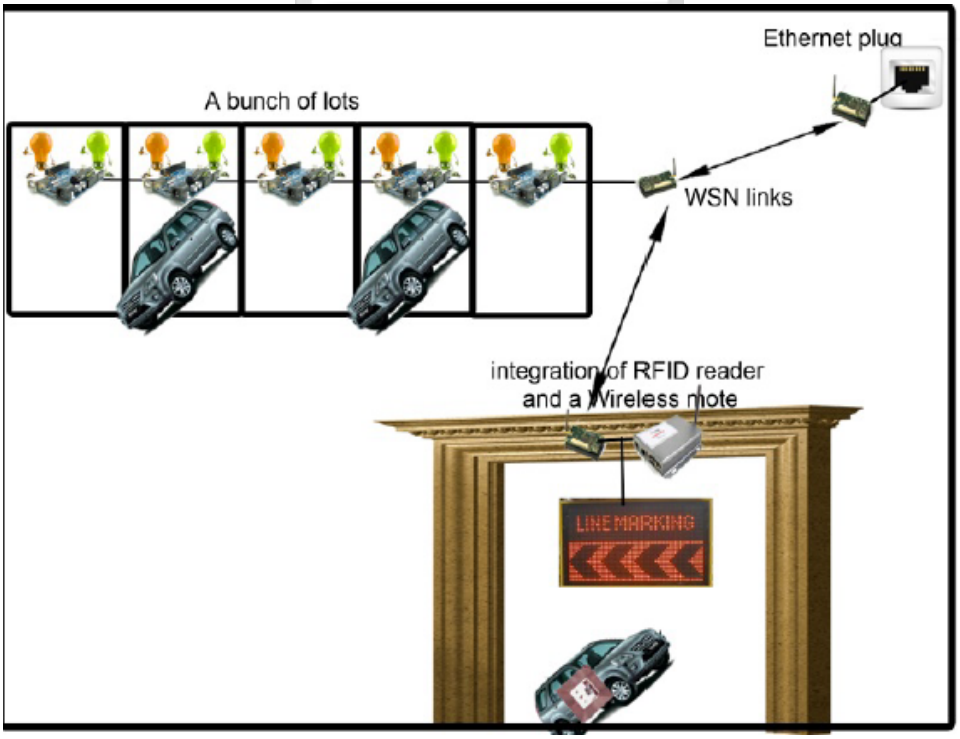

Figure 2.2: Parking Floor Manager Pattern

The floor management contains several types of nodes used; i) Bunches of lots with clustered sensor boards, one per spot, integrated RFID and wireless mote, Variable message screen

connected to guiding nodes and an ethernet plug connection to a sink node to enable communication to the parking manager .The pattern and the multihop architecture between the motes provide a scalable level manager . (Elmouatez Billah Karbab, 2015) .

2.6.3 Car Park Framework Architecture

The framework has 4 layers of architecture that is ubiquitous . The detection and security lare is composed of sensors hosting the hybrid sensors . The communication and transfer of information between the gateways and sensors is enabled by a network that is a mix of both wireless and wired communication . Tge next layer sitting on top of the network layer is ta middleware that stores data snd inturn enables visualization as an interface between the application and the network layers . At this layer , different smart parking services are implemented . The framework implementation includes three parst interconnected using th network. The first is the parking manager storing all data. It can be a source of information to clients on say available parking slots . Pyment services are also implemented within the parking maager . Second is the gate manager that is a controller of the WSN forwarding the status of the gate to the parking manager . Lasty the parking manager has a responsibility to monitor the pa lots and vehicles in that particular level . WSN carries the status traffic of the parking spots to the sink which is later transmitted using the LAN .

2.6.4 Rea Track Parking Management Model

This is a system which is ideally customized according to the customer requirements and integrates with smart systems providing data in real-time. It's a web based model .An administrator can create segments of the parking areas declaring and configuring guidelines on various time zones and time-groups . To create the segment, an administrator would need would configure and choose create-zone command and then proceed to add information in the system (Reltronics, 2017).

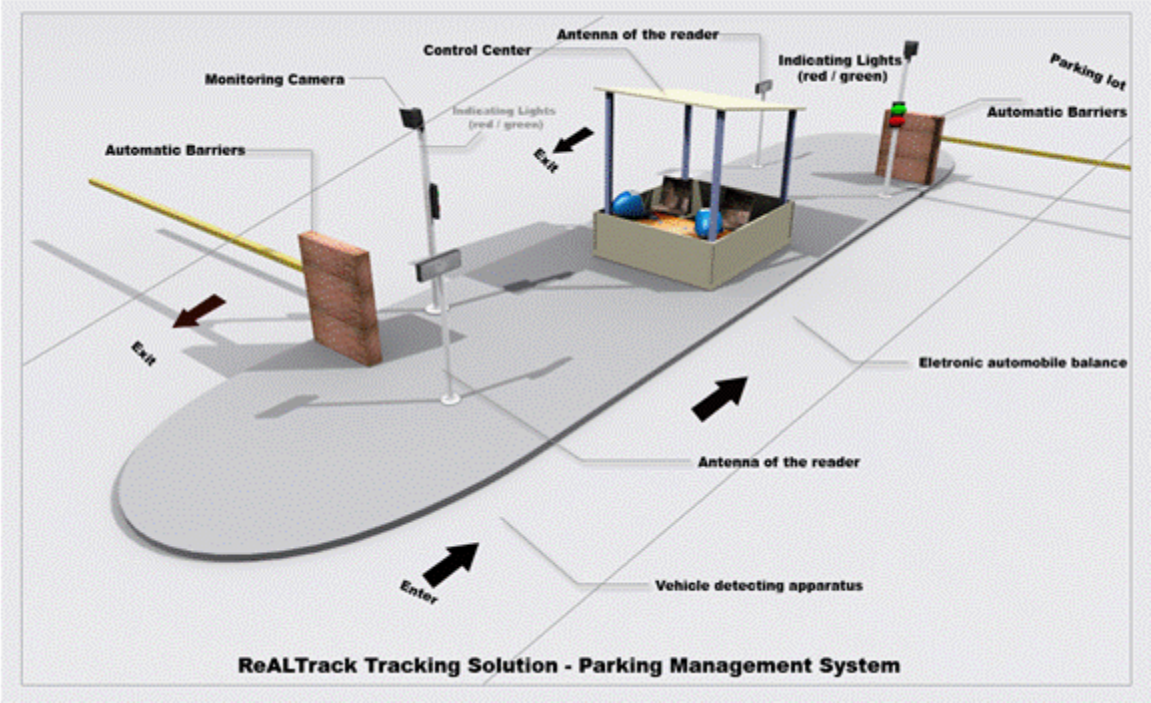

Figure 2.3 Parking Lot System Architecture

It is a robust system by nature and highly a scalable and extensible solution that due tu its proper design of tracking hardware that is compliant , well managed resource utilization and very modern application created using efficient development frameworks and languages .

2.6.5 Smart Parking System Architecture

Involves mounting of magnetic sensors on each parking slot, to sense vehicles interrupting the uniform intensity and direction of the earth's magnetic field. Ultrasonic sensors mounted on the ceiling measure the distance between the sensor and the first obstacle, which could be the pavement or a vehicle

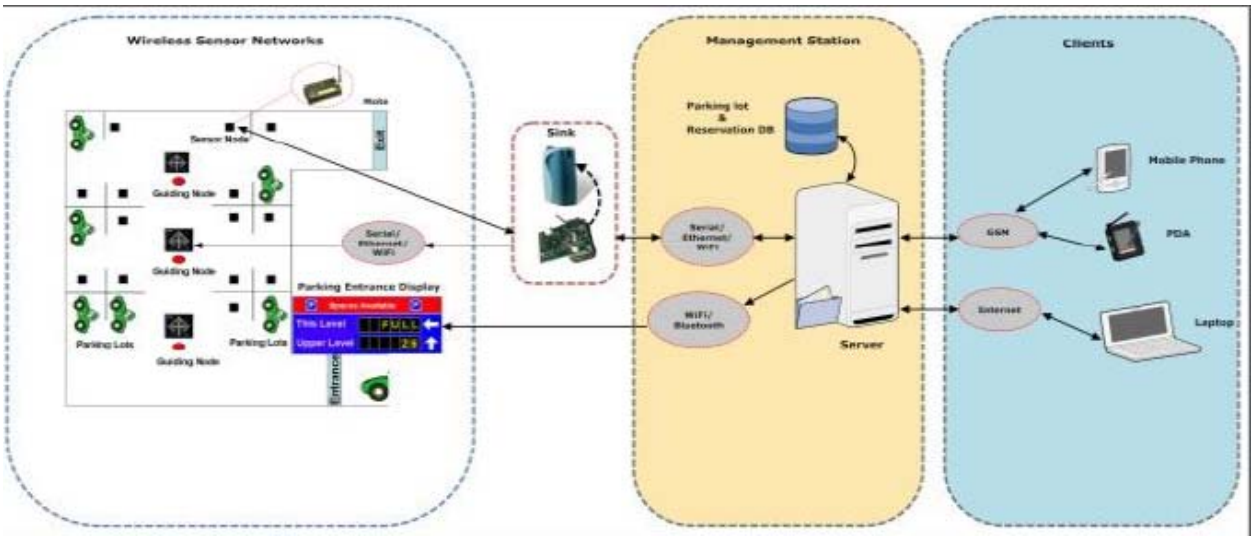

Figure 2.4 Smart Parking system architecture

To detect parking spaces, infrared sensors can be incorporated. Clients are able to reserve parking spots prior while the operator can handle the data .The time used to search parking spots online can be reduced using an optimised architecture of a parking detection system .

2.6.6 **Intelligent Parking architecture**

Parking infrastructure depend on devices interconnected to detect availability and varied methods are used in this case. Inductive loopes coupled with wireless sensors , magnetic sensors , pneumatic tubes etc are used. The devices are directly connected to the controlling computers . The long wiring, complicates the system and brings about complexity . Developer costs for this systems are also very hing due to the large number of sensors to be configured. Figure 2.5 shows the architecture of an intelligent parking system

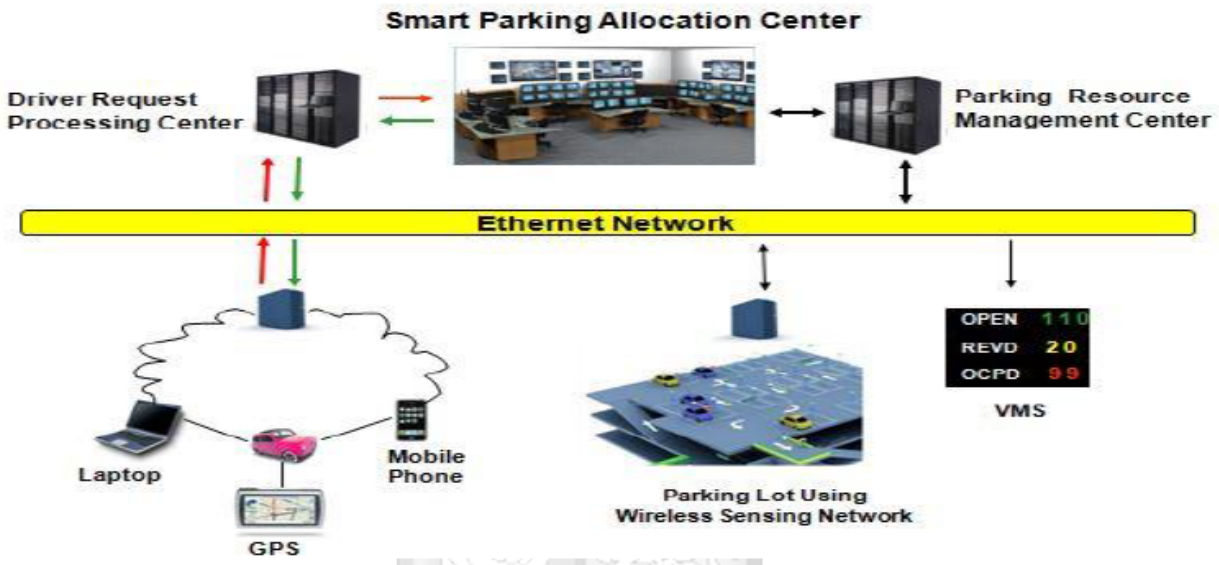

Figure 2.5 Intelligent Parking System Architecture

The system utilizes roadside infrastructure to communicate with the gps vehicle locater and the system . The Roadside infrastructure has certificates for security and information on parking. This ensures that drivers are allotted spots fairly. This architecture ensures that information is primarily held by the infrastructure and not dependent on the users, enhancing privacy and security.

2.7 Mapping Tools to Navigate Parking

Several tools are used by drivers to navigate direction and destinations including parking spots and one of the most common tools being google maps. This process dragging a mao with grids that have been downloaded from google cloud. User who have searched for a spot, get the results downloaded , and all this happens in the background and inserted in the map and panel . Locations are drawn when the pin is positioned and is composed of various images from the map

Systems based on location, allow for navigation locating precise positions of lots using systems that position and get direction, navigating to the destination or location . The avail data in

real time to the user. With improved network capacities, the transmission of large data volumes from the systems is no longer limiting.

. They potentially give users the access to real-time data. The limitation of large volumes of data needed to be transferred over wireless network is decreasing as many network operators offer unlimited or reasonably priced data transfer

2.8 Conceptual Model

This model describes a connected parking management system with a GIS enabled digital road map of the city, occupied with the power of analytics. After collecting the information from the spatial and raster environment, the webtool aligns the data in real time with the GS mapping and parking spaces provide information to motorists on the best route to take, thereby helping to reduce traffic pile up. This model should produce a product which easily integrates with older systems in setting up and tuning the model, initializing all the territorial and mobility data and finally adapting the product to the specific user needs and situations. All the data to be used can be shared with the planning environment: real observed traffic conditions, reconstructed network states, and other estimations. This can take place through data exchange through the defined formats and protocols. This helps in tuning the model and in carrying out predictive simulations based on sets of real data.

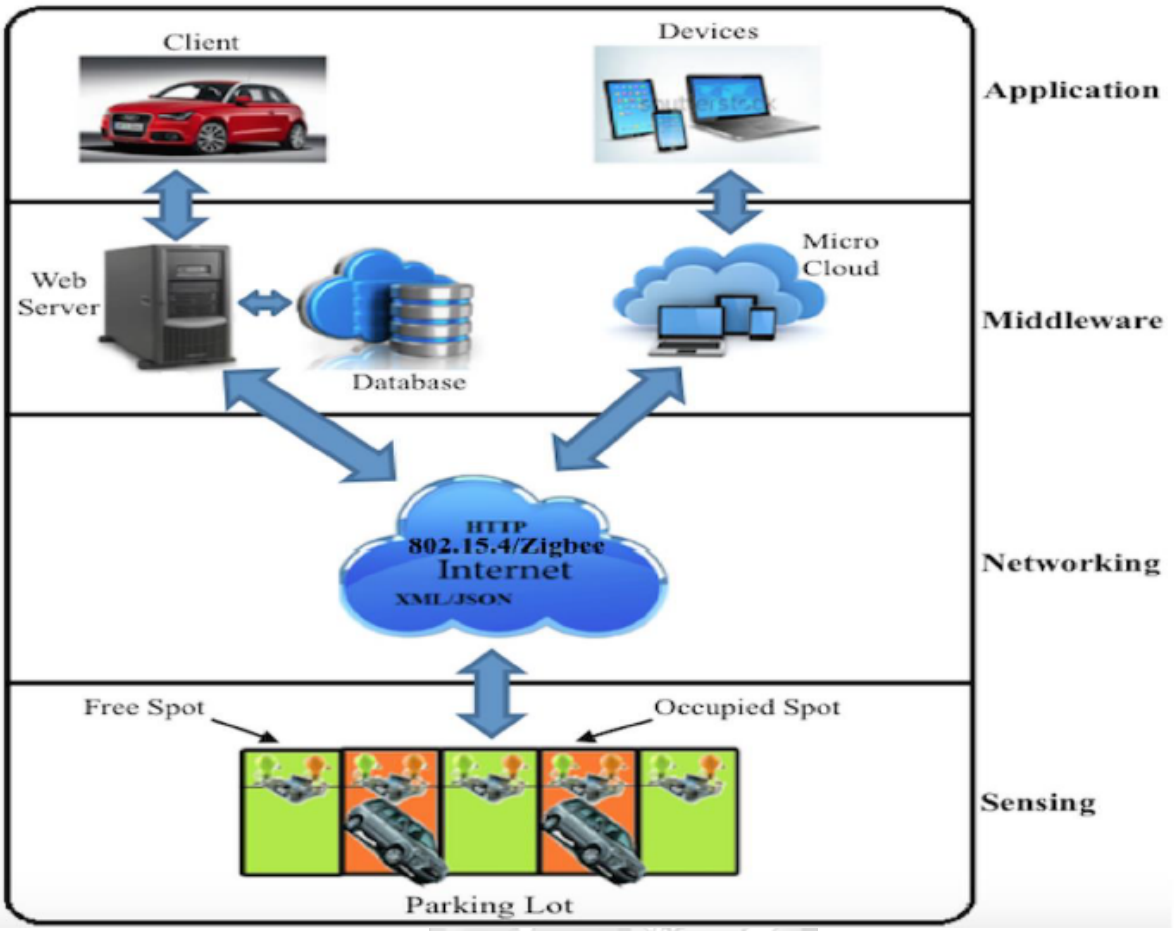

Figure 2.6 Conceptual Model

Chapter 3: Research Methodology

3.1 Introduction

This chapter introduces the research approach and the techniques applied. The chapter defines the scope and limitations of the research design, and situates the research amongst existing research traditions in information systems. In this chapter we will be using various techniques f research to conduct the study. We will use a scientific model approach to identify, select, process and analyse information about this topic. There will be a combination of techniques to increase the accuracy of findings and quality of analysis. It provides a detailed assessment of the various methods applied during the study. From the design of the method and its structure, population and sampling data collection methods, analysis and drawing conclusions. In addition, application development approaches such as requirements gathering, system design, development, deployment and maintenance are all covered.

According to (Igwenagu, 2016) , methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. This study will employ qualitative and quantitative research design to identify the variables that influence parking management in the Nairobi central district and the impact of manipulating the variables.

3.2 Research Design

A research design is used to structure the research, to show how all the major parts of the project work together to try to address the central research questions. It is the conceptual structure within which research is conducted; it constitutes the blueprint for the collection, measurement and analysis of data. For this study, exploratory research was used because it facilitates in-depth investigation to unravel unclear areas relating to this study. For instance, current parking process in the county of Nairobi, fees collection and receipting, parking allocation to a driver after finally going through the process. The following steps will be factored to guide the research design approach;

i. Identify the research problem clearly and justify its selection,
ii. Review previously published literature associated with the problem area,

iii. Clearly and explicitly specify hypotheses [i.e., research questions] central to the problem selected,

iv. Effectively describe the data which will be necessary for an adequate test of the hypotheses and explain how such data will be obtained, and

v. Describe the methods of analysis which will be applied to the data in determining whether or not the hypotheses are true or false.

In designing the system, the research implemented agile development methodology. This methodology allowed the researcher to determine system requirements long before programming so as to minimize changes as development progressed.

3.3 Population and Sampling

The target population was the county citizens of Nairobi who commute everyday within the city either going to work, doing business, transiting to different towns, seeking services from the government or private sector, schooling or doing recreational activities. Another target group with employees of the county government of Nairobi who are the agents of service on behalf of the county. This provided information on how the county is carrying out its current parking services and plans they have on improving how best the service can be offered both to the citizen's benefit and the county governments.

Sample population was twofold for the research to increase accuracy and also give input as to the best recommendations. The first group of individuals was be the county citizens who are the consumers of this service every day. They shared their experiences, first-hand, and this gave a true picture of what actually happens. Secondly they contributed on the best approach to manage parking in the central business district and from the aggregated opinions, recommendations with be produced.

The second group is the Nairobi county government employees who are the agents that deliver these services. The county has a method which is currently being used, supposedly have a plan of improvement to be implemented. The county employees also enlightened the research by sharing the current challenges that they are experiencing with the current approach.

To increase the accuracy of data the best sample size is established According to (Systems, 2016) the formula for sample size is;

Population:150 Accuracy: 90%: Margin of error: 5%

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

Where:

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

p = percentage picking a choice, expressed as decimal

(.5 used for sample size needed)

c = confidence interval, expressed as decimal

(e.g., .04 = ±4)

Equation 3.1 Equation to Calculate Sample Size

Note that the sample size calculator assumes a normal distribution of (50%) for optimum size calculation

3.4 Data Collection Instruments

The importance of data collection instruments This to capture quality evidence that would answer the overall research question in the study. through various approaches to data collection, the researcher will deduce information that will contribute to making inform decisions. To improve the quality of information, it is expedient that data is collected so that you can draw inferences and

make informed decisions on what is considered factual. Data collection will employ several methods.

3.4.1 Observation

Observation method is a very common method of data collection and simple in nature. It has been used in numerous studies before and has high levels of accuracy. Observation method will come in handy as the research question could be answered by observing how the process is being carried out currently. Observation has been defined as a systematic approach of data collection where researchers utilize all the five senses to evaluate and examine the naturally occurring components or settings within the area of study. The main types of observation include the social situation or prolonged engagement. In this particular study, the researcher will take some time to observe the different pattern within the city regarding the city's population pattern, parking system, payment activities, vehicle movements, people movement, among other things that are that are targeted to address the research question

3.4.2 Document Reviewing

To get relevant information regarding components of parking management, reviews of some of the documents from different offices and websites will be done. One of the core document reviews utilized involves library research whereby a number of materials from the local libraries will be reviewed. This will help collect information on traditional approaches to parking management. The other reason for utilizing library review is that t avails right knowledge regarding the best study theories and models, which will make it easy to conduct an effective research. Additionally, both local and international periodicals and journals will be reviewed to collect important information. The research will concentrate on online research to study different websites that have published information about the parking management of the Nairobi county e.g. patterns of parking management, payment processes, challenges and any other relevant information that could aid a quality research.

3.4.3 Online and One on One Surveys What surveys?

Surveying is one of the critical measurements employed across study disciplines, such as social research. It involves asking questions to respondents as a way of collecting data. The main

approaches to surveying include questionnaires and interviews whereby the respondents are required to answer questions as directed by the researcher. Applied survey method will be deployed to obtain data on parking experiences and capacity by parking type. In order to collect data on demand supply and parking duration in a specific parking type, surveys will be conducted around several car parks including on street, off-street and parking in buildings.

3.4.4 Questionnaires – You are not explaining much in this case

To allow respondents to participate in the process, questionnaires were made available online and in public offices where the sampled respondents collected and filled them with the right answers. Questionnaires were to the respondents (citizens and county employees). Citizens shared feedback on their experiences and gave opinions on how best management should be handled while employees shared insider information on the current approach, challenges and underway plans around the whole process. Most look like theory and not really things you did – and if you so you need to say what you did actually – step by step.

Questionnaires seek some answers regarding preference of people within the CBD on various modes of transport and patterns created regarding parking and the movement within the streets. There were numerous advantages of using this method of data collection in the case of this study. When questionnaires are distributed, respondents are able to freely contribute their suggestions, views and critique of the current state of parking management. Also, the method allows critical information to be shared since it is highly confidential.

3.4.5 Interviews

Apart from the methods sated above the study will conduct some structured interviews. questions will be prepared in advance and asked during interviews. Then the respondents will be alerted on the procedures where those interested will volunteer for the interview sessions. It will be a voluntary process so that the willing respondents may comfortably give unbiased information.

The first section of the interview will contain some extent of bio data with some details being optional to stat e such as name and mobile phone contacts. The second part will their knowledge on current parking management approaches and third about their reactions concerning

the current systems and management. The final section will be accommodating their suggestions and preferences for future development.

The interviews will help evaluate even the emotional and physical responses from the interviewees. This increases quality of data collected. Again, hidden aspects such as social cultural aspects of development will be revealed. Shortcomings of this method are but not limited to cost and some respondents not fully responding to all questions as expected.

3.5 Application Development

The methodology that you will use Agile - denoting "the quality of being agile, readiness for motion, nimbleness, activity, dexterity in motion" - software development methods are attempting to offer an answer to the eager business community asking for lighter weight along with faster and nimbler software development processes. This is especially the case with the rapidly growing and volatile Internet software industry as well as for the emerging mobile application environment. The new agile methods have evoked substantial amount of literature and debates. However, academic research on the subject is still scarce, as most of existing publications are written by practitioners or consultants. The aim of this publication is to begin filling this gap by systematically reviewing the existing literature on agile software development methodologies. This publication has three purposes. First, it proposes a definition and a classification of agile software development approaches. Second, it analyses ten software development methods that can be characterized as being "agile" against the defined criterion. Third, it compares these methods and highlights their similarities and differences. Based on this analysis, future research needs are identified and discussed (Pekka Abrahamson, 2017).

Agile software development refers to a group of software development methodologies based on iterative development, where requirements and solutions evolve through collaboration between self-organizing cross-functional teams. Agile methods or Agile processes generally promote a disciplined project management process that encourages frequent inspection and adaptation, a leadership philosophy that encourages teamwork, self-organization and accountability, a set of engineering best practices intended to allow for rapid delivery of high-quality software, and a business approach that aligns development with customer needs and

company goals. Agile development refers to any development process that is aligned with the concepts of the Agile Manifesto. The Manifesto was developed by a group fourteen leading Figures in the software industry, and reflects their experience of what approaches do and do not work for software development (Pekka Abrahamson, 2017).

There six stages of agile development

i. Scope out and prioritize projects
ii. Diagram requirements for the initial sprint
iii. Construction/iteration
iv. Release the iteration into production
v. Production and ongoing support for the software release
vi. Retirement

The application followed the standard SDLC cycle in sequence of conception, initiation, analysis, design, development testing production and implementation and maintenance.

3.5.1 Requirements Gathering and Analysis

This phase defines the user expectation. It encompassed the activities the determined the user needs that ought to be met for the system All possible requirements were collected from all stakeholders and potential users, then documented in a specifications document. Each of these listed items is scantily explained.

3.5.2 System Design and development

The requirements gathering phase give an input to the design phase. When the requirements are analysed, the design phase commences factoring in the analysis. This will use the agile process mentioned above until the system is ready.

3.5.3 System Implementation

With input from system design, the system will first be developed in small programs called units called units, which will be integrated in the next phase. Each unit will be developed, and functionality tested

3.5.4 System Integration and Testing

All the units in the implementation with then be integrated into the system after testing of each unit. Post integration the entire system will be tested for any faults and failures.

3.5.5 System Deployment

The system once fully tested and approved, will then be deployed into production environment. In the production environment the system is normally available to an extensive scope of users,

3.5.6 System Maintenance

There are some issues which may arise after deployment of the system even after deployment. This could be change requests or functional improvements to the system. This is a continuous process and happens even as the system is in production.

3.6 Data Analysis

The research design refers to the overall strategy chosen to integrate the different components of the study in a coherent and logical way, thereby, ensuring the research problem is effectively addressed; it constitutes the blueprint for the collection, measurement, and analysis of data. This section analyses some of the commonly used methods in research.

3.6.1 Case Study Design

A case study is an in-depth study of a particular research problem rather than a sweeping statistical survey. It is often used to narrow down a very broad field of research into one or a few easily researchable examples. The case study research design is also useful for testing whether a specific theory and model actually applies to phenomena in the real world. It is a useful design when not much is known about a phenomenon.

3.6.2 Descriptive Design

Descriptive research designs help provide answers to the questions of who, what, when, where, and how associated with a particular research problem; a descriptive study cannot

conclusively ascertain answers to why. Descriptive research is used to obtain information concerning the current status of the phenomena and to describe "what exists" with respect to variables or conditions in a situation.

3.6.3 Applied Research Design

Applied research refers to scientific study and research that seeks to solve practical problems. Applied research is used to find solutions to everyday problems, cure illness, and develop innovative technologies. It is often used by researchers working in human factors or industrial/organizational fields

3.6.4 Basic vs Applied Research

Basic research is designed to generate new knowledge; whereas, applied research is designed to solve particular problems. Examples of basic research would be the study of the Big Bang theory or what's at the centre of a black hole. These studies provide us with knowledge but have little impact on our daily lives. Applied research studies can be used to address problems and improve life for individuals both in the workplace and the communities they live in.

3.7 Research Validity

Validity, reliability and objectivity are three major components to measure the quality or trustworthiness of the" study. Consequently, the following describes the validity, reliability and objectivity of this study.

3.7.1 Research Validity

Validity determines whether the researcher is studying the phenomenon he/she purports to be studying. There are two kinds of validity, namely internal and external. In terms of internal validity, it evaluates how well there is a match between the empirical findings and theory. In contrast, external validity measures the extent to which results from the measurements are coherent with the reality and whether generalizations can be drawn from the result (Ghauri & Gronhaug, 2005). In order to maintain external validity in this research, questionnaires were used. In terms of

internal validity in this research, focus was on an open approach in order to maintain a high internal validity. The open approach doesn't manipulate the outcome of the questionnaires. There may be a weakness in the internal validity in this research because a few of the respondents may not have dealt directly with implementation of information systems. As a result, this may cause more general answers, not specific to the implementation of information systems.

3.7.2 Research Reliability

Reliability measures the extent to which the same conclusions drawn can be repeated if the research is done again (Ghauri & Gronhaug, 2005). Reliability in this research was achieved by having a structured research method. In order to construct reliability in this study, all respondents were subjected to the same set of questions. In addition, analysis of data from respondents was done using the same procedure.

3.7.3 Research Objectivity

Objectivity is a measure of how researchers undertake and carry out their research in that it requires them to be precise, unbiased, open, honest and receptive to criticism. In a similar vein, objectivity means being aware and honest about how one's own beliefs, values, and biases affect the research process. To achieve objectivity various individuals that interact with the county parking system will be interviewed i.e. citizens and internal employees of the county.

3.8 Ethical Considerations

Ethics refers to the principles of right and wrong that individuals, acting as free moral agents, use to make choices to guide their behaviours (Laudon & Laudon, 2012). Research ethics is critical since it guides the interactions with people, organisations and institutions (Christensen, Johnson & Turner, 2010). Assurance is given that information provided for purposes of this research will be treated with the highest level of confidentiality. The responses provided by the respondents will not be shared with any person or institution without consent. In addition, this research report will be subjected to the Turnitin/Plagiarism-checker (EduBirdie) tool for similarity assessment.

Chapter 4: System Architecture and Design

4.1 Introduction

System architecture describes the major components that it of a system, how they relate to each other in structures and their interaction. System architecture and design has several contributing factors such as business requirements, guilty attributes, human dynamic, design components and the environment in which the system operates.

System design builds a plan that elaborates a system by describing how the elements of a system fit and work together to achieve all the requirements of the system. The intention of having a design plan is to settle on specific system requirements, align with user expectations that could be any user who will potentially interact with the system. The system design also acts as a blueprint of what is expected during the development process guiding the implementation tasks that would extend to integration, coding and testing.

Evaluation of the design and architecture of the proposed system was done by factoring in the requirements collected from potential users and ability to function as fully expected. To attain this, diagrammatic representations were created using modelling software to bring out detailed understanding of each element. These are data flow diagrams and use case diagrams with descriptions. The diagrams show how data is relayed from the user interface to the database and how different users interact with the application.

4.2 Proposed Systems Architecture

The architecture of the parking system consists of several components mainly, communication devices. The parking spot booking information is used to monitor the status of each slo.. The information is monitored at regular intervals due to its dynamic nature. The information is available at the central server which is used to store data about the parking status. When a drive reeds parking at a certain area, he initiates the requests via browser from a phone or a personal computer. This request is sent to the central server as indicated in Figure 4.1

. The request is made through various steps after accessing the browser. The user needs internet to access the url through a browser. The url is written on the browser and loaded to redirect

to the log in page. The system, us since it's a web application, is hosted in a cloud environment that can be accessed from anywhere as long as the user has internet connectivity to access the webserver. The browser is the client in this context and interacts with the database using the web interface. The database holds all information regarding parking spaces and the system and updates request in real-time once they are made or expire. Once a user accesses the web application portal, available slots are displayed from the database.

The illustrations are as per Figure 4.1 It is shown that the central server receives parking information from all facilities and stores the information in the database server. A user in motion can place a request and get real-time update of the available slots and get a precise from the central server The automated parking guidance system considers various parking facilities in the city that are labelled based on zone, street/road and a number e.g. CBD-KenyAV-003 (this is a parking spot number found on Kenyatta avenue in the central business district of Nairobi). Whenever the central server receives any request, the request is forwarded to the central server. Now central server, in association with the server database, display the available parking spaces for the user to choose from.

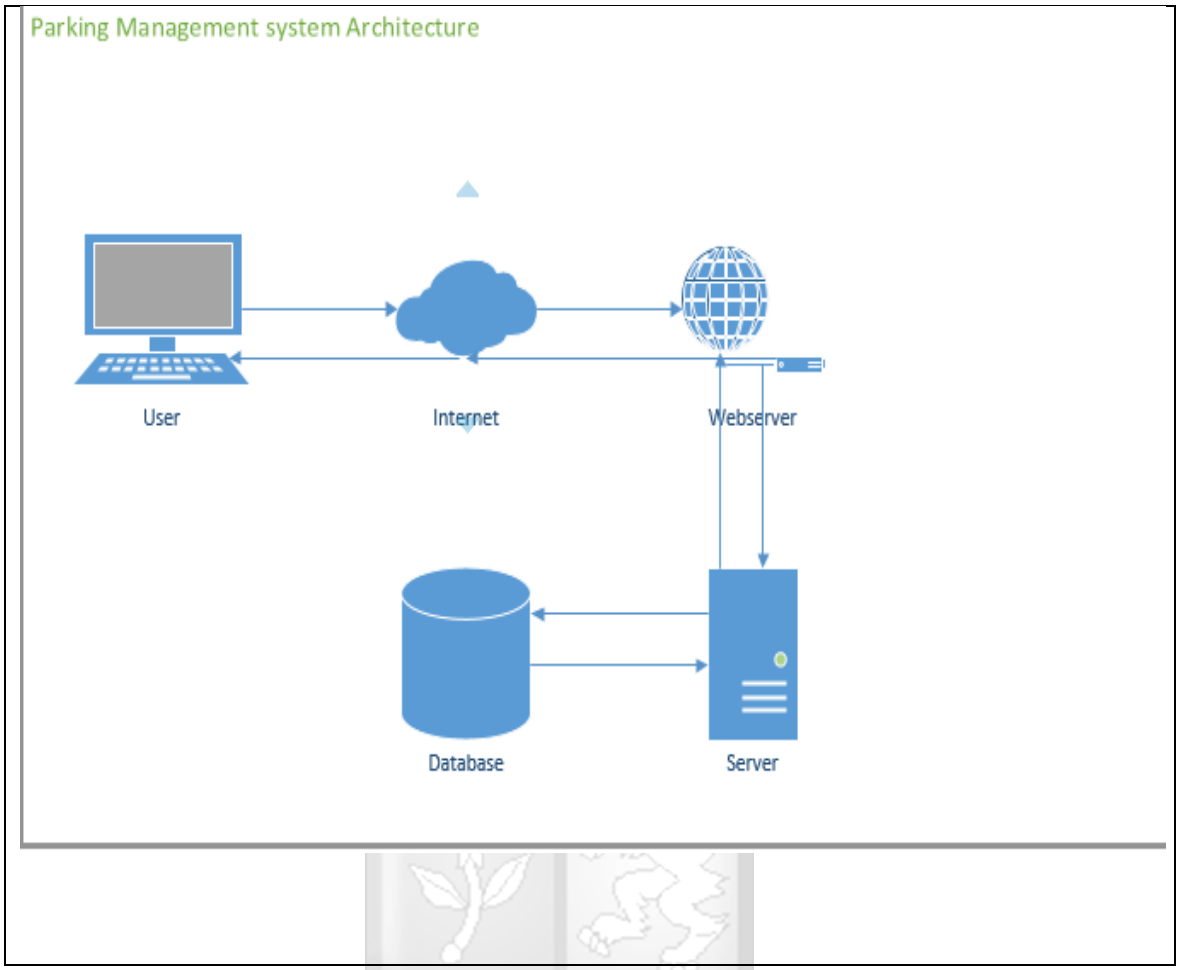

Figure 4.1 System Architecture

4.3 Requirements and System analysis

This section focuses on the requirements that the researcher attained from respondents based on the data collected from the users. These requirements are used as a guide to determine the specific needs to meet the new system taking into account varied interests from users in the ideal system capability

4.3.1 Requirements Analysis

4.3.1.1 *Usability*

The application has a simple user-friendly interface that users will interact with to place and follow up requests. The user access the web portal using an internet browser through a url that is made available to them. They are allowed to log in and place request within a very short time.

4.3.1.2 *Compatibility*

The first phase of the application will be web based. Therefore, access will be using computer web browser interface from either a phone or a personal computer. This means that there are very many options availed to the user to access the system and can use any operating system However the second and third phases will develop android and iOS mobile applications.

4.3.1.3 *Functionality*

The application is able to predict availability of parking. The user is able to plan for parking and can book in advance. Online payment for parking will be available via MPESA and eventually integrations to payment card systems. Time slots to parking services will be dynamic thus, a driver can specify the amount of time they need a parking space and also extend.

4.3.1.4 *Reliability*

The application service is available 24/7. This is because it will be hosted in a public cloud environment which increases availability. System tests will be conducted quarterly to ensure that performance and efficiency of the system is optimized and continually improved. Information on the status of all parking system will be available to all users indiscriminatively hence increasing the reliability Its also important to note that access to the system will be from any browser using personal computers, Table ts and smart phones.

4.4 Sequence Diagram

The Figure 4.2 shows activities in sequence. The driver inputs his username and password for verification. He/She then once authenticated, is able to navigate the application to find the most convenient parking and selects it then submits the request. The database server upon verification sends a confirmation to the driver for them to initiate a payment based on how long they need the space. The service is on a first come first served basis

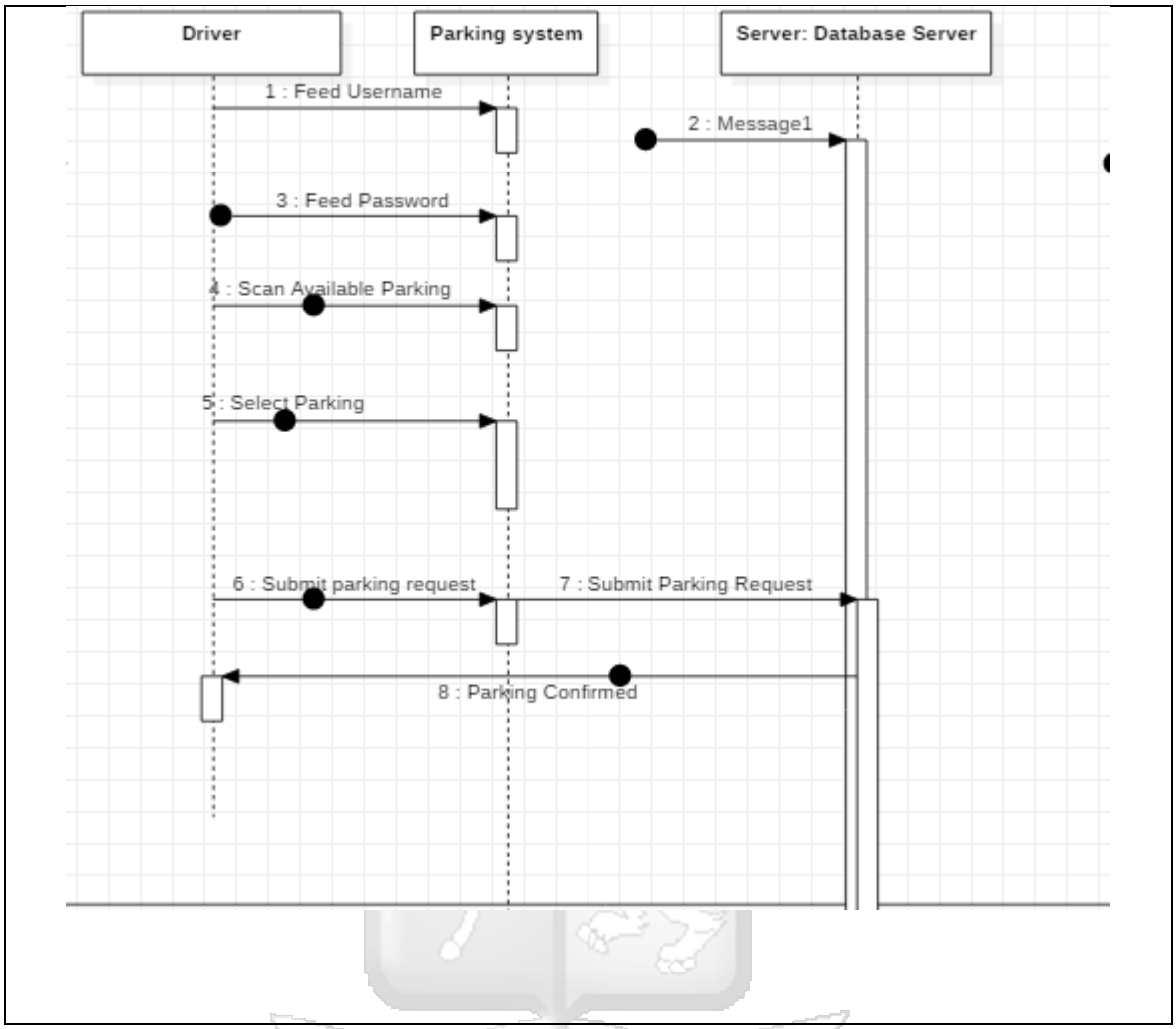

Figure 4.2 Sequence Diagram

4.5 System Design

Custom development was used as the design strategy. Object oriented design was used in defining the requirements identified during system analysis. User requirements were obtained from the findings of the survey. These user requirements were summarized into design class diagrams (DCD) and entity relationship diagrams (ERD). This is important to illustrate how objects, interact with each other and outline the processes involved in implementation of systems.

4.5.1 Entity Relationship Diagram (ERD)

An ERD contains different symbols and connectors that visualize two important information: The major entities within the system scope, and the inter-relationships among these entities. Here we have the driver details, vehicle to be parked details, Parking spot details, MPESA transaction details and the administrator details. This ER information inturn is used to build the database in the MySQL platform as shown in Figure 4.3. The database organizes data according to a database model. It determines what data must be stored and how the data elements interrelate. Database design involves classifying data and identifying interrelationships. The database for the parking management system is derived from the entity relationship diagrams and all the entities have primary keys that uniquely identify them as per the Figure 4.4

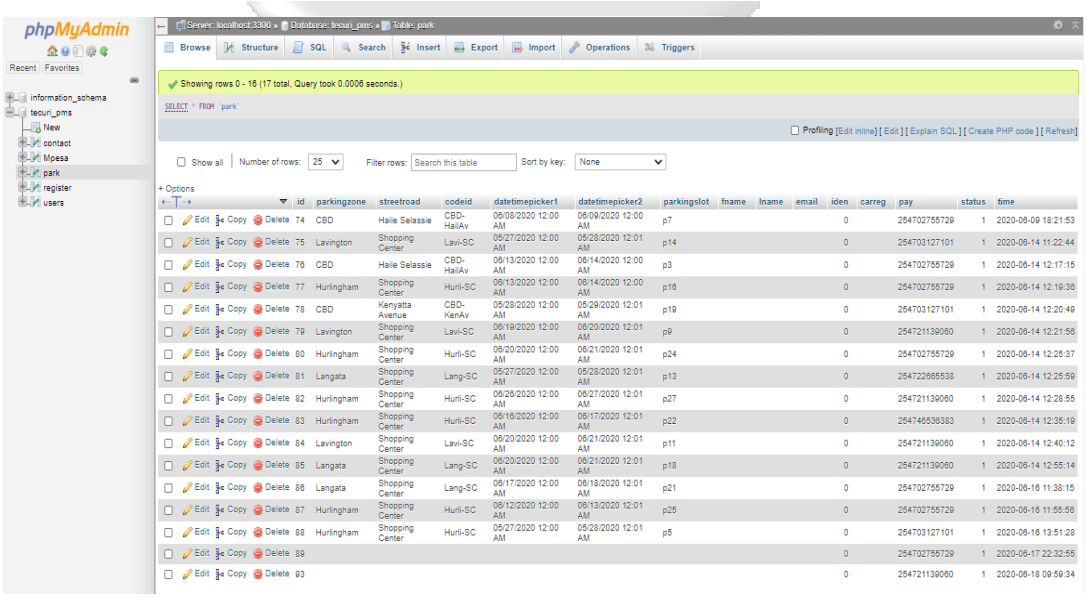

Figure 4.3 MySQL database extract

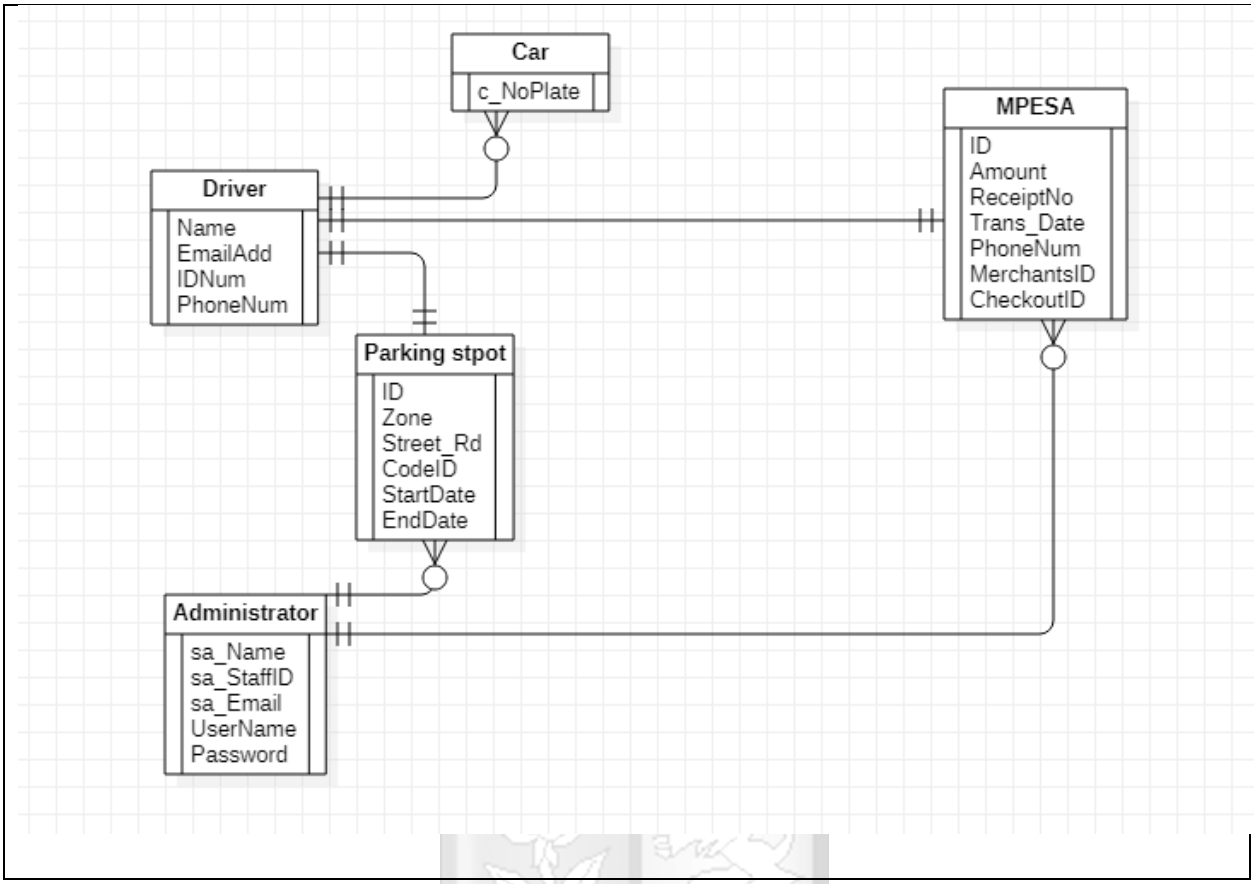

Figure 4.4 Entity Relationship Diagram

4.6 Activity Diagram

Activity diagram is basically a flowchart to represent the flow from one activity to another activity. The activity can be described as an operation of the system. The control flow is drawn from one operation to another. In the Figure 4.5 , the first activity is a user initiating a request for an available parking slot . The system then avails available parking slots for the user to make a choice. If the parking slots are unavailable, the user can tell from the interface since all booked spots are displayed and flagged in red Figure 4.6 . If there are available slots, they are marked in green without any ref flagging as shown .

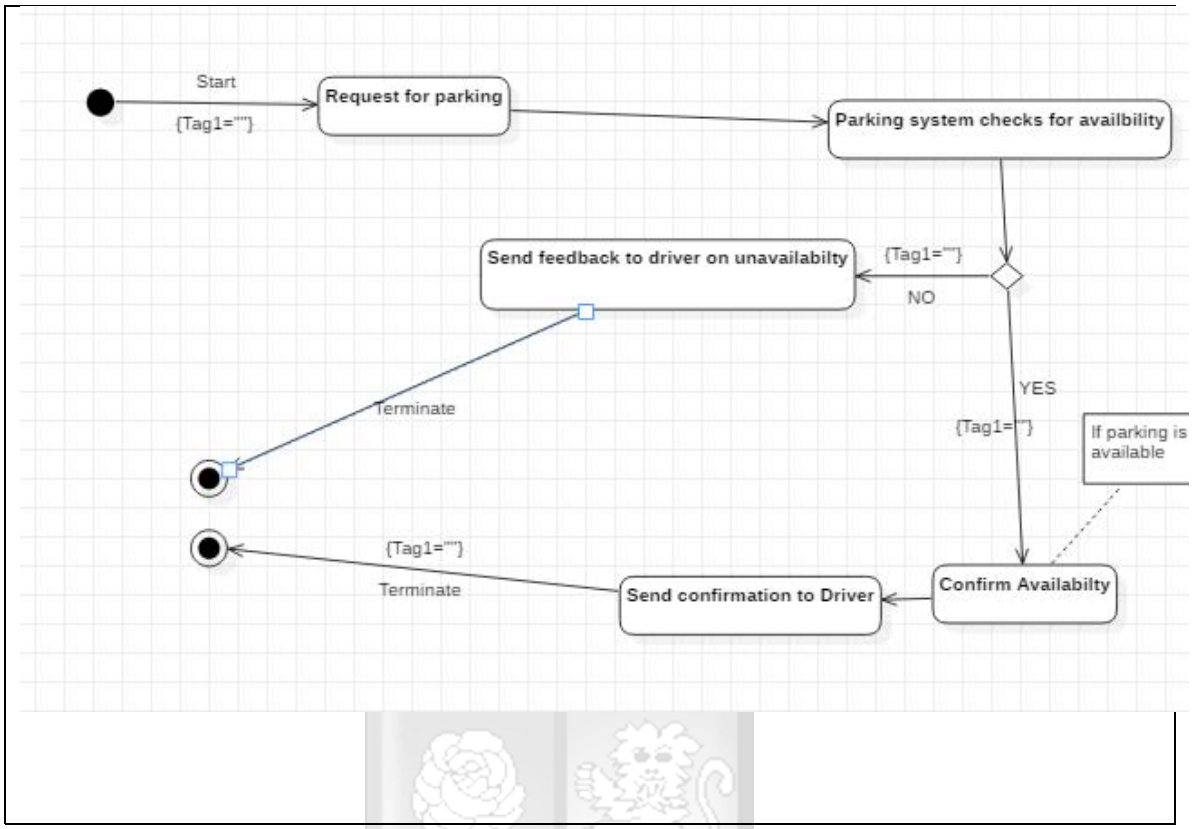

Figure 4.5 Activity Diagram

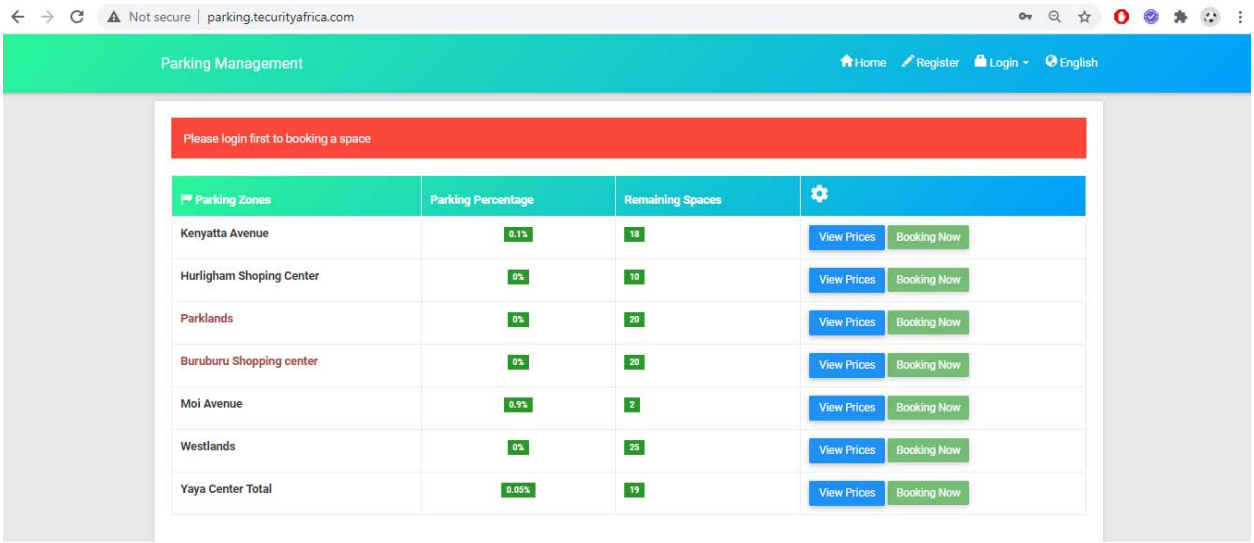

Figure 4.6 Parking System Interface

4.7 Security Design

Both the system approach and data approach were considered in designing the security of the system. Security of data is ensured by requiring access to the system through username and password. In addition, the characters of the password are masked even in the storage to ensure that even the administrator cannot tell the user password. In addition, there is a password policy which defines the type of characters to be used, minimum number of characters allowed, duration of use of the password and prohibits use of a password that had been used before. Further, a lockout policy is implemented in the system that locks out users after a specified number of unsuccessful logins attempts and after a given duration of when the system is idle. To ensure security of the system and data, access to the system is authenticated. Access is only granted in accordance to the privileges accorded to the user.

4.8 Use case diagram

There are 2 main actors for the application to complete a fully efficient service as shown in Figure 4.7 . A driver is the registered user who seeks to use the parking management services within the county of Nairobi. The service administrator representing the county and their role is to oversee the services allocation processes by the system and also check on defaulters who mostly exceed parking time without paying for it. The administrator reconciles all payments with the number of hours booked by users in the system and can choose to create a portal for the finance operations to be performed or generate reports for them. System administrates are to ensure service availability by securing, updating and patching the system.

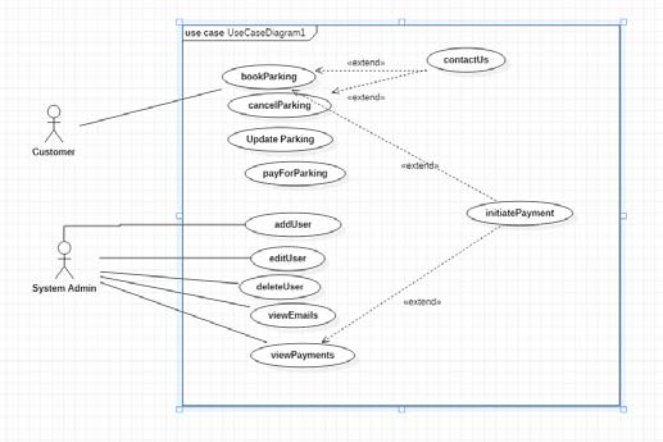

Figure 4.7 Use Case Diagram

4.9 Data Flow Diagram

Illustrates the step by step processes followed in the application and the data stores of various data. A registered user logs into the system and his credentials verified. Each user has an accessible and editable user profile. After login the user is presented with a main menu where they can choose the most convenient parking space they need. The drivers also have provision to cancel parking spaces booked up to 30 minutes before the start time. Otherwise the full amount is charged to the driver.

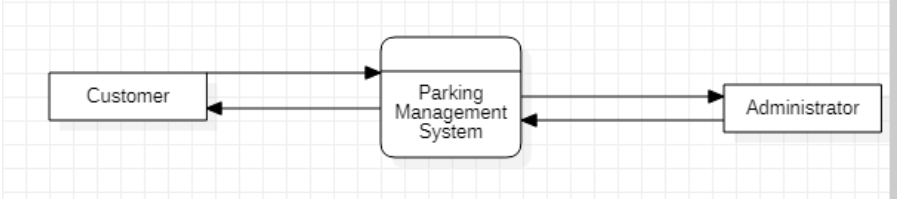

Figure 4.8 Context Diagram

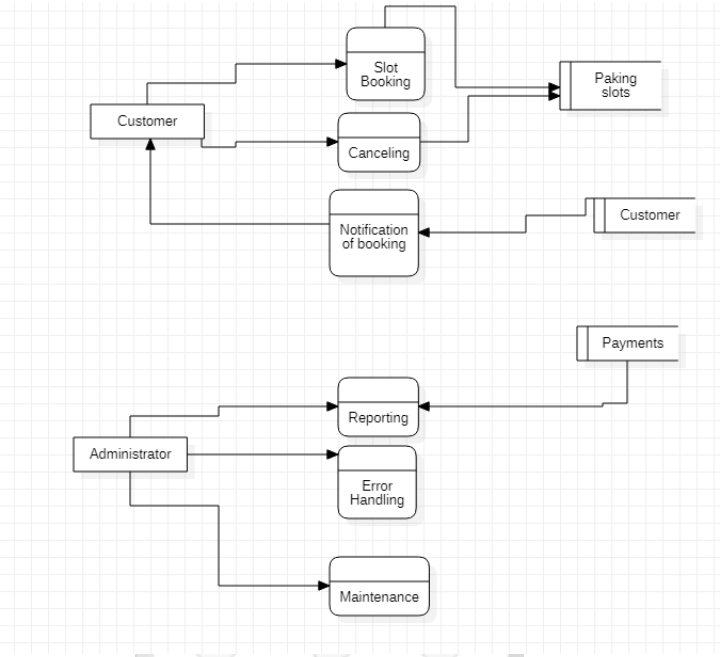

Figure 4.9 Data Flow Diagram

Chapter 5: System Implementation and Testing

5.1 Introduction

System implementation is the sequence of activities that formulate an action plan. Prior to implementation team. Its overall objective is to ensure that the system is operational. Users are allowed to take over its operation for use assessment and evaluation. Users are trained to interact and handle the system plan for a sooth conversion. System Testing uses a black box testing approach done to evaluate if the system actually met the requirements for which were proposed. During testing, the functionalities of the system are tested from an end-to-end perspective. System Testing is usually carried out by a team that is independent of the development team in order to measure the quality of the system unbiased. It includes both functional and Non-Functional testing.

5.2 WireFrames of the Parking Management System

Wireframing is a way to design a website service at the structural level. A wireframe is commonly used to lay out content and functionality on a page which takes into account user needs and user journeys. Examples are shown below in Figures 5.1,5.2 and 5.3 for logging in , homepage and booking interface .

5.2.1 Login Page

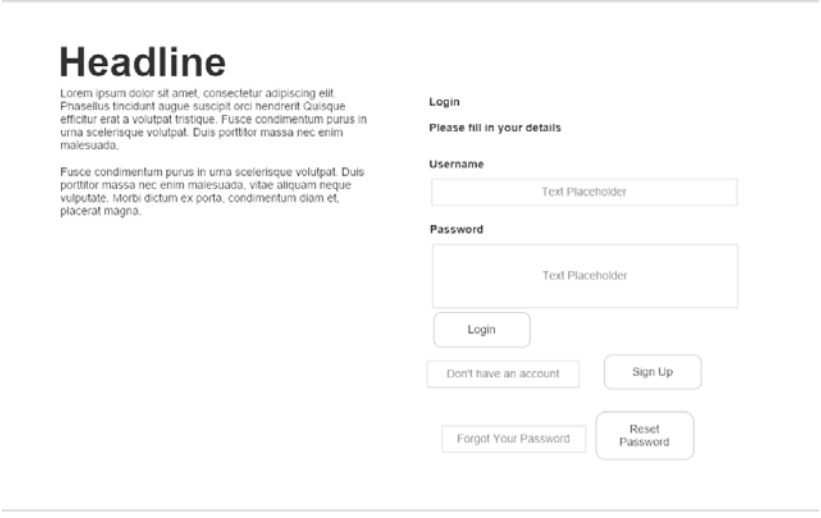

Figure 5.1 Login Wireframe

5.2.2 Home Page

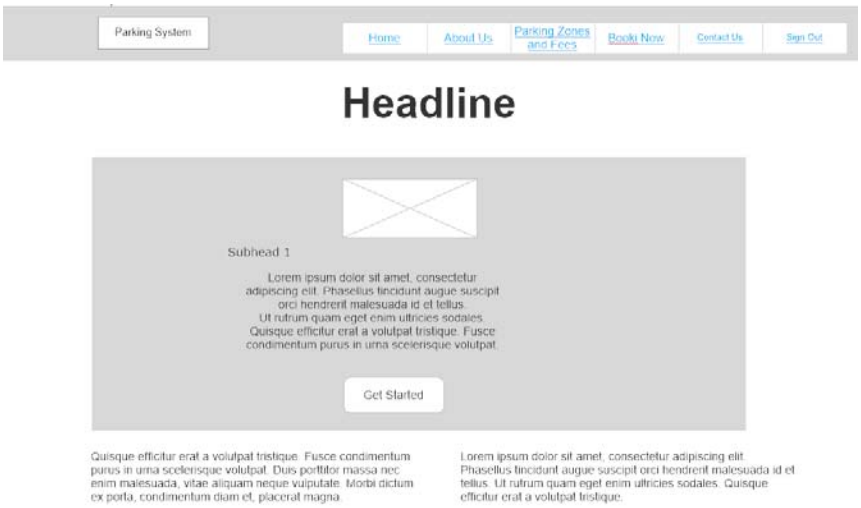

Figure 5.2 Home page Wireframe

5.2.3 Booking

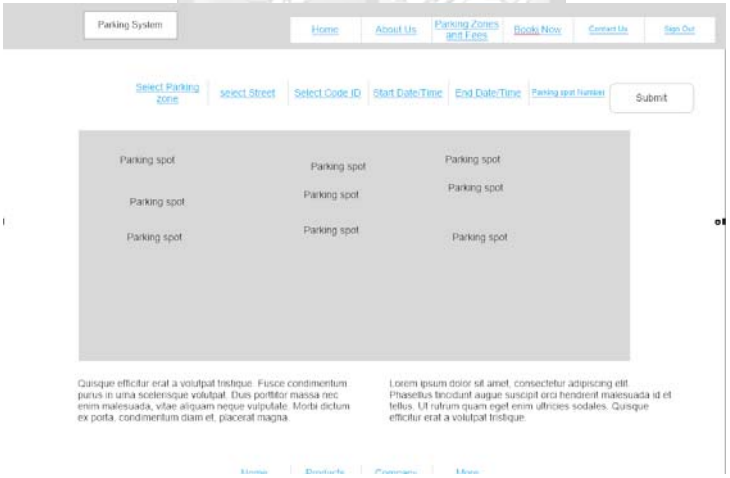

Figure 5.3 Booking Interface

Further before the System implementation and testing, you need to show the wireframes for what the system will have to show – with all the interfaces expected first mocked out (wireframes) and then later you show the actual implementations (from really system). You have missed a key component that must be added.

5.3 System Implementation and Testing

The research resulted into an application that can run as a web application on mobile devices where registered users have access to the main menu. The process begins with user authentication where a driver provides his/her credentials that uniquely identify them to access the system and request services. The details are verified by an authentication server and once this happens, the user can search and request for a public parking space anywhere within the county of Nairobi.

5.4 System Components

5.4.1.1 *Login*

A url is loaded on a browser by a user directing them to a login page where they can create a new user or login as an existing user. In case of a new user, there is provision of a sign up now option as shown in the Figure 5.1 were a user fills in their preferred username and also able to set a secure password of a minimum of seven characters .For an existing user, the system provisions a login here button that provides a form to fill in the username and password . Once logged on, the system loads the main menu page. During log in, the system verifies the user's authenticity from the database.

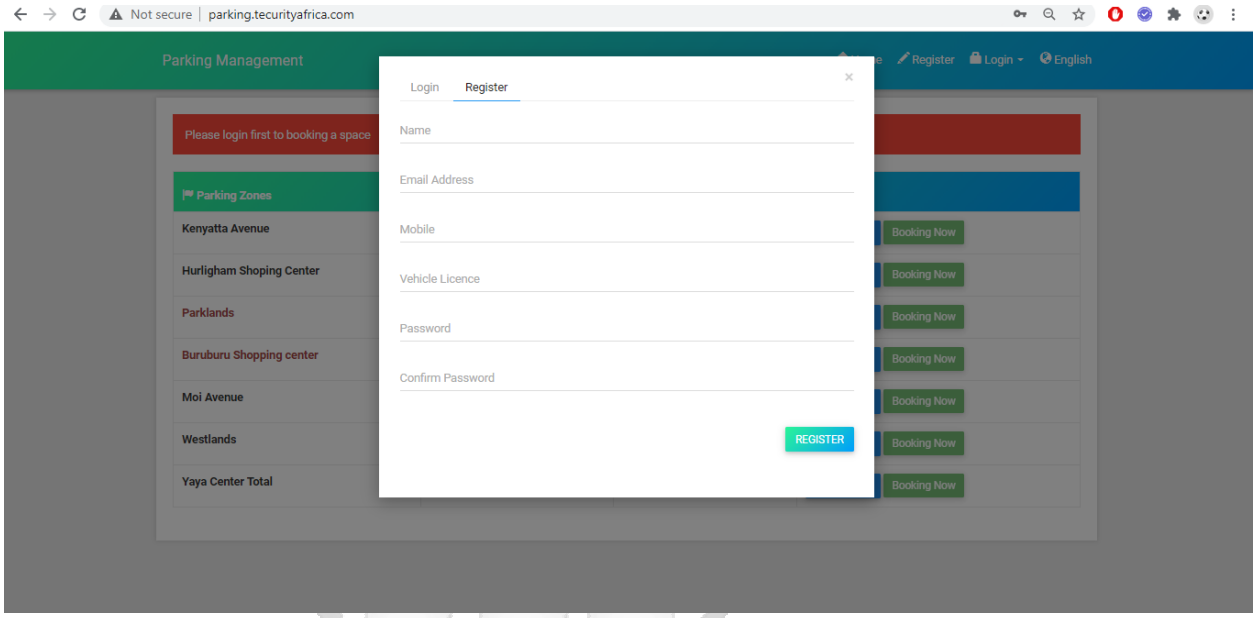

Figure 5.4 User Registration Page

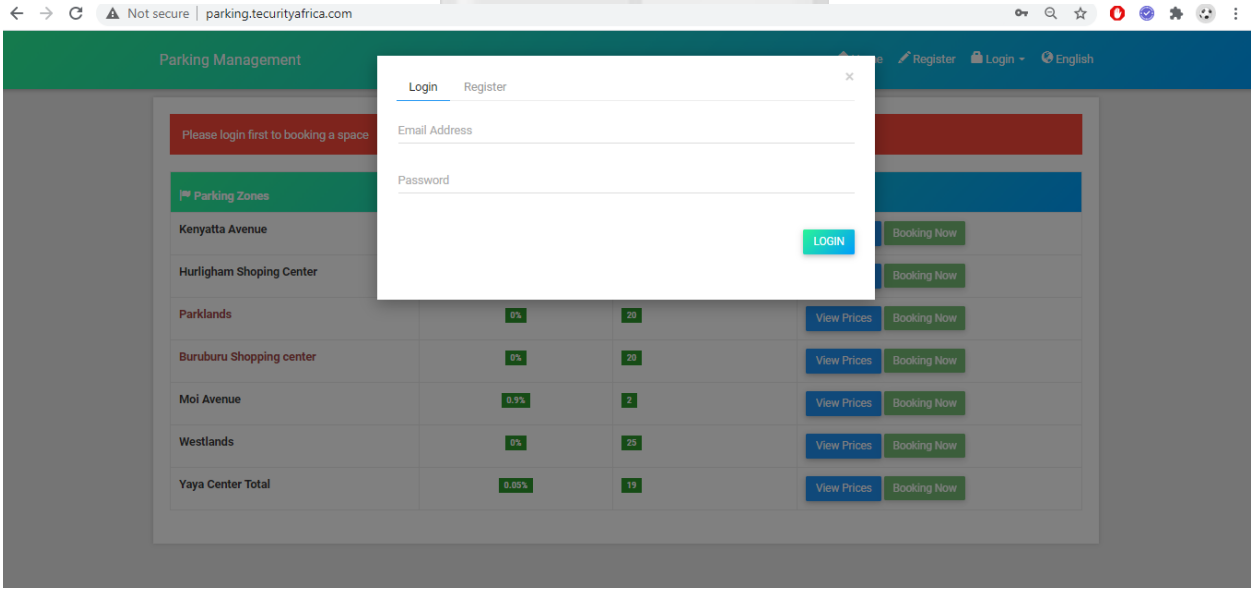

Figure 5.5 User Login Page

5.4.1.2 *Main Menu*

Once logged in, the user finds the main menu that consists of various options. These options are, pay parking option, view history option, user profile, payment information and several other features

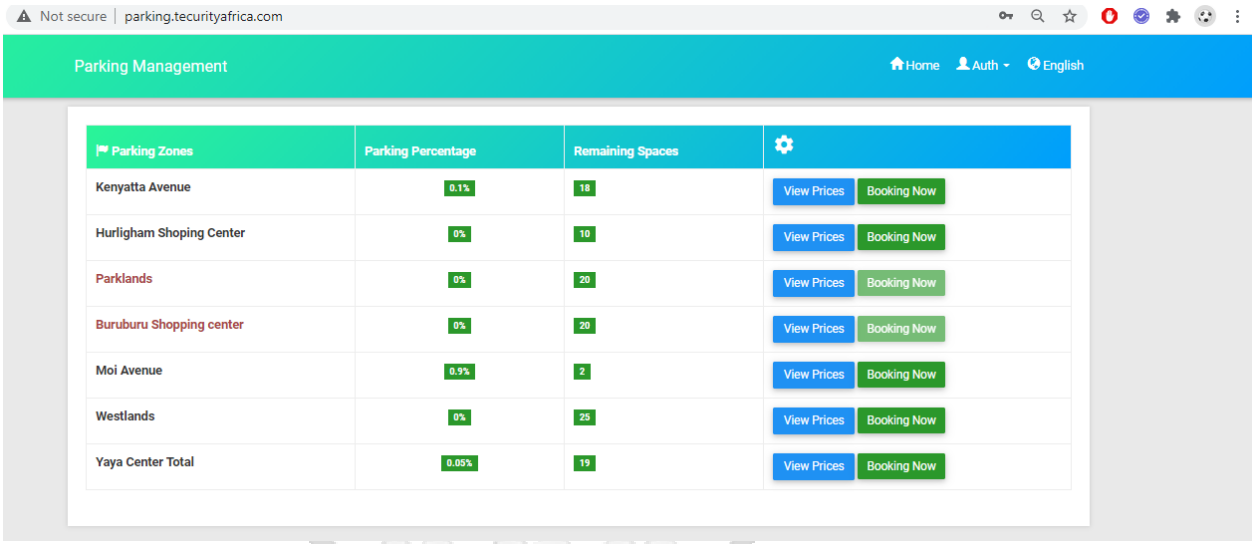

Figure 5.6 Main Menu Page

You have not shown the many snapshots of how the system works. We need to get into the details of what the systems does and share that with the readers.

Without these details you will be considered not to have done anything to warrant a masters. This is familiar to you well.

You risk the same issues this time around with a few cosmetic snapshots of the supposed system.

5.4.1.3 *Home*

The home page contains a welcome message once a user logs in and gives a high level overview of the expected service from the platform and is demonstrated in the Figure 5.3 .

5.4.1.4 *About us*

This tab contain highlevel information of the County government f Nairobi, Includes an introduction, Vision and mission statements, core values and the various aspects of governance such as Health Services Sector, Public management sector and Public works, road and transport sectors where the system fits .

5.4.1.5 *Parking zones*

This button gives a list of all available parking zones within the county's jurisdiction as shown in Figure E.g. Central business district (1), Langata (2), Lavington (3) , Hurlingham (4), Kilimani (5) and Parklands (6) . It's important to note that not all zones are active at the moment as there are many factors that will be involved to get the system up and running to manage the whole county parking spaces

5.4.1.6 *Book now*

This is the core of the whole centralized parking management system. When a user clicks on the Book Now button, they are redirected to a page where they can initiate the booking process. The interface displays real-time available parking spots as at the time of booking as shown in Figure 5.7

Figure 5.7 Parking Zones and Fees

The user can select the Parking zone e,g Central business district (1), Langata (2), Lavington (3) , Hurlingham (4), Kilimanu (5) and Parklands (6) , narrow down to a street road in the zone and select the code ID that appears automatically from the options . The user species the date and time using the calendar provided in the form . Different examples

of booking zones are shown in the Figures 5.9 for Langata Figure 5.10 for Lavington and Figure 5.11 for Parklands .

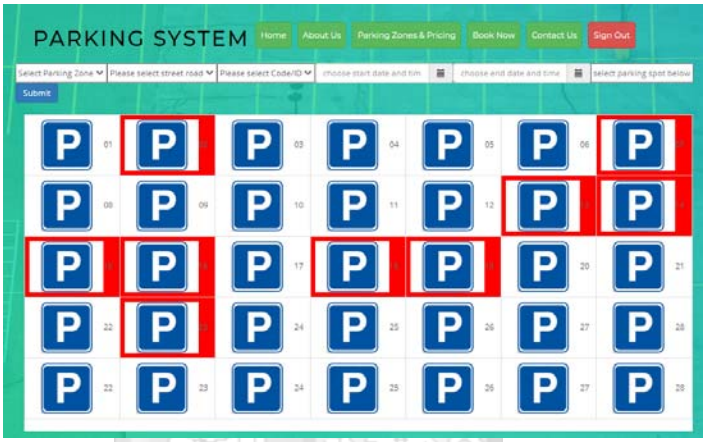

Figure 5.8 Parking Layout Overview

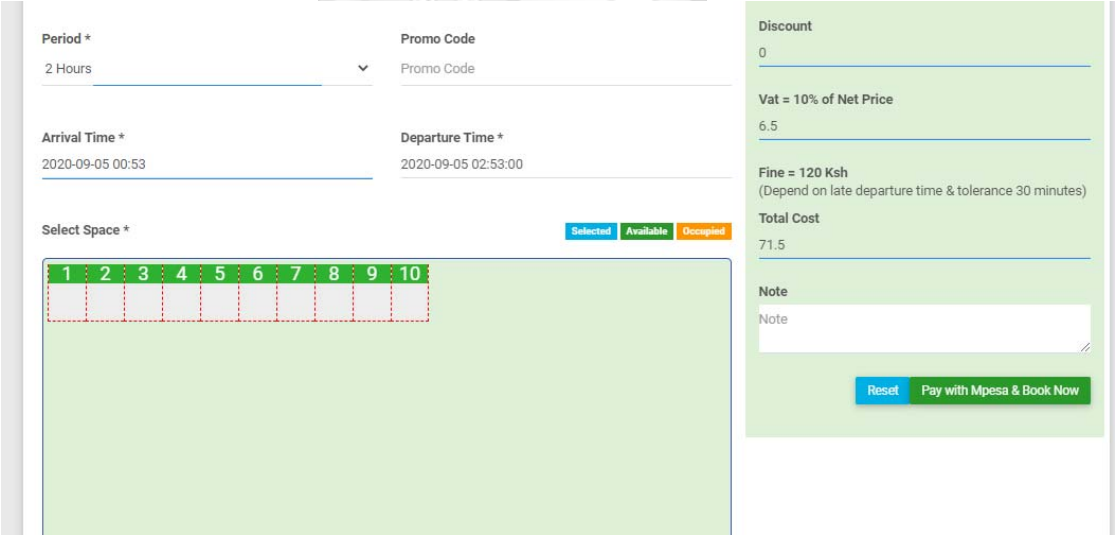

Figure 5.9 Hurlingham Parking Booking

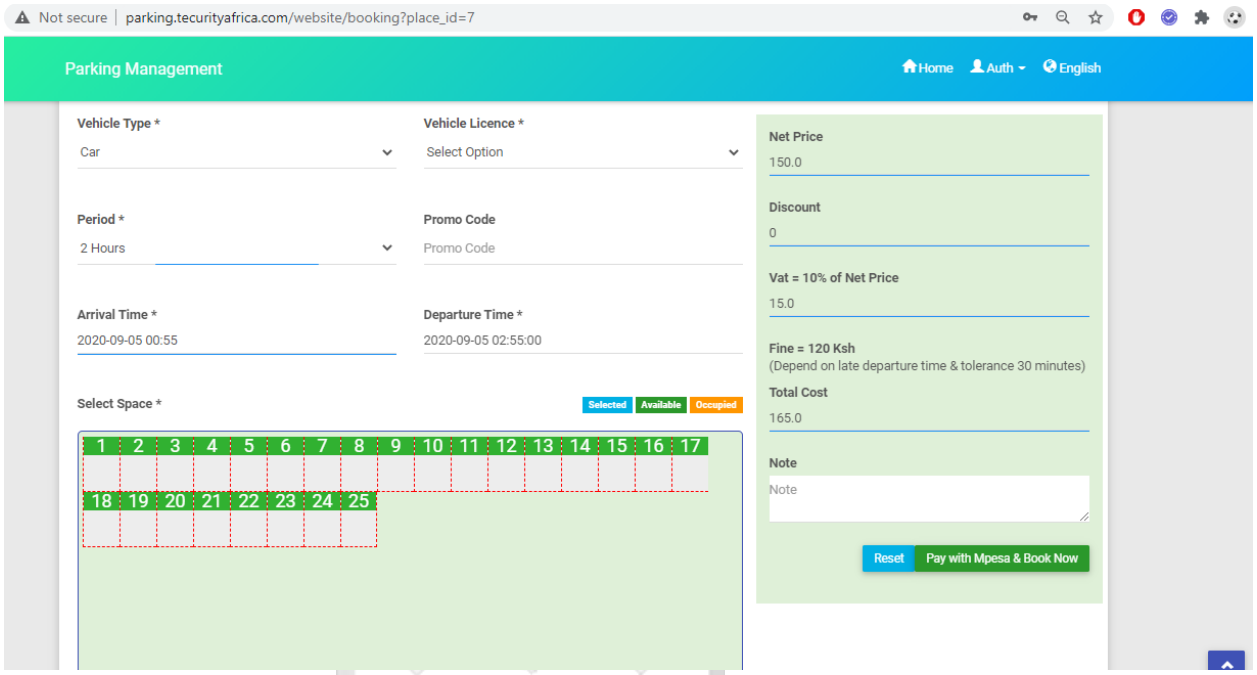

Figure 5.10 Westlands Parking Booking

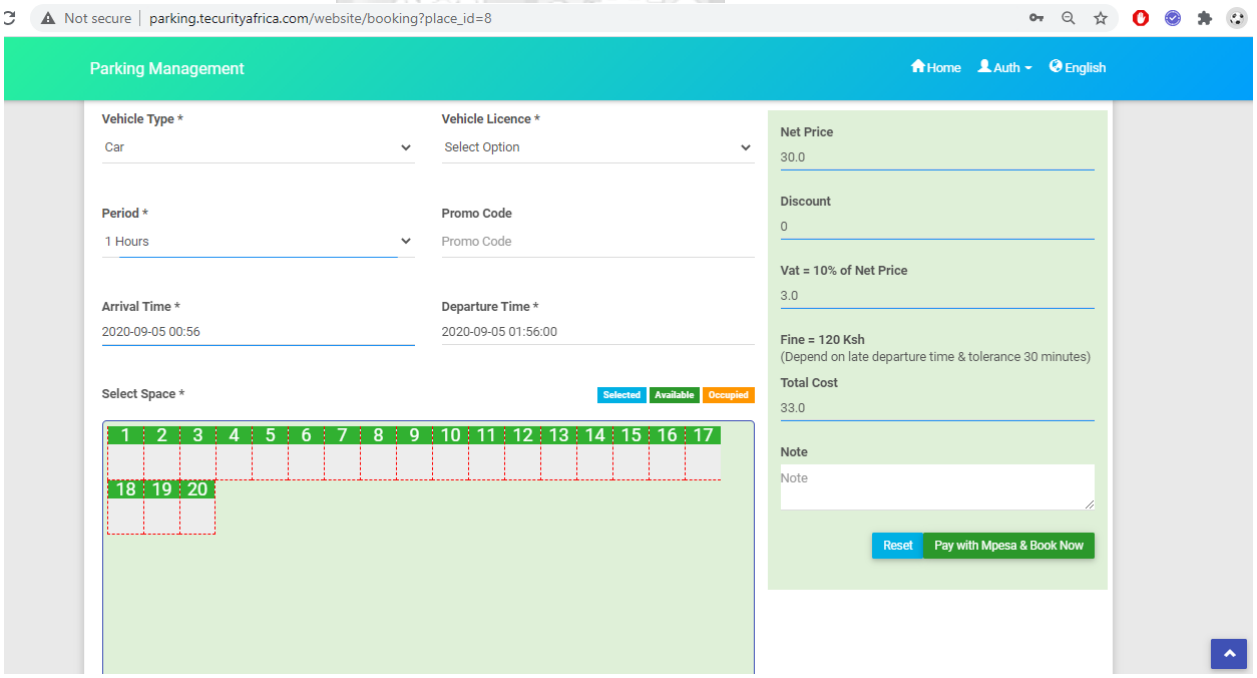

Figure 5.11Yaya centre Total Parking Booking

5.4.1.7 *Payment*

After filling up the specifications of the preferred parking spot based on the availability, the user submits the form details and is prompted to make a payment using MPESA mobile money payment. The system provisions a textbox to insert the mobile number as shown on Figure 5.12 The system is able to cache previous number used and hence provides the history to choose from as an option .

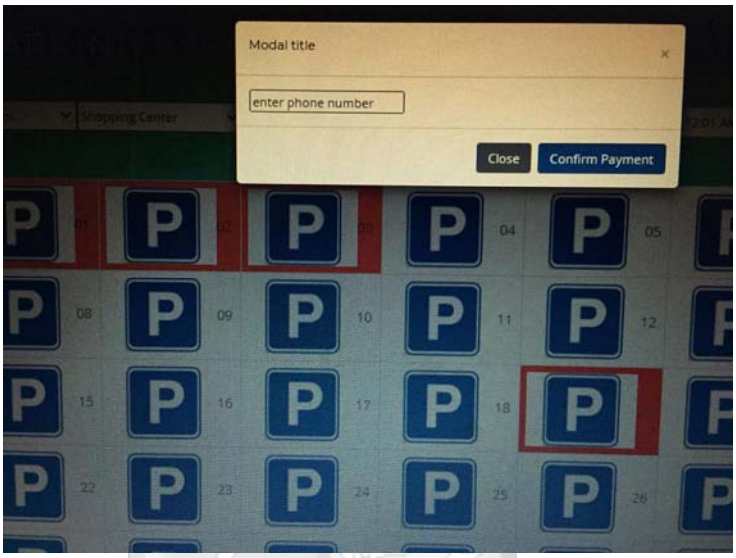

Figure 5.12 Mpesa Payment Prompt

Once the user enters the phone number and confirms, an MPESA interferes on the phone prompting them for the pin with a pre-set amount to be deducted . MPESA is a mobile money platform that is offered as a service by safaricom who is a leading internet service provider in the region. The MPESA API key is integrated to the system hence enabling payments through the platform.

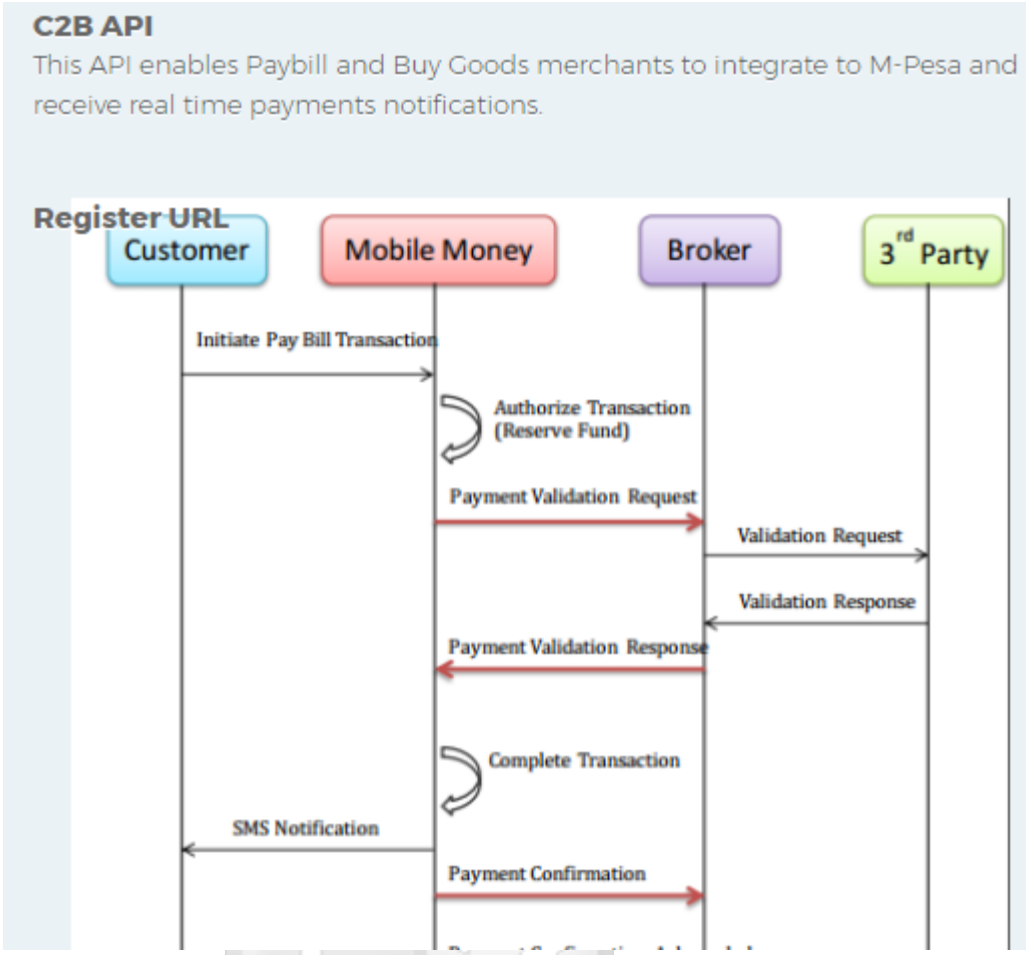

Figure 5.13 MPESA C2B Validation Process

After submitting the mobile phone number of a sure , the user is prompted to put in the MPSA pin by a push notification being sent to their phone by the MPESA plat form. When the user feeds the PIN and confirms, the parking is now automat ically booked and reserved until that time elapses . The PUSH notification is as shown in Figure …….

Figure 5.14 Mobile phone prompt

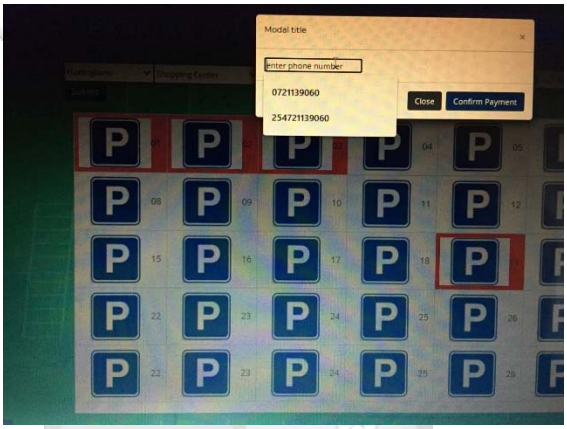

Figure 5.15 Mpesa

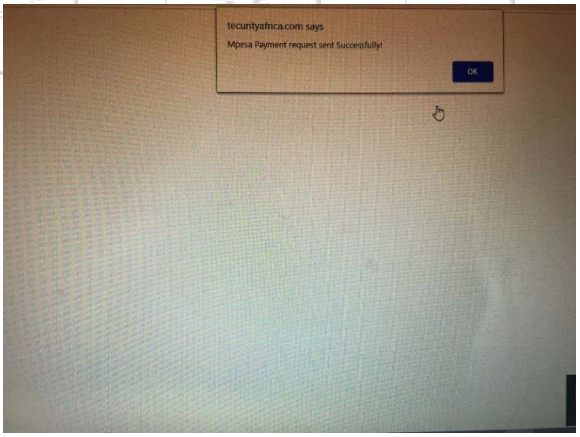

Figure 5.16 Figure Confirmation

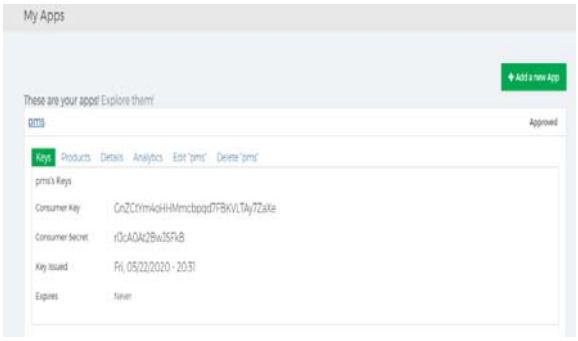

Figure 5.17 MPESA API Key

5.4.1.8 *Contact us*

The system has a provision of contacting the system administrator directly by a form provisioned to capture details of the client and also a textbox to write down a message to the administrator. The contact page is demonstrated by Figure 5.17 .

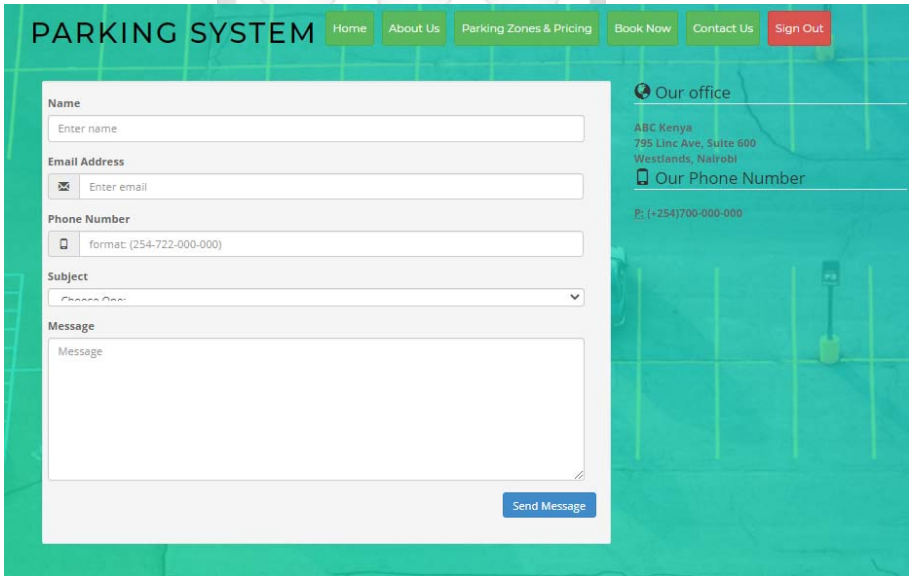

Figure 5.18 Feedback Form

5.4.1.9 *Sign out*

For various reasons including confidentiality, Integrity and privacy, the user is also able to sign-out from the system using the signout button provisioned on the menu bar , After signing out, the user is taken back to the login page as captured in Figure 5.18

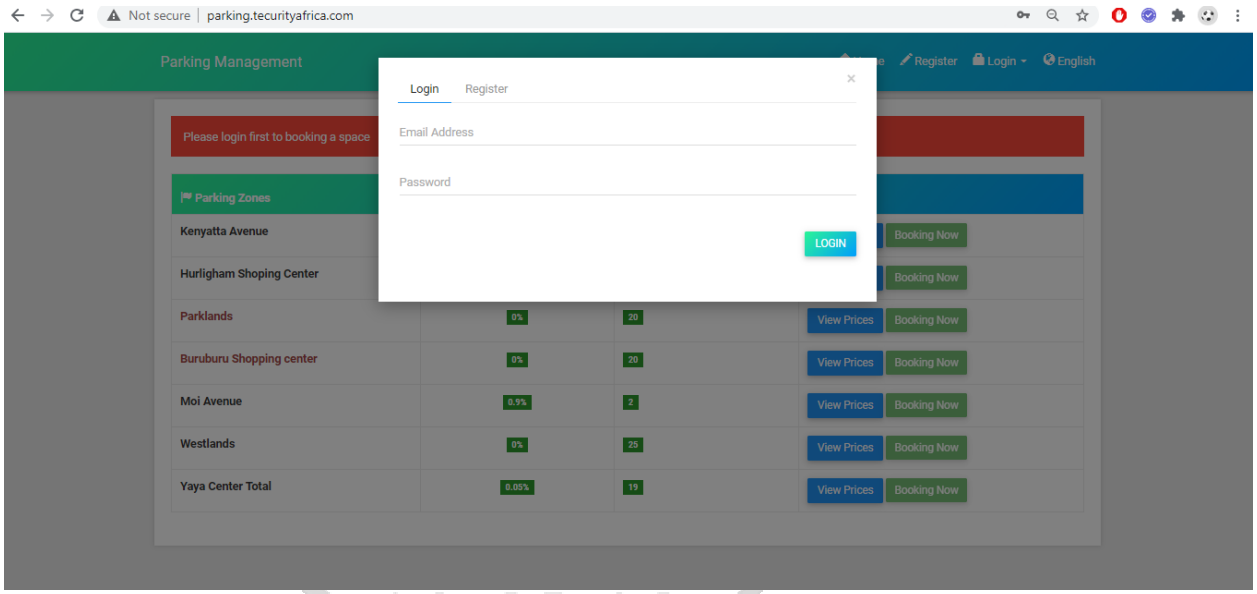

Figure 5.19 Sign Out Interface

This is the interface where al administrative controls are overseen and errors corrected identifying all issues with the system. Other admin roles that feature are Adding, removing, or updating user account information and resetting passwords. The admin page is as demonstrated in Figure 5.19

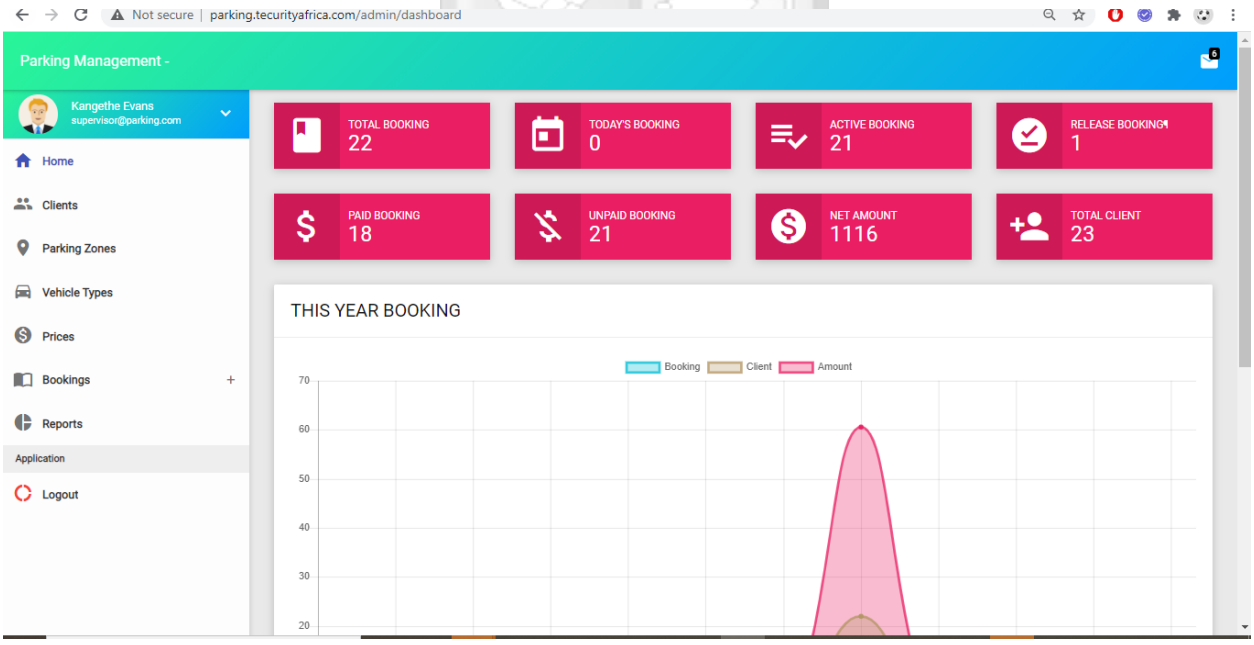

Figure 5.20 Admin Page

5.5 System Implementation

System implementation is necessary because of the following; There is need to make the system available to potential users and this must be accompanied by continuous maintenance and support . In more detail, implementation encompasses all steps to build user capacity on how to interact with the system, placing the system into live production, ensuring all data necessary for the initial system use are accurate and available.

In system implementation, the environment is highly unshielded compared to the fact that all other phases were in secured, controlled environment. In shielded environments, system issues arising have very minimal impact or none at all on operations whereas in live environment is on the contrary . Its is only through thorough planning management of execution, that the risk can be minimized and the impact limited and also putting contingency measures in place to address any arising issue.

System Implementation went through the following phases;

i. System implementation planning where careful thought is given to all the necessary steps required for deployment including consumer and production community preparations

ii. Actual system deployment which involves execution of the plan and this is also validated.

iii. Transition of functions in the performing organization where transfer of responsibility moves from the project team to the performing organization mainly maintenance and support team .

5.6 System Testing

The system was first tested on user registration and authentication. This was important since a user must log on to interact with the system. The researcher attempted to use unregistered

credentials to test the security aspect for authentication and could not log in as shown in Figure 5.20

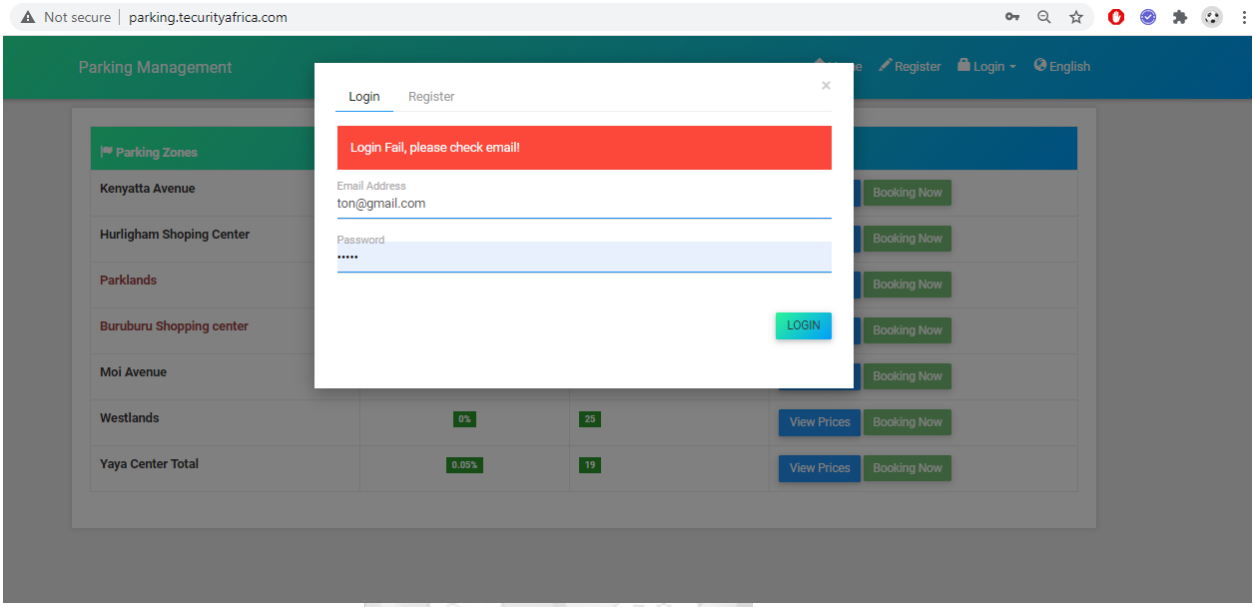

Figure 5.21 Authentication Error

This system does not allow authentication for unregistered users and when an unknown user tries to, they are rejected as shown. Then testing the process flow for the parking request which is the major process. A created user requested and paid for parking via the MPESA payment provision on the system.

5.7 Usability Testing

The application developed had to be in its simplest form avoiding any complexities since a significant percentage of potential users were below???? average literacy levels. The user interface was presented to 4 random taxi drivers within the city to ascertain ease of use and interaction with the system and the results were as in Table 5.1 ;

Table 5.1 Usability test feedback

Driver	Remarks
Driver 1	Easy to navigate
Driver 2	Short processes
Driver 3	Simplified process
Driver 4	Easy to navigate

5.8 Unit Testing

Unit testing was conducted on the different modules in the application to check whether there were working properly. The unit testing was done to complement integration and system testing and to ensure bugs were identified and fixed early on in the coding process of the application. Some of the test cases used during unit testing are captured in Table 5.2

Table 5.2:Unit Testing Table

Function	Test Cases	Recorded Behaviour	Errors	Remarks
Login Function	Enter Valid Login Details (Username & Password)	Passed	None	Tested
	Enter Invalid Login Details	Passed	None	Tested
	Empty credentials Login	Passed	None	Tested
	Provision only one credential (Either username or password) Login	Passed	None	Tested
User Interface Functions	Test is all the buttons, Menus, Navigation panel, details ans links are working as expected	PassedAll the elements in the User Interface were functional	None	Tested
Database Connections	Test if connections to the MYMYSQL database are active, and that the application is able to connect, update, edit, delete and read database items	Passed-Database connection was successful. There was some errors in updating the database which were fixed and the test case repeated.	None	Tested
Back end connections	Test for Model Integration and ability to download results into database.	Passed	None	Tested
	Transformation of results into tables and charts	Passed	None	Tested
	Storage and retrieval of forecasts	Passed	None	Tested
	Generate data to be shown in the user Interface	Passed	None	Tested

5.9 Compatibility Testing

The application was developed to run on any device supporting HTTP and web functionality being mainly developed from PHP and HTML and an MYMYSQL database. The application was tested on the following devices listed in Table 5.8.1 .

Table 5.3: Compatibility Testing with different operating systems

Device	Details	Operating System	Compatibility
Laptop	Lenovo	Windows 10	Compatible
Laptop	HP	Kali Linux	Compatible
iPhone 6	Apple	iOS	Compatible

5.10 Test Conclusions

The results from the tests carried out showed that the application works well with variations to each device and room for improvement. On the laptop which did not have a touch screen, the input device was a mouse which proved quite easy to use. The users described it as practical and easy to use, with the only fear being cost of devices with stylus. The application's response on different browsers was almost identically. This was tested on Chrome, Opera, Mozilla and Internet Explorer.

5.11 Software Flow

The application was made using PHP and HTML with a. To mimic a live site, the application was run on XAMPP from the localhost with Apache as the HTTP web server and as the database. Upon registration, the data was sent and stored into the database. During login this data was fetched for authentication. Once logged in, the application allows for the user to navigate and use the parking service system.

Chapter 6: Discussions

6.1 Introduction

Systems are complex by nature and have various stringent requirement that they demand in order for them to function optimally and reduce chances of failure. This chapter discusses various aspects to consider to achieve a sustainable service for the county citizens

6.1.1 Interface

The system has a user-friendly interface which creates an interaction between the stake holders and the application in an easy-to-understand way. One of this interface is the web interface the functionality is the same, but the look and feel is slightly different. By default, the WebUI is configured to work over the Hypertext Transfer Protocol Secure (HTTPS). It connects to the database server hence every booking is visible. It allows the user to have a real-time visibility of available parking in an area. The administrator on the other hand ensure that they oversee and control the available parking spaces ensuring smooth flow of services. As from the use cases above, the stakeholders have unique roles defined to enable efficient management of this spaces. The system has been designed and developed in a way that its accessible and can be modified into flexible dissemination modes such as web, cloud, desktop, mobile and manual.

6.1.2 Integration

From the way the prototype is designed, it can process huge amounts of data and is scalable. The data, spatial and non-spatial, is evenly distributed to users in the system and can concurrently use it. The users will interact with information that is queried in the database specifically sharing the parking spots identity, timing, charges etc. However, the system will continually be improved as it adopts to the nature of the parking cycle and ore features will be integrated including maps, payment options, etc.

The system is integrated to a SQL database that stores and synchronized data in real-time . This data includes but not limited to Contact data, parking data, user database, An example of The sample schema for the user database is shown in Figure 6.1 .

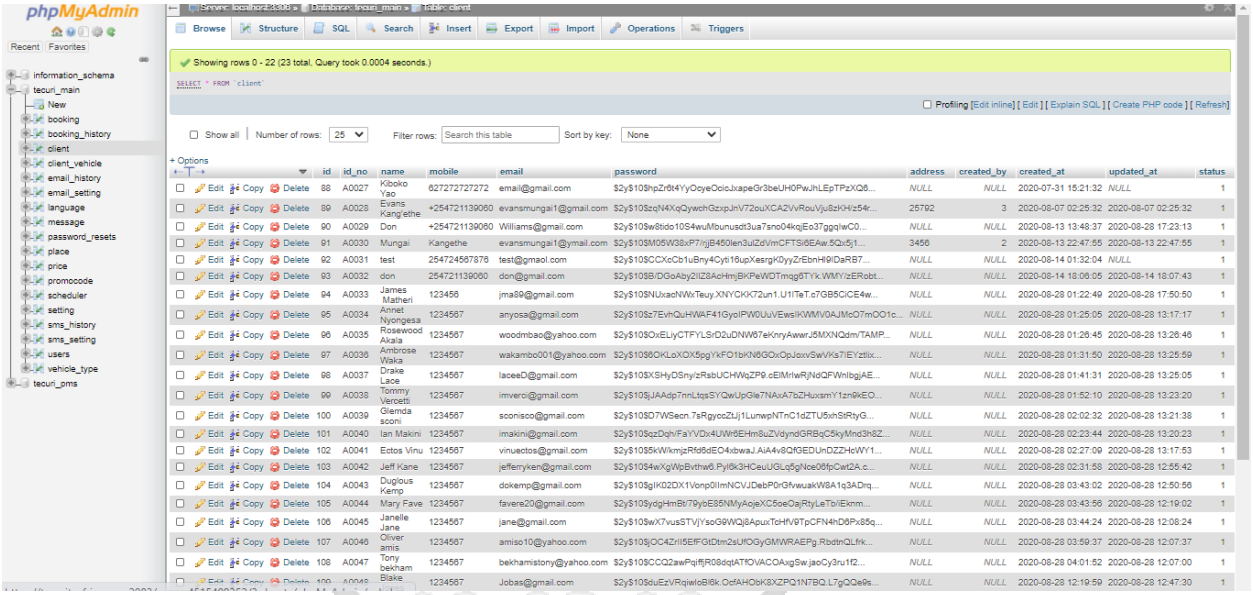

Table 6.1 MySQL Database

The system is integrated with an external payment system called MPESA which enables clients to process parking payments that are pre-set in the system. A PUSH notification is sent to their mobile phones to complete the payment as shown in the Figure 6.1 .

Figure 6.1 MPESA PIN Prompt

6.1.3 Performance

The expectations that the system will perform optimally in its runtime environment. The application runs on internet as one of its baseline requirements and in the absence of internet, the service is unavailable. Its internet based since it can reach multiple people in different geographical locations and available on demand.

6.1.4 Efficiency

The first efficiency element is data. For the prototype to function efficiently, it needs adequate data. Hardware and software requirements were defined and adopted while creating the system.

The system has central aggregation of data thus being more reusable and accessible for users. Different users are able to access the information, geo location notwithstanding. The information they get is standard across board since the databases are online based and any requests are processed in real-time. The time used to process in formation from the user to the database is almost instant, <2 seconds, while querying. Details captured by the system are very granular abd the system is able to efficiently communicate with the user for example, information collected pertaining to parking database is shown in Figure 6.2 .

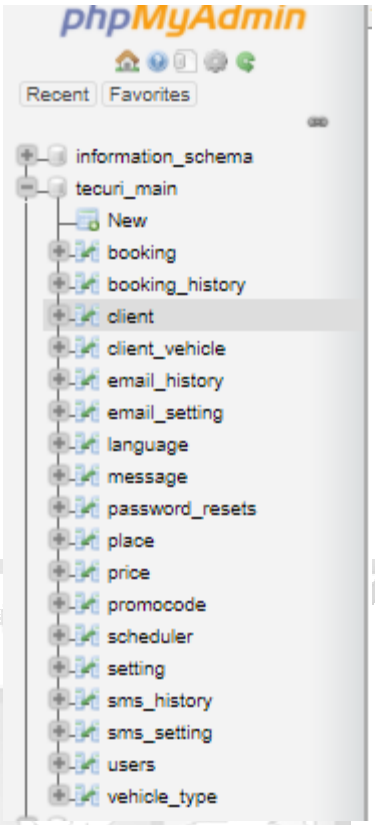

Figure 6.2 Parking Database Schema

6.1.5 **Accuracy**

The accuracy of the system depends on the integrity of the data stored in the database. The database should be synchronizing and updating in real-time to avoid requests clashing an inconveniencing user. Accuracy should be factored in how the data is collected, stored and presented. The data is processed in real-time and the communication from the user interface to the database happens in real-time .The primary keys are defined in the database structures to maintain the accuracy and other database best practises are factored too .

6.1.6 **Maintainability**

This is a measurement of resources committed to an application in a unit of measure. This can vary from hard disk storage, database size, RAM, CPU utilization etc. Factors that can affect the overall system maintainability can be the quality of code, code defects that make the system vulnerable hence very cumbersome to monitor and improve functionality.

6.2 Flexibility

The system a single threaded application by design. since threading complicates functionality. Error handling is factored in the application with the aim of keeping errors on a minimum by removing clutter so that exceptions are called accurately. From the framework in use, code is clustered for reusability hence duplication kept on a minimum and troubleshooting and patching made easy. This also eliminates potential errors. Modifications are made without affecting core functionalities of the system

6.3 Availability

The architecture of the application and the frameworks in use indicate high availability considerations since the application is live and real-time. The minimum required availability is dependent on the function being performed and the expectation is that the system should attempt 99.9999% availability. Availability is measured by the system performance in case of failure, its ability to recover from a downtime and ability to perform other tasks affecting service e.g. configuration and upgrade changes in a manner that eliminates or minimizes downtime.

The system availability will be ensured by monitoring the system performance in real-time. System resources will be monitored in real-time using a SIEM and resources such as CPU, RAM and HDD storage are always perfuming optimally and never stretched. This reduces chances of crushing or hanging thus unable to process requests.

Forecasting of resources utilized will also be done to avoid stressing the resources in use and making the system scalable, by identifying points of expansion for resources for example when a storage hard disk is 85% full, means that in less than a moth, the storage needs to be expanded.

6.4 Robustness

Application share ability to cope with errors just like computer systems, during code execution including the testing phase. Robustness in this application has been captured in the architecture and framework in areas of development such as secure networking, programming and

machine learning. Formal techniques such as j-unit testing capture robustness since this type of testing involves invalid RTO and RPO are defined .

6.5 Fault to Tolerance

Parking management systems have significantly applied fault tolerance concept in a proactive and repeatable way. through extensive testing and debugging they can be removed. Nevertheless, no amount of testing can declare a system fault-free. This means removal and avoidance and faults cannot be perfect. Therefore, any practical piece of software presumably contains faults, hence designers and developers should manage these faults realistically to an acceptable level. The residue faults after are usually bugs that elude detection during testing activities.

To achieve a higher tolerance rate, continuous improvement of the system is factored in. This is benchmarking the system best practices and continually amending the system to be better. Redundancies will be created as the system will be moved to a public loud, either AWS cloud or Azure cloud where there are various copies of the system distributed in cloud infrastructures in various parts of the globe. As for AWS datacenters, they are captured in the Figure 6.3 showing their zone distribution.

Figure 6.3 Amazon Web Services Datacentres

6.6 Usability and Accessibility

What largely determines the Usability and user experience of parking systems is factoring in effectiveness and efficiency during design. What we supplication usability means is Usability is a measure of the interactive user experience associated with a system such as a business system, website, or mobile application and is a focus of fields of the Human Factors Psychology and Human-Computer Interaction (HCI) fields of study. (Adams, 2020) . The extent to which a piece of software can be used by specified users to achieve specified goals. Accessibility addresses discriminatory aspects since anyone, even the disabled, can have access. There is no age limit to usability and users can be trained.

6.7 Platform Compatibility and Portability

The parking system is portable and compatible across multiple vendor platforms as the existing models and frameworks previously developed. Portably also enables developers reduces costs related to developments and shorten the curve to finishing the application. Hardware are also doable while retaining software applications in place and minimizing costs.

6.8 Security

Many application architectures have now embraced security in all development aspects. I am very critical for applications to be secure otherwise they lose credibility amongst stakeholders and users. In this applications security has been factored from a user identify level, where every user has a unique identity. The Database structure is well defined as to notice any form of anomalies that occur in the database by logging activities. the application will be hosted on a cloud environment that is public- Amazon Web services, and the security fabric that comes with the environment will be activated i.e. DDOS protection, embedded firewalls, database monitoring, IAM etc.

6.9 Functionality and Correctness

The application developed seeks to solve the parking management headache within the county of Nairobi. This is by provisioning a system that can allocate parking spaces at defined

times to users all around the county. The functionality is kept simple for users to be able to make their requests and reservations without human intervention.

6.10 Contribution of the study

One of the main contributions of this study is that for the first time in the Nairobi county, parking spots will be managed efficiently in a proactive manner. Users are able to book in advance for their parking spots and reserve them for a definite amount of time. This means that parking spots can be used severally by different vehicles depending on how much time a user has reserved. Also, if the user desires to extend parking time and the slot is available they can still do so. If not, they would have to book another slot and move the car for the user that has reserved a specific time. The system does this on a first come first serve basis. Parking spots in Nairobi will also be marked clearly and allocated unique Identity thus enabling efficient management as shown in the Table 6.2 .

Table 6.2 Parking spot Nomenclature

Zone	Street/Road	Cdoe/ID	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
CBD	kenyatta Avenue	CBD-KenAv	1	2	3	4	5	6	7	8	9	10
CBD	Haile Selassie Aenue	CBD-HailAv	1	2	3	4	5	6	7	8	9	10
Parklands	1st Avenue	Prkld-1Av	1	2	3	4	5	6	7	8	9	10
Kilimani	Shopping Centre	Kilm-SC	1	2	3	4	5	6	7	8	9	10
Langata	Shopping Centre	Lang-SC	1	2	3	4	5	6	7	8	9	10
Hurlingham	Shopping Centre	Hurl-SC	1	2	3	4	5	6	7	8	9	10
Lavington	Shopping Centre	Lavi-SC	1	2	3	4	5	6	7	8	9	10
CBD	Moi Avenue	CBD-MoiAv	1	2	3	4	5	6	7	8	9	10
CBD	Mama Nguna street	CBD-MMng	1	2	3	4	5	6	7	8	9	10
			Example									
			CBD-KenAv-001									

Chapter 7: Conclusions and Recommendations

7.1 Conclusion

The study achieved the first objective of reviewing the current parking approach. This was conducted through observation and verbal interviews with citizens of the Nairobi county. It was established that the current process is mostly manual and tedious. County clerks physically man parking spaces on the streets and for anyone interested in using the parking service, a cash transaction has to be made and manual receipt issued. There are several other public parking spaces that have an automated process. This are selected independent fields in the city that have a system that issues tickets upon entry that have time stamps and therefore a driver is charged against how much time they consume on the space. Payments are done by cash either to a clerk or a payment machine within the field.

The study also achieved the second objective which is to help the county manage its parking better. This was evaluated as in objective one and a gap analysis was conducted thereafter. There current process is highly manual in service and thus less efficient in timeliness. The county needs to reduce manual processes to be more effective in service. The processes are also time consuming since there is lots of external interaction with clerks, to issue payment, receipt and directing where to park. Recommendations of automation, central management and prior booking are the best option to improve the current challenge.

The third objective of analysing how parking management is done in other countries was achieved and evidence collected and documented in chapter two of this document. Most developed countries have well defined structures to parking that are highly tech oriented and include even sensor technologies that increase the accuracy synchronizing the physical parking spot information and the system-database information.

The fourth objective which is to create a system that is cost effective and efficient was also achieved. Automation would reduce the human resource costs since there will be less human intervention in the parking process thus reducing manpower. The less human interaction there is, the less the error rate in the process to mis-account or conduct fraud. Systems seal loopholes since

the they are intelligent, and their operations and execution is predetermined. The best solution was creating a web application that could handle the whole parking process from booking to receipting and parking allocation.

Limitations of the prototype

The major limitation with the prototype is the low literacy levels within the county government staff population. It requires that the county invests time and money to build capacity of its personnel for them to be able to administrate and implement the system. This will guarantee the optimization of the county parking functions and increase revenue since the collection and accountability of parking fees is more transparent with less vulnerabilities to fraud.

7.2 Recommendations

i. Automation of services creates a highly efficient economic environment since clients are able to do service activities at the convenience of their mobile phones. County governments should adopt systems such as this to enable them to serve their citizens better and eventually create a smart service environment for each of traffic especially in the urban areas within the counties

ii. The county government should also focus on capacity building of their staff to empower them to run innovations and research that could continually grow the knowledge base of parking management practise

iii. Parking systems should be adopted by county governments all around Kenya to help manage congestion

iv. The county government should create structures of operation for parking management based on the demand curve e.g Hotels and restaurants should be limited to receive deliveries before 7:00 AM since this reduce congestion of commercial vehicles in a central business district.

v. Parking policy makers and controllers should adopt dynamic parking rates for residents and also create reward programs for the loyal clients.

vi. Policy makers and the county government should aim to roll ut a phased approach in rolling out centralized parking management and continually monitor and improve functionality for different regions of the county.

vii. The Government of Kenya should influence all counties to adopt the centralized parking management approach to increase efficiency of revenue collection, accountability and traffic.

7.3 Future works

In the future, the parking management should consider aspect that make it more effective in terms of administration and also user experience. Aggregating parking spaces in a central system lays out a baseline for improving the system. Processes can be automated and continuously improved over time such as adoption of sensors, loyalty programs, adoption of advances system analytics and machine learning. With this, the county is able to make informed decisions e. on parking space planning, security planning, traffic management, county residents pretences on parking, demand and supply curves for the services.

7.4 Limitations and Delimitations

i. Centralized parking management services have various stakeholders with high interest in the business. There are chances of deliberate sabotage and laxity to implement this framework as its going to close lots of loopholes for funds leakage and cartel groups in the city. This however could be managed by the county government through fair policy practise and also stringent implementation of the practise

ii. Majority of the county government operations are highly manual and so is the workforce culture. This makes it challenging to quickly adopt and influence support in automated initiatives. However, with training and county leadership influence of work culture, the initiative will eventually get buy-in from various stakeholders over time.

iii. The county government has not been keen to adopt new technologies and integrating them into their operations hence the technology gap both in knowledge and infrastructure are a great setback. However, with an accurate strategy and framework of adoption, this can be changed within 24-36months.

References

Adams, C. (2020). *Modern Analyst*. Retrieved from Modern Analyst: https://www.modernanalyst.com/Careers/InterviewQuestions/tabid/128/ID/2190/What-is-meant-by-application-usability.aspx

Africanmodern. (2017, February 17). *World population review* . Retrieved from World Population Review: https://worldpopulationreview.com/world-cities/nairobi-population/

Barone, R. E., Giuffrè, T., Siniscalchi, S. M., Morgano, M. A., & Tesoriere, G. (2014). Architecture for parking management in smart cities . *Digital library*, 445-452.

Bedir Tekinerdogan, R. S. (2016). Software development lifecycle. *Science Direct*, 2.

Behrends, S. (2015). Recent developments in urban logistics research – a review of the proceedings of the international conference on city logistics 2009-2013. *Science Direct*, 11.

Cambridge. (2020). *Cambridge dictionary*. Retrieved from Cambridge Dictionary: https://dictionary.cambridge.org/dictionary/english/system

County, H. (2020). *Hamilton County , Ohio*. Retrieved from Hamilton County: https://www.hamiltoncountyohio.gov/government/board_of_county_commissioners/county_government_functions_and_responsibilities

Dai Tamagawaa, E. T. (2010). *Evaluating city logistics measures using a multi-agent model.* Science Direct.

Deblanc Laetitia, M. C. (2011, August 31). City distribution and urban freight Transport. *City distribution and urban freight Transport*, p. 288.

Direct, S. (2005). Server infrastructure . *Science DIrect*, 1.

Elmouatez Billah Karbab, D. D. (2015). Park management with networked wireless sensors and active RFID. *Research Gate*, 374.

Gunawardena, N. K. (2014). Introduction to geographic information system . *Research Gate*, 2.

Gurkok, C. (n.d.). Securing cloud computing systems. *ScienceDirect*, 1.

Igwenagu, C. (2016). *Fundamentals of research methodology and data collection.* Nnsuka, Nigeria: ResearchGate.

LITMAN, T. (2008). Parking Management Best Practices. *ITE Journal on the web*, 69-73.

LITMAN, T. (2018, 11 26). Parking Management Comprehensive Implementation Guide. *Victoria Transport Policy Institute*, p. 2.

Michael Browne, J. A. (2010). Analysing the results of UK urban freight studies. *Science Direct*, 12.

Naiirobi County Government. (2014). *Nairobi County Integrated Development Plan.* Nairobi: Naiirobi County Government.

Nairobi County Government. (2019, December 5). Nairobi City County Public Road Transport and Traffic Management Bill. *NAIROBI COUNTY GAZETTE SUPPLEMENT*, pp. 25-26.

Nairobi, C. G. (2018). *County intergrated development plan (CIDP).* Nairobi: County Government of Nairobi.

Patrick Auwerx, R. P. (2019). *Parking and sustainable urban mobilit planning.* Brussels: European Commission.

Pekka Abrahamson, O. S. (2017). *Agile software develoment methods.* Finland: VTT Technical Research Centre of Finland.

Pekka Abrahamsson, O. S. (2017). *Agile Software Development Methods.* Finland: VTT Technical Research Centre of Finland.

Reltronics. (2017). *Real track parking lot management system.* Retrieved from Reltronics: http://www.reltronicstech.com/Parking_Lot.html

Shoup, D. (2005). The high cost of free parking. In D. Shoup, *The high cost of free parking.*

Systems, S. (2016). *The survey system*. Retrieved from Creative Research: https://www.surveysystem.com/sample-size-formula.htm

Taniguchi, E. (2014). Concepts of city logistics for sustainable and liveable cities. *Science Direct*, 1.

Tom Rye, T. K. (2015). Parking management. *Research Gate*, 29.

UNHABITAT. (2013). UN Habitat 2013., State of the World's Cities 2012/2013: Prosperity of Cities. Nairobi, Kenya: UN Habitat. *STATE OF THE WORLD'S CITIES* (p. 152). NAIROBI: UNHABITAT.

Waweru, T. (2015). Intoduction to internet technologies. *Academia*, 1.

Wikipidea. (2020, August). *Wikipedia*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Operating_system#:~:text=An%20operating%20system%20(OS)%

20is,common%20services%20for%20computer%20programs.&text=The%20dominant%20desktop%20operating%20system,market%20share%20of%20around%2082.74%25.

Winnie Mitullah, T. M. (2008). *Role of ICT in local government.* Nairobi: University of Nairobi.