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A Prototype for Locating and Choosing Office Space as a Service:

A Case of Nairobi City

Mwenda Protasio Kithinji



Master of Science in Computer-Based Information Systems

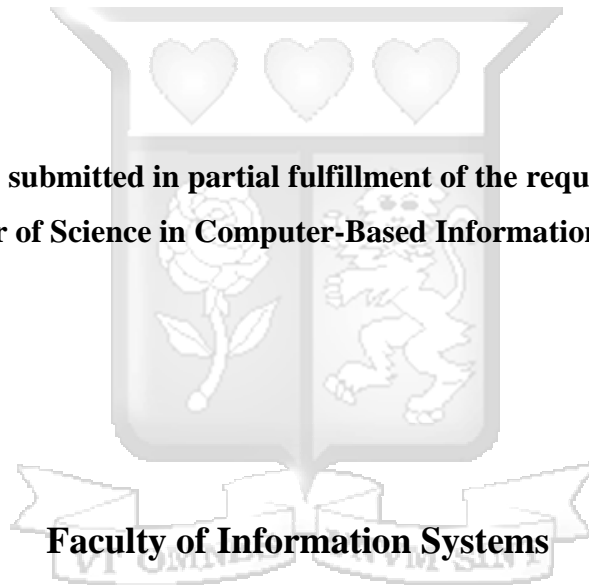
March 2016

A Prototype for Locating and Choosing Office Space as a Service:

A Case of Nairobi City

Mwenda Protasio Kithinji

**A research dissertation submitted in partial fulfillment of the requirements for the Degree
of Master of Science in Computer-Based Information Systems**



Strathmore University

Nairobi, Kenya

June, 2016

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Abstract

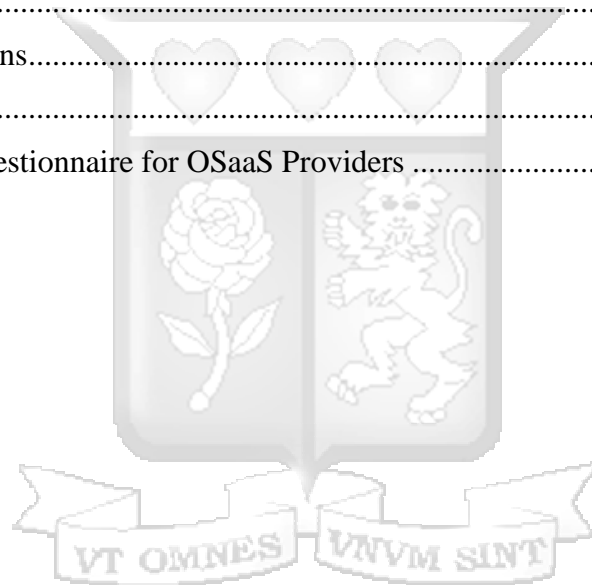
Traditional work arrangements were relatively static with all the staff having a physical fixed office. This is where at some point of the day they reported to meet their supervisors, colleagues or clients. In the today's knowledge and collaborative economy, mobile and flexible work arrangements are the norm. That means that a good number of the staff can and indeed work from other places apart from the fixed central office. These alternative work arrangements are enabled by information and communications technology implemented in a variety of quasi-office setups with their attendant benefits and challenges. Among options available, commercial implementation of Office Space as a Service (OSaaS) has the best potential of meeting real business' need. Unlike many other remote working arrangements, Office Space as a Service offer for hire, a formal office setup complete with required furniture, fast and secure internet connectivity, formality and privacy close to the traditional fixed office. But choosing a suitable office location, whether to hire as a service or not has been a challenge for many entrepreneurs. The choice needs to be informed by the fundamental factors that can be enablers or inhibitors of business in such a location. These include issues such as localized security and demography of the area and the actual hire/lease costs of the offices among others. Disparate information sets about OSaaS facilities has been one of the major challenges for individuals/organizations seeking to utilize these new, flexible and cost efficient office space arrangements. This research seeks to come up with an application for mapping out Office Space as a Service facilities in a given city/neighbourhood mapped against applicable localized business factors into a geo-spatial database. The application will offer an easy, quick and intuitive platform for locating and selecting available OSaaS facilities that meet a given criteria as defined by the user and a two-way communication channel between potential clients and the providers of the facilities.

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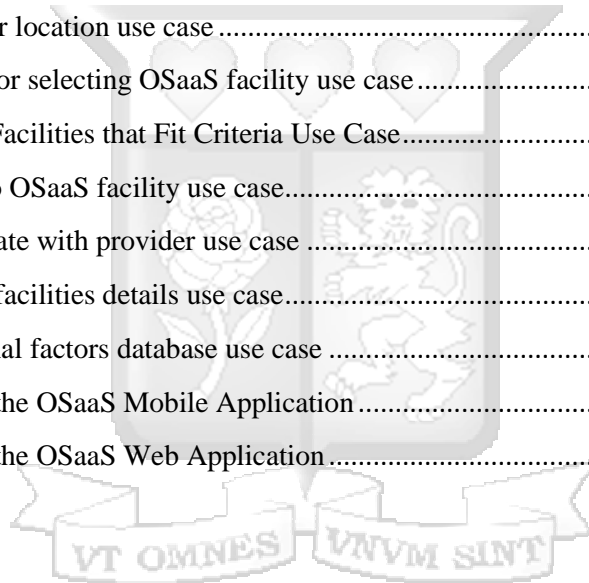


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Abbreviations/Acronyms

A-GPS	-	Assisted –Global Positioning System
API	-	Application Programming Interface
AT&T	-	American Telephone & Telegraph Company
ATAC	-	Australian Telework Advisory Committee
D-GPS	-	Differential- Global Positioning System
GII	-	Global Innovation Index
GIS	-	Geographic Information System
GLONASS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
GSA	-	General Services Administration agency
HTML5	-	HyperText Markup Language Version five
ICT	-	Information and Communications Technology
LAN	-	Local Area Network
LBS	-	Locational Based Service
LCT	-	Location Collection Technology
OGC	-	Open Geospatial Consortium
OSaaS	-	Office Space as a Service
SMS	-	Short Message Service
XML	-	eXtensible Markup Language

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Chapter 1: Introduction

1.1 Background of Study

Organizations appreciate the fact that the traditional model of work is experiencing fast changes. There are rapid changes in technology, economy, customer preferences and employee tastes and habits. Therefore, every organization needs to be agile enough to adapt as soon as the changes occur in-order to remain competitive in business. One approach to quickly adapt to the changing business requirements is adopting “virtual structures” (Helms & Raiszadeh, 2002). The definition of the word “virtual” according to Meriam Webster dictionary is “existing or occurring on computers or on the Internet” and the other definition is “very close to being something without actually being it.” A structure on the other hand is defined as the way a group of people are organized. Therefore virtual structures imply “working teams organized by computers or internet”.

The economist (2009) says that a virtual organization has an almost infinite variety of structures, all of them fluid and changing and alleges that most of the future organizations will be virtual. It further states that most of the time, a virtual organization relies on a network of part-time electronically connected freelancers or staff located in diverse places, engaged for varying durations of time to achieve specific tasks. The said staff could work from their homes, airport lobby, hotel or in an Office Space as a Service establishment as long as there is an Internet connection. Hence a virtual organization may require very little or no permanent office space for its staff.

A current concept which is one of the main enablers of the virtual organization is the concept of the Office Space as a Service (OSaaS). Dishman (2013) refers to it as “flex space”, while Stokes et al. (2014) refers to it as “co-working”. The general concept here is that of an office space shared by different individuals and/or organizations. OSaaS as the term suggests, converts rental office space into a consumable service just like the other information technology enabled services such as Software as a Service (SaaS). This Office Space as a Service can be seen as part of the new collaborative economy also referred to as on-demand economy (Stokes et al., 2014). Others in this category include current approaches like city-wide bike schemes, car-pooling, and even crowdfunding. But particularly in the computer world, there are already mature models of on-

demand economy which include Software as a Service (SaaS), Database as a Service (DaaS), Infrastructure as a Service (IaaS) and Platform as a Service (PaaS). The main distinctive characteristic of all these working arrangements is the fact that resources are not owned by the consumer, but instead, hired out from independent third parties on need basis. This basically eliminates the hogging of the physical resource by one consumer and brings in smarter utilization of the said resource by opening it up to multiple consumers (Stokes et al., 2014). The hire duration can range from a few hours, days, months or years depending on the need.

The U.S General Services Administration agency (GSA, 2011) in their Mobile Worker Toolkit Notional guide best describes the current push into virtual working arrangements with their opening notion that: “Work is what we do, not where we are.” That statement aptly captures the intended flexibility and mobility of the new work arrangements that are not limited by walls of brick and motor. Certainly, one of the ways organizations can offer this flexibility and mobility to their staff is by embracing the Office Space as a Service concept, which would allow their staff to work from wherever they are as long as there is an OSaaS facility thereof which can be hired for the required duration.

GSA further says they believe that employees are more productive at work with flexible workplace arrangements. This assertion is supported by a study by the Australian Telework Advisory Committee (ATAC), (2006) that reported there was evidence confirming that teleworkers can be up to 40 per cent more productive than workers located in traditional office environments. This can be directly attributed to the flexible work arrangements offered by teleworking which enables them to maximize on their best time to work. Lister and Harnish (2013) in their Global Workspace Analytics report are more conservative and they give increase in productivity attributable to teleworking as 12.5%. GSA summarizes the need for mobile work arrangements with this statement which is one of their core agendas: “We are seeking to create an adaptable work environment in which employees can respond in the most agile way possible to business demands while having the control and influence over their own work environment.”

1.2 Methods of Locating OSaaS Facilities

How do individuals or companies come to know about the existence or availability of these OSaaS facilities? Rueger (2014) gives some of the methods used in locating office space. This applies for

both OSaaS and traditional offices. These include the use of real estate brokers/agents, searching from listing websites such as loopnet.com and subscription services. Manual search is also identified as an applicable method. Major providers of OSaaS such as Regus provide a mobile application downloadable from their website that can be used to locate and book their own OSaaS facilities (Regus.com, 2015). As discussed in subsequent sections, each of these methods and the actual process of selecting a suitable office location have its own unique challenges.

1.3 Challenges with Locating an OSaaS Facility

The choice of where to do business or locate an office can be quite a big dilemma especially for start-ups. Being quite conversant with this problem, the Small Business Administration (SBA), (2012) of the US articulates this challenge well on their website. They say: “Choosing a business location is perhaps the most important decision a small business owner or startup will make, so it requires precise planning and research.” “It involves looking at demographics, security, costs, and state laws among other things.” These are the fundamental factors that would either aide or hinder a business located in a given locality. For example, reported high crime rates in a given locality can deter potential clients from visiting such an area where a given office/business is located. This and more locational factors are examined in more details in subsequent chapters.

The second challenge which is applicable in varying degrees across different geographical areas is scarcity. For example: According to Baum and Hartzell (2011), office buildings are scarce in Egypt, and most offices are located within residential buildings. They further assert that while many of the new housing developments in Egypt on the outskirts of the cities have been for office use, most of them are addressing the upper-end market segment, leaving the middle-end and lower-end office demand unfulfilled. According to them, provision of office space to this middle and lower segments is an area of substantial potential for expansion in the congested cities. This presents a good opportunity for the OSaaS concept where the scarce available office space will no longer be held perpetually by one company but will be made available to multiple users to hire on need basis.

Other challenges likely to be faced by potential users of OSaaS in their endeavor to locate and hire such are untrustworthy agents who misrepresent facts about facilities, incomplete or scattered information about facilities found on the web, time to search and knowledge constraints on the side of these potential customers. Therefore, while the OSaaS holds a lot of promise for many

companies in terms of its versatility and quick adoption, just like the other service oriented offerings, individuals/companies still have to contend with a number of challenges in the process of choosing and locating the ideal OSaaS facility for use. This gives rise to the need for a system/application that addresses these challenges.

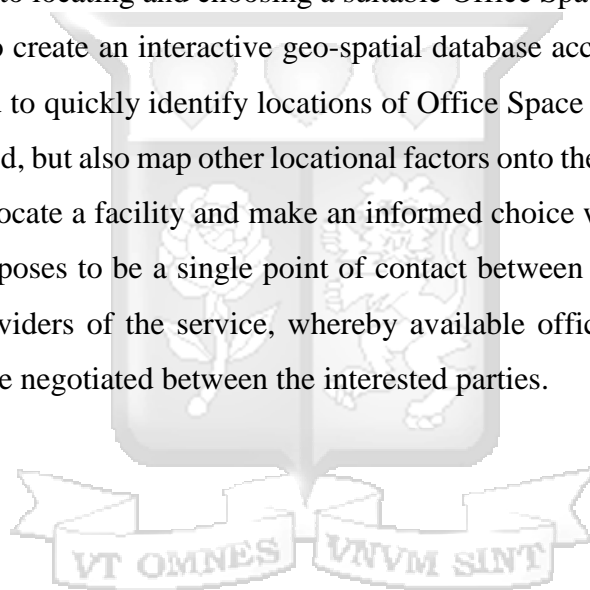
1.4 Locational-based Services

This research uses Locational-Based Services (LBS) to locate OSaaS facilities. Brimicombe and Li (2009) defines LBS as the delivery of data and information services where the content of those services is tailored to the current or some projected location and context of a mobile user. Due to the current craze of social media, the best known Locational based feature today is geo-tagging. This is a process through which any news article, blog or wall post, twitter tweet, or any other web action is assigned geographical information referred to as geocodes (latitude-longitude pair values). This enables location-based searches or tracking to be performed on them (Chawdhary, 2012). Apart from geo-tagging, Chawdhary (2012) further states that the US government uses LBS for emergency services 9-1-1 to be able to quickly identify the caller position. For commercial services, LBS are extensively used in car navigation systems to give drivers a turn-by-turn instructions to a given location. LBS as supported by mobile telephone networks is used by the police in tracking criminals. Air traffic control, seaport control, freight management, car and transport tracking are still other users of LBS. For the purpose of this research, LBS are not only used to identify the geographical location of a potential customer, but also the OSaaS facilities located in close proximity to such a customer. Secondly, the ability to map various locational factors into a geo-spatial space and match them against available OSaaS using LBS is also employed in the conceptual application.

1.5 Problem Statement

The rising cost of leasing conventional office space is a quantifiable reason to invest in flexible working arrangements such as hot-seating and Office Space as a Service (Ashton, 2005). Additionally, finding a suitable office space to hire either as a service or as a product has been a problem especially in Nairobi, Kenya (Olingo, 2012). Soskin (2010) concurs with this and says that looking for office space is not only time consuming but also highly risky. That has been primarily due to scattered, incomplete or un-available information about the available office spaces and the applicable locational factors. While various online sites have come up to provide much needed information on this, they have mostly been geared towards advertisement of traditional rental offices as opposed to locating and choosing a suitable Office Space as a Service facility.

This research proposes to create an interactive geo-spatial database accessible from a web portal that will not only be used to quickly identify locations of Office Space as a Service facilities in a given city or neighborhood, but also map other locational factors onto the identified locations. This will help users to easily locate a facility and make an informed choice when considering hiring it for use. The solution proposes to be a single point of contact between potential clients for these OSaaS facilities and providers of the service, whereby available office space will not only be advertised, but can also be negotiated between the interested parties.

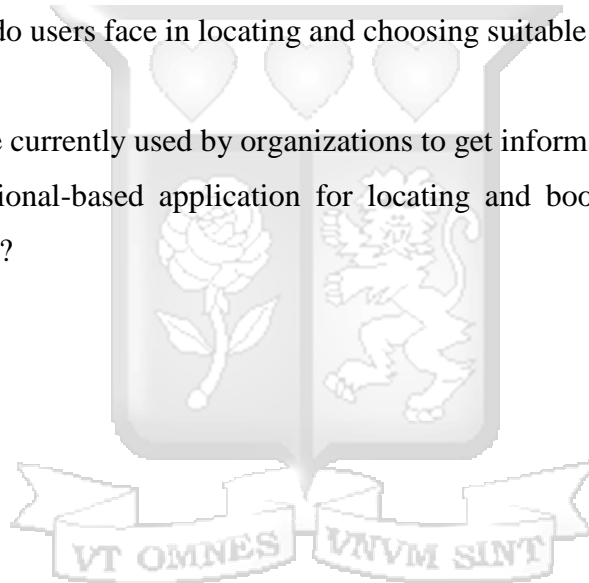


1.6 Research Objectives

- i. To identify the factors considered in choosing an office location
- ii. To identify the challenges of existing methods of locating and choosing suitable OSaaS facilities.
- iii. To review existing methods of locating OSaaS facilities
- iv. To use location based technologies to create a prototype for locating and choosing OSaaS and test it.

1.7 Research Questions

- i. What are the main factors that influence choice of office locations?
- ii. What challenges do users face in locating and choosing suitable Office Space as a Service facilities?
- iii. What methods are currently used by organizations to get information about OSaaS?
- iv. How can a locational-based application for locating and booking OSaaS facilities be created and tested?



1.8 Justification for the Research

The facts presented above show a global trend in the increased uptake and use of alternative work arrangements in different office setups. Current data available on the suitability of various locations for OSaaS facilities and actual geographical location of such is not only scattered across multiple sources, but also incomplete in many aspects. Major providers of OSaaS like Regus have created a mobile application that seeks to locate their own OSaaS facilities within a given city or neighborhood. But the said application is specific to Regus alone and does not give the user an opportunity to preview any locational factors when considering to hire such office space.

If more companies are to take advantage of the flexibilities and convenience of Office Space as a Service, then more information and data about such, and the attendant locational factors has to be more widely available. As Otieno (2014) observes “data in itself is of no value unless converted into information that can yield strategic intelligence”. This scarcity of collated data about OSaaS facilities gives rise to a need for a third party managed platform that can: a) consolidate information regarding the location and availability of OSaaS in different neighbourhoods and b) the localized business factors affecting different neighbourhoods. The said information will then be accessible to interested parties through a mobile and/or desktop application.



Chapter 2: Literature Review

This chapter gives a description of what Office Space as a Service entails, then examines the factors that are considered by businesses in choosing an office location. Data supporting the fact that virtual working arrangements is the future is presented alongside the reasons why it is gaining traction. The chapter then elaborates on the LBS infrastructure which is the core technology used in the application. Lastly, some of the methods/systems that have been used in locating and choosing offices are examined and then the conceptual platform is presented.

2.1 “Office Space as a Service” Defined

Trends in hire and use of office space indicate a continuum of different office hire arrangements in use today. These range from the traditional fixed office space where each employee had a dedicated workstation and a computer in an office block somewhere, all the way to the fully virtualized organization with no fixed office with its employees working from wherever they get internet access. Ward (2015) identifies some of these alternate office models as: Office sharing across non-competitive industries, co-work shared space options, and the fully virtualized organization. Bartolot (2014) sees a virtual organization as one that may exist just as a website domain, but may not have a physical business location. It relies on staff and consultants hired on demand and who work from wherever they have an internet connection to accomplish a given task. Ward (2015) asserts that the key drivers to these new trends in office space are the need for higher flexibility and collaboration on the part of staff and reduction of overheads and other real-estates costs on the part of the employing company. Facilityinnovations.com (2009) introduces another office concept called “Office hoteling.” The concept implies management of an office space like a hotel. Different employees book to use the limited available company office space(s) at different times of the day or diverse days of the week. As used in this research, Office Space as a Service (OSaaS) refers to this kind of concept, but with the professionalism that comes with a third party management of such a facility. The OSaaS therefore commercializes the office hoteling concept by availing to anyone for hire on hourly, daily, monthly or yearly basis all the facilities provided in a traditional office setup and even more. Hence, the hiring party enjoys facilities such as a private or shared office space complete with workstations, fast internet connections, boardrooms, telephones, photocopiers, high definition video conferencing facilities and many more, without the hassles of the elaborate office lease agreement or tying huge sums of money to leasing the same.

The hiring party just pays for the number of hours and staff who use the facility and for the particular office service(s) required.

When examined in more details, OSaaS can be seen as a subset of mobile working arrangements generally referred to as teleworking as defined by Bui et al., (1996). Others include: telecommuting, working from company owned satellite offices located near population centres and the mobile worker working maybe from a customer premises. But a more complete definition of teleworking as given by Gajendran and Harrison (2007) is an alternative work arrangement in which employees perform tasks elsewhere that are normally done in a primary or central workplace, for at least some portion of their work schedule, using electronic media to interact with others inside and outside the organization.

All this indicates that mobile work arrangements including OSaaS are the way to the future computing world. According to Helms and Raiszadeh (2002) the main driver for adoption and use of OSaaS facilities in most companies is cost reduction in real estate, recruitment and training. According to an IPSOS poll reported by Reany (2012) on Reuter's media-house, about one in every five workers around the world, especially employees in the Middle East, Latin America and Asia, telecommute frequently and nearly 10 percent work from home every day. The report further state that advances in technology and communications have enabled people to work effectively and efficiently without being constantly at their desks in the company office. It further asserts that remote working is a trend that has grown and one which looks like it will continue with 34 percent of connected workers saying that they would be willing to telecommute on a full-time basis if they could.

2.2 Other Examples of Service-Oriented Economy Applications

Computer applications have been the main enablers of the serviced oriented economy also referred to as the on-demand economy. These have been employed with satisfactory levels of success in different sectors of the economy. Some examples of such applications are briefly explained below.

2.2.1 Zipcar

Zipcar is a pay-as-you-drive car-sharing company where users rent cars for short periods of time, often by the hour. Their mantra is “own the trip, not the car.” This UK based company runs the www.zipcar.co.uk online marketplace which is the bedrock of their operations. In 2014, they had a membership of over 850,000 individuals with access to over 10,000 vehicles worldwide including at least 1500 vehicles spread across 4 cities in the UK. The main difference between the traditional car hire model and zipcar is that in the latter case, cars are spread across different cities and are not owned by the leasing company but by individuals who like to make use of the idling capacity of their cars to earn some money. The primary target of the service is people who occasionally need a vehicle thus providing a more sustainable alternative to car ownership. With the help of internet technologies, members can quickly and easily book and access a vehicle at any time (Stokes et al., 2014).

2.2.2 Airbnb

This is an US based online marketplace or e-commerce portal that seeks to trade spare rooms in peoples’ homes. It connects people seeking short-term accommodation to those looking to rent out rooms in their homes or full homes for a short duration of time. Both the guests and hosts maintain online profiles and can book directly through the website and provide reciprocal reviews and recommendations after their stay. Apart from offering travellers a generally cheaper accommodation alternative, the website makes smart utilization of idling capacity of idle rooms and entire homes. As at the end of 2014, the website had grown to have listings in over 34,000 cities across 190 countries in the world (Stokes et al., 2014).

2.2.3 LiquidSpace

Dail (2014) describes LiquidSpace as an innovative company that has commoditized functional office space to serve mobile workers. The US based company tracks and avails Office Space primarily in the US, Canada and Australia. The engine of their system is a cloud based web platform and a cellphone application that can be downloaded and used by clients to find a place to work, meeting rooms, training rooms or boardrooms in the listed cities. The mobile application is similar to other reservation applications and allows the user to view space available near them, the price, amenities offered and pictures of the workspace (Dail, 2014). This is indeed very similar to the proposed Office Space as a Service application, but in this case there is no mention about the ranking of available OSaaS facilities neither directions to be offered to the user when he/she selects

a given facility. Secondly there is no reference to locational factors being brought into play into office space selection. Lastly, actual technologies used to implement the LiquidSpace platform are hardly mentioned nor discussed.

2.3 Factors that Affect Choice of Office Location

Pinson and Jinnett (2006) describe a manual method of evaluating a potential office location using maps as follows. The user begins by drawing a map of the area where they wish to locate their office. Secondly he/she gets a number of copies of this map and one blank transparency. On the transparency, the location sites available within the target area are indicated and marked with a colored pen or assigned each a number. The user uses the duplicate maps for coding additional information about the location. To do this, the transparency is placed over the coded map in order to get a feeling of each site as various key business factors in a given location are considered. To get a feel of the security around a given location, the user does the following: Takes one of the duplicate maps to the police department and asks about crime rates. The reported high crime areas are then shaded on the map. When the transparency is placed over the shaded duplicate, it is easily seen if any of the potential office locations earlier identified fall within high crime areas.

This is clearly a laborious and long manual process. Google maps have a repository of maps for almost every area or locality. Therefore there is no need to re-draw the map. The crime data is also available with the police department in many countries on geo-tagged maps. Instead of the manual process described above the proposed OSaaS application will digitally amalgamate the available locations with the given crime data into one system and make the process not only much shorter but also fast and efficient.

Apart from security, other factors identified as possible determinants for choosing a given office location are discussed below.

2.3.1 Demographics -Markets and Labor force

Pinson and Jinnett (2006) identify the target market for the offered goods or services as instrumental in the choice of a business location. They rightly state that businesses should be located within easy reach of the potential customers. In addition to that, a business must be able to satisfy all its markets from the chosen location. The local labor force required by the business is also part of demographical consideration. SBA (2012) agrees with this notion and confirms that a

business office need to be located where there will be enough potential employees and the said employees will not have to commute long distances to work.

2.3.2 Cost of Office Space

While cost of hiring or leasing is a poor indicator of the value of the space in consideration according to Pinson and Jinnett (2006), it is still a major determinant on whether the selected location is leased or not. Indeed it is one of the primary reasons for the shift from fixed physical offices to the OSaaS model. Other considerations in the choice of office location include: presence or absence of competitors or complementary businesses in the target location, availability or easy access to raw materials, the transport infrastructure (railway and road networks) available among other factors. These factors are summarized as in the figure 2.1.

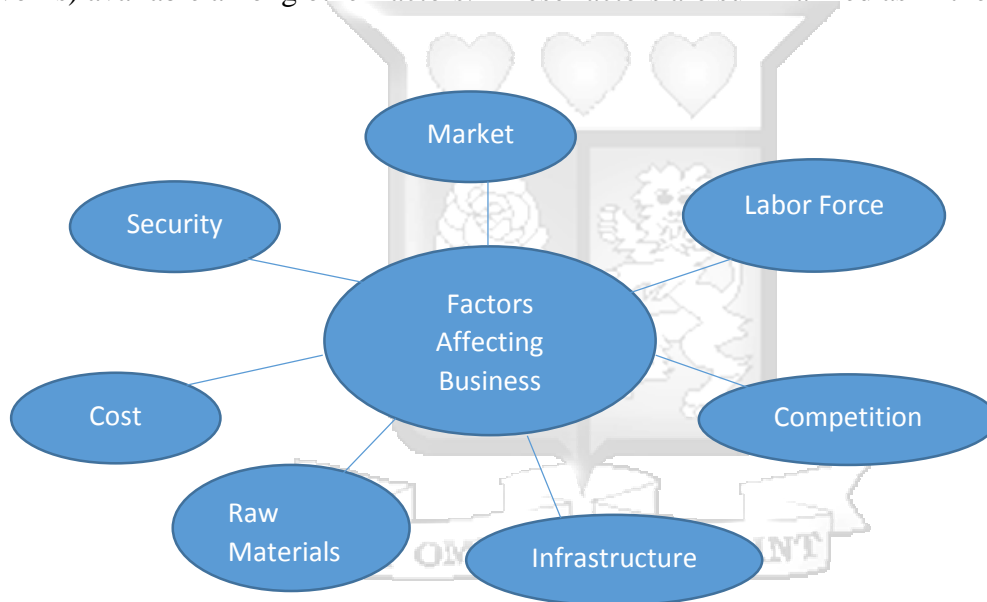


Figure 2.1: Factors affecting choice of business location

2.4 Adoption and Use of Virtual Working Arrangements

As explained in chapter one, Office Space as a Service is one of the enablers of virtual working arrangements. Statistics from the Global Innovation Index (GII) survey of 2014 on how Information and Communication Technology (ICT) has enabled new organizational models offer an insight into the adoption of virtual working arrangements and by extension OSaaS. It shows a general trend towards greater adoption of virtual and flexible working arrangements by more and

more entities across the world. These statistics are given in table 2.1, for the top ten countries in the world and two countries in Africa where Kenya is number two. The particular statistics of interest to this work are responses to the survey question on the extent of ICT as an enabler for new organizational models (e.g. virtual teams, remote working, and telecommuting) within businesses. The Likert scale was 1 = not at all; 7 = to a great extent.

Table 2.1: The extent to which ICT enable new organizational models Globally (GII, 2014)

Position	Country	Value	Percentage (0-100)
1	Finland	5.74	79
2	Qatar	5.53	75.5
3	Estonia	5.46	74.33
4	Sweden	5.44	74
5	Netherlands	5.41	73.5
6	United Kingdom	5.39	73.17
7	United States of America	5.32	72
8	Norway	5.31	71.83
9	Singapore	5.31	71.83
10	United Arab Emirates	5.31	71.83
...			
48	Guatemala	4.48	58
48	South Africa	4.48	58
50	Kenya	4.46	57.67

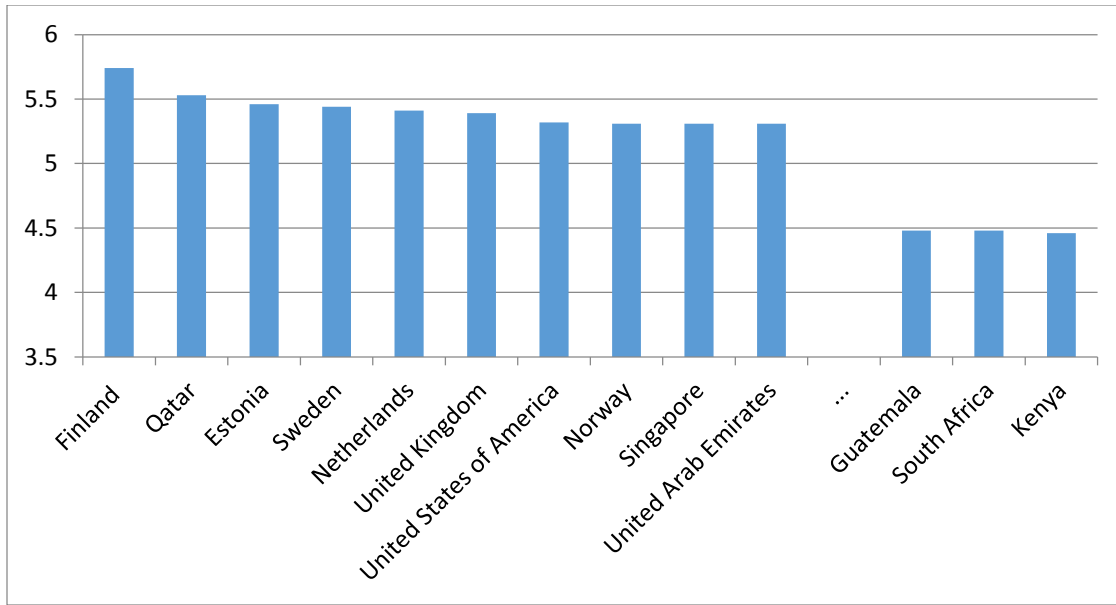


Figure 2.2: The extent to which ICT enable new organizational models Globally (GII, 2014)

As seen in Table 2.1 and Figure 2.2, globally, Finland had the highest score of 5.74 out of the possible total score of 7. That means that it has the largest number of people using ICT enabled alternative work arrangements in the world. The first country in Africa is South Africa with a score of 4.48 and its ranked 48th globally. Kenya follows closely at position 2 in Africa and 50th globally with a score of 4.46.

From these statistics, it can be seen that OSaaS and related technologies have been successfully adopted as an enabler for business in varying degrees in different parts of the world. From this data, it can also be concluded that the developed countries are using more of these alternative working options than the developing economies. Easy access to requisite information is likely to be a major influence in the choice and adoption of these ICT technologies. Another question that arises from this observation is whether increased adoption of these technologies result in higher development or does higher development result in higher adoption of these ICT enabled work arrangements? The higher probability is that it's actually a cycle which begins with better development of the available ICT Infrastructure. This results into higher uptake of related working arrangements which results in higher utilization of available human capital and hence greater development. Therefore, there is high likelihood that there will be greater adoption of OSaaS and related technologies with increased development of the requisite ICT infrastructure in the developing countries.

2.5 Defining Features of an Office Space as a Service

According to Tukker and Tischner (2006), an Office Space as a Service supplies the full range of services and infrastructure required for a complete office. Clients are required to pay only for the duration when they use the service. These periods can range from a few hours, days, months or years. Indeed, most OSaaS facilities are designed to provide the full functionality, efficiency and comfort of a traditional office but at an adaptive flexible cost. In order to be a true substitute for the traditional office, the OSaaS facility is usually equipped with computers, printers, scanners, Internet access, teleconferencing facilities and more. Other services likely to be offered therein include: secretarial services, receptionists, personalized voicemail, answering and remittance of calls and fax, transmission of mails with personal address and creation of business stationery among others, not to mention a business address in the “right place”. Some OSaaS will also offer more specialized services such as support for advertising campaigns, administrative assistance and bank services (Tukker & Tischner, 2006; Lizieri, 2003).

To appreciate the significance of OSaaS in comparison to other remote/mobile work arrangements, the following sections explore some of the services offered in OSaaS facilities.

2.5.1 Internet Services

As already mentioned, mobile work arrangements mean that a worker can remotely work from home, hotel, airport lounge, at a public hotspot or by the roadside as long as he/she can get Internet access to connect back to the main office. The ATAC (2006) report identifies lack of adequate technical back-up and real-time help-desk support for teleworkers and home-based workers as one of the main impediment to the effective realisation of ICT-enabled flexible working arrangements for many workers. The report also references an American Telephone & Telegraph Company (AT&T) survey that found out that broadband-enabled employees worked at home twice as often as those that did not have access to high-speed Internet. The said report further identified the inability to download large files as the single most important inhibitor to the adoption of telework arrangements. Wi-Fi hotspots that offer easy connection to the Internet from public places often present security risks. Specifically, accesses through an unprotected public hotspot to messaging facilities that do not incorporate encryption features allow the transmission of identifiers and passwords in plain text which is risky (Assing, 2013). This kind of information security threat is not found in most OSaaS facilities, who offer fixed cable-based internet access. Therefore it can

correctly be deduced that internet access in OSaaS is not only faster and more reliable, but also is safer for use.

2.5.2 Teleconferencing

Chua and Pheanis (2006) states that, teleconferencing is an essential feature in any business telephone system. It is enabled by ICT and it allows associates to engage in a group discussion by conducting a virtual meeting while remaining at geographically dispersed locations. They further assert that teleconferencing increases productivity while reducing travel costs and saving travel time. Clearly this kind of engagement with either the central office or another OSaaS is not very practical in a public hotspot or an airport lounge, but the privacy behind the walls of a OSaaS facility make it practical therein.

2.5.3 Collaboration

According to Laudon and Laudon (2012) collaboration is working with others to achieve shared and explicit goals. In this context, collaboration entails sharing ideas, resources, office space and everything else necessary to achieve the common goal. This can be within the same office, different parts of the city or across continents from own or OSaaS locations. The participants could be own staff or freelance consultants participating on a single company or multi-company project(s). In today's knowledge driven economy, the crucial role of collaboration cannot be underestimated. Brimicombe and Li (2009) asserts that collaborative networking allow individuals and organizations to maximize their exposure to sentient knowledge and nascent ideas and, therefore, maximize their chances over a longer period of coming up with new ideas, noticing opportunities and participating in innovation.

The report by ATAC (2006) points out that the narrow-band internet connectivity options available in a number of homes and outback areas in Australia present a constraint to the effective use of real-time collaboration applications and video-conferencing tools. In addition to that, network reliability issues especially in the homes potentially undermine the efficacy of working from home. On the other hand, an OSaaS facility being a proper commercial space is less likely to use a narrow-band Internet connection and the link reliability thereof is likely to be much higher. Therefore, users will get a better collaborative experience in an OSaaS environment than from any other teleworking arrangement.

Other advantages of OSaaS arrangements as identified in the ATAC (2006) report include:

- i. In OSaaS arrangements, work activities do not need to be done locally, but they are moved to the lowest cost delivery location and executed remotely.
- ii. Instead of moving resources to where work is, work is moved to where resources are located since that is always the cheaper option.
- iii. A work location can be anywhere; just book the nearest OSaaS facility in any city and you start working.

The report concludes these advantages by giving an example of Shell Australia. Shell Australia had an office of 250 staff based in Melbourne, with only 120 desks. That means staff only came into the main office to do collaborative work requiring face-to-face interaction, otherwise the rest of the time they were working from remote OSaaS sites, homes or from client's site.

2.6 Some Providers of Office Space as a Service in Kenya

Although the concept of OSaaS is relatively new in Kenya, quite a number of companies have come up and begun offering the services. Some of them like Regus are multi-national companies with OSaaS locations not just in Kenya but in the US, UK, Germany and many other parts of the world (Regus.co.ke). Their wide office network gives clients, especially foreign companies who are not sure whether to set up a proper local office or not a flexible arrangement of a convenient cost effective OSaaS office to work from while doing their due diligence. The identified providers of OSaaS facilities in Kenya include: a) Regus with OSaaS facilities in the following addresses in Nairobi Kenya: Kenyatta Avenue- ICEA Building 17th Floor, Westlands/Museum Hill-Purshottam place, 14 Riverside 4th Floor Cavendish Block Riverside Business Park, Laiboni Center 4th Floor, Westlands Delta Corner Tower 7th Floor, Delta Corner Tower 2 13th floor Westlands and Village Market 2nd Floor Eaton Place on United Nations Crescent road, b) Virtual Office Solutions Ltd with their OSaaS facility located on 6th floor suite 6A TRV Plaza 58 Muthithi Road- Westlands, c) Arklinn Offices with their OSaaS facility located on Top Plaza Building 1st floor suite 9, Kindaruma road off Ngong Road, d) Horizons Office- 1st Floor Luther plaza on University way, e) Landmark OSaaS on Groganville Estate, f) Wilson Business park in Nairobi West Estate, g) Genius Executives located on 15th floor View Park Towers-Utalii lane, h) Solis Limited located on Westend Towers 6th Floor.

2.7 Technologies for Location-Based Services

Ferraro and Aktihanoglu (2011) declare that the usefulness of many of today's popular mobile applications and services is primarily based on their ability to determine where the user is located at a particular time he or she is using the application/service. They further state that an LBS application should be able to give the user current locational details, additional features of interest nearby, and a dynamic or two-way interaction with the location information or content. The proposed system is to be built on these three principles. That means it will be able to identify the position of the user upon which, it will display the available OSaaS facilities in the neighborhood alongside the applicable locational factors for the area. Alternatively, a client would input some locational information (geo-codes) about a desired location for a required OSaaS into the system, and the system will return the OSaaS facilities in that neighborhood. According to Brimicombe and Li (2009), Location-based services (LBS) are the delivery of data and information services where the content of those services is tailored to the current or some projected location and context of a mobile user. While the mobile user has been the main target for LBS, this has now extended into normal computer users especially when connected to the Internet. LBS are really an amalgamation of many technologies working together. For the key positioning element, the mobile devices predominantly use the Global Positioning System (GPS) while the computers will use a mix of IP addresses and the service provider's details to approximate their location. Since LBS is a key technology embodied in the proposed system, more information and data about the same was researched on as presented in the next section.

According to Steiniger, Neun, Edwardes and Lenz (2012), the infrastructural elements necessary to implement a location-based service system are: a) Communication network, b) Positioning component, c) Mobile devices, d) Data and content provider, e) Service and Application Provider. In some cases, the service and content provider can be viewed as one entity; this is shown in figure 2.3. A good example of this is Google who provides both the Geo database and the applications, Google maps and Google earth, to access it.

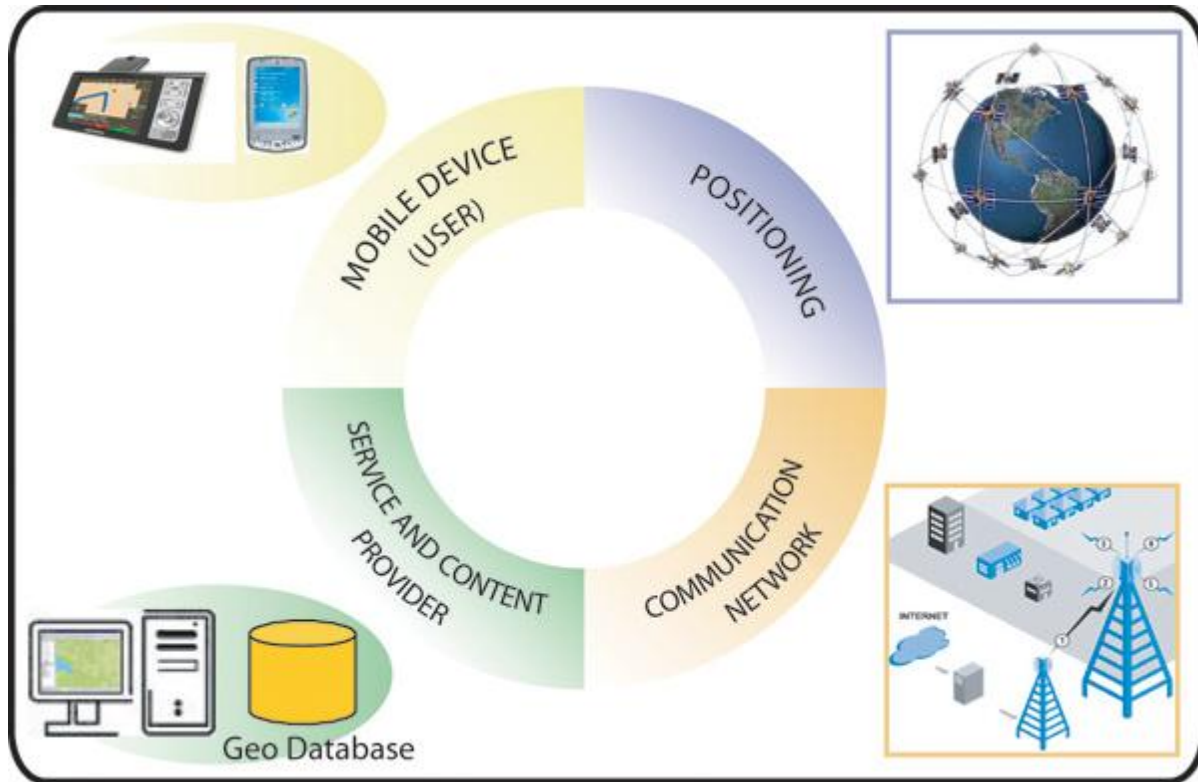


Figure 2.3: The Basic Components of LBS (Steiniger et al., 2012)

In the next section, each of these LBS components is examined in more details.

2.7.1 Communication network

Steiniger et al., (2012) describes the communication network as the component that transfers data and service requests from the user mobile device to a service provider and the requested geo-spatial data back to the user. Nait-Sidi-Moh, Bakhouya, and Gaber (2013) identifies the technologies used in these communication networks as explained in the section below.

2.7.1.1 Cellular Networks: GSM, GPRS, 3G, 4G

These use radio frequency signals to communicate with mobile devices located within a geographical coverage area called a “cell”, hence the name. At the centre of each cell, there is a base transceiver station (BTS) that transmits signals to and receives signals from the mobile stations within its coverage area. The BTS also links with the Network Switching Subsystem (NSS) for control of the devices connected thereof (Kurose & Ross, 2013). Global System for Mobile Communications (GSM) is identified as the first digital cellular phone technology based on Time Division Multiple Access (TDMA) system that originated in Europe and enabled roaming

services for mobile users. 3rd Generation Partnership Project (3GPP), a global collaboration group of telecommunication companies, asserts that since GSM was a ‘circuit-switched’ network, it was ideal for voice but had severe limitations for data transfer. They further state that the General Packet Radio Service (GPRS) added the ‘packet-switched’ layer to the GSM in the year 2000 and started off efficient data transfers on mobile networks. The current 3rd and 4th Generation (3G & 4G) cellular networks enables mobile devices to achieve data download speeds from 1Mbps up to 28Mbps respectively (3GPP, 2015).

2.7.1.2 Wireless Networks: Wi-Fi, ZigBee, WAVE

Many of today’s smartphones are equipped with Wi-Fi receivers that allow them to use Wireless Local Area Networks (WLAN) also known as Wi-Fi to access some geo-spatial data. Wireless Access in the Vehicular Environment (WAVE) is also used for deployment of LBS applications. In Indoors, ZigBee networks are quite reliable and cheap to implement and hence can be used for deployment or access to LBS- based applications (Nait-Sidi-Moh et al., 2013).

2.7.2 Positioning Systems and Techniques

The primary purpose of these technologies is to determine the location of given user who is in possession of positioning device. Shek (2010) calls these Location Collection Technologies (LCT). Shek (2010), Solanki and Hu (2005) broadly classify these techniques into three categories as explained below. These differ in the infrastructure used, precision latency and accuracy.

2.7.2.1 Indoor Localization Techniques

These are used for short range finding of a bearer of the device supporting such LCT and are based on pervasive computing. They are typically found in campuses or buildings. Main technologies used here include WiFi, Radio Frequency Identification (RFID), Bluetooth, Zig Bee and Ultrasound positioning. Note that all these technologies apart from RFID, support localization as an add-on feature but their core function is really data transfer. Also the core function of RFID is identification.

The main advantages of using these LCT as compared to the other categories is that they use low power and cheap receivers and the fact that they can be deployed indoors and in other areas without clear access to the skies like inside mines, trains, and buildings. Their main disadvantage is that they have very limited coverage.

2.7.2.2 Satellite Positioning Techniques

This is the main method used today in positioning and it's described in more details later. Different schemes for these do exist. Each of them has a constellation of many satellites, usually 24, and uses signals from at least 3 of them to accurately determine the location of a transmitting/receiving device through a process called trilateration (Nait-Sidi-Moh et al., 2013, Brimicombe & Li, 2009). Its main advantages include the fact that it is quite accurate and available in almost every corner of the earth as long as the recipient possesses a suitable receiving device. (Most smartphones today have an inbuilt GPS receiver). It is also a free service for individual mobile users. The main disadvantages of this method is that it requires substantially high power and performs poorly indoors or in areas crowded with many tall buildings.

2.7.2.3 Mobile phone Localization Techniques

This is useful on handsets without GPS receivers. It uses different parameters encoded in the signals from cellular networks base stations (cells) to help identify location. The parameters include cell identification, Time Difference of Arrival (TODA), propagation time and Angle of Arrival (AOA) (Solanki & Hu, 2005). These parameters help get an approximate location of the receiver. Its primary advantage is that it is implicitly provided for in most cellular networks. Secondly, it is the only option for users who have non-GPS enabled mobile phones or where GPS functionality has been switched off on the devices. The main disadvantage of this technique is that it relies on non-standardized and sometimes proprietary technologies built into different cellular networks (Nait-Sidi-Moh et al., 2013).

2.7.3 Satellite Positioning

The most popular and commonly used of these is the US based Global Positioning System (GPS). GPS is a world-wide radio navigation system comprising of a group of 24 satellites in medium earth orbit at a nominal altitude of 20,200 km and their ground stations. The satellites are clustered in groups of four, called constellations. Each of these constellations is separated by 60° in longitude, such that at anytime, anywhere in the world, a GPS receiver can pick up signals from at least four satellites (Pratt, Bostian & Allnutt, 2003).

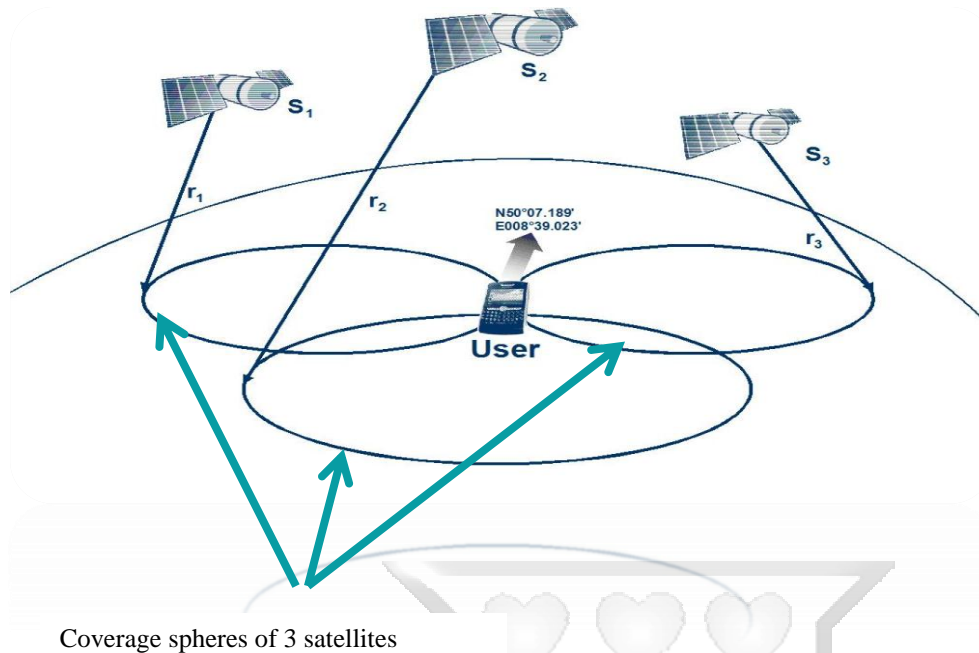


Figure 2.4: Satellite Positioning Principle (Kassem, 2013)

Europe has deployed a similar system called the Galileo Systems while Russia manages Global Navigation Satellite System (GLONASS) (Nait-Sidi-Moh et al., 2013, Brimicombe & Li, 2009).

As earlier mentioned, basic satellite positioning uses at least 3 satellites as shown in figure 2.4.

With a known satellite position, the satellite receiver will predominantly use the propagation delay (Δt) of signals from visible satellites and the speed of light (c) to find out how far it is from them (Kassem, 2013). $r_1 = c * \Delta t$ (Distance from the receiver to satellite S1)

Satellites S1 and S2 are each at the center of an imaginary sphere, the radius which is equal to the distance to the receiver. By knowing the distance to a third satellite S3, the receiver computes its correct position in terms of latitude and longitude at the intersection of the three spheres.

In order to increase the accuracy of GPS and to eliminate most of the errors, two cost effective alterations to standard GPS are used. These are Differential GPS (D-GPS) and Assisted GPS (A-GPS). D-GPS employs two receivers, one roving (user) and the other stationery. The stationery one ties all satellite measurements to solid local references. This process improves the locational accuracy of D-GPS from about 10 meters (standard GPS) to about 3 feet or better (Solanki & Hu, 2005).

The Assisted GPS uses an “assistance” locational server from the mobile network to very fast get initial position details such as available satellite orbit information, accurate timestamps or possibly snapshots of GPS signals. This can allow GPS accuracy with initial location information within seconds, thereby making it practical for use in LBSs. Since it does not solely rely on satellites for locational information, A-GPS can also be used effectively in more areas such as densely populated cities where the number of satellites visible for GPS signals could only be one or two (Shek, 2010). The generic infrastructure of A-GPS is as seen in figure 2.5. The A-GPS server regularly collects locational information that is quickly supplied to requesting mobile device on its network. The mobile device uses those values as a starting point for further iteration to quickly get its exact location.

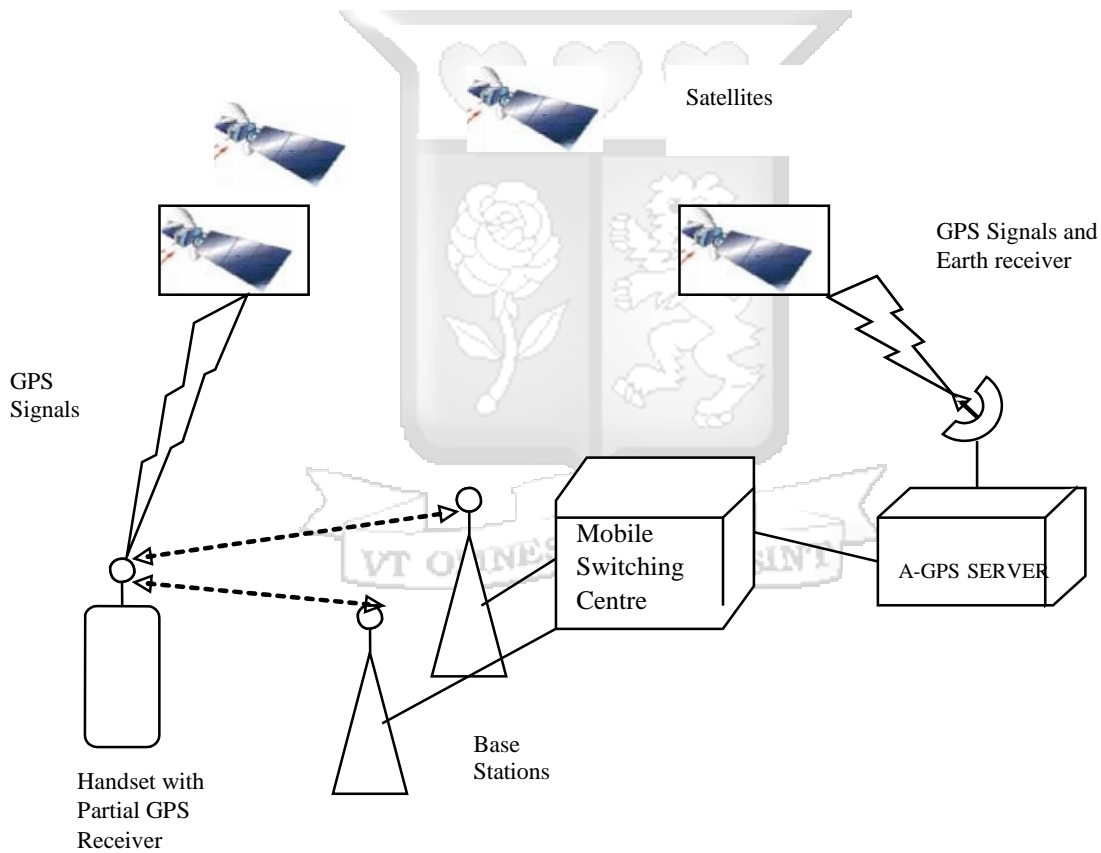


Figure 2.5: Assisted GPS Infrastructure (Solanki & Hu, 2005)

2.7.4 Locational-based Service Mobile Devices

According to Steiniger et al., (2012), these can be divided into two categories. The first category is the single purpose devices such as a car navigation box or a dedicated GPS receiver. The other category consists of multi-purpose devices which, apart from giving locational information, serve

other purposes. These include most smartphones with integrated GPS receivers, personal digital assistants, tablets and even laptops with integrated GPS receivers.



Figure 2.6: Different LBS Devices

As seen in figure 2.6, some modern laptops have integrated GPS receivers for accurate determination of location. Apart from the laptops, many of these other LBS devices as seen in figure 2.6 have limited internal memory and computing power. Hence a good portion of the spatial search calculations and routing operations are designed to be done on the server side and it is only the results that are relayed to the device (Steiniger et al., 2012).

2.7.5 Cartography and Geographical Information Systems

Solanki and Hu (2005) define Geographical Information System (GIS) as a software system used to gather, store, manage, analyze and display geographical information; that is data identified according to location. Without GIS, there would be no LBS applications since they rely on GISs to represent geolocation data. GIS and cartography are used to manage and organize localized geographical information, and to make objects available in a geo-referenced system. They facilitate the superimposition of maps from different sources, and access to information about all the geographical objects located in a given neighborhood or at a given distance from an office or

other location. Generally, the GIS system is responsible for geocoding (converting of text addresses to geocodes) and reverse geocoding (Nait-Sidi-Moh et al., 2013).

2.7.6 Standardization and Maturing of Locational-based Service Standards

Shek (2010) explores the maturing of the LBS standards, where different layers of an LBS system have now been identified and specifications spelt out. He asserts that the Open Geospatial Consortium (OGC), consisting of companies such as IBM, Oracle, ESRI, Google, European and US agencies is one such group coming up with LBS standards. These common standards allow developers to concentrate on their applications rather than the LBS core components. The main standards for LBS as proposed by OGC are discussed below.

2.7.6.1 Open Location Services

This Open Location Services (OpenLS) standard does not just define the cartographic language to be used for encoding geospatial data, but the entire architecture for LBS and interface specifications for various components (Shek, 2010). This proposal separates the LBS architecture into (i) Location collecting services, (ii) LBS application providers and (iii) a “GeoMobility” server. The GeoMobility server represents a web service-enabled middleware that handles common LBS functionality. These include LBS directory service, gateway service, location utility service, map presentation service, routing services and tracking services. While this standard has not been fully implemented by Google Maps, the functionality offered thereof is close to this standard (Shek, 2010).

2.7.6.2 Standards for Location Data

These are typically programming languages used in GIS. Geography Markup Language (GML) is an eXtensible Markup (XML)-based Language used to represent various points of interest on a map. It is extensively used in OpenLS standard and in general for transferring geography data. Keyhole Markup Language (KML) was initially created by Google. It complements GML by providing information about annotations and markings on a map (visualization) (Shek, 2010). Transport Protocol Experts Group (TPEG) and the standard specification for European traffic information (DATEX) are other upcoming protocols used in coding GIS data (Nait-Sidi-Moh et al., 2013).

2.7.6.3 Service and Application Provider

This is identified as the final layer made up of the core business tasks directly interacting with the user in the LBS implementation stack. Shek (2010) sees this layer as being made up of a server component (processing and routing) and a smartphone component (GPS sensor and a server access application). According to the Service Oriented Architecture (SOA), which defines a group of principles and methods for the implementation of software components as interoperable services, this layer ought to be independent of underlying infrastructure and able to run on different platforms (Nait-Sidi-Moh et al., 2013). According to Steiniger et al. (2012), the application provider offers different location based services and is responsible for the service request processing. This could be specific tracking information regarding some animal(s), yellow pages information or OSaaS facilities information as proposed in this research. He further asserts that these kinds of service providers do not usually store all the information required by end users, but rely on the maintaining authority and other business partners to provide base geo-spatial data and location information.

This layer need also consist of software components that exchange data using standard Extensible Markup Language (XML) and run on an a web service platform. The conceived application can be based on XML or HTML5 which have integrated support for geolocation and would run on most standard web servers.

2.8 Locating OSaaS Facilities

Office Space as a Service is a relatively new concept and explicit systems or models for locating and choosing such could not be found. But since the existence of OSaaS is tied first to the availability of normal office space, this research assumes that the models or systems that apply to the traditional office will also apply to a OSaaS. The systems described in the next section had reference to traditional offices but seen as applicable to OSaaS too.

2.8.1 A Support system for delineating location sets for office space

Manzato, Arentze, Timmermans & Ettema, (2014) in their research paper titled: A Support system for delineating location sets of a firm seeking office space, propose a GIS-based tool for helping firms and real estate agents seeking office space in a given region. The model uses decision tables to find the best match between the requirements of a given organization in terms of office location and the available locations and the features found thereof. More specifically, they envisage three

components interacting in this process of selecting an office location. These are: the organization with a set of requirements; the potential location sites, which have a set of inherent characteristics; the relational matching mechanism, which links both organization requirements and location characteristics. This matching now gives the degree of suitability of a given site.

The decision tables used in this model employ a logic of exclusivity where each condition (C1) for a given site is represented by two or more mutually exclusive values V1a or V1b as seen in the table 2.2. In this evaluation, if condition C1 is satisfied by value V1a, then the other conditions C2 and C3 do not really matter and the evaluation is complete with decision A1 being taken. It is only when C1 evaluates to V1b that the other conditions are considered. Similarly the decisions/actions A1, A2, A3 and A4 are mutually exclusive.

Table 2.2: Example of a Decision Table (Manzato et al., 2014)

C1	V1a	V1b		
C2	-	V2a	V2b	
C3	-	-	V3a	V3b
Actions	A1	A2	A3	A4

To come up with accurate decision tables for locational choices and parameters, the researchers interviewed real estate agents who were seen as experts in that knowledge domain. For office requirement conditions, the researchers assumed six different firm types with varied office needs. To calculate locational variables on the supply side of offices, they used historical GIS-datasets from the government. That included elements like airports, roads and railway network and demography. This information was then extracted and matched to the offices location database. This database forms the core of the supply side for the proposed tool for delineation of location sets as designed by Manzato et al. (2014).

2.8.1.1 Merits and Demerits of this model

Although the decision tables used herein form a good approach upon which decision support systems can be fully built, they fall short in multi-criteria setups where different parameters have

different bearing (weight) on the decision to be made. The central database of office locations as used in this model is fundamental in terms of a decision support system and it is also used in the conceptual model. But it is worth noting that this was just a model and it is not certain that real systems have been built around it. Secondly, the actual technologies or architecture to fully implement such a model are hardly discussed by that research. The conceptual model contextualizes the physical location of a user to OSaaS facilities available in the neighborhood using the mobile platform, an aspect fully missing on this model.

2.8.2 Google search/maps

This option gives amazing accurate locational information for almost anything, anywhere in the world. A quick google search for “Office space as a service” returned 60,500 entries. That exposes the main problem with this approach. To fully illustrate this problem, Strother, Ulijn and Fazal (2012) give another example of searching for the phrase, *Information Overload* from the Google platform which returned 22,800,000 hits. The main problem with this method of locating OSaaS facilities is that of “information overload”. This is defined by Businessdictionary.com as the “stress induced by reception of more information than is necessary to make a decision (or that which cannot be understood and digested in the time available).”

Do users really have the time to go through 60,500 entries/results? Some of the entries returned include advertisements for office space in the city alongside some factual data on OSaaS locations. The conclusion here is that data supplied with this option is very general and time consuming to glean the required OSaaS facts therein.

The second inherent weakness of thematic search is as explained by Lewandowski (2012). He asks whether such a search for a name or phrase, should return a list of webpages dealing with a geographical aspect of the place, photos showing a landmark, nearby validated businesses or events, interesting hiking tracks or geo-tagged character with a similar name? Such is the dilemma of general thematic searches. While Google has tried to contextualize available geographical data, it really remains an open guess on what the user is really looking for when he or she enters a phrase or word to search.

But the powerful search capabilities and the rich coverage of Google maps remains a gem to be mined for both the ordinary thematic searches as applied above and in the conceptual model that

uses Google maps to not only find the locations of the user relative to the OSaaS locations, but also the directions to the selected facility.

2.8.3 Multi-Criteria Decision Strategies in Location-Based Decision Support

Another approach used in solving the problem of locating offices is as researched and documented by Claus and Martin (2004). In their paper, the authors present a model whereby user preferences towards a facility in a given location are presented in a qualitative way and then used as input for a multi-criteria evaluation of the given facility within a given geographical region. In their model, users select pre-defined decision related attributes to be used as evaluation criteria; identify good, fair and poor criterion value or value ranges to allow for comparison of standardized criterion values; and define the relative importance of the criteria by assigning weights. The weighted criterion values are then combined based on a decision rule, resulting in evaluation for each decision alternative. Then the Ordered Weighting Average (OWA) decision rule is used that allows users to specify a personal decision strategy as part of the decision making process. The decision strategy employed here could be optimistic (facilities are generally good), neutral (does not know) or pessimistic (expected poor quality). An example used here is for a traveler who has arrived in a new town and needs to find a hotel within 500M radius. But the hotel needs to fit his/her requirements in terms of price of the room, check-out time and other subjective parameters. Since the weighting of these parameters will depend on each individual traveler, the assigned value(s) will be different hence also the choice of the facility. The location (a radius of 500M) in this case is a non-compensatory factor which must be satisfied in this decision logic. The price, late check-out time, and private baths are compensatory factors whereby, depending on the assigned weight, a lower ranking on one factor can be compensated for by a higher ranking on another factor.

Merits of this model

The model convincingly aggregates a number of parameters into multi-criteria evaluation tool which was successfully demonstrated in terms of its workability in location decision support. The use of the Ordered Weighted Averages is also very appropriate for such multi-criteria scenarios.

Gaps in the model

The authors confirm that the data used for the user location was entered by the user and not determined by the mobile device possessed by the user. Secondly, only a single locational factor is weighted on this model. That is the proximity of the user to the facility. While that is key, there is need to incorporate other locational factors such as security, Infrastructure or demographics to the evaluation of the location especially when it is an office space required. Thirdly the parameters considered are system predefined. A possibility of user created and defined parameter(s) is not addressed by the model. Lastly, a two way engagement between the service providers, hotels in this case and the user (traveler) is not envisaged in this model.

2.9 Architectures for Locational-based Service Applications

According to Merriam Webster dictionary, architecture refers to the way in which parts of a system are organized. Therefore, the LBS application architecture describes how the different constituent components of such an application are designed and brought together to offer the full intended functionality.

2.9.1 The Standard Locational-based Service Application Architecture

The general architecture of an LBS “application” is seen as consisting of the elements as seen in figure 2.7. According to Shek (2010) and Kushwaha (2011) and as seen in figure 2.7 a complete LBS system consist of: LBS application as the top most layer, the LBS middleware, Location tracking component, the GIS provider component, and the Location Collecting Service (LCS) component. Each of these components and their functionality are further explained below.

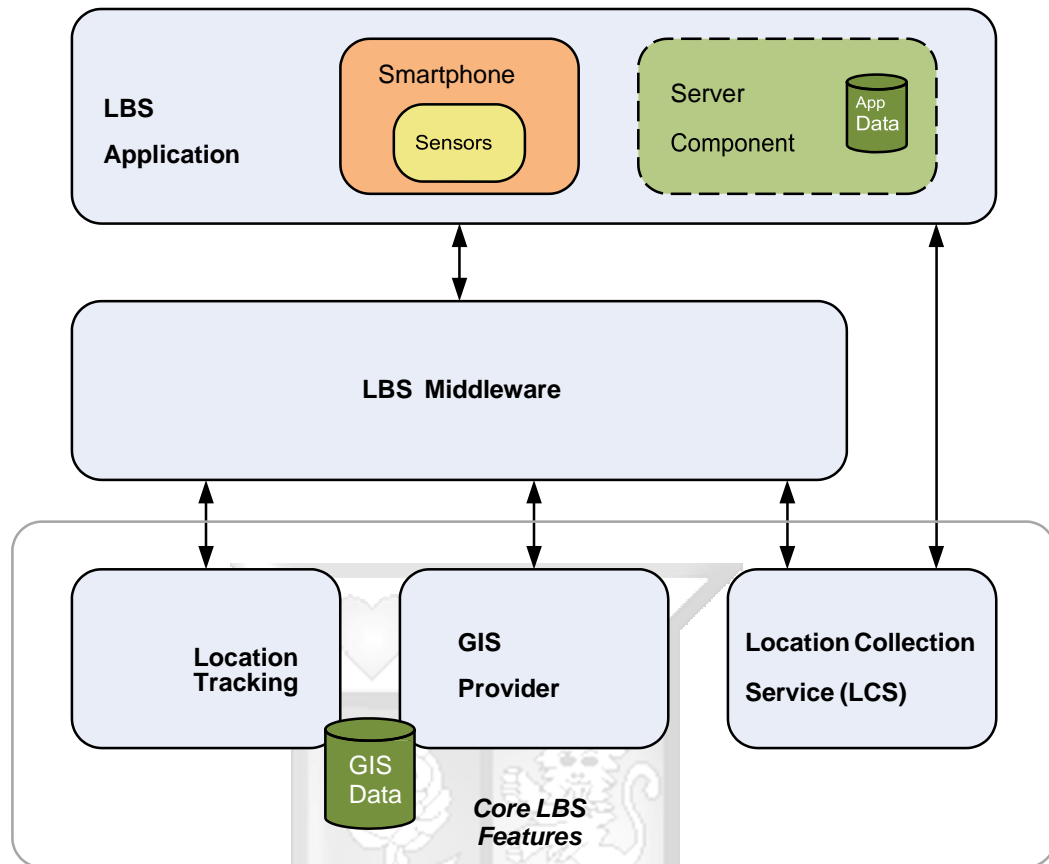


Figure 2.7: LBS Architecture (Shek , 2010; Kushwaha, 2011)

2.9.1.1 LBS Application

This layer represents particular application that uses LBS principles such as “Find My Friends”, Animal tracking or the conceived “Find OSaaS facilities nearby”. It is seen as consisting of a smartphone app and the locational sensors thereof and possibly a server component that will possibly store geo-tagged attributes of a particular data (Shek , 2010; Kushwaha, 2011).

2.9.1.2 LBS Middleware

This bridges protocols and network technology with wireless and Internet technology. It wraps up the core LBS components to provide a consistent interface to LBS applications. The OpenLS specification earlier mentioned provides one of the available standards for middleware. This can either be deployed within the mobile network by the operator or hosted by the application service provider (Shek, 2010; Doshi, Jain, Shakwala, 2014)

2.9.1.3 Location Tracking

It’s really a subset of GPS functionality on GPS enabled devices to monitor the changing location of a user and relay this information to a server. It stores the current and historical traced locational

information of a user, which could be used to predict future movement and route. According to Shek (2010), this component could also determine when a specific user has entered or exit from a particular area and notify other components and also determine which users are within a given area.

2.9.1.4 GIS Provider

This element provides geospatial functionality for LBS including map information, map visualization, and directory services. Google Maps with its Application Programming Interface (API) is a good example of GIS provider (Shek, 2010).

2.9.1.5 Location Collection Service

The main work of this component is to get the latitude and longitude of a given user. This component in most cases is accessed directly from the GPS receivers of the Smartphones or through the middleware from the mobile network triangulation via a service provider (Shek, 2010; Doshi et al., 2014).

The gist of this research is centered on the first layer which consists of the Smartphone application and the Application server element. As per that architecture, the server element will store geo-tagged data for available OSaaS facilities and also the available locational parameters.

2.9.2 Conceptual Framework

The proposed application is generally based on the standard LBS architecture explained in section 2.7. In particular it seeks to build an LBS application for the top most layer as per figure 2.7. The other components thereof will be retrieved from third party providers such as Google Maps. More particularly, the proposed platform leans towards the Claus and Martin (2004) model and expands it by introducing the OSaaS dimensions/factors to it and contextualizing that with the location of a mobile user. The application will not only contain information about OSaaS facilities in Kenya and the facilities offered therein, but also an indication of the weighting of other locational factors associated with the identified location to help a user make an informed choice of where and what to hire for use. For the user defined OSaaS parameters, the model uses the Ordered Weighted Averages (OWA) decision rules as employed by Claus and Martin (2004) and explained in more detail in chapter 3 to help make a choice between available facilities. The platform will be accessible from both a computer and a smartphone.

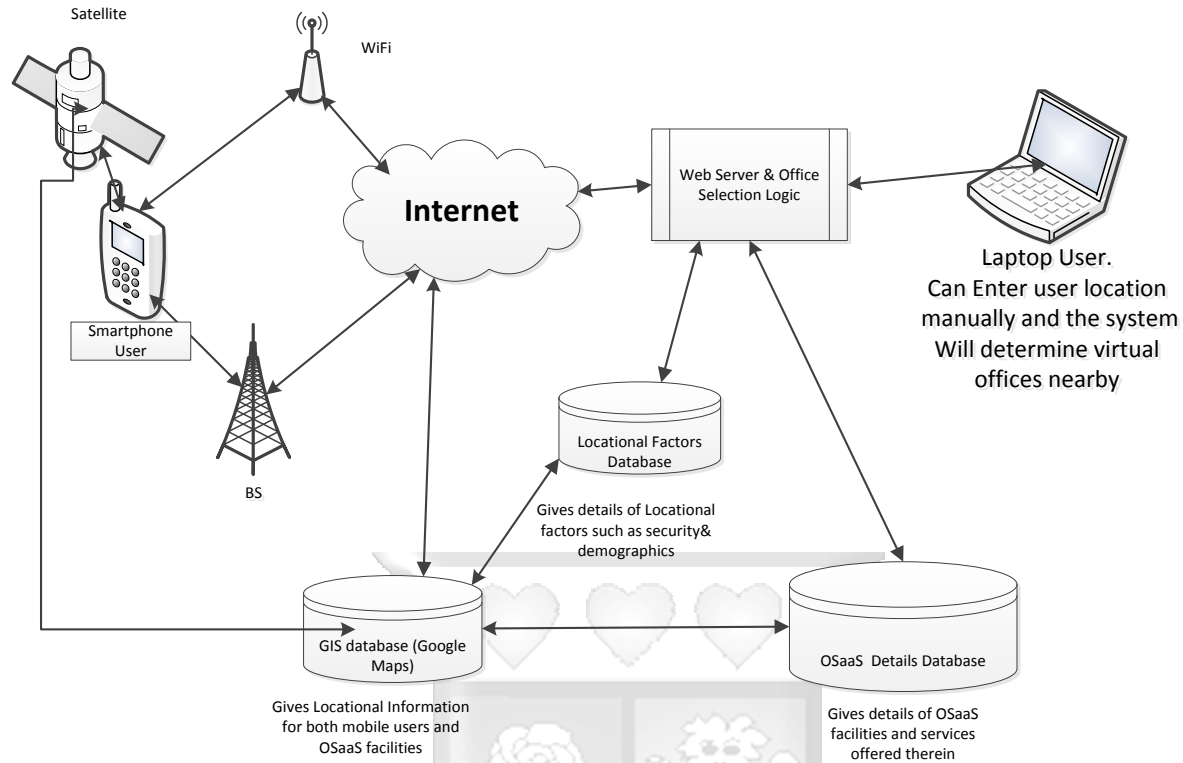


Figure 2.8: Conceptual Architecture

As shown in figure 2.8, the application consist of five subsystems. These are the OSaaS facilities details database, Locational factors database, the web server and mobile interface platform(server), a mobile application for downloading and installing on smartphones and a desktop application to run on computers to access the web based service. Also as seen in the figure 2.8, the locational information will not be coded, but retrieved from Google maps using the Google maps Application Programming Interface (API).

When started, the smart phone application gets the user’s current position from the inbuilt GPS receiver on the phone or uses the mobile network triangulation to get the same. Then the application will connect to the application web portal using WiFi or the mobile network through the Base Stations (BS). The portal will use the GPS coordinates provided by the mobile phone to determine from its own database of OSaaS facilities and their coordinates, the facilities located within the preferred radius, usually 1-3 KM. It will fetch a list of applicable virtual offices attributes from the OSaaS database and prompt the user to select the required attributes and submit. Based on the selected options, the system will return to the user a subset of the OSaaS facilities

ranked according to the user options. Then it will fetch from the locational factors database location factors information, such as security data of the applicable neighbourhood. This will be displayed as a heat map layer on top of the map of the ranked and filtered OSaaS facilities on the screen of the mobile user. Based on all these factors, the user will select one of the OSaaS facility and the application will use the third party GIS database(s) to get and give directions to such a facility from user location.



Chapter 3: Research Methodology and Design

3.1 Introduction

Research Methodology is the technique or the research program used to collect data, collate it and make inferences from it (Cooper & Schindler, 2011). This research is about an existing problem and how to solve it. Therefore an applied research methodology was identified as the most suitable approach for the task. Donaldson, Chirstie and Mark (2009) define the purpose of applied research as to understand how to prevent or solve practical problems that affect “real” people, societies or communities across the world. They further suggest that this kind of research can be divided into either descriptive or evaluative sub-genres. The descriptive applied research helps advance our understanding of practical problems and their potential solutions. On the other hand, evaluative applied research comes up with strategies to improve or determine the effectiveness of actions (e.g., social programs) to prevent and solve practical problems. Since this research is based on a perceived “real world” problem and a proposed solution, it fits in as an applied research problem. But as Bryman and Bell (2007) puts it, many practical researches usually borrow from different methodologies so as to fulfil the stipulated research goals. This research is no different and it uses quantitative data from secondary sources about the facilities offered in virtual offices in Nairobi County to come up with the envisaged solution. In this chapter quantitative data gathered about the location of Office Space as a Service facilities and the amenities found therein is presented and analyzed. This was later used in the system design.

3.2 Population and Sampling

According to Bryman and Bell (2007), population is the universe of the units from which the sample being studied is drawn from. This being a case study, the research first sort to know the total population of providers of Office Space as a service in Nairobi Kenya. That constituted the total population for this research. To this end various online databases such as Kenya National Bureau of Statistics (KNBS) and the Kenya Institute for Public Policy Research and Analysis (KIPPRA) were searched, but this being a relatively new business area, minimal information about OSaaS was found in such. Online search for OSaaS in Nairobi and further counter referencing yielded 8 providers of the service in Nairobi city and that constitutes the total population for

investigation. Purposeful sampling was used to select 3 providers from that list who had posted most of their information on their websites. But gauging by the number of offices managed by the first respondent, that is Regus, with 7 OSaaS facilities within Nairobi County and each of the other providers each with a single OSaaS location, then the sample chosen was more than half the total population. The main variables used in the system design was the physical location of the facilities (coordinates) and the actual services/amenities offered thereof.

3.3 Ethical Considerations

According to Cooper and Schindler (2011), ethics are norms or standards that guide moral choices about our behavior and our relationships with others. They continue to say that the main purpose of ethics in research is to ensure that no one suffers or is harmed by the research activities. The main target of ethics in research is to safeguard the rights of the participant. Therefore, research must be designed so that the participant does not suffer physical harm, embarrassment, discomfort, pain or loss of privacy (Cooper & Schindler, 2011). The subject of this research was quite general and most likely do not warrant any levels of secrecy, privacy, or attract the need for an informed consent. Indeed, the data used in this research was publicly available data posted on the websites of the OSaaS providers. However, that notwithstanding, the questionnaire was categorical that any data collected in the process was to be used for academic research purposes only and no personal data was to be collected.

3.4 Data Collection Methods

Although a questionnaire as seen in Appendix A was designed as one of the data collection tools, most of the data used in this research was secondary data from public facing websites of the OSaaS providers. The data harvested from these websites fulfilled to a satisfactory degree the requirements for this research in terms of the primary variable, which was the location of the facilities (latitude and longitudes) and the secondary variables of the amenities found in the OSaaS facility under consideration. The locational factors (security, demographics, Infrastructure and others as per chapter 2) data could not be collected in the available duration. The data presented herein is sample data for security as a locational factor.

3.5 Data Analysis and Presentation

The main tool used for data analysis was Microsoft Excel and tables were used to present the collected data as seen Tables 3.1 and 3.2. The primary data of interest was the coordinates of the office location, and the amenities offered thereof. In these tables, presence of the amenities was represented by T (True), while absence of the same was represented by False (F). The quoted price was for the advertised basic OSaaS package offered by the facility, although each of them offered many more customized ‘OSaaS’ packages at different rates depending on other factors. That would be an avenue for system improvement, whereby the price would not be a static parameter, but dependent on the user inputs. But for the purpose of demonstrating the concepts presented in this research, the price was used as a static parameter. The occupancy level was given as a percentage of occupied slots vis-à-vis available slots and was also used as a static parameter. But in a real environment, it would be a dynamic figure updated automatically or manually on hourly basis. Owing to this dynamism, the occupancy figures quoted thereof were arbitrary just meant to demonstrate the concept.

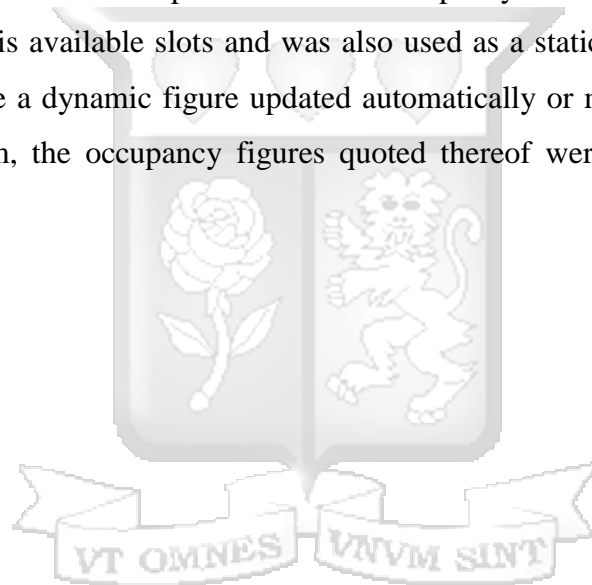


Table 3.1: Sampled OSaaS facilities in Nairobi County and their Attributes- Part A

ID	Provider	Street	Building	Floor	Latitude	Longitude	Receptionist	Support Staff	Lounge	Cable Internet	WiFi	Shower	Computer
V01	Regus	Kenyatta Avenue	ICEA Bldg	17th Floor	-1.284323	36.8188909,17	F	T	T	T	T	F	F
V02	Regus	Chiromo Road	Purshottam Place	Purshottam Place	-1.273317	36.8098589,17	T	T	T	T	T	F	F
V03	Regus	14 Riverside Business Park	Cavendish Block,	4th Floor	-1.270249	36.8017427,17	F	T	T	T	T	F	F
V04	Regus	Lenana Road,Kilimani	Laiboni Centre	4th Floor	-1.289077	36.7910619,17	F	T	T	T	T	F	F
V05	Regus	Chiromo Road,Westlands	Delta Corner Tower	07th Floor	-1.265837	36.7998234,17	F	T	T	T	T	F	F
V06	Regus	Chiromo Road, Westlands	Delta Corner Towers2	13th floor, Tower 2	-1.265936	36.7997499,17	F	T	T	T	T	T	F
V07	Regus	United Nations Crescent	Village Mkt, Eaton Place	2nd Floor	-1.22884	36.8032408,17	T	T	T	T	T	F	F
V08	Arklinn Offices	Kindaruma Road off Ngong Road	Top Plaza building	Top Plaza building	-1.297671	36.7873425,17	T	T	T	T	T	F	F
V09	Virtual Office Solutions Ltd	58 Muthithi Road	TRV Plaza, Westlands	6th floor suite 6A	-1.268727	36.8073065,17	T	T	T	T	T	F	F
	Number of Virtual offices having a given Attribute						4	9	9	9	9	1	0

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Table 3.2: Sampled OSaaS Facilities in Nairobi County and their Attributes- Part B

ID	Provider	Scanner & Printer	Open Office	Private Office	Underground Parking	Video Conference	24hr CCTV	Voice mail	GYM & Fitness Room	24hr Access	Virtual Assistant	Cost of Basic Package in USD	Occupancy %
V01	Regus	T	T	T	T	T	T	T	T	T	F	49	26
V02	Regus	T	T	T	T	T	T	T	T	T	F	59	35
V03	Regus	T	T	T	T	T	T	T	F	T	F	39	32
V04	Regus	T	T	T	T	T	T	T	F	T	F	49	41
V05	Regus	T	T	T	T	T	T	T	F	T	F	69	50
V06	Regus	T	T	T	T	T	T	T	F	T	F	69	16
V07	Regus	T	T	T	T	T	T	T	F	T	F	49	25
V08	Arklinn Offices	T	T	T	F	T	T	T	F	F	T	90	38
V09	Virtual Office Solutions Ltd	T	T	T	F	F	T	T	F	F	F	48	20
	Number of Virtual offices having a given Attribute	9	9	9	7	8	9	9	2	7	1		

From the tables 3.1 and 3.2, it can be seen that most OSaaS facilities offer the basic office requirements such as shared work space, scanners and printers, fast cable Internet connection and video conferencing. This confirms the earlier assertion in chapter 1 that indeed OSaaS can be a true replacement of traditional fixed offices. But it's also worth noting that some OSaaS facilities offer additional features such as a virtual assistant, gymnastics and fitness club, and a hot shower. These are amenities which are not commonly found in traditional office setups and it points to a possibility of higher satisfaction levels and better productivity for the users of OSaaS as compared to the traditional office setup. From this data gathered, the primary part of the application for locating and choosing OSaaS facilities was thus designed.

Table 3.3: Sample Data of Security Incidents reported in a month

Loc_ID	Street	Latitude	Longitude	Number of Incidents
C1	Kenyatta Avenue	-1.2863232	36.8188909,17	6
C2	Chiromo Road	-1.2743166	36.8098589,17	4
C3	14 Riverside Business Park	-1.2712486	36.8017427,17	3
C4	Lenana Road,Kilimani	-1.2900771	36.7910619,17	3
C5	Chiromo Road,Westlands	-1.2668372	36.7998234,17	2
C6	Chiromo Road, Westlands	-1.2669356	36.7997499,17	2
C7	United Nations Crescent	-1.2298403	36.8032408,17	1
C8	Kindaruma Road off Ngong Road	-1.2986711	36.7873425,17	9
C9	58 Muthithi Road	-1.2697267	36.8073065,17	4

Table 3.3 represents sample data for security incidents on different streets of the city. Such data could be sourced from the law enforcement agents. But so far, in this case study of Nairobi County, locational data of crime incidents had not been sought and found in the right format within the available duration. While the format and content of this data reflects a typical real county scenario, no conclusions are drawn from this because it is sample data. It was just used for the design purposes of the application.

3.6 Research Validity

Kumar (2011) explains that the validity of research findings depend on whether or not they are in accordance to what was designed to be found out, while the reliability of an instrument refers to its ability to produce consistent measurements each time. The data presented above regarding the location of OSaaS facilities and the amenities found thereof is factual. The same information would have been gotten using any other research instrument save what was used in this research.

Chapter 4: System Analysis and Design

4.1 Introduction

As explained in chapter 3 applied research was the main method employed in this research. In this approach, a real-world problem is identified and a solution for the same proposed. In chapter 2 the problem of locating OSaaS facilities was well articulated. This chapter explores the development of the proposed solution.

4.2 System Analysis

Hoffer, George and Valacich (2014) define a system development methodology as a standard process used by an organization to conduct all the stages required to analyze, design, implement and maintain information systems. Traditionally this has been referred to as the Systems Development life cycle (SDLC). As seen in figure 4.1, five main steps have been identified as making up the SDLC (Hoffer et al., 2014, Whitten & Bentley, 2007)

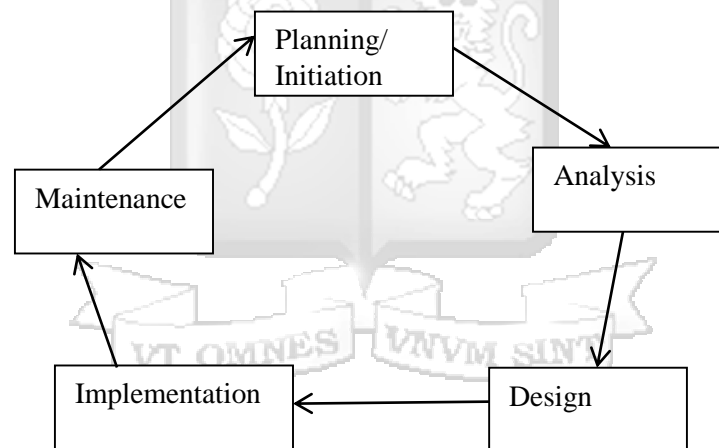


Figure 4.1: Systems Development Life Cycle (Hoffer et al., 2014)

While the steps appear to have a good sequential order, Hoffer et al. (2014) observes that this is hardly the case in real project implementations. There are usually forward and backward movements in many software projects as the requirements for each stage get more refined as a result of some data from subsequent stages. The key activities that comprise each of these steps in the SDLC as elaborated by Whitten and Bentley (2007) are the Identification of the problem, that is the need for a system in the initiation stage, thorough analysis of the problem for better understanding and identification of solution requirements and expectations in the analysis stage, the actual design for logical and physical specifications in the design stage, actual coding, testing

and installation in the implementation stage, and ensuring that the application runs optimally with inclusion of operational updates and newer versions in the maintenance stage.

Different methodologies are used in executing these five stages of software development. These include the common agile methodologies such as eXtreme programming and the standard structured waterfall methodology (Hoffer et al. 2014).

The application development for this research uses the waterfall methodology with feedback at each stage as seen in figure 4.2.

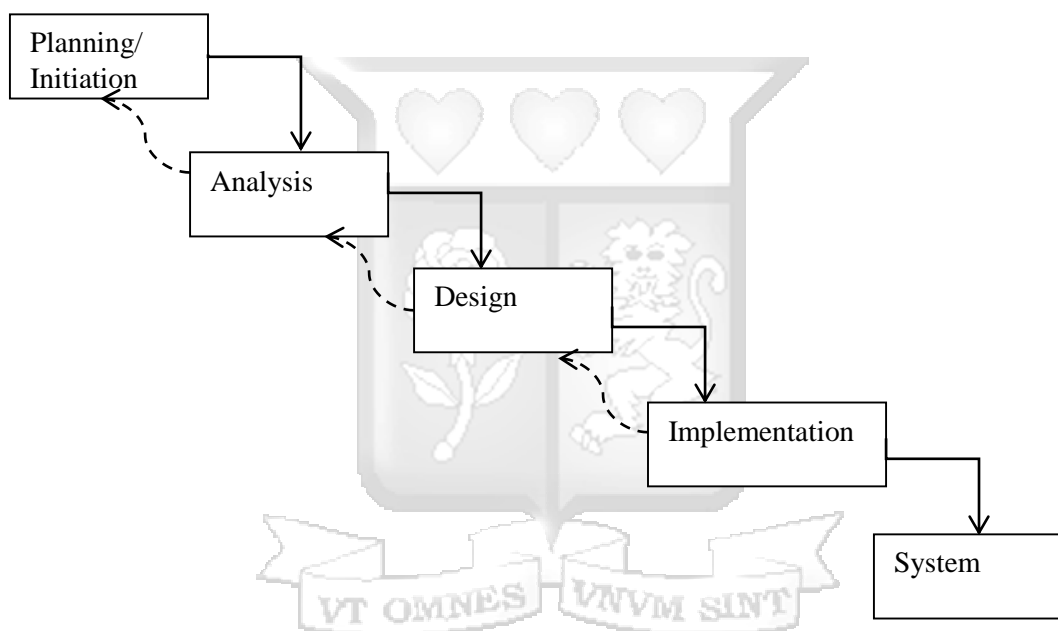


Figure 4.2: Waterfall development (Roth, Dennis, & Wixom, 2013)

In this methodology, system development proceeds sequentially from one stage to another with the outputs of one phase being the input for the next (Roth et al., 2013).

4.2.1 System Initiation/Planning

In this stage, the purpose, cost, size, scope and the economic value of the conceived system are identified and documented (Roth et al., 2013). In the Literature review, it has been demonstrated that OSaaS is a major trend in today's business world. The challenges of locating suitable OSaaS facilities in Nairobi Kenya using the current methods have also been documented. The proposed application for addressing these challenges alongside the results from the exploratory research as seen in tables 3.1 and 3.2 is the basis of the application development.

4.2.2 Analysis Phase

This is the second and one of the critical stages of the systems development life cycle. In this stage, the functional and non-functional requirements of the new system are determined and documented. Actual system analysis involves three main steps. These are; understanding the existing situation or system if any exists, identifying improvements, and defining of requirements for the new system (Roth et al., 2013). The literature review has already covered the first two points. Therefore, in this section more attention has been directed to defining requirements of the new system. Some of the techniques available to elicit user requirements include: questionnaires, interviews, joint application development (JAD), document analysis and observation (Roth et al., 2013). Document analysis and observation are the key methods employed in this research to capture the system requirements. Use cases and Process models as seen in subsequent section have been used to document the detailed system requirements as identified in this phase.

4.2.2.1 System requirements

As implied in chapter 2, the key functional requirements for the proposed system included:

- a) Run on mobile devices.

Since the mobile component of the application identifies the location of a mobile user, then it was crucial to have it designed in such a manner that it would run on as many mobile devices as possible. The popular open Android mobile platform which runs many of the today's smartphones was chosen as the design platform for the prototype.

- b) Ability to identify user location

A key feature for the system was the ability to relate user location with nearby facilities. This could only be made possible by employing LBS which requires locational information. The design needed to incorporate available options for locational determination.

- c) Able to determine distance between the user and the available OSaaS facilities

The logic behind the system was to locate the user and the facilities nearby. As seen in subsequent sections, this was implemented using Harvesine formula.

- d) Multi-criteria decision support.

As implied in chapter 2 and 3, the system needed to be able to take in multi-criteria options about the amenities offered on available facilities and use a suitable formula/method to select/rank the available OSaaS facilities. As explained in section 4.2.2.2, this was implemented using the Ordered Weighted Aggregator (OWA) function.

e) Web Server

Mobile devices have limited memory and processing capacity. Much of the processing for mobile application requests are processed on the server end. Therefore there was a need to have a publically accessible web server to process these requests as implemented in this research.

f) Database server

The providers of the Office Space as a Service and the attributes of each of them required to be stored in a manner that they could be easily retrieved and compared with each other. A relational database management system was identified as required for this purpose.

Wasserman (2010) identifies the main non-functional requirements for a mobile application as performance- efficient use of resources, security, reliability and usability. The Android operating system with its default sandboxing, separate Linux processes and unique virtual machine for each application running on its platform powered devices provided for the first 3 requirements satisfactorily and hence was chosen as the design and test platform. Other non-functional requirements considered for the rest of the system including the web platform included:

a) Adaptive window for the mobile application

It was noted that different phone brands had different screen sizes and therefore, the application needed to be able to automatically adapt the display window to fill the available screen size.

b) Password protected access to modification of any of the office or user details on the web platform.

c) Ability to zoom in and out on identified user or office locations

4.2.2.2 System Design Explained

To meet the above requirements, the conceived system was designed to consist of two primary components. That was a server component and a mobile application component. The server component consisted of the OSaaS facilities database, the locational factors database, the selection

logic and the web interface to allow access from the mobile application. The mobile application, referred to as Office Space as a Service App in subsequent sections, hosted the logic for determining the current location of a user using available technologies as discussed in chapter 2 and a set of user configurable options/factors that the user would select/deselect and then relay this data to the server. The server use the supplied information to locate the nearest OSaaS facilities that meet a given criteria based on the attributes data stored in its databases.

The smartphone OSaaS application used Java embedded in XML as the primary programming language for this research (but any other suitable language for LBS can be used). When accessed on the phone, the application launches the positioning techniques available on the smartphone (GPS or mobile network triangulation to identify the current location of the user (Latitude and longitude). Then it calls up a Google map centered on the identified user location and displays this on the user screen. Secondly, it passes the identified user location to the back office (server component) application which computes, using Haversine formula (explained later), and from its own database of OSaaS and their coordinates, all the OSaaS facilities located within a radius of 3Km or less from the user and display this on user screen, together with summarized details of each facility as captured in the database. Thirdly, the smartphone application pops up a scrollable list of user selectable features required for a OSaaS facility such as seen in table 4.1, and prompt the user to select appropriate features required to be found in the desired facility and assign it a desirability level and a priority value. (For desirability, 3 means a highly desirable requirement, 2 refers to moderate and 1 a low or optional requirement. Unchecked, means, not required).

For the priority, the order of selection gave the ranking. The first attribute to be selected is automatically assigned rank 1 and interpreted as the most critical requirement for the user. The next selected desirable feature is assigned priority number 2, then number 3, up to the highest number to cover all the selected features without skipping a number. Any un-selected feature has both the priority and desirability options disabled. While the first set of attributes are yes or no features as seen in table 4.1, (unselected is equal to no, reducing the number of required user clicks), the cost for hire feature price ranges and the rank assigned after the price range has been selected.

Table 4.1: Some features to be found in OSaaS facilities

Feature	Required	Desirability	Priority
High speed internet	Yes <input checked="" type="checkbox"/>		
Desktop Computer	Yes <input type="checkbox"/>		
WiFi Internet	Yes <input type="checkbox"/>		
Scanner & Printer	Yes <input checked="" type="checkbox"/>		
Teleconferencing	Yes <input checked="" type="checkbox"/>		
Boardroom	Yes <input type="checkbox"/>		
Receptionist	Yes <input checked="" type="checkbox"/>		
Messenger	Yes <input type="checkbox"/>		
Underground parking	Yes <input checked="" type="checkbox"/>		
Lounge	Yes <input type="checkbox"/>		
Hot Shower	Yes <input type="checkbox"/>		
Private work space (Cubicle office)	Yes <input type="checkbox"/>		
Shared work space (open office)	Yes <input checked="" type="checkbox"/>		
Cost- Hourly Rate (USD)	<= 50 <input checked="" type="checkbox"/>		
	51- 100 <input type="checkbox"/>		
	101- 200 <input type="checkbox"/>		
	201-300 <input type="checkbox"/>		
	301- 400 <input type="checkbox"/>		
	401- 500 <input type="checkbox"/>		
	Above 500 <input type="checkbox"/>		

These attributes are stored on a relational database (MySQL) alongside the facility details. This means that the application first query the longitude and latitude details for the OSaaS facilities and then use these to compute the distance from the user by means of the Haversine formula or using Google API. This distance from the user is the first non-compensatory criteria to determine the sub-set of OSaaS attributes used as the secondary compensatory selection criteria. The second non-

compensatory criterion is the occupancy levels. Any facility with occupancy levels above a given threshold is automatically omitted from the rest of the selection process. The determination of the secondary compensatory selection use the Ordered Weighted Averaging (OWA) aggregator as explained in the next section.

The last selection criteria of the OSaaS facility is based on locational factors, also called the heat maps and this is a manual selection based on the different color codes as displayed by the heat maps.

4.2.2.3 The Ordered Weighted Averaging (OWA) aggregation Operator

It can be deduced that the problem of selecting a suitable OSaaS facility as explained in the preceding section is a multi-criteria problem that requires multiple inputs to make the best decision. This is typical of human problems where multiple elements are usually considered in normal decision making (Claus & Martin, 2004; Lamata & Pérez, 2012). The OWA decision rule is one of the methods that can be coded into systems and used to solve this problem. The rule was first proposed by Yager in 1988 and has been further developed and used in GIS and LBS systems as cited by Claus and Martin (2004). The method associates weights to a set of criteria and in this way indicate the relative importance of each criterion (Lamata & Pérez, 2012).

In this context, the attributes of the OSaaS facilities forms the full set of compensatory primary criteria. The first criteria of the proximity of the facility to the user, although it is also user defined, it is a non-compensatory criteria. The second criterion of occupancy levels is also non-compensatory. Any OSaaS facility which has a reported occupancy level of 100% or another set percentage is automatically dropped from the rest of the selection process. These two criteria have no trade-off with the rest of the attributes. In this setup, the desirability levels of the OSaaS attributes have been converted into qualitative values of 3 being translated as a mandatory (highly) required attribute, 2 useful (moderate requirement) and 1 as optional (low requirement). The order of selection of the attributes is automatically interpreted by the application as the allocated priority/ranking of each of the attributes as seen in table 4.2.

According to Yager as cited by Lamata and Pérez (2012) and Merigó and Casanovas (2011), an OWA operator of dimension n is a mapping $OWA: R^n \rightarrow R$ that has an associated weighting vector $W = [w_1, w_2, \dots, w_n]$ of dimension n that fulfils the following two conditions:

$$a) \sum_{j=1}^n w_j = 1$$

(The summation of the weights is equal to 1)

$$b) w_j \in [0, 1]$$

(Weight w_j is an element of the set $[0, 1]$)

Such that:

$$OWA(a_1, a_2, \dots, a_n) = \sum_{j=1}^n w_j b_j$$

where b_j is the j th largest of the a_i .

According to Claus and Martin (2004), OWA allows the user to specify a set of weights representing the relative importance of criteria according to user's preference. This weight of a criterion will determine its impact in compensatory aggregation. By default, these criterion weights are set to $1/n$ to represent n equally important criteria. However, Lamata and Pérez (2012) propose the use of the Borda–Kendall law to obtain these weights and give the formula for this as:

$$w_j = \frac{2(n+1-j)}{n(n+1)}$$

In this formula n is the total number of available criteria and w_j is the importance nominal weight of the j th ranked criterion. Lamata and Pérez (2012) argue that this formula is the commonest method used in decision problems to obtain importance weights, and the same is used in this research. For example for $n=4$, with the above formula, we get $w_1=0.4$, $w_2=0.3$, $w_3=0.2$ and $w_4=0.1$ and it can be seen that this fulfils the first and second conditions of OWA such that $\sum_{j=1}^n w_j = 1$, that is; $(0.4+0.3+0.2+0.1) = 1$, and $w_j \in [0, 1]$.

Claus and Martin (2004) clarifies that OWA can take into consideration order weights (ranking) in addition to the importance (desirability) weights assigned. As seen in the formula above, the selected desirability values b_j are multiplied with the corresponding importance/rank weights w_j . This ensures that it is not only the desirability level (high, moderate or low) that is taken into consideration, but also the priority ranking of a given attribute in comparison to the others. Thus $a_i = w_j b_j$ is the weighted criterion value for alternative i and these can be re-ordered such that $a_n > a_{n-1} > \dots > a_1$. Final evaluation scores are now calculated as the sum of the re-ordered standardized criterion values with an optional additional weighting of the positions (Claus & Martin, 2004). The

ranking in this research is implemented as the priority levels for various options and as seen later, its fundamental to this decision making process. The order of user selecting the available attributes is automatically inferred as the priority weight assigned to each option.

Table 4.2: Example of user selections for a required OSaaS facility

Feature	Required	Desirability Weight (b_j)	Priority Weight	Nominal Weight (w_j)	($b_j * w_j$)
Cable internet	Yes <input checked="" type="checkbox"/>	3	3	0.17	0.50
Desktop Computer	Yes <input type="checkbox"/>				
WiFi	Yes <input type="checkbox"/>				
Scanner & Printer	Yes <input checked="" type="checkbox"/>	1	5	0.11	0.11
Video conferencing	Yes <input checked="" type="checkbox"/>	2	4	0.14	0.28
Receptionist	Yes <input checked="" type="checkbox"/>	1	6	0.08	0.08
Boardroom	Yes <input type="checkbox"/>				
Messenger	Yes <input type="checkbox"/>				
Underground Parking	Yes <input checked="" type="checkbox"/>	2	7	0.06	0.11
Lounge	Yes <input type="checkbox"/>				
Hot Shower	Yes <input checked="" type="checkbox"/>	1	8	0.03	0.03
Private work space (Cubicle office)	Yes <input type="checkbox"/>				
Shared work space (open office)	Yes <input checked="" type="checkbox"/>	3	1	0.22	0.67
Cost- Hourly Rate (USD)	<= 50 <input checked="" type="checkbox"/>	3	2	0.19	0.58
	51- 100 <input type="checkbox"/>				
	101- 200 <input type="checkbox"/>				
	201- 300 <input type="checkbox"/>				
	301- 400 <input type="checkbox"/>				
	401- 500 <input type="checkbox"/>				
	Above 500 <input type="checkbox"/>				
Count of Selected options			8	Sum (OWA)	2.36

Table 4.2 shows an example of user selected options for a desired OSaaS facility in a given locality. Note that the occupancy level is not part of the user selectable attributes. It is just used to filter out fully booked facilities. From table 4.2, it can be seen that the most critical attribute which is desired by this user in the OSaaS facility is an open workspace hence given priority 1. The second in rank of the important attributes for the desired facility is the cost which needs to be a package of not

more than USD 50 per hour. Note that these two attributes are not negotiable according to the user. Their desirability level has been set as mandatory (high) by the user; that is value 3. The high speed internet is also mandatory, but its rank in terms of importance is number 3. All the other items have been either ranked as moderate or low. We then use the Borda-Kendall formula as given above to obtain the nominal weights from these rankings and the results are as seen on table 4.2.

For example for $j=1$ and $n=8$ from the formula;

$$w_j = \frac{2(n + 1 - j)}{n(n + 1)}$$

The result is:

$$w_j = \frac{2(8+1-1)}{8(8+1)}=16/72=0.22; \text{ and for } j=2, w_j = \frac{2(8+1-2)}{8(8+1)}= 14/72= 0.19.$$

It's worth noting that the total count of the weighted options is derived from the number of the selected attributes (8) and not the total attributes for the facility. That affects the computed weighted values and it's also a closer reflection to the user preferences as opposed to a scenario where the weights would be based on all the facility attributes irrespective of the selected subset. The total OWA for this user selection computes to 2.36.

The selection for nearby identified OSaaS facilities is now based on the selected user criteria. Only the options selected by the user are considered for computing the OWA of the facility. Even then, the research proposes an inclusion of a provision for the full listing of the facility features as captured in the attributes database as part of user available options. The user selected choices as per table 4.2 are then matched against the data collected for the available OSaaS facilities offering different amenities as seen in tables 3.1 and 3.2 in chapter 3. Table 4.3 shows how the computation for the facility attributes OWA has been computed for OSaaS facilities 1 and 2. Table 4.4 gives a summary of all the OWA values for the remaining 7 listed OSaaS facilities. In these computations, the user preferences are mapped against the facility attributes and the differences between the offered and required attributes is highlighted.

Table 4.3: OWA computation for attributes of OSaaS facilities 1 and 2

	Virtual Office V01	Virtual Office V02
--	--------------------	--------------------

Attributes									
Feature	Required	(b _j)	Priority Weight	(w _j)	(b _j *w _j)	(b _j)	Priority Weight	(w _j)	(b _j *w _j)
Cable Internet	Yes <input checked="" type="checkbox"/>	3	3	0.17	0.50	3	3	0.17	0.50
Computer	Yes <input type="checkbox"/>								
WiFi	Yes <input type="checkbox"/>								
Scanner & Printer	Yes <input checked="" type="checkbox"/>	1	5	0.11	0.11	1	5	0.11	0.11
Video conf.	Yes <input checked="" type="checkbox"/>	2	4	0.14	0.28	2	4	0.14	0.28
Receptionist	Yes <input checked="" type="checkbox"/>	0	6	0.08	0	1	6	0.08	0.08
B. Room	Yes <input type="checkbox"/>								
Messenger	Yes <input type="checkbox"/>								
U. Parking	Yes <input checked="" type="checkbox"/>	2	7	0.06	0.11	2	7	0.06	0.11
Hot Shower	Yes <input checked="" type="checkbox"/>	0	8	0.03	0	0	8	0.028	0
Lounge	Yes <input type="checkbox"/>								
Cubicle Off.	Yes <input type="checkbox"/>								
Open office	Yes <input checked="" type="checkbox"/>	3	1	0.22	0.67	3	1	0.22	0.67
Rate (USD)	<= 50 <input checked="" type="checkbox"/>	3	2	0.19	0.58	0	2	0.19	0.00
Count of Selected options		8		OWA	2.25		8	OWA	1.75

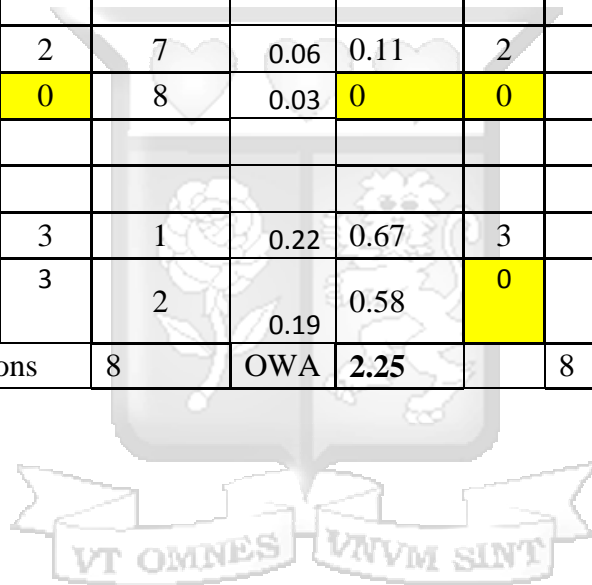


Table 4.4: OWA computation for attributes of OSaaS facilities 3 to 9

Attributes		Virtual Offices						
		V03	V04	V05	V06	V07	V08	V09
Feature	Required	(bj*wj)	(bj*wj)	(bj*wj)	(bj*wj)	(bj*wj)	(bj*wj)	(bj*wj)
High speed internet	Yes <input checked="" type="checkbox"/>	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Video Conferencing	Yes <input checked="" type="checkbox"/>	0.28	0.28	0.28	0.28	0.28	0.28	0.00
WiFi Internet	Yes <input type="checkbox"/>							
Scanner & Printer	Yes <input checked="" type="checkbox"/>	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Computer	Yes <input type="checkbox"/>							
Receptionist	Yes <input checked="" type="checkbox"/>	0.00	0.00	0.00	0.00	0.08	0.08	0.08
Board Room	Yes <input type="checkbox"/>							
Messenger	Yes <input type="checkbox"/>							
Underground Parking	Yes <input checked="" type="checkbox"/>	0.11	0.11	0.11	0.11	0.11	0.00	0.00
Hot Shower	Yes <input checked="" type="checkbox"/>	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Lounge	Yes <input type="checkbox"/>							
Private work space (Cubicle office)	Yes <input type="checkbox"/>							
Shared work space (open office)	Yes <input checked="" type="checkbox"/>	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Cost- Hourly Rate (USD)	<= 50 <input checked="" type="checkbox"/>	0.58	0.58	0.00	0.00	0.58	0.00	0.58
OWA		2.25	2.25	1.67	1.69	2.33	1.64	1.94

It can be seen from tables 4.3 and 4.4 that, if a given OSaaS facility has the requested attribute, then it is assigned the same weight as assigned by user in the selection process, otherwise assigned 0. From these two tables, it can be seen that any of the facilities that have a missing mandatory (High) requirement has significant low rating as seen in OSaaS facilities V02, V05, V06, V08 and V09. OSaaS facility V07 has an OWA score closest to the user OWA even though it does not have one of the optional facilities, a hot shower, as requested by the user. Therefore, from these OWA calculations, OSaaS facility V07 will be ranked first in the results returned to the user. But the

distance to the said facility and additional heat maps can lead the user from not selecting the first ranked facility and maybe select number two, three or any of the available OSaaS facilities.

After the system uses the Ordered Weighted Average as described above to determine how each of the nearby OSaaS facilities fits into the user supplied criteria, the results are displayed on the map as a percentage of facility OWA against the user requirements OWA. 100% indicates that the said facility matches all the requirements as entered by the user. A lesser percentage indicates a mismatch between the requested and available attributes. The security and infrastructure heat maps will help the user to make a final selection of the now ranked facilities based on his/her security concerns and the distance to the facility. When a facility is selected by clicking on it, the application will automatically use Google maps to get road directions to the facility from the current user location.

Lastly, the complete system proposed to have a provision for a customer who desired a certain OSaaS facility in a given neighborhood as displayed on the first map of available OSaaS facilities to submit a proposal to hire such a facility at a given fee to the provider of the facility. The proposal would have the requested attributes and the desired hire price. The provider would then review the proposal and respond either with an acceptance of the request or a counter offer to the customer. This would hopefully improve the OSaaS occupancy levels through a negotiation process.

4.2.2.4 Heat map Layer for locational factors

According to Google Developers (2016), a heat map is a visualization used to depict the intensity of data at geographical points. When the Heat map Layer is enabled on a given map rendering application, a coloured overlay appears on top of the map. On these heat maps, areas of higher intensity are usually coloured red, and areas of lower intensity appear green by default. These heat maps are the best bet for representing locational factors on top of the ranked OSaaS locations map. The proposed method of rendering the heat map data is by the use of Google Maps JavaScript Application Programming Interface (API). While this can create heat maps using either the client side data or the server-side data using a fusion table, the preferred approach for this system is the fusion table. This is not only due to the fact that fusion tables can handle much bigger datasets, but also weighted values of the location can easily be integrated into the data. The actual implementation of heat maps involves the loading and integration of the `google.maps.visualization` library into the XML/HTML5 code. The visualization classes are

a self-contained Java library, separate from the main Google Maps API JavaScript code. To use the functionality contained within this library, it needs to be first loaded using the `libraries` parameter in the Maps API bootstrap URL as seen in the code segment below.

```
<script type="text/javascript"
  src="https://maps.googleapis.com/maps/api/js?key=YOUR_API_KEY&libraries=visualization">
</script>
```

To load and use these libraries, an `API_KEY`, a unique alphanumeric number assigned by Google is required as a form of licensing to use the libraries.

To add a Heat map Layer, a new `HeatmapLayer` object is first created, and provided with some geographic data in the form of an array object. The data may be either a coordinates object (Latitude, Longitude) or a Weighted Location object. After the `HeatmapLayer` object has been instantiated, it is added to the map by calling the `setMap()` method. As earlier suggested, the conceived system for OSaaS facilities uses weighted location objects. In this case, weight is a linear scale whereby the normal coordinate object without any additional parameter is assigned an implied weight of 1. Explicitly specifying additional weight for any coordinate pair object will cause the referenced location to be rendered with a higher intensity than one with a lower weight. For example, the intensity of the rendering of the location referenced as `{location: new google.maps.LatLng(37.782, -1.22441), weight: 3}` will be three times more intense than one referenced simply as `{location: new google.maps.LatLng(37.782, -1.22441)}` (Google Developers, 2016).

In the design of the conceptual application, the first locational factor to be considered is security. The weight in this case as seen in table 3.3 is the number of security incidences reported within a given area/street. As explained above, the higher the number, the higher the intensity of the heat map rendering for the given area. Hence the OSaaS facility located in such a neighbourhood or street would most likely be less attractive, especially for a visiting customer because of security concerns.

Any other locational factor data, such as demographics or Infrastructure can easily be rendered as a heat map layer on top of the ranked OSaaS. The coordinates indicate the affected area and the weight/intensity of the rendering of the heat map would just be the total population of such a neighborhood or the total number of road/railway networks connecting such a location. The application would then give the user an opportunity to choose which heat map data to superimpose on his/her ranked OSaaS facilities.

4.2.2.5 The Haversine Formula

To calculate distance between the identified user location and the OSaaS locations so that the application gets a subset of the ones near the user, the Haversine formula is used. According to Westra (2010), this formula assumes that the earth is a sphere and the calculated distance is the shortest distance over the earth's surface – giving an ‘as-the-crow-flies’ distance between the points. To use the formula the latitude and longitude values are first converted to radians. Then the latitude and longitude differences between the two points are calculated and these are passed through a trigonometric function to get the great sphere distance as seen in formula below. The mean radius of the earth sphere (R) is a constant given as 6371 kilometres. The formula then is as below.

$$\Delta\text{lat} = \text{latA} - \text{latB}$$

(Difference in latitude between points A and B in radians)

$$\Delta\text{long} = \text{longA} - \text{longB}$$

(Difference in Longitude between points A and B in radians)

$$a = \sin^2(\Delta\text{lat}/2) + \cos(\text{lat1}) * \cos(\text{lat2}) * \sin^2(\Delta\text{long}/2)$$

$$c = 2 * \text{atan2}(\sqrt{a}, \sqrt{1-a})$$

$$d = R * c$$

d is now the distance in kilometers between the two points represented by the two coordinate sets.

4.2.2.6 The Use Case analysis

A use case describes the behavior of a system under various conditions as the system responds to requests from the principal actors (Hoffer et al., 2014). According to Roth et al. (2013), each use case describes how an external user triggers an event to which the system must respond. More precisely the use case represents an identified complete system function. The use case model diagrammatically represents the system showing all the use cases and the actors (triggers) of the

use cases. Hoffer et al. (2014) defines an actor in this case as an external entity that interacts with the system. It can be a person or another system. It's worth noting here that the actor specifically represents a role that can be played by a user when he or she interacts with the system. In the use case model, the actor's name indicates the role played in the system. Hoffer et al. (2014) notes that use cases focus on system functionality and business processes but provide minimal information about the data flow through the system and that is why they are combined with the data flow diagrams (DFDs) to give the analysts a more complete picture of the whole system. Figure 4.3 shows the use case diagram for the OSaaS locating and choosing application.

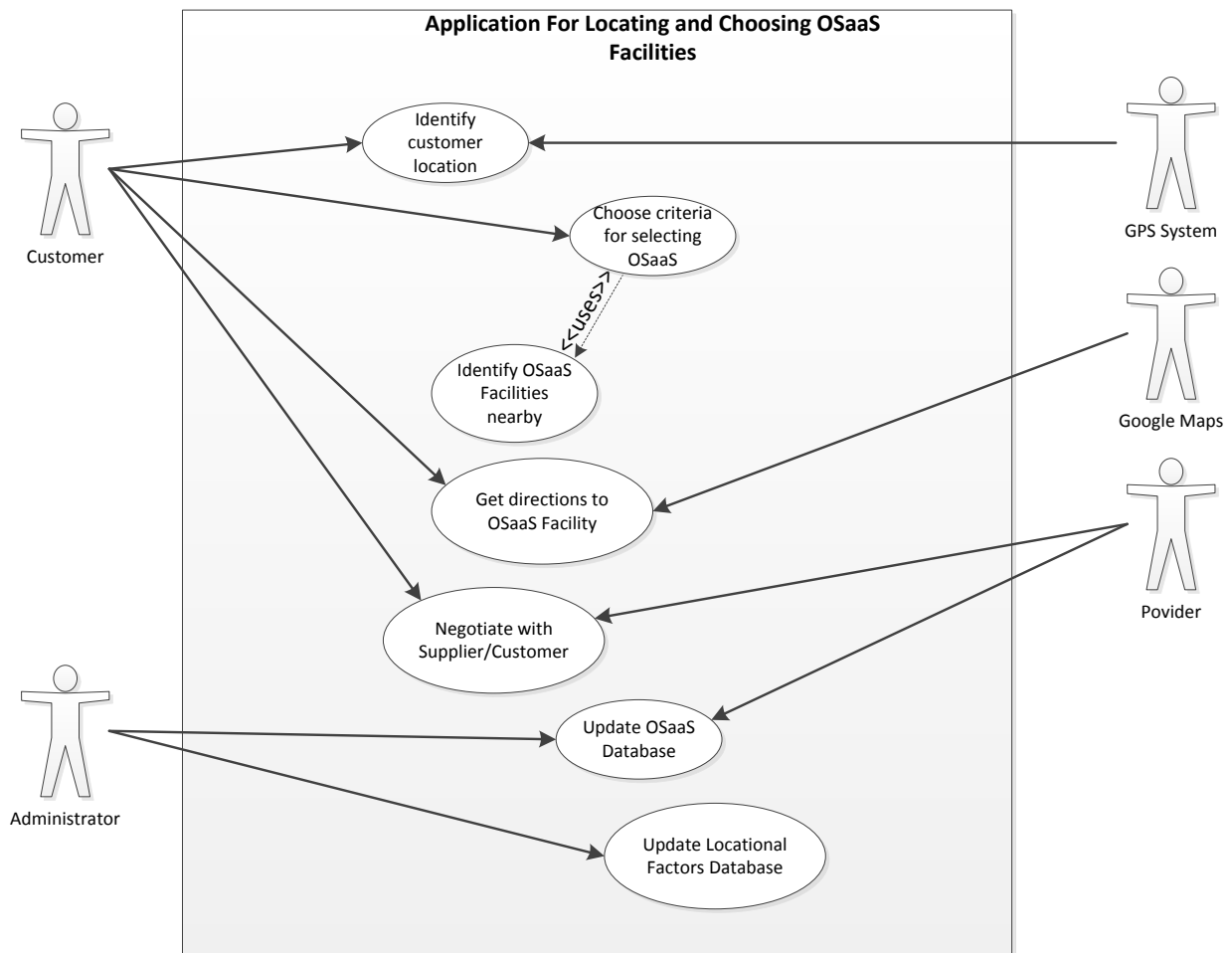


Figure 4.3: Use case diagram for the system of locating and choosing OSaaS facilities

The following section gives the details of each use case.

Table 4.5: Identify customer location use case

Use Case Name: Identify Customer Location		ID Number : 1	
Short Description: This describes how a customer uses the system to identify their current location in order to look for OSaaS facilities nearby.			
Trigger: Customer launches the OSaaS Office App on their mobile phone			
Type: External			
Major Inputs		Major Outputs	
Description	Source	Description	Destination
a. Start-up of the OSaaS Office App on phone	Customer	Latitude and Longitude coordinates of customer	System
b. Phone use GPS or network to determine location	Customer		
Major Steps Performed			Information for steps
1. Customer downloads and installs OSaaS Office App into their smartphones.			← Website/Online store for App download
2. Customer activates GPS receiver on their phone			
3. Customer launches OSaaS office app on their phone			
4. OSaaS office App uses available techniques to identify customer location.			← Available positioning technologies
5. Customer location relayed to the system to locate OSaaS facilities nearby			→ Customer coordinates

Table 4.6: Choose criteria for selecting OSaaS facility use case

Use Case Name: Choose Criteria for selecting OSaaS facility		ID Number : 2	
Short Description: This describes how a customer will set desirable criteria to choose a OSaaS facility.			
Trigger: Mobile App returns Customer location to the System			
Type: External			
Major Inputs		Major Outputs	
Description	Source	Description	Destination
a. Customer Location coordinates (latitude and longitude).	Customer (phone)	a. List of nearby OSaaS facilities	System
b. Required distance to nearby OSaaS facilities	Customer	b. Selected list of attributes for OSaaS facilities	System
c. Full set of attributes for OSaaS facilities nearby	System		
Major Steps Performed			Information for steps
1. Determined customer location is passed on to the system by mobile phone.			→ Customer Latitude and longitude details
2. System asks Customer to input desired distance to OSaaS facilities- usually 3 KM			→ Variable distance entry parameter.

3. System returns a list of attributes of nearby OSaaS and asks user to make a selection.	← Attributes of OSaaS facilities nearby
4. Customer inputs selection and submits to the backend system	→ Selected attributes
5. System uses the identify OSaaS use case to do final selection of fitting facilities	← Fitting OSaaS facilities nearby.

Table 4.7: Identify OSaaS Facilities that Fit Criteria Use Case

Use Case Name: Identify OSaaS facilities fitting criteria		ID Number : 3	
Short Description: This describes how the system will use customer position to identify OSaaS facilities nearby that fit a given criteria.			
Trigger: Mobile App returns Customer location to the System			
Type: External			
Major Inputs		Major Outputs	
Description	Source	Description	Destination
a. Customer Location coordinates (latitude and longitude).	Customer (phone)	a. List of nearby OSaaS facilities that fit criteria	Customer
b. Selected subset of attributes for desired OSaaS facility	Customer		
Major Steps Performed			Information for steps
1. Selected attributes and their weights are passed to system.			→ OWA of selected attributes
2. System checks all OSaaS facilities that fit criteria, ranks them and returns to user phone.			← Ranked OSaaS nearby.
3. System reads locational factors database and presents this as heat maps behind the ranked OSaaS facilities			← Security data from own database or third parties

Table 4.8: Get Directions to OSaaS facility use case

Use Case Name: Get directions to nearby selected OSaaS facility		ID Number : 4	
Short Description: This describes how the system will use customer position to get directions to nearby selected OSaaS facility.			
Trigger: Customer selects one of the ranked OSaaS facilities			
Type: External			
Major Inputs		Major Outputs	
Description	Source	Description	Destination
a. Customer selection on one of the ranked OSaaS facilities.	Customer	a. Driving directions to selected OSaaS facility	Google Maps/Customer
Major Steps Performed			Information for steps
1. Customer makes a selection of OSaaS facility based on ranking and heat maps and double-clicks on it.			→ Click action
2. Coordinates of selected OSaaS are read from system database and sent to Google maps.			→ Selected OSaaS coordinates
3. System acquires from Google maps driving instructions to the selected OSaaS facility and avails the same to the user phone.			← Driving directions on a map

Table 4.9: Customer negotiate with provider use case

Use Case Name: Negotiations between customer and provider		ID Number :5	
Short Description: This describes how the system will provide an avenue for two way interaction between OSaaS provider and customer.			
Trigger: Customer searches and selects OSaaS facility nearby			
Type: External			
Major Inputs		Major Outputs	
Description	Source	Description	Destination
a. Customer selection of nearby OSaaS.	Customer (phone)	a. Selected OSaaS facility	Provider
b. Customer hire proposal of OSaaS	customer	b. Hire proposal	Provider
c. Provider offer for hire of selected OSaaS.	Provider	c. Hire offer	Customer
Major Steps Performed			Information for steps
1. From required criteria and heat map, customer selects one of the OSaaS facilities nearby.			→ Selected OSaaS facility
2. Customer desires different pricing for facility and submits proposal for such to the system.			→ Hire terms from customer
3. Provider of facility responds agreeing to proposal or with a counter offer			← Hire terms from provider.

Table 4.10: Update OSaaS facilities details use case

Use Case Name: Update OSaaS facilities database		ID Number :6	
Short Description: This describes how the Administrator will update the OSaaS database.			
Trigger: Administrator gets information about new OSaaS facility in the town.			
Type: External			
Major Inputs		Major Outputs	
Description	Source	Description	Destination
a. Details of new OSaaS facility	External	a. Updated list of OSaaS	System
b. Attributes of new OSaaS facility	External	b. Updated list of OSaaS attributes	System
Major Steps Performed			Information for steps
1. Administrator or provider logs into the backend system.			→ OSaaS details and attributes
2. Administrator or provider uses web forms to connect to the OSaaS database and updates the facility details and/or the attributes of the same. While administrator can update all facilities details, the provider can only see or update own OSaaS details			
3. System gives confirmation message of changes effected			← Confirmation message

Table 4.11: Update locational factors database use case

Use Case Name: Update Locational Factors database	ID Number : 7
--	----------------------

Short Description: This describes how the administrator will update the Locational factors database.			
Trigger: Administrator gets new locational factors details			
Type: External			
Major Inputs		Major Outputs	
Description	Source	Description	Destination
a. New locational factors	External/third parties	c. Updated locational factors	Locational factors database
Major Steps Performed			<u>Information for steps</u>
1. Administrator gets details of updated locational factors from security agents or other state departments.			→ New locational factors
2. Administrator connects to the locational factors database through the web interface and updates.			
3. System gives confirmation message of changes effected			← Confirmation message

4.3 System Design

In this stage, various techniques are used to represent the system requirements gathered in the previous stages in a format easily understood by both the system analysts and the users. The techniques used in this research include data flow modelling and the Entity-Relationship models.

4.3.1 Data flow modelling

Data flow diagrams enable the modelling of how data flows through an information system, the relationship among the data flows, how data come to be stored at specific locations and the processes that transform or change this data (Hoffer et al., 2014). Since data flow diagrams represent movement of data between the various processes of the system, these diagrams are called process models. One of the popular process model used by many analysts is the data flow diagram (DFD). It graphically represents the processes that capture, manipulate, store, and distribute data between a system and its environment and between components within a system in varying levels of granularity (Hoffer et al., 2014). The highest-level view of the system is depicted by a DFD called the context diagram which shows the entire system as a single process and the data sources/sinks that interact with the system from the environment. The second level, called Level-0 diagram shows the whole system now broken down into the primary individual processes, the data sinks/sources, and data stores that facilitate processing of data between such. If a primary process has a number of other sub-process, it can further be broken into level-1 diagram which

will show the interaction of the sub-processes and the data sources/sinks and stores. These sub-processes can further be decomposed into level-2 diagram depending on the secondary sub-processes that make up any of the primary sub-process (Hoffer et al., 2014). Figure 4.4 shows the Context diagram of our OSaaS locating and choosing application, while figure 3.5 shows the Level-0 diagram of the same.

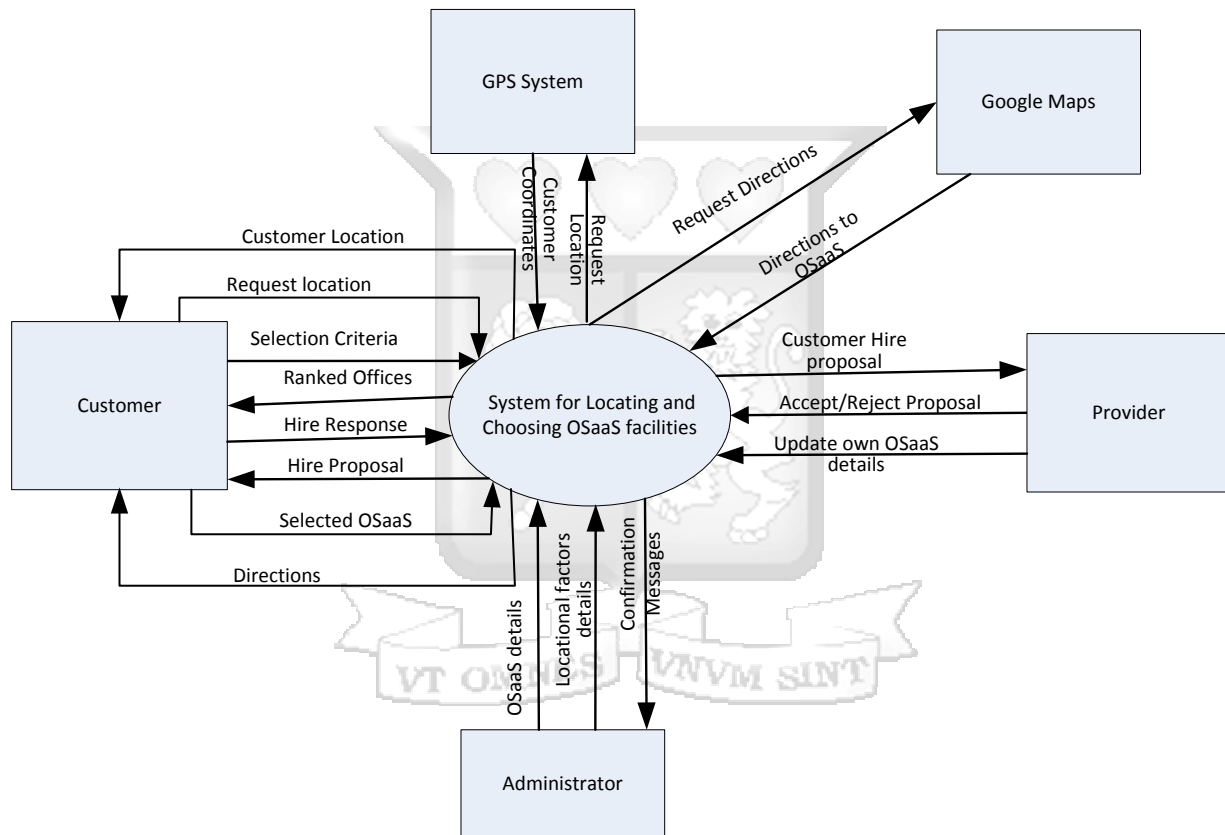


Figure 4.4: Context diagram of the System for locating and choosing OSaaS facilities

As seen in figure 4.4 the main actor in this system is really the customer since it's a customer facing application. But we also have other actors onto the application such as the administrator who actually creates and updates the OSaaS facilities details database and the provider who could be allowed to access and update own OSaaS facility details. We also have the GPS system from which the customer location is obtained and Google maps that give directions to the selected OSaaS facility.

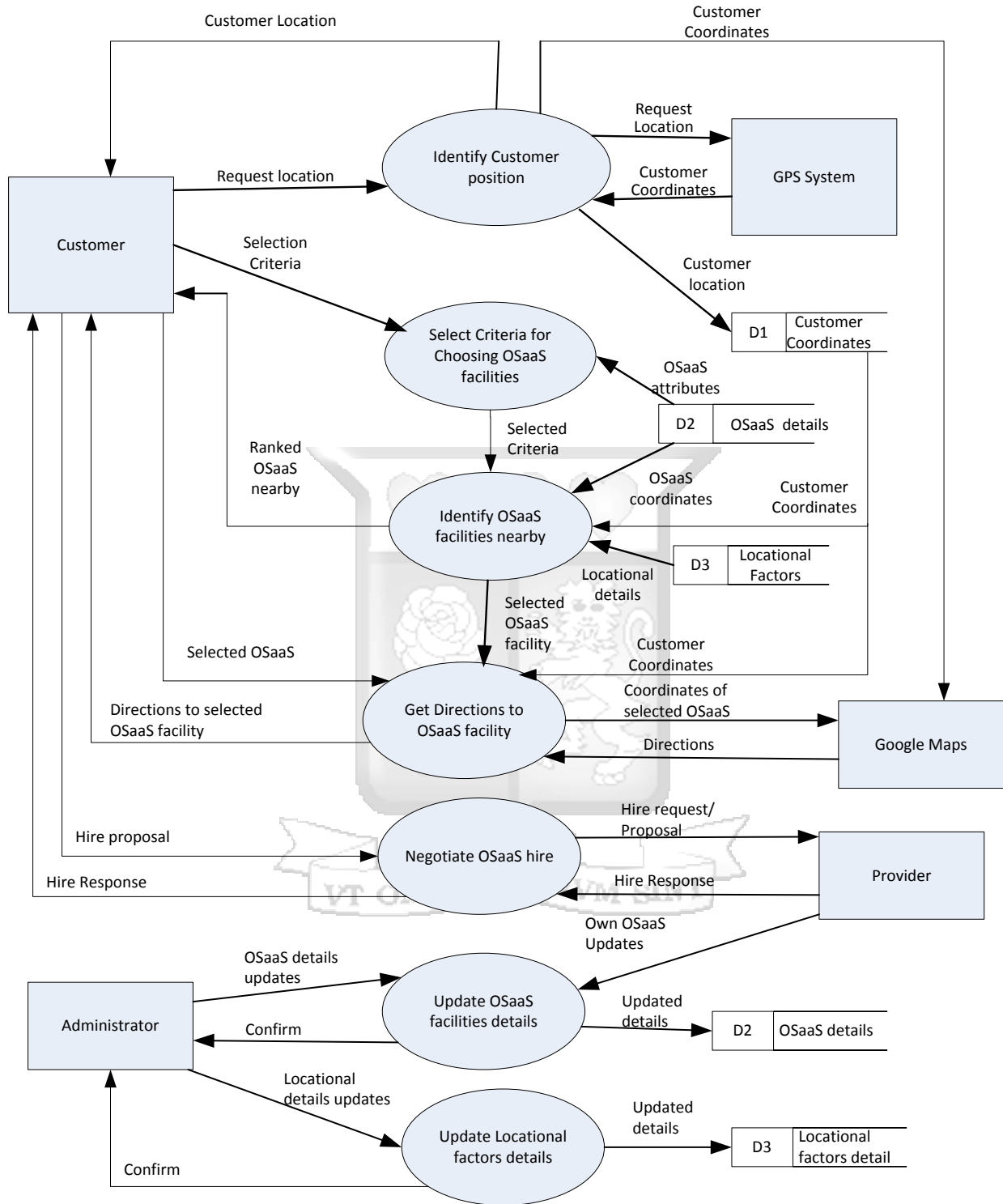


Figure 4.5: Level- 0 DFD of the system for locating and choosing OSaaS facilities

This Level-0 DFD has fully decomposed the system into the primary processes and therefore level-1 or level-2 data flow diagrams are not necessary for any of the processes. The main data stores (databases) as seen in figure 4.5 are the OSaaS facilities details and the locational factors details. The customer coordinates store (D1) is a temporal store that is created and destroyed during the application processing time.

4.3.2 The Entity-Relationship (E-R) data model

Data modelling develops the definition, structure and relationship within the different data being used or given out by a system (Hoffer et al., 2014). Hoffer et al. (2014) suggest that data is not only the most complex aspect of many modern information systems, but also the pillar in many of such systems hence the need to fully take into consideration the data aspect during the system design. He further points out that the characteristics of data captured and agreed upon during the system analysis phase, inadvertently determine not only the design but even the actual system functionality. A data model documents the file and database requirements and the business meaning (rules) of data to be included in an information system. The entity-relationship (E-R) diagramming is the commonest format used for data modelling and the same is used in the design of the conceptual application. In the design of the OSaaS facilities locating and choosing application, the most crucial database is the OSaaS facilities details database. As seen in figure 4.6, it carries not just the attributes of the offices, but also their locational details. For the E-R model represented by figure 4.6, the full listing of OSaaS facilities attributes is as given in tables 3.1 and 3.2. In this model, the Security data table captures the localized security incidents for a given city or neighbourhood.

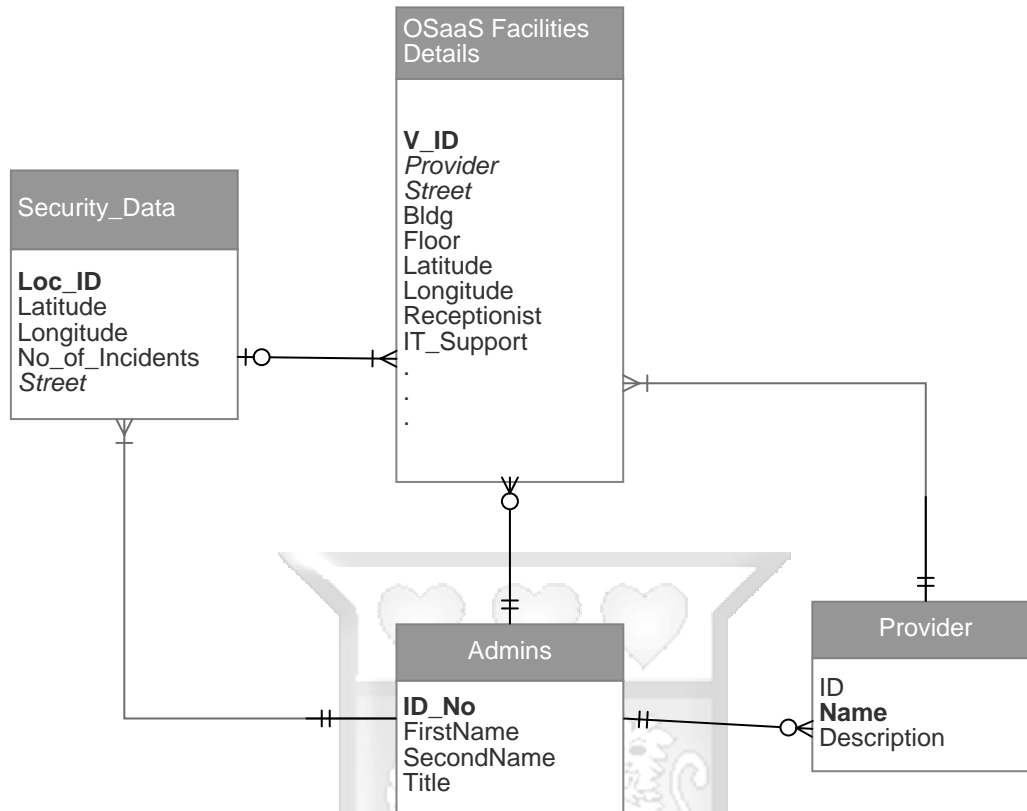


Figure 4.6: E-R diagram of databases involved in locating and Choosing OSaaS facilities

The main identifier for this data is the street that can have one or many OSaaS facilities. The street that hosts the building with a given OSaaS facility can be referenced in the security table or not. If it is not referenced, it either means that the security data for the street is missing or it had zero security incidents recorded in the period under review. These two tables use the Street value as the join between the two. On the Administrator and the rest of the databases relationship, one administrator manages and updates OSaaS facility details for several providers and also security data for several streets. It can also be seen that the administrator creates and maintains details of all providers who might be given permission to modify their own OSaaS facility details. The provider on the other hand can only manage his/her own OSaaS details which can be one or many of such. A given OSaaS facility belongs to only one provider. The name of the provider is the primary key in the providers table and it appears as a foreign key in the OSaaS facilities details table under a column name “provider”. Although the customer location appears as data store in the DFD, it is a temporal store actually stored in a variable and do not warrant a table in the database.

Chapter 5: System Testing and Implementation

5.1 Introduction

This is the fourth stage of a system development life-cycle. The phase includes actual coding, testing and installation of the application. For the actual coding, the OSaaS application design employed the three tier application design as seen in figure 5.1. Here the mobile phone interface was primarily designed using eXtensible Markup Language (XML) for the presentation and appearance of the user interface. The intelligence for querying the GPS system and directions from Google maps and other logical operations was coded using Java. The programming platform was Android Studio Integrated Development Interface (IDE). The webserver used was Apache and the back-end database system used was MySQL. Functional testing was done for each of the designed modules and for the complete application prototype. Installation of the application was done on a few end-user Android mobile devices.

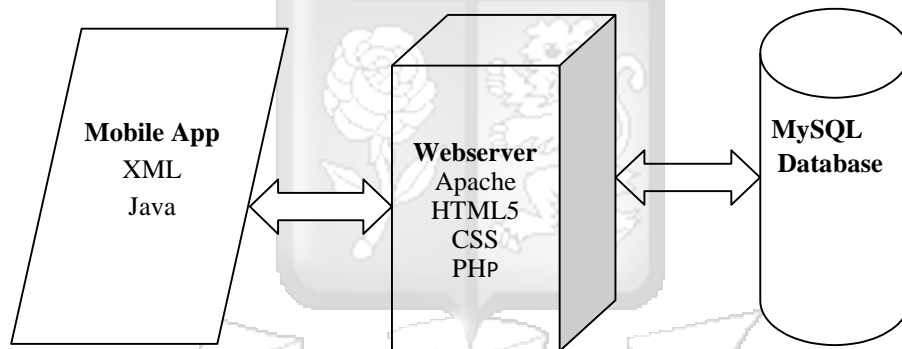


Figure 5.1: OSaaS Application Implementation Architecture

5.2 The Mobile Application Module

This is what the customer would download from the webserver or any other participating mobile app store. It is the main interface with the customer. The coding of the display area and the logic thereof was done using XML which has native support for LBS applications. The styling of the appearance of the user interface was done using the layout files as offered in Android Studio. The intelligence for loading and interacting with Google API and maps was implemented using JavaScript. When downloaded and installed onto a user device, the app remain resident in the user mobile device, until when activated by the user. Figures 5.2 to 5.3 show screenshots of the various stages of using the mobile App after it has been installed onto a smartphone.

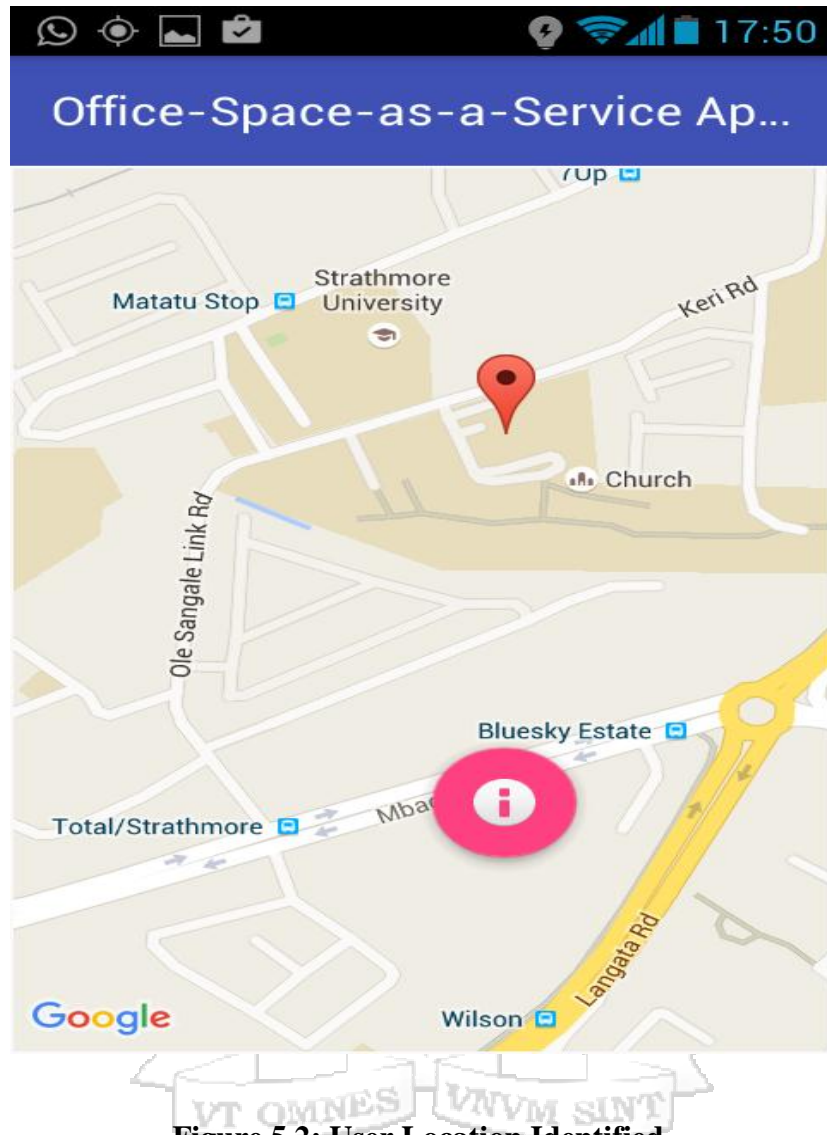


Figure 5.2: User Location Identified

When the application starts, it automatically identifies the user location using available technologies as seen in figure 5.2.

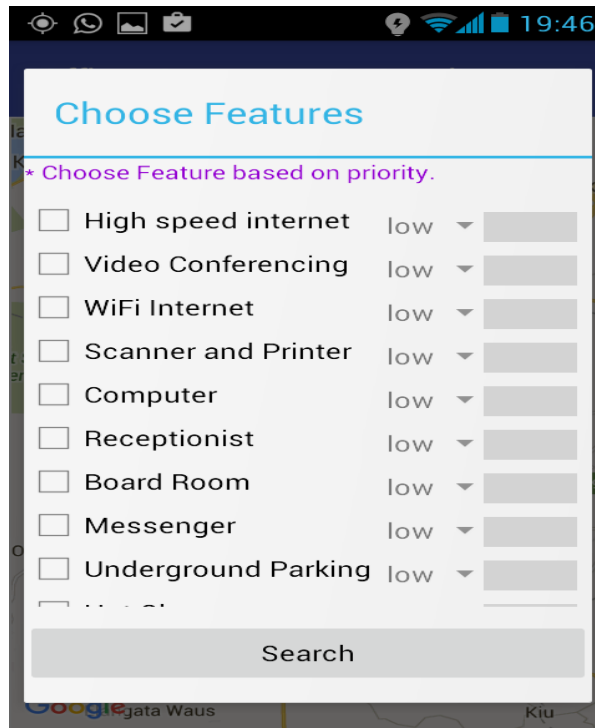


Figure 5.3: List of Selectable OSaaS Attributes

As in seen in figure 5.3, after identifying the customer location, the application presents a list of aggregated OSaaS attributes for nearby facilities for the user to select from the list.

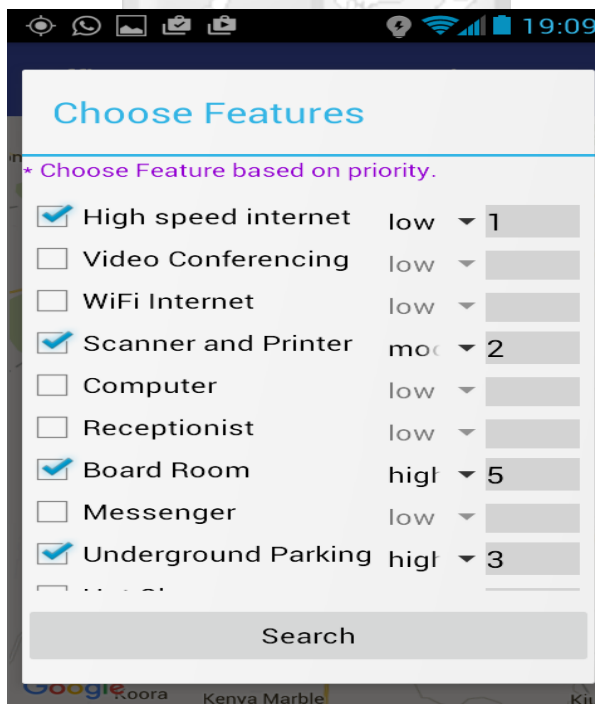


Figure 5.4: Selected Attributes

As the attributes are selected, the user assigns it an importance value of High, Moderate or Low as seen in figure 5.4. The ranking (priority) weight is automatically computed by the system on the basis of the order of selection and the total value of the selected attributes n also determined.

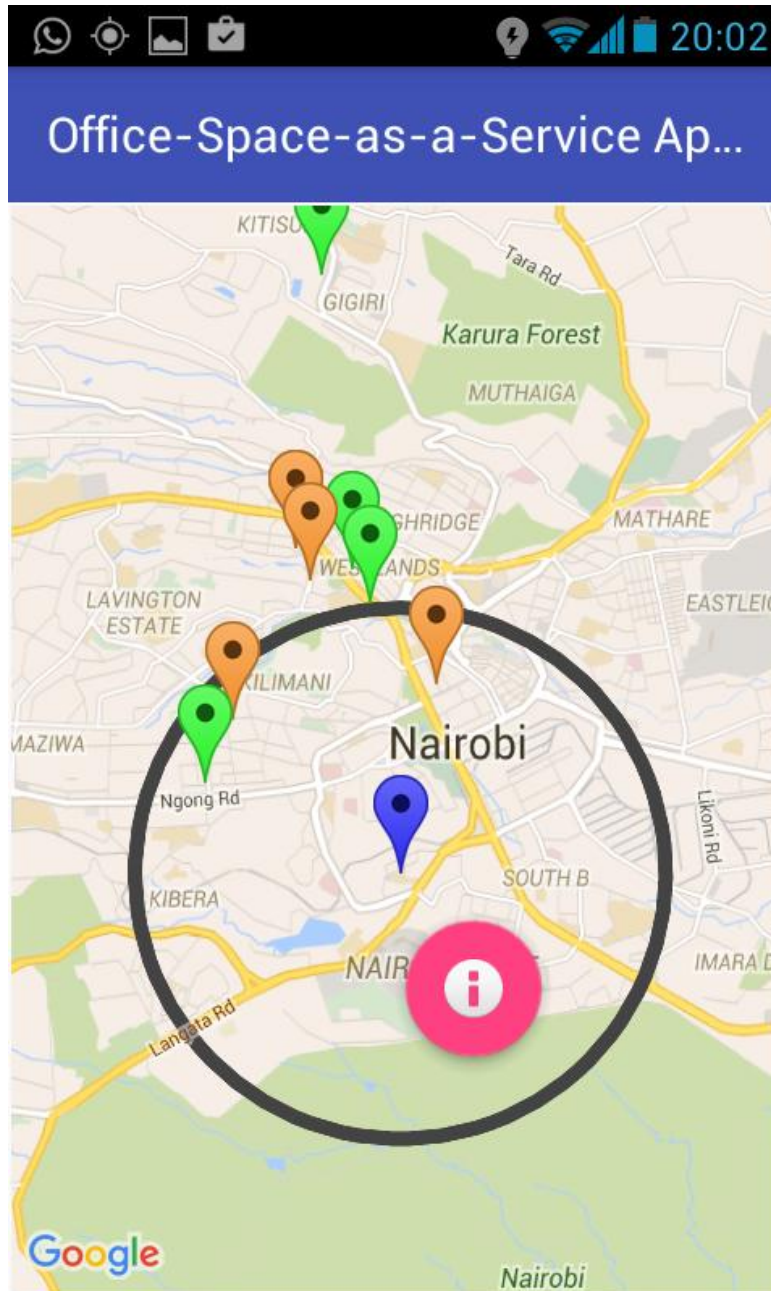


Figure 5.5: Customer Location and Ranked OSaaS Facilities

Figure 5.5 now shows the customer location and OSaaS facilities nearby which have been ranked as per the user submitted attributes. These are colour coded. Anything above 80% in terms of the facility OWA vis-à-vis the customer OWA is shown in green. Anything from 50% to 79% is

indicated in orange and less than 50% is shown in red. The customer can then pick on any of the green ones. The black ring indicates a pre-set distance of 3 KMs from the customer location.

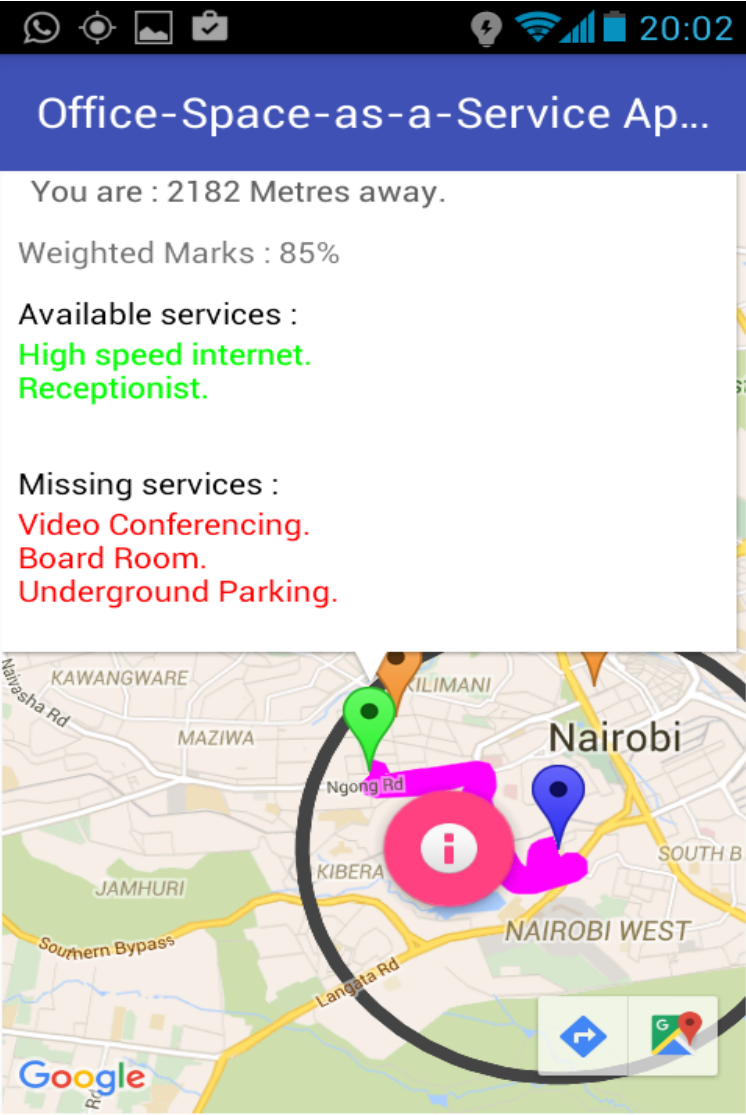


Figure 5.6: Selected OSaaS Facility Details

When the customer clicks on any of the OSaaS facility markers, as seen in figure 5.6 more details about the same are displayed including the distance from the current user location and a summary of the available and missing features. Notice because of the importance ranking and OWA computation, only two of the most important features can make up 85% of the compensatory requirement. As earlier explained, the driving road directions are also traced on the map when one of the facilities is selected as seen in figure 5.6.

5.3 The Webservice

The main functionality of the webservice interface is to offer the administrator an interface to manage the database(s) used by the application. The computation of the distances, directions and the Ordered Weighted Averages of the attributes are also done by the webservice. It is also the repository of the webpages that are displayed on the mobile App. The main engine running here is the Apache webservice application. The web forms used to manage the databases have been coded using HTML5 and PHP: Hypertext Preprocessor (PHP). Figures 5.7 to 5.10 show the various screenshots of testing and using the webservice for the OSaaS Application.

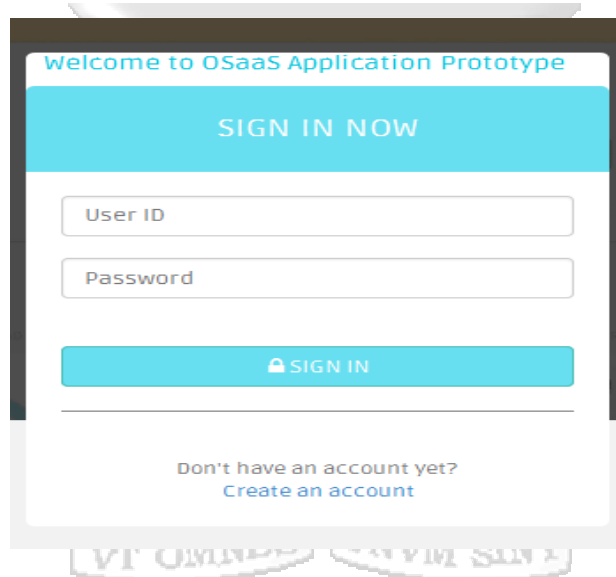


Figure 5.7: Logging Into OSaaS Application

Figure 5.7 is the screen for the administrators and/or providers to log into the management interface of the OSaaS application. A username and password as assigned by the super user is required. When the administrator logs in, he or she can view, modify or delete details regarding all OSaaS facilities. When a provider logs in, he/she can only view, modify or delete details appertaining to own OSaaS facility.

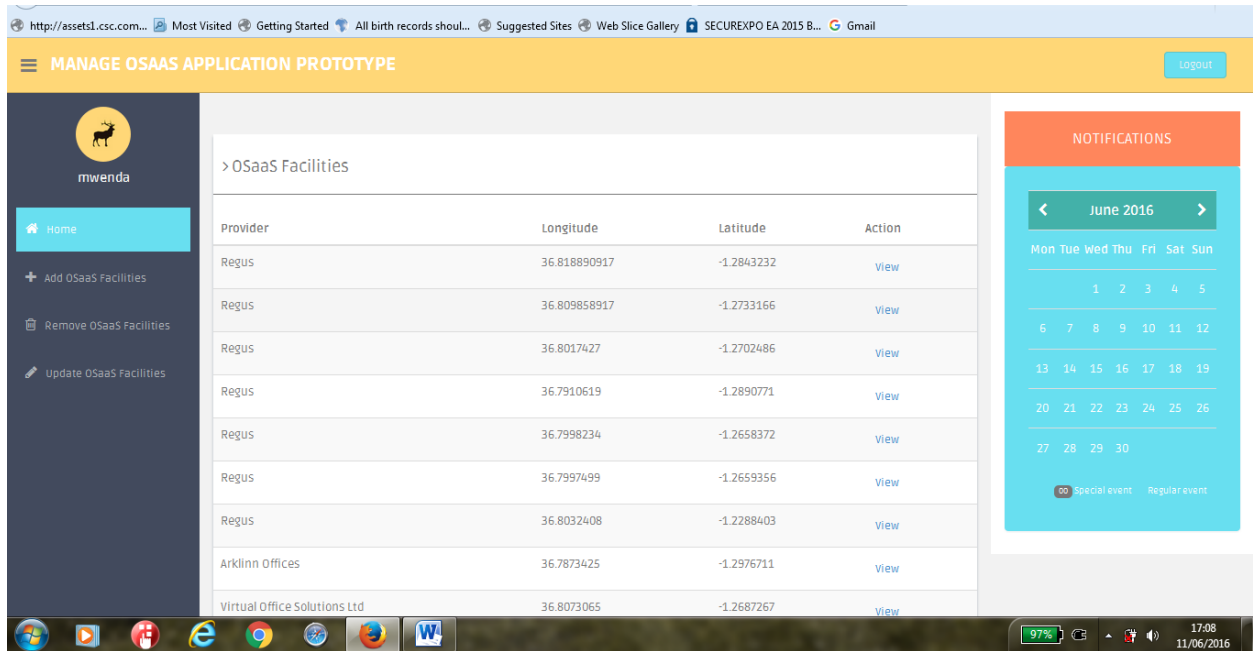


Figure 5.8: Main OSaaS Application Dashboard

When the administrator logs in, he sees the dashboard in figure 5.8. From here, he can view, modify, add or delete OSaaS facilities and/or their attributes.

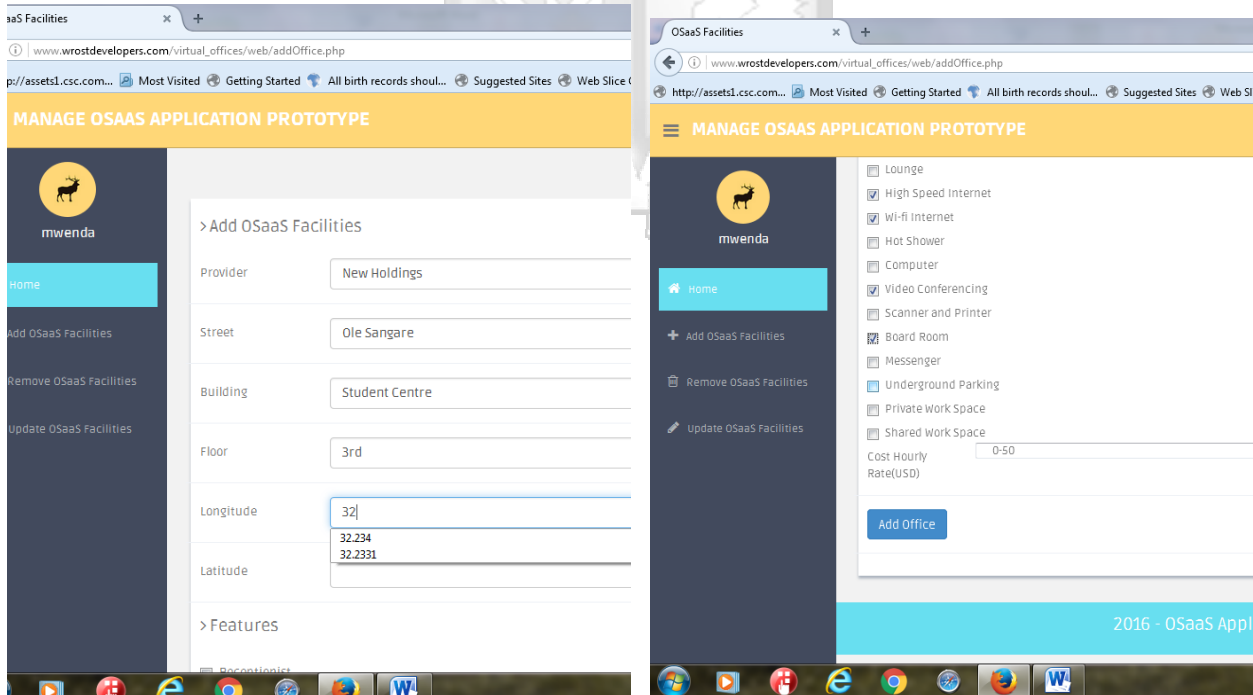


Figure 5.9: Adding a New OSaaS Facility and Selecting Attributes

As seen in figure 5.9, the OSaaS details are keyed in as required. Attributes of the OSaaS facility are selected through check boxes as appropriate. The appropriate price range for the facility is selected and then to save the record, the Add office box is clicked one more time.

On adding it gives the message ‘Successfully Added’. Similarly on deleting, the application gives a message “successfully deleted” as seen in figure 5.10 and 5.11 respectively.

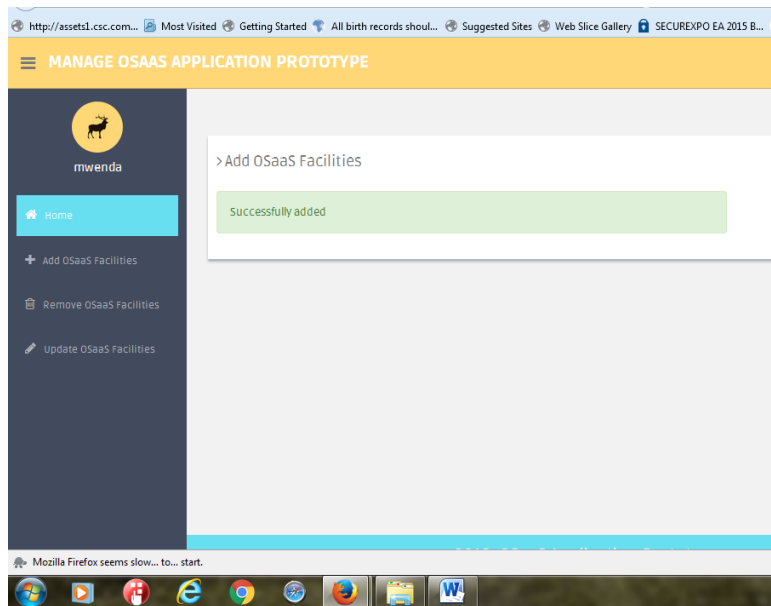


Figure 5.10: Adding OSaaS Facility

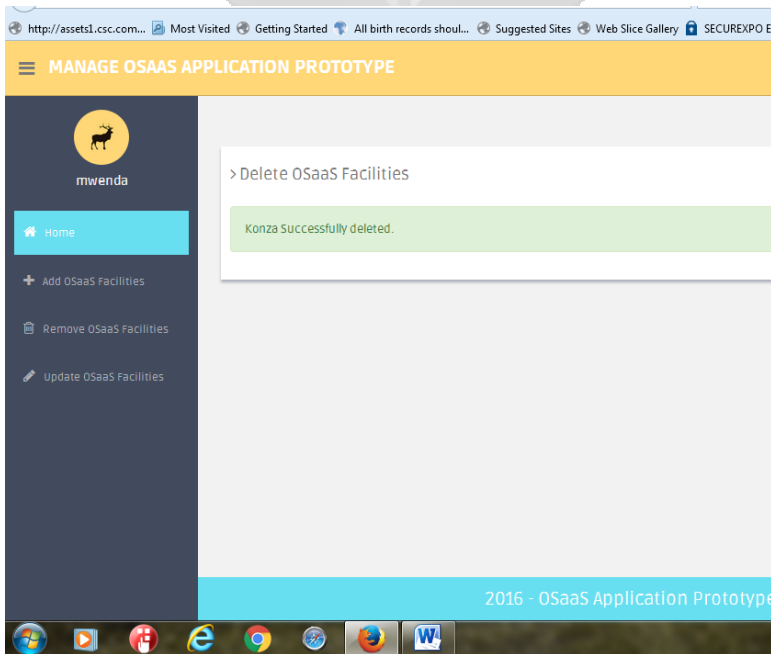
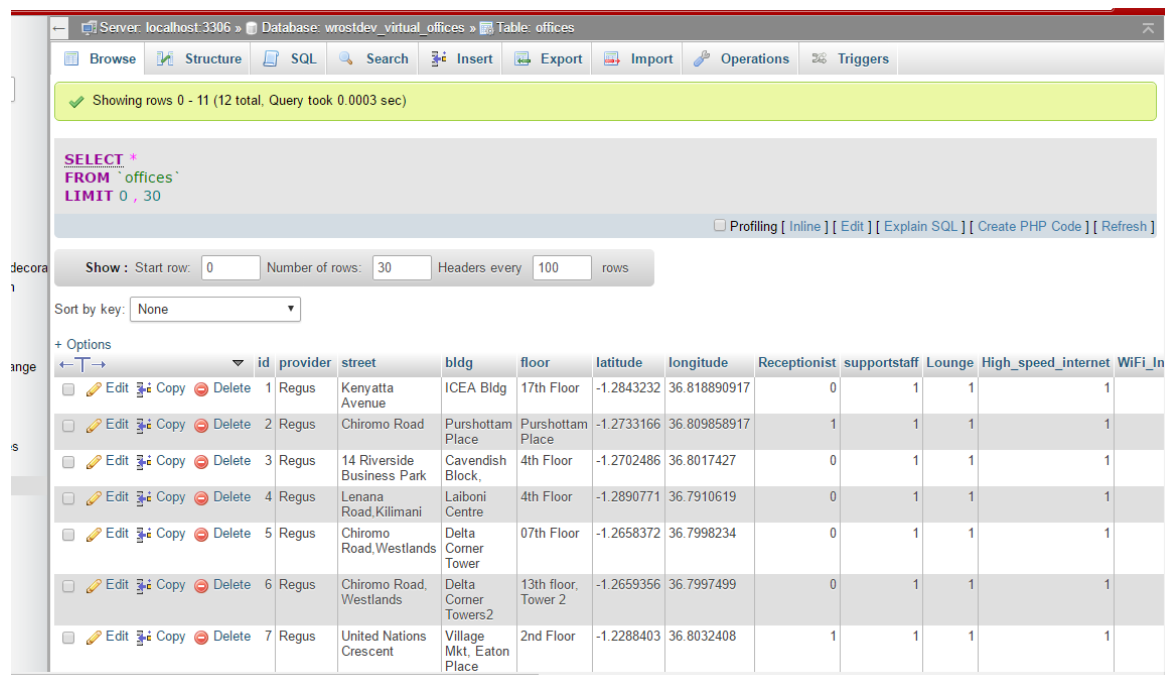


Figure 5.11: Deleting OSaaS Facility

5.4 The Database

MySQL was used as the relational database to store the OSaaS facilities details and their attributes, the locational details, the administrators and providers of the virtual offices. As per the E-R diagram, the main table, OSaaS facilities details relationships was set up as a table as shown in figure 5.12



The screenshot shows a MySQL database interface with the following data in the 'offices' table:

id	provider	street	bldg	floor	latitude	longitude	Receptionist	supportstaff	Lounge	High_speed_internet	WiFi_In
1	Regus	Kenyatta Avenue	ICEA Bldg	17th Floor	-1.2843232	36.818890917	0	1	1		1
2	Regus	Chiromo Road	Purshottam Place	Purshottam Place	-1.2733166	36.809858917	1	1	1		1
3	Regus	14 Riverside Business Park	Cavendish Block,	4th Floor	-1.2702486	36.8017427	0	1	1		1
4	Regus	Lenana Road, Kilimani	Laiboni Centre	4th Floor	-1.2890771	36.7910619	0	1	1		1
5	Regus	Chiromo Road, Westlands	Delta Corner Tower	07th Floor	-1.2658372	36.7998234	0	1	1		1
6	Regus	Chiromo Road, Westlands	Delta Corner Towers2	13th floor, Tower 2	-1.2659356	36.7997499	0	1	1		1
7	Regus	United Nations Crescent	Village Mkt, Eaton Place	2nd Floor	-1.2288403	36.8032408	1	1	1		1

Figure 5.12: OSaaS Facilities Details Table

As seen in table 5.12, the absence or presence of an OSaaS attribute (amenity) is represented by binary value 0 or 1 respectively. The latitude and longitude details are a floating point data type, while the id, provider, street, building and floor are all a variable character data type (VarChar), since any of them could have a mixture of numbers and letters.

5.5 Summary of the Application Test Results

The mobile application was tested on both Huawei Y300 mobile phone running Android version 4.1.1 and on Samsung Galaxy S3 running the same Android version. The minimum Software Development Kit (SDK) for the application was selected as version 14 since versions before that did not offer full support for LBS functionality.

Table 5.1: Test Results for the OSaaS Mobile Application

Functionality	Tested	Test Results
Application running on selected mobile device(s)	Yes	Pass
Accurate determination of user location	Yes	Pass
Display of OSaaS attributes	Yes	Pass
Locate OSaaS facilities within given radius-3KM	Yes	Pass
Take selected OSaaS attributes	Yes	Pass
Compute OWA on selected attributes	Yes	Pass
Rank OSaaS facilities based on OWA calculations	Yes	Pass
Directions to Selected OSaaS facility	Yes	Pass
Display heatmaps for security	No	N/A
Customer interact with provider	No	N/A

Table 5.2: Test Results for the OSaaS Web Application

Functionality	Tested	Test Results
Request Username and password to log in	Yes	Pass
Block log on using wrong username/password	Yes	Pass
Display attributes of OSaaS attributes	Yes	Pass
Add OSaaS providers and their attributes	Yes	Pass
Modify existing OSaaS provider details	Yes	Pass
Delete OSaaS provider(s)	Yes	Pass
Communicate with Mobile App to give search and computation results	Yes	Pass

Table 5.3: Usability Tests of the OSaaS Mobile Application

Feature	Values	Comments
Size	11MB	The small size means that the application is light to download and execute on many smartphones even those with limited memory.
Time to load	About 2 seconds	Reasonable time
Screen use	Full Zoom and adaptive to screen size	Application map filled the whole screen for ease of navigating
Ranking of Selected amenities for OWA computation	Automatically done by system based on selection sequence	Reduces user inputs and number of required clicks
Ranked offices	Given different colours	Virtual presentation of available ranked offices in different colours makes selection process much easier
Directions to Selected OSaaS facility	Automatically given once facility is selected.	Reduces user inputs or clicks to achieve the required goal.

Chapter 6: Discussion

In this chapter the designed application for locating and choosing OSaaS facilities is re-examined. The advantages it offers above other methods available are identified as well as the current technologies used which can be borrowed and used in similar applications. The challenges experienced in the application design and the limitations of the prototype are also identified and briefly explained.

6.1 The Application for Locating and Choosing OSaaS Facilities

Today in the computing world many of the hitherto in-house services such as ICT infrastructural components, storage, databases and software are all being offered as a service in varying degrees from third party independent providers of such. The company hiring such a service does not have to invest anymore in expensive ICT infrastructure, hardware or software. It just needs to pay to use what it requires at a given time without owning such. The statistics presented in this research show that Office Space as a Service has also come of age and it's happening here in Kenya-Nairobi County. This is a trend likely to continue being more and more popular due to its flexibility and agility in the provisioning of the required service. The Office Space as a Service presents an excellent alternative for start-ups who have challenges with high capital outlays to lease an office block, but still need an operating base to meet their clients or hold consultative forums. But this being a relatively new concept in the market, the existence and locations of these facilities is still not known by the many would-be consumers of the service. That is why this application comes in handy to help users in locating and choosing the right OSaaS facility for their use.

6.1.1 Benefits to the Customer

Instead of spending long hours doing thematic searches for OSaaS, this application presents an already filtered list of OSaaS facilities in a given neighbourhood. In addition to that, it identifies the location of the customer using GPS in relation to nearby facilities, a feature that was missing from both the Manzato et al. (2014) and Claus and Martin (2004) models. Once the OSaaS facilities have been ranked and the customer selects one of them, the application automatically gives directions to the said facility without additional mouse clicks or searches on their end. Lastly the application gives the customer a unique option of finding out the localized locational factors such

as security, demographics and Infrastructure that are likely to affect their business if they choose to hire a given OSaaS facility.

6.1.2 Benefits to the Provider

The existence of the application with a consolidated database of OSaaS facilities is in itself an advertisement for such facilities. Secondly, the application makes a provision for a two-way communication between the customer and the providers of such facilities. This would facilitate a negotiation process between these two parties which would most likely improve customer satisfaction and the occupancy levels of the such offices.

6.2 Challenges in realizing the Prototype

In Nairobi County, we do not yet have a government managed GIS system to capture locational factors data such as security, Infrastructure or demographics. Hence, although some of that data was available, it was in a form that could not be integrated into the application since it did not have coordinates details. Even where such data as security incidents reported within a given street or neighbourhood was available, access to such remains a challenge due to the sensitivity of security issues. Secondly, the heatmap design and coding as envisaged for the locational factors was not actualized within the allocated time frame

6.3 Application Limitations

The following were identified as the limitations of the prototype.

- i. Attributes used in the design of the prototype were deliberately given simple status of presence (true) or absence (false). This was to allow the research be accomplished in the allocated research duration. In the real world, each of the attributes will have varied states and would require a table for each of them, but the given logic for choosing an OSaaS facility based on a selected attribute set would still be valid.
- ii. The locational factors data could not be gotten in the short time of the research and the prototype uses some assumed security data values to demonstrate the logic of the heat maps.
- iii. The two-way communication between the customer and the provider as envisioned in the application could also not be coded within the available time.

- iv. Occupancy levels of the OSaaS facilities are a parameter designed to be updated manually by the administrator or provider according to this prototype. A better option for this would be where the provider's system for booking OSaaS facilities would automatically relay and update such information onto the OSaaS application. This is a limitation on the prototype. To allow for a seamless data interchange between the mentioned applications in real practice, extensive consultations and data sharing agreements between the parties involved are likely to be required.
- v. The mobile application was tested on an Android platform only. To run on other platforms like Windows, Symbian or Apple Operating System, a re-compilation of the source codes for such will be necessary.



Chapter 7: Conclusion

7.1 Introduction

The prototype for locating and choosing OSaaS facilities demonstrates how LBS can be brought into play into multi-criteria decision support system involving different layers of geo-spatial data. The application easily solves a number of customer problems and gives additional information to the user interested in using OSaaS facilities. For someone visiting a new city or neighbourhood, the application first solves the problem of identifying OSaaS offices nearby. Secondly it solves the problem of knowing the amenities offered therein by giving a consolidated list of the amenities. Thirdly it helps the user in their decision making process by not only filtering out the facilities that do not meet a given criteria but also ranking the rest of the OSaaS facilities based on the user selected attribute list. Lastly, it brings in locational factors to bear on the choices of available facilities to help the customer choose what is best for them.

The primary objective of the research was to come up with an LBS application that could be used to easily identify and locate Office-Space-as-a-Service facilities near an arbitrary user location in the Nairobi County. As seen in the screen shots and the test results this objective was fully met. The objectives of identifying the factors considered in the choice of office locations and the challenges in the current methods of locating office space have also been met satisfactorily by the research. The methods of locating OSaaS facilities have also been well reviewed as per one of the research objectives. But the derived objective of coding locational factors into heatmaps to influence the choice of office location was not fully meant due to challenges in getting the heatmaps code right within the available time.

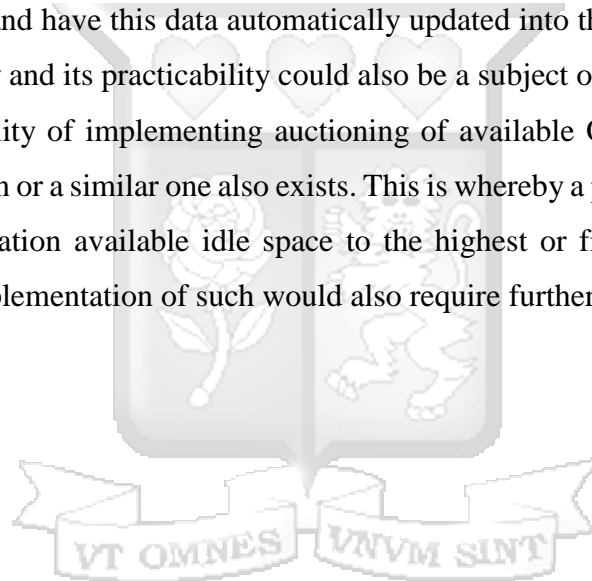
7.2 Recommendations

While the prototype for locating and choosing OSaaS facilities represents a practical LBS application for such a task, a few limitations were identified that could form a basis for further research. These are as enumerated below.

- i. The prototype reduces the choice of the office attributes to a simple Yes or No decision. In practical scenarios, the attributes have varied features. For example, if an attribute like a receptionist is required, it may also require such a person to be proficient in foreign languages like German, Spanish or French. The prototype as

currently designed does not take into consideration such a variation in the attribute states. For this to be taken into consideration, each of the attributes will have to form an independent table related to the applicable OSaaS facility with some primary-foreign key constraint. As earlier illustrated, these attributes are many and combining all such attributes from different tables and doing a decision analysis on them require more research.

- ii. OSaaS details database is a major component of this application. As per this design, the administrator needs to gather data about available OSaaS facilities and their attributes and then update this onto this database. The researcher sees a possibility of employing a customized web-crawler to gather data specific to OSaaS facilities and have this data automatically updated into the required database. This possibility and its practicability could also be a subject of another research.
- iii. A possibility of implementing auctioning of available OSaaS space through this application or a similar one also exists. This is whereby a provider can offer through the application available idle space to the highest or first available bidder. The actual implementation of such would also require further research.



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Appendix A: Sample Questionnaire for OSaaS Providers

This questionnaire seeks to gather information about Office Space as a Service (OSaaS) facilities for academic purposes only and no personal details are gathered. However, the researcher and the university undertake to protect the privacy of individuals and entities mentioned herein. No data appertaining such institutions will be revealed or published apart from that which is already in the public domain.

For the purpose of this research, an OSaaS is defined as a third party managed office space with requisite office infrastructure such as workstations, telephones, Internet and photocopiers. This space so equipped, is then hired out to individuals or companies at a given rate on hourly, daily, monthly or yearly basis. Thanks in advance.

- i. How many OSaaS facilities do you manage in Nairobi Kenya?

- ii. Kindly give the location (Street and Building) of the OSaaS facilities managed by yourselves.

- iii. What services do you offer therein? Tick as appropriate.

- Boardroom
- Teleconferencing facilities
- Reception
- Lounge
- Broadband Internet
- Snail mail receiving and forwarding

- Kitchen
- Hot shower
- Human messenger(s)
- Video conferencing
- Underground parking
- 24 hour access
- Private Office cubicles
- Shared sitting office space with work stations
- Others Specify: _____

- iv. If available what is the capacity of the following amenities?
- a. Boardroom: _____
 - b. Private Office Cubicles (how Many?): _____
 - c. Shared sitting office space with work stations: _____

- v. What is your main method(s) of advertising for the facilities?
- _____
- _____

- vi. What is your hourly rate in USD for a basic OSaaS package hire?
- _____

- vii. Who are your typical clients? Tick as appropriate.

- Multi-national corporations
- Local established companies
- Individual Freelance workers
- Individual entrepreneurs
- Others _____