An Intelligent Mobile-Phone Based Appointment Management System

A CASE STUDY OF ZION HEALTH CENTRE KITEBI

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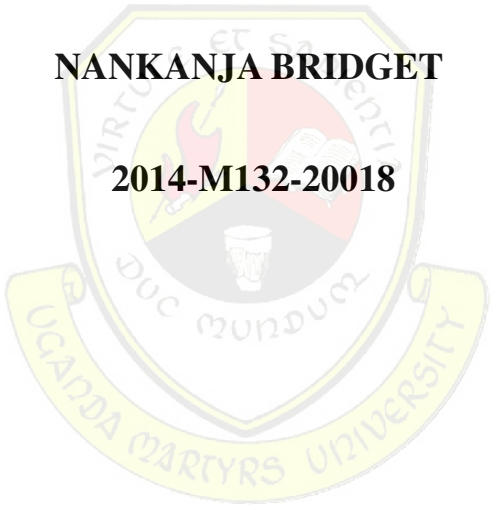

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An Intelligent Mobile-Phone Based Appointment Management System

A Case Study of Zion Health Centre Kitebi

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of the degree Master of Science

in Information systems

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DEDICATION

I dedicate this research to my dear parents Dr. Ssemaluulu Paul and Mrs Rosemary Ssemaluulu who have been tireless in their encouragement and support physically, emotionally and financially.

I also dedicate it to my siblings Fr.Walugembe Denis, Rev.Sr. Nakibowa Agnes, Fr. Kavuma Joseph, Fr Lugoloobi Lawrence and Ms Naggita Mary Grace for their support, prayers and encouragement.

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Lastly but most importantly I thank Mr. Sanya Rahman , my supervisor whose guidance and consultation was unmatched.

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LIST OF ACRONYMS

EMR -Electronic Medical Record

ASRS – Appointment Scheduling Rules

WHO-World Health Organisation

GUI -Graphical User Interface

HCF-Health Care Facilities

PASHA-Personal Assistant for Scheduling Appointments

NFC-Near Field Communication Technology

FIPA- Foundation for Intelligent Physical Agents

BDI-Belief Desire Intention Algorithm

IABSS-Intelligent Agent Based Student Staff Scheduling System

UML-Unified Modeling Language

JADE-Java Agent Development Framework

MYSQL- Structured Query Language

IMTAMS- Intelligent Mobile Telephone Based Appointment Management System

APK-Android Application Package

OS – Operating System

Xml – Extensible Mark-Up Language

ABSTRACT

Making appointments at health facilities is time consuming and tedious. In recent years, a lot of research has been done to solve the scheduling problem in Hospitals. Much of this is towards online appointment scheduling using Web based applications. This has led to further research into use software agents. Over the past considerable amount of work have been done by using software Agents in areas like m-commerce, telemedicine, and engineering among others. This research aimed at solving the appointment scheduling problem by developing an Intelligent Mobile-Phone based appointment system. In this project, the system aims at making appointments using intelligent agents that negotiate amongst themselves for appropriate patient appointments and doctor schedules and emergency situations. This is done with no input from physical agents of patient and doctor. Other research objectives included analyzing existing systems, designing a model and implement the model for the system. Before commencing of data collection, extensive review of literature was done to understand how appointment management is done in the hospital environment and to identify the best frameworks, technologies and methodologies to use in order to accomplish the research objectives. The user centered design approach was used so that users would fully be involved in the system development so as to fully meet their needs. The purpose of User-Centered Design is to involve end users in the development process of the product or system in a way that the prototypes and designs, and finally the products or systems would meet the needs and requirements of the users as well as possible. Under this process data collection techniques included document review, interviews, observation and questionnaires. All these were given to the target users and data from the data collection was categorized and analyzed to come up with system requirements. The findings of the study show that many of the target users already own smart phones and a change in appointment scheduling would be very good especially for the patients and administrators who share the burden of poor scheduling methods more. The report shows evidence of implementation of the system. One of the key findings is that given more time and resources, the system can be scaled out to a bigger hospital environment and more hospital administration tasks besides scheduling.

CHAPTER ONE

GENERAL INTRODUCTION

This chapter discusses the introduction, the background of the study, the statement of the problem, the objectives, scope and significance of the project as well as the conceptual model. The domain for this research project is in the domain of Distributed Artificial intelligence (DAI) with a sub domain of Agent based systems (ABS).

1.0 Introduction

Deshmukh (2012) defines Distributed Artificial Intelligence as the science of distributing, coordinating and predicting the performance of tasks, goals or decisions in a multiple agent environment. It is an approach to solving complex learning, planning, and decision making problems. An intelligent agent mobile-phone based appointment management system was the aim of this research working towards providing real time interaction of patients and health care providers while relieving hospital administrators from juggling schedules and doctors' as well as endless patient requests. In the long run, it reduces appointment waiting times thus saving time for all stakeholders. Hylton III and Suresh (2012) define an agent as a software that has the ability to serve an environment that it is located in, then carries out some action based on the information it gathers. Agents take on the actions of their human counterparts. These agents are implemented using the Java Agent Development Framework (JADE). It is a framework that facilitates the development of agent applications. It tries to keep the high performance of an agent system implemented with Java thus simplifying the development while ensuring standard compliance to FIPA specifications. JADE uses a model that allows high runtime efficiency, software reuse, agent mobility and realization of different agent architectures (Chuan-Jun and Chang-Yu, 2012).

Mardiah and Basri (2013) define the term of "appointment" as the period of time allocated in the schedule to a particular patient's visit and "service time" refer to the amount of time the physician actually spends with the patient (which may be shorter or longer than the appointment duration).

Scheduling appointments is one of the most important administrative responsibilities performed in the medical office. Scheduling them correctly and efficiently is crucial to the smooth operation of health services (Scheduling appointments, 2011). Srividya et al (2011) observed that Hospital schedules especially in large hospitals are very dynamic and difficult to manage. They therefore take up a lot of the administrators' time as they try to juggle multiple phone calls, physician requests and patient demands (Srividya et al, 2011).

According to Relgado (2013), mobile computers are spreading faster than any other consumer technology in history. Mobile are therefore becoming more popular since they enable access to information without limitations of space and time (Aharony, 2013).

With the advance in mobile technologies, research has been done in application of agents on mobile phones to solve the scheduling problem (Chuan and Chang-Yu, 2012).

1.1 Background

The health care industry now is one of the largest and most important industries in most countries. In many health care facilities, however, there exists a severe need for improvement in quality of service and patient waiting times. Hospitals are continuously fighting a scheduling problem that causes either a waste in medical experts' time or a decrease in patient satisfaction and staff morale (Hylton III & Sankaranarayanan, 2012).

The use of Electronic Medical Record (EMR) technology has already begun and it is evident that more health care organizations are moving from a paper-based system to EMR systems in developed countries (Hylton III & Sankaranarayanan, 2012). The internet initially revolutionized communication and access to information; however, in more recent times it has been the rapid improvements in mobile technology that has further expanded the communicative abilities of individuals and businesses alike. These mobile technologies, combined with the use of the internet have pushed mankind to a new frontier of information distribution and gathering (Edwards and Suresh, 2009). These abilities can be better exploited to solve the continuous scheduling problems.

Appointment Scheduling systems have seen low adoption rates and many hospitals and clinics manually maintain the patient appointment records. This can be attributed to enormous challenges that include but are not limited to a lack of ICT infrastructure and the necessary technical support to maintain such health care systems, large financial investment in hardware

and software, security threats to patient records in addition to low literacy levels and skills of intended users especially in developing countries (Mardiah and Basri, 2013). Each time a patient seeks an appointment, ledgers are opened and time slots are manually scanned for a vacancy while the patient waits on the other end of the telephone line.

Online registration and scheduling of appointments is one of the options for the healthcare administration to avoid the hassle of queuing and filling out registration forms but it has become inefficient as the transfer of patient's data can be infiltrated online and hence the risk of online hacking as well as inaccessibility to computers by patients (Wani and Sankaranarayanan, 2014). More to that, no prioritization facility is available for the online registered patients and so there is delay in entertaining them before they are called for consultation. Lastly there is no reminder system on any platforms (Wani and Sankaranarayanan, 2014).

With the advance in technology, mobile applications are the way to go because of the wide spread and acceptability of mobile telephones globally. According to Regalado (2013), Mobile computers are spreading faster than any other consumer technology in history. In the U.S mobile report (2014), it is put forward that, the days of desktop dominance are over. Mobile has swiftly risen to become the leading digital platform, with total activity on smartphones and tablets accounting for an astounding 60 percent of digital media time spent in the U.S. The fuel driving mobile's relentless growth is primarily app usage, which alone makes up a majority of total digital media engagement at 52 percent. According to Kearny (2013), the popularity of mobile phones is trending even more than most forms of technology due to their portability and affordable cost.

Mobile phones are a candidate platform for delivering and retrieving health information due to its widespread adoption, and technical capabilities. Their functionalities may include retrieving a patient's medical records anytime and anywhere, and the generation of tailored messages to patient's smartphones as a reminder of his/her appointment a few hours before the appointed time (Klansja and Pratt, 2012). Being more affordable than desktop computers and laptops, Mobile technology also offers ways to help with health care challenges. Through mobile health applications, sensors, medical devices, and remote patient monitoring products, there are avenues

through which health care delivery can be improved. These technologies can help lower costs by facilitating the delivery of care, and connecting people to their health care providers (Singh and Saravann, 2014).

People have been using various computerized appointment systems like Microsoft outlook among others to solve the scheduling problem. In addition to the use of ICT in appointment system, there is still involvement of human beings towards scheduling of appointments. In the field of computing, the use of software agents to automate tasks has been on the lips of every computer scientist. Multi-agent system technology has become a popular paradigm over the few years in the design modeling and implementation of software solutions.

In Zion Health Centre, the first come first served method is largely employed. In other words, the patient is assigned to a doctor after they walk in and state their problem and most of the patient records are kept in manual files and ledgers thus prone to error and time wastage. In case one already has an assigned doctor, then they will wait in line until the doctor is free to see them and may sometimes make appointments to come on a later date if the doctor is fully booked for that particular day.

1.2 Statement of the problem

Over the past years, several initiatives have been undertaken to address different applications of e-health issues, ranging from doctor (e.g remote access to medical data) to patient (e.g remote monitoring of vital signs), up to Internet based medical data access. The development of cost effective health care systems is urgently needed. Mobile Agents have attracted much attention as they address the issue of insufficient capital resources for purchase of hardware and software (Chuan-Jun and Chang-Yu, 2012). Patient waits have been a long standing concern in health care. In this new era, people have little tolerance for waiting since they have busy lives and believe their time as very valuable (Scheduling appointments, 2011). Scheduling difficulties lead to prolonged wait times enhanced by an imbalance of supply and demand of doctors and patients respectively in both the public and private care sectors (Mardiah and Basri, 2013).

Research into the scheduling problem has become an active field and many web based systems have been developed. However literature reveals that they do not address the scheduling

problems in developing countries where not only is technology infrastructure low but technical skills and computer literacy less available (Singh and Saravanan, 2014).

In Uganda today, very limited health centers use web based appointment systems and many rely on a paper based system which is associated with first come first served tendency which may leave patients frustrated. Based on the survey report published in 2007, most of the complaints are on the time spent in the waiting room and in that 19% of the patients complained that they could not get an appointment within a week's time. Paulussen et al, (2011) explain that barriers to follow up appointments include delay between scheduled appointments, lack of understanding, clerical errors, waiting for long durations for appointments on the telephone lines, calling again and again to secure an appointment and not being able to meet the doctor on time, among others. All these issues still remain a challenge in the healthcare industry worldwide (Wani and Sankaranarayanan, 2014). Therefore, there is rationale in developing an intelligent mobile phone based appointment management system that can optimize resource use of doctor's time by leaving no doctor without a patient and also not over loading them, provide real time feedback and interaction between patients and doctors while reducing administrators' time spent on making coordinating schedules and patient visits.

1.3 Research Objectives

1.3.1 Main Objective

To develop an intelligent mobile-phone based appointment management system to improve hospital schedule management.

1.3.2 Specific Objectives

To analyze the existing appointment management systems in hospitals and review related literature so as to determine requirements for the proposed system.

To design a model for an Intelligent Mobile-phone Based Appointment management System

To implement the model for an Intelligent Mobile-phone Based Appointment management System

To test the designed system to ensure that it is ready to use and meets functional requirements

1.4 Scope of the Study

The research was carried out at Zion Health Centre, Kitebi Kampala. This is a relatively sizable health centre with a large patient base and medical personnel that can be representative of other patients and doctors in Uganda. The specific target group was the doctors and patients because they were the main users. I studied how appointments were made by the patients and how the doctors made appointments with the patients for review or further consultation.

1.4.1 Geographical Scope

The system was developed for health centers in Uganda with a focus on Zion Health Centre located in Kitebi Kampala.

1.4.2 System Scope

The study focused on analyzing the existing hospital scheduling systems in depth to identify how they improve service delivery. Special attention was be put on how best these systems can be doctored to fit the needs of Developing countries especially Uganda by use of mobile telephones which are more widely spread than computers.

The developed system registers users who are both the patients and doctors. The administrator does not actively schedule appointments but the hospital agent acts intelligently to accomplish the tasks of approving appointments, cancelling them, updating the database among others. The patients and doctors can make or cancel appointments without the need of a middle person. The system is limited to appointment scheduling and not any other administrative tasks in the health Centre.

1.5 Significance of the study

From previous research, it was noted that delayed access to health care owing to poor patient scheduling and management is assumed to negatively affect health due to delays in diagnosis and treatment. In worst case scenario may result into death. (Kenagy et al, 2004) in another study, it was observed that most health facility administrators ignore the fact that proper patient scheduling and management can help improve health services and save lives(Sarda, 2016);yet causes of mortality in health facilities as a result of the above mentioned reasons can be avoided and controlled.

Therefore, the proposed Intelligent Mobile-Phone based Appointment management system will improve appointment scheduling by providing real time interaction between doctors and patients through automated messages and calls, giving them feedback on appointments, giving reminders to both the doctor and patient on upcoming appointments. The system provides an approach that takes into consideration of the scarce resource that are; doctor's time and patients' time while balancing the decision making needs for both the hospital administration and patients.

The doctors will have information prior to meeting their patients, giving them time to prepare and this will improve the quality of services offered. Also the system will give priority to patients that need urgent medical attention hence reducing avoidable medical complications or deaths. Because it does not need physical administrators to carry out the appointment scheduling, they will have more time to attend to other duties. Lastly the system will reduce errors like loss of appointment records and forgetfulness that leads to missed appointments and failure to get appointment slots.

1.6 Conceptual Framework

The conceptual framework shows the relationship between hospital variables and how they affect appointment scheduling and quality of services offered in the long run. Many factors affect the Performance of appointment systems which include arrival, patient and doctor preferences, available information technology and the experience level of the scheduling staff. (Sarda, 2014) These factors also include waiting times, hospital facilities and capacity and cost of operation of the hospital. Thus a proper scheduling system has to be developed by considering all these factors which will increase patient satisfaction, which in turn increases quality of service delivered.

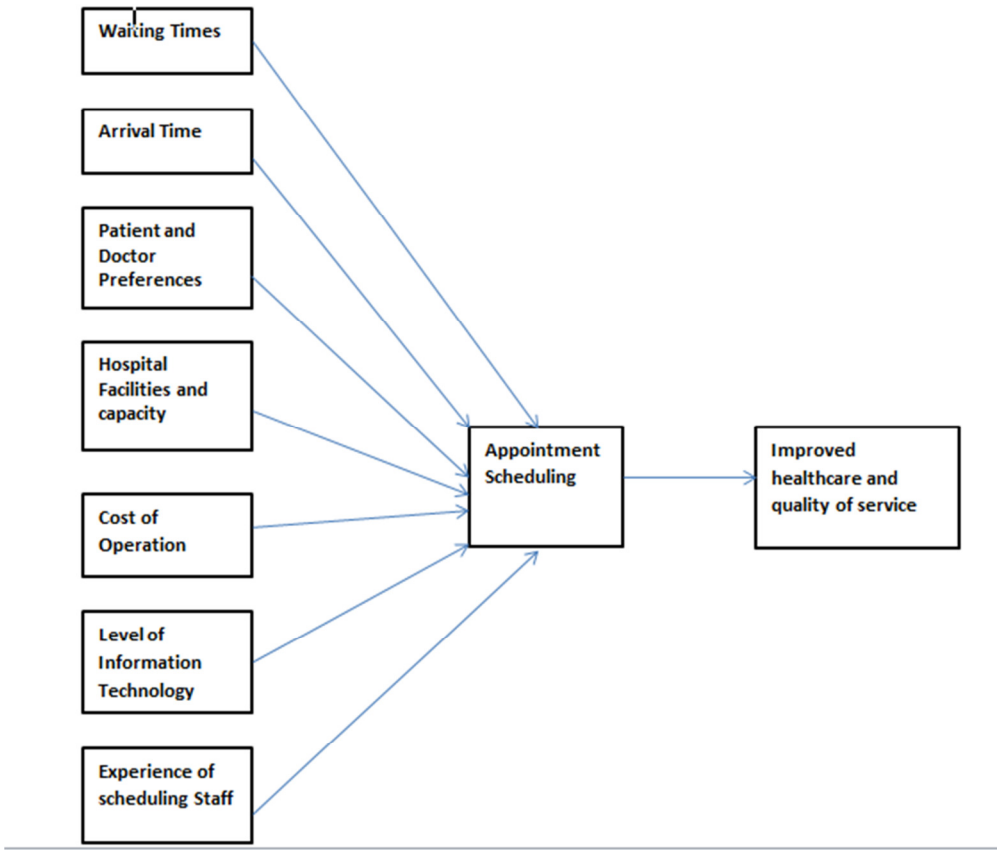

Figure 1.1: Conceptual Model

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter is based on reviewing the literature that is relevant to the research project. It gives a general overview of how appointment scheduling is done, and past and ongoing research in appointment scheduling. It discusses the advantages and challenges of appointment scheduling using agents with mobile telephones as well as the research methodologies used during the research.

2.1 Definition of Key terms

2.1.1 Appointment

Nadia and Basri(2013) define appointment as the period of time allocated in the schedule to a particular patient's visit.

2.1.2 Appointment Scheduling Systems

In his report Hutzschenreuter(2004) defines an appointment scheduling system as one used to manage appointment calendars and scheduling appointments for physicians, dentists and other health care providers. It allocates appointments to time slots during the consultation hours. This allocation is done according to the appointment scheduling rules (ASRS) (Hutzschenreuter, 2004). Unfortunately, many factors affect the performance of appointment systems which include arrival and service time variability, patient and provider preferences, available information technology and the experience level of the scheduling staff (Nazia and Sarda, 2014). Wenjun, (2011) classifies scheduling methods into; Double booking, Like Visits Together, Ten Minute Increments, Modified Wave Scheduling, Staggered Starts and Group Meetings.

2.1.3 Mobile Telephones

Sharon (2010) defines mobile telephones as hand held communication devices connected to a wireless network that allow users to make voice calls, send text messages and run applications.

2.1.4 Agent Based Systems

According to Shehory (2003), Agent systems are autonomous computer systems that reside in a distributed environment and interact with users and perform tasks on their behalf. An agent is "autonomous" to the degree that it decides for itself how to relate data to commands in its efforts to achieve goals, satisfy motivations, etc. Intelligent agents, as an entity, should be able to solve problems; understand information; have intentions; draw distinctions between situations; generalise; synthesise new concepts/ideas; model the world they live in and plan and predict consequences of actions, evaluate alternatives (Roozemond and Veer, 2011).

2.1.4.1 Attributes and Properties of Agents.

Macal and North (2014) discuss agent properties of autonomy, modularity, sociality and conditionality in detail. For practical modeling purposes, we consider agents to have certain properties and attributes, as follows:

Autonomy: An agent is autonomous and self-directed. An agent can function independently in its environment and in its interactions with other agents, generally from a limited range of situations that are of interest and that arise in the model. When we refer to an agent's *behavior*, we refer to a general process that links the information the agent senses from its environment and interactions to its decisions and actions.

Modularity. Agents are modular or self-contained. An agent is an identifiable, discrete entity with a set of characteristics or attributes, behaviors, and decision-making capability. The modularity requirement implies that an agent has a boundary, and one can easily determine whether something (that is, an element of the model's state) is part of an agent or is not part of an agent, or is a characteristic shared among agents.

Sociality. An agent is social, interacting with other agents. Common agent interaction protocols include contention for space and collision avoidance, agent recognition, communication and information exchange, influence, and other domain-or application-specific mechanisms.

Conditionality. An agent has a state that varies over time. Just as a system has a state consisting of the collection of its state variables, an agent also has a state that represents its condition, defined by the essential variables associated with its current situation. An agent's state consists of a set or subset of its attributes and its behaviors. The state of an agent-based model is the collective states of all the agents along with the state of the environment. An agent's behaviors

are conditioned on its state. As such, the richer the set of an agent's possible states, the richer the set of behaviors that an agent can have.

Agents often have additional properties, which may or may not be considered as requisite properties for agency. An agent may have explicit goals that drive its behavior, not necessarily objectives to maximize as much as criteria against which to assess the effectiveness of its decision and actions. An agent may have the ability to learn and adapt its behaviors based on its experiences. At the individual level, learning and adaptation can be modeled as agent behaviors. Individual learning and adaptation requires an agent to have memory as a dynamically updated attribute of the agent. At the population level, adaptation can be modeled by aggregate changes in individual behaviors or by allowing agents to enter and leave the population, with the more successful agents increasing their relative numbers in the population over time (Macal and North, 2014). The above attributes are represented in Figure 2.1 as seen below.

Agent Environment

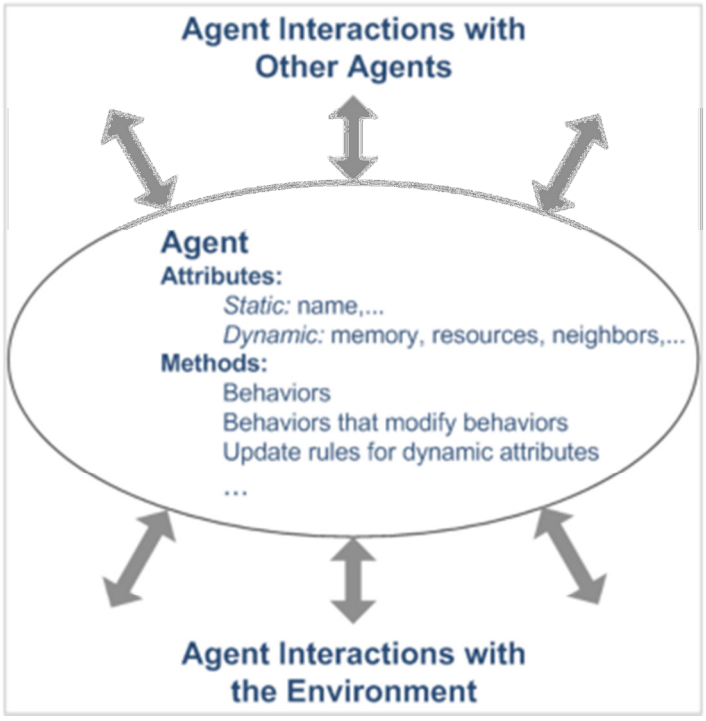

Figure 2.1: Agent Environments

2.1.4.2 Usability of Agent Based Systems.

In his work, Bevan (2000) defines usability as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a

specified context of use. He further explains it as the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions (Bevan 2000).

Usability in this research therefore looks at the applicability of autonomous and distributed artificial intelligent systems appointment scheduling. Increasing autonomy of intelligent systems in automation is a key element, aiming at reducing the need for human intervention; relieving humans of attending other, more complex procedures and providing intelligent assistance in the decision making processes (Roozemond and Veer, 2011). With the help of automated and intelligent systems the need for human intervention has already been diminished. With intelligent autonomous agents or intelligent subsystems, further automation can be combined with more flexibility and better performance.

It is the goal of the research to implement a system that can be adopted by the users and that can respond to scheduling problems in real time while maintaining its functionality. Simply put, usability is determined by the very users. Basically, if users don't like it, they wouldn't use it (Belson and Ho, 2011). Good usability leaves a good impression on the user, and gives the user reason to want to come back again and again. Bad usability, on the other hand, would only give user headaches trying to figure out how to use the application. We use computers to improve and make things more efficient, but if that process actually takes more time than doing it manually, it's really not worth all that effort (Belson and Ho, 2011).

Usability can be achieved by focusing on the five dimensions of usability: **Effective** is the completeness and accuracy with which users achieve their goals; **Efficient** is the speed with which users complete their tasks; **Error tolerant** is the ability of the interface to prevent errors or help users recover from those that occur; **engaging** is how pleasant or satisfying the interface is to use and **easy to learn** supports initial learning and continued learning (Belson and Ho, 2011).

2.2 Relevance of appointment scheduling

Patient scheduling is an integral part of daily work for health care professionals (Bhat et al, 2011). Scheduling appointments correctly and efficiently is crucial to the smooth operation of the medical office. Managing patient appointments is an area that typically consumes a great deal of administrative overhead and cost. An argument is made by Srividiya (2011) that Clinic and

office administrators are typically juggling multiple phone calls, physician requests, and patient demands. It is also a source of frustration for many patients due to the delays and inefficiencies in speaking with the clinic or office administrator. This leads to no-shows, lost revenue, and operational inefficiencies (Bhat et al, 2011).

The major advantages of appointment scheduling systems include; automated record keeping. While many attempt to do this manually, it is obvious that manual record keeping cannot be completely accurate, error free, and acceptable (Hayday, 2014). Using Appointment Scheduling minimizes errors that arise due to human negligence. Hayday (2014) observes that manual record keeping automatically becomes a hazard that can get a doctor in trouble with law enforcement. With electronic appointments, each appointment's time, date and nature is stored electronically. This information could be complemented with other data just as the medicine prescribed, doctor's notes about the patient condition and future plan of action to maintain comprehensive and complete patient records.

Therefore, every health care organization should identify how to choose the most appropriate method of appointment system and how best to organize it to meet the needs of its patients (Zaghloul and Enein, 2010). Patient scheduling is an important tool for efficient outpatient department management as well as rationally operating outpatient resources and critical areas like physician productivity, patient satisfaction, and practice profits (Zaghloul and Enein, 2010).

2.3 Information Technology in Health Care.

As Hylton III and Suresh (2012) clearly discuss, Information Technologies are being employed in many industries today, mainly for the significant benefits to be gained through the use of Information and Communication Technology (ICT). They point out benefits like improvements in process efficiency and information dissemination, quality of performance and effective standards of medical care and services.

However, the Health Care Industry has been slow in accepting the use of ICT and for many years relied on paper based systems (Symey et al, 2013). Health Care Facilities are able to use ICTs such as Internet based applications to provide current and potential clients with the information they need when they need it (Hylton III and Sankaranarayanan, 2012). The World health Organisation observed that, through the use of ICTs such as the Internet, caregivers and family

members have easy access to health care information, which allows them better deal with persons within their care. Clinicians are also able to continue enhancing their knowledge by participating in online courses and research in new areas, and improvements in other treatment areas (World Health Organisation, 2005).

2.3.1 Traditional Paper based Appointment systems

In traditional appointment systems patients come to the hospital and queue at the appointment window to make the appointment. But they usually end up waiting for very long periods of time (Nazia and Sarda, 2014). The Paper-based system mostly requires patients to fill up the forms and submit to the registration desk or they could simply place their identification card or appointment card in the box provided and wait for their name to be called (Wani and Sankaranarayanan, 2014). Based on the survey report published in 2007, most of the complained issues are on the time spent in the waiting room and in that 19% of the patients complained that they could not get an appointment within a week's time. This issue still remains a challenge in the healthcare industry worldwide (Wani and Sankaranarayanan, 2014). With the paper based system, files and patient's health records are stored in physical storage, and will be transferred by nurses or administrators to the doctor's office for consultation. This system is obviously inefficient and time-consuming, and the risk of misplacing records is more likely (Symey et al, 2013).

2.3.2 Web-based/ Online Appointment Systems

Online scheduling system is a Web based application that allows individuals to conveniently and securely book their appointments and reservations online through any Web connected device, such as a computer, laptop, smartphone or tablet. Once a date and time are selected, the system will automatically confirm the booking and instantly record it within the system, without any staff action needed (Appointment plus, 2012). In addition to that, the patient can also provide additional information to the doctor, making the doctor aware of their situation and giving the doctor time to prepare the necessary information for when the patient's arrives. In this way, online appointment scheduling can help the practitioner, the office staff, and the patient's. For doctors, online appointment scheduling brings a lot of value add services and benefits, like

engaging the patient, making the patient feel appreciated, and being able to store patients' data securely for future reference (Hayday, 2014) .

Online appointment scheduling has been one of the options for the patients to avoid the hassle of queuing and filling out registration forms. It also gives the advantage for administrator to monitor and easy searching of any medical records or personal information as it is available online. However, it becomes inefficient as the transfer of data can be infiltrated and accessible online and hence, the risk of online hacking is very huge and doesn't provide for prioritization of patients according to severity and urgency of the case. Last but not least, there are inefficient reminder systems on appointments platforms, which have been confirmed by the healthcare administrators (Wenjun,2011).

2.4 Mobile Technology in Hospitals

Technology continues to make our lives simple sharing and providing information to lessen our workload (Hayday, 2014). Recently there has been a tremendous development in smart phones particularly in the hardware and software utilities, leading to implementation of Mobile health care (Wani and Sankaranarayanan, 2014). Healthcare industry has slowly moved towards implementing cloud-based platforms, regardless of security issues that may or may not happen. With the existence of such systems, storage size and ability to manage records and data centrally will be tackled (Symey et al., 2013). The adoption rate of mobile technology has been rapid (Roney, 2012). It is not new to health care either. Many health care personnel use phones and ipads. Oscar (2011) asserts that mobile technology can help increase medication compliance, improve post treatment understanding, patient access to health information and provide data to improve health care services. Quinn (2011) agrees that mobile phone based initiatives can solve several of the major problems encountered in low income countries; distance, limited computer access and lack of health care workers thus enabling improvements in terms of efficiency and lower health care delivery costs.

However, more than often than not it seems the patients are trying to reach their providers for routine services. It is argued that a provider should be able to create proactive systems where he is the one reaching out to the patients. Doctors must therefore invest in efficient solutions. There

is no denying that technology is completely part of our lives. By using mobile appointment scheduling human error and workload can be eliminated in the long run.

2.5 Fuzzy Logic Systems

Mendel (1995) defines a fuzzy logic system (FLS) as the nonlinear mapping of an input data set to a scalar output data. A FLS consists of four main parts: fuzzifier, rules, inference engine, and defuzzifier. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s (Rouse, 2016).

As illustrated in figure 2.2 below, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step is known as fuzzification. Afterwards, an inference is made based on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification step.

Illustration of a fuzzy Logic System

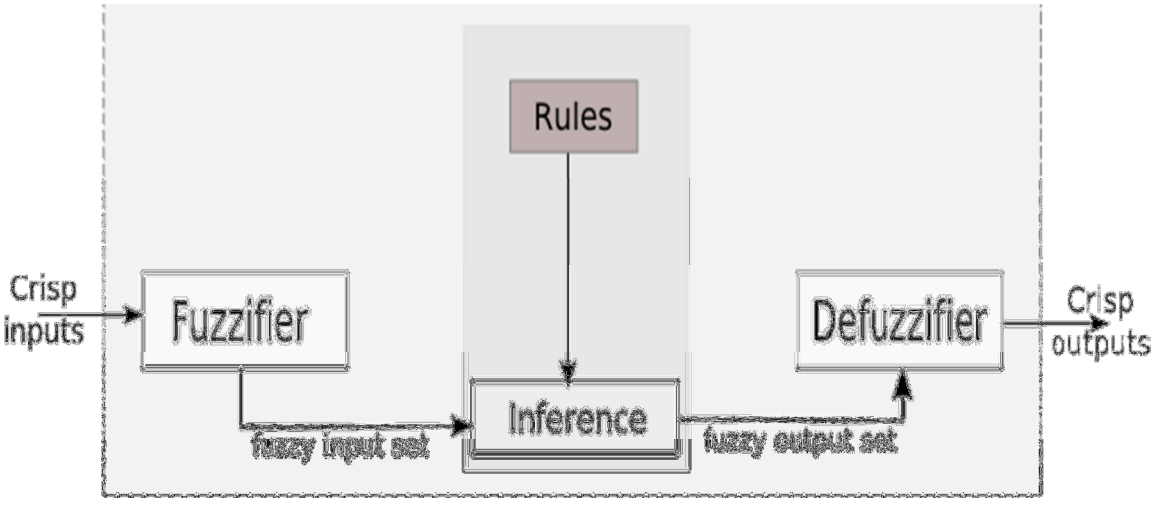

Figure 2.2 : Fuzzy Logic System

[Source: A short fuzzy Logic Tutorial 2010]

Belohlavek, Klir, Lewis and Way (2002) elaborate that Fuzzy Logic is a methodology for expressing operational laws of a system in linguistic terms instead of mathematical equations. Wide spread of the fuzzy control and high effectiveness of its applications in a great extent is

determined by formalization opportunities of necessary behavior of a controller as a “fuzzy” (flexible) representation

2.5.1 Fuzzy Logic Membership Functions and Algorithm

Fuzzy logic seems closer to the way our brains work. We aggregate data and form a number of partial truths which we aggregate further into higher truths which in turn, when certain thresholds are exceeded, cause certain further results such as motor reaction (Belohlavek, Klir, Lewis and Way, 2002). Fuzzy logic includes 0 and 1 as extreme cases of truth but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but "tallness."

The membership functions are found in the **Fuzzification Module/ Fuzzifier** where the system inputs are transformed from crisp inputs to fuzzy sets. It splits the input signal into five membership functions as illustrated below;

Fuzzy logic membership functions

LP	x is Large Positive
MP	x is Medium Positive
S	x is Small
MN	x is Medium Negative
LN	x is Large Negative

Table 1: Fuzzy logic membership functions

Membership functions allow you to quantify linguistic term and represent a fuzzy set graphically. A **membership function** for a fuzzy *set A* on the universe of discourse X is defined as $\mu A:X \rightarrow [0,1]$. Here, each element of *X* is mapped to a value between 0 and 1. It is called **membership value** or **degree of membership**. It quantifies the degree of membership of the element in *X* to the fuzzy set *A*. The x axis represents the universe of discourse while the y axis represents the degrees of membership in the [0, 1] interval (Belohlavek, Klir, Lewis and Way, 2002).

There can be multiple membership functions applicable to fuzzify a numerical value. Simple membership functions are used as use of complex functions does not add more precision in the output. All membership functions for **LP, MP, S, MN,** and **LN** are shown as below;

Membership Function Variables

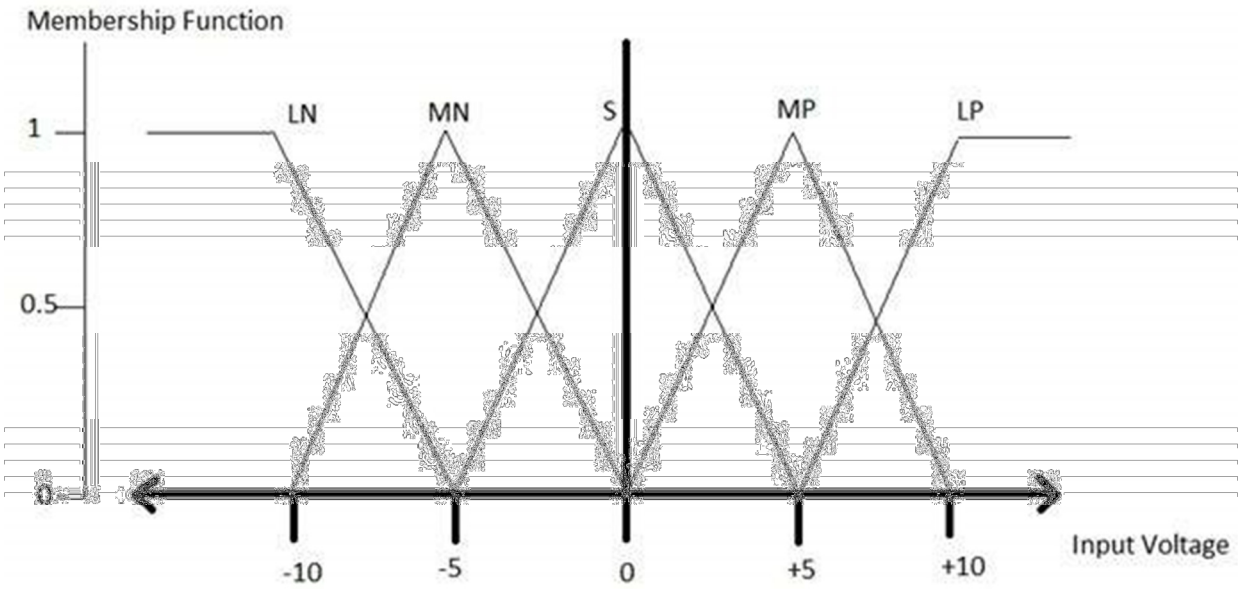

Fig 2.3 Membership Function Variables

2.5.2 Developing Fuzzy Logic Algorithm.

The fuzzy logic algorithm can be developed following the simple steps of; defining linguistic variables and terms, constructing membership functions for them, constructing knowledge base of rules, converting crisp data into fuzzy data sets using membership functions (fuzzification), evaluating rules in the rule base (interface engine), combining results from each rule (interface engine) and lastly converting output data into non-fuzzy values. (defuzzification)

2.5.3 Advantages of Fuzzy Logic Algorithm

Fuzzy logic is easily applicable because, Mathematical concepts within fuzzy reasoning are very simple, you can modify a FLS by just adding or deleting rules due to it's flexibility. Fuzzy logic

Systems can take imprecise, distorted, noisy input information they are easy to construct and understand and they are a solution to complex problems in all fields of life, including medicine, as it resembles human reasoning and decision making. As a result it has been applied in many studies of Agent based systems and will be applied in the proposed system too.

Hylton III and Sankaranarayanan (2013) developed agents to function based on fuzzy preference rules, to make a proper decision regarding making an appointment for patient and other hospital staff . The fuzzy preferences where implemented in the scheduler agent for making appointments. In their system, the Agent gathers the information from the user and schedules an appointment with the hospital based on fuzzy preferences.

Another use of Fuzzy logic was by Sankaranarayanan and Sait (2013) in their development of the Near field communication agent based system. The agents developed were based on using fuzzy preferences, to gather information from patients and schedules appointment with the healthcare facility.

2.6 Belief desire Intention (BDI) Algorithm

According to Buse (2007), the agent's knowledge base is described by a set of beliefs ,desires and intentions. These are explicitly represented in the knowledge base; for example, the Procedural Reasoning System (PRS) implementation represents beliefs and goals as ground literals (sentences containing no implications, binary operators or variables) in first-order logic. In an earlier research by Georgeff and Rao (1995), it is put forward that a BDI agent is capable of both reactive and deliberative behavior. On each execution cycle of the interpreter, the agent retrieves new events from the environment. It then generates a set of options, which are plans or procedures that the agent is capable of carrying out, both in response to events and in order to achieve its goals. The agent will then execute, or partially execute, one or more of the selected options. This process is repeated for the agent's lifetime.

Singh, Rao and Georgeff (2000) give a set of algorithms for a basic BDI interpreter.

The main interpreter loop is as follows:

```
BDI-Interpreter()
initialise-state();
do
    options := option-generator(event-queue, B, G, I);
    selected-options := deliberate(options, B, G, I);
    update-intentions(selected-options, I);
    execute(I);
    get-new-external-events();
    drop-successful-attitudes(B, G, I);
    drop-impossible-attitudes(B, G, I);
    until quit;
```

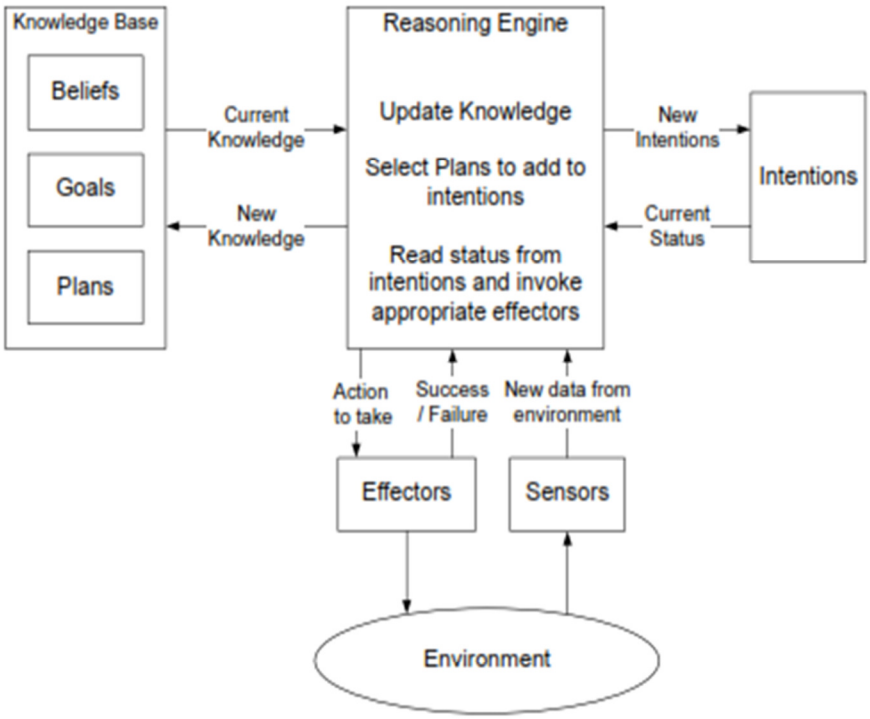

Figure 2.3 : BDI Agent structure

Although applicable, the above algorithm is tied to particular frameworks like Jadex making it inapplicable in some scenarios especially if required functionalities cannot be achieved with that framework.

2.6.2 Conclusion

With the analysis of both algorithms mentioned above, the fuzzy logic algorithm is seen as a better fit given the intentions of the proposed system. Due to the flexibility and applicability of the fuzzy logic algorithm, it was used in implementation of the proposed system.

2.7 Frameworks for developing intelligent agent based systems.

To ease large-scale realization of agent applications there is an urgent need for frameworks, methodologies and toolkits that support the effective development of agent systems. Moreover, since one of the main tasks for which agent systems were invented is the integration between heterogeneous software, independently developed agents should be able to interact successfully (Bellifemine, Poggi and Rimassa 2001).

2.7.1 JADE Framework

Bellifemine, Caire, Trucco and Rimassa (2010) define Java Agent Development Framework as a software development framework aimed at developing multi-agent systems and applications conforming to FIPA standards for intelligent agents. Jade comes with an independent FIPA compliant agent platform and package to develop Java agents.

JADE simplifies development while ensuring standard compliance through a comprehensive set of system services and agents (Bellifemine, Poggi and Rimassa 2001).

JADE is an enabling technology, a middle--ware for the development and run-time execution of peer-to-peer applications which are based on the agents paradigm and which can seamless work and interoperate both in wired and wireless environment (Bellifemine, Poggi and Rimassa 2001). The internal architecture of JADE is unique even if it fully complies with FIPA. The FIPA standard fully embraces the agent framework and, in particular, it defines the reference model of an agent platform and a set of services that should be provided. The collection of these services, and their standard interfaces, the normative rules that allow a society of agents to exist, operate, and be managed (Bellifemine, Caire, Poggi and Rimassa, 2003).

Benefits of the JADE framework in development of Agent Systems

As a framework, JADE brings many advantages to the table, some of which have been mentioned below.

a) Negotiation and Coordination

JADE simplifies the development of applications that require negotiation and coordination among a set of agents, where the resources and the control logics are distributed in the environment. In fact, easy-to-use software libraries to implement peer-to-peer communication and interaction protocols are provided by JADE to developers.

b) Pro-activity

JADE agents control their own thread of execution and therefore, they can be easily programmed to initiate the execution of actions without human intervention just on the basis of a goal and state changes. This feature, that is usually called proactivity, makes JADE a suitable environment for the realization of machine-to-machine applications.

c) Multi-party applications

Peer-to-peer architectures are more efficient than client-server architectures for developing multi-party applications, as the server might become the bottleneck and the point of failure of the entire system. Because JADE agents can both provide and consume services, they remove any need to distinguish between clients and servers. JADE agents allow clients to communicate each other without the intervention of a central server. Moreover, the fact that intelligence, information and control are distributed, allows the realization of applications where the ownership is distributed among the peers (agents) given that each peer may be able, and authorized to perform, just a subset of the actions of the application.

d) **Interoperability**

JADE complies with the FIPA specifications that enable end-to-end interoperability between agents of different agent platforms. All applications where inter-organization communication is needed can benefit from interoperability, including machine-to-machine and holonic manufacturing.

e) Openness

JADE is an open-source project that involves the contributions and collaborations of the user community. This user-driven approach allows both users and developers to contribute with suggestions and new code, which guarantees openness and usefulness of the APIs. Of course,

anarchy must be avoided and the JADE Governing Board is the actor that formally controls the evolution of JADE in terms of new APIs and functionalities.

f) Versatility

JADE provides a homogeneous set of APIs that are independent from the underlying network and Java version. It in fact it provides the same APIs both for the J2EE, J2SE and J2ME environment. This feature allows application developers to reuse the same application code both for a PC, a PDA or a Java phone, it allows to postpone this choice as late as possible, in theory, until the deploy-time.

g) Ease of use and mobile applications

JADE API's are easy to learn and use. JADE has been designed to simplify the management of communication and message transport by making transparent to the developer the management of the different communication layers used to send a message from an agent to another agent, and so allowing her/him to concentrate on the logic of the application. JADE reduces the application development time in respect to the time necessary to develop the same application by using only Java standard packages. In particular when developing distributed applications for mobile terminals, JADE APIs and ready-to-use functionalities allow to strongly reduce the application development time and costs.

Rajguru (2011) further explains the advantages of the Jade framework as follows; JADE tries to keep high the performance of a distributed agent system implemented with the Java language. Its communication architecture offers flexible and efficient messaging, transparently choosing the best transport available and leveraging state of the art distributed object technology embedded within Java runtime environment. Jade allows for easy building of intricate, real world business models without being constrained by the mechanics of storing and accessing data. Developers can easily store, retrieve and rapidly traverse complex, interconnected object structures. It makes it easier to build and run distributed systems that take advantage of modern, high performance hardware platforms. Lastly, according to the literature JADE is the only multi-agent toolkit capable of creating agents that can execute on a mobile device with limited resources (Edwards and Suaresh, 2010).

Shortcomings of the Jade Framework

Based on the limited amount of insight we have on the platform itself regarding implementation details, one of the main problems that the JADE platform may face when trying to adapt to a wide-area environment is its naïve failure detection mechanism based on a simplistic timeout.

2.7.2 Cougaar

Helsinger and Wright (2005) follows a Cognitive Agent Architecture and is a DARPA-funded open-source agent platform that offers special support for logistics problems. The platform is not FIPA-compliant. It facilitates the development of agent based applications that are complex, large scale and distributed. Cougaar's cognitive architecture is another promising feature since the majority of the available platforms does not handle with such issues despite the fact that they are important for simulating human thinking and acting.

2.7.3 Jadex

This is a BDI Agent System. Torsten,O. et al.,(2013) follows the Belief Desire Intention (BDI) model and facilitates easy intelligent agent construction with sound software engineering foundations. It allows for programming intelligent software agents in XML and Java. Jadex has been put into practice in the context of several research, teaching, and industrial application scenarios. It has been used to build applications in different domains such as simulation, scheduling, and mobile computing. For example, Jadex was used to develop a multi-agent application for negotiation of treatment schedules in hospitals (Braubach et al., 2014). In the latest version, the programming model of Jadex is based on the notion of active components that are conceptually based on SCA (service component architecture). This allows for designing an application as hierarchical decomposition of components interacting via services and thus helps making complexity controllable. Active components extend SCA in several directions as it is intended to work in concurrent and dynamic distributed systems.

2.7.4 Conclusion

Use of already existing frameworks ensures that the programmer adheres to standards and also enhances application development. Jade was chosen as the best fit framework for developing an intelligent mobile based appointment system since it is FIPA compliant, JADE reduces the application development time, has ready-to-use functionalities that reduce the application development time and costs in addition JADE is the only multi-agent toolkit capable of creating

agents that can execute on a mobile device with limited resources. It is not tied to any algorithm or model like Jadex hence making it a framework of choice in this study.

2.8 Comparison of Existing Systems

Schmeier and Schumpeter (1996) propose a Personal Assistant for Scheduling appointments (PASHA II) technology using intelligent agents. PASHA was designed to act more like a personal assistant. It initiates an appointment by sending all the free time slots for a person to all the people who are intended to be invited to the meeting. PASHA II was designed to replicate how a secretary manages appointment in the real world. However, the agents in PASHA have limited or uncertain information, stopping them from making optimal individual decisions.

Symey, Sankaranarayanan and Sait (2013) carried out a study, based on Near Field communication Technology. It is a wireless communication that is used to transmit data at a short range of distance, approximately 10cm. The intelligent agent system was developed for appointment scheduling where patients can register and make appointments through mobile devices and eliminate the registration desk staff however on arrival for the appointment, Patients need to tap their NFC cards into NFC readers at the main entrance gate of the hospital, and once there is an information match, the other scheduling procedures follows. This had added costs of printing NFC cards, purchasing NFC readers by the hospital and deploying physical security.

Parchment and Sankaranarayanan (2013) proposed an Intelligent Agent based Student-Staff Scheduling System that aimed at reducing the waiting time needed towards appointment scheduling between lecturers and students and also appointment scheduling between fellow lecturers too. However, it doesn't allow Heads of Departments to schedule meeting with staff and no automatic meeting reminder for both staff and student neither through SMS or e-mail.

The literature shows that intelligent based appointment systems have been developed but they lack automatic reminder systems. Prioritization on scheduling is still an issue, while scheduling for emergency cases is not catered for either. The proposed system therefore looks at addressing these issues to eventually provide better appointment scheduling capabilities.

2.9 CONCLUSION

The major aim for reviewing literature was to get better understanding of the research that was carried out as well as ensure that the literature was in sync with the research objectives. From the literature, it was discovered that there is still need for cheaper and simpler ways of scheduling appointments in health facilities. The available literature reveals that the current systems much as they try to address some scheduling issues still fall short when it comes to real time feedback to the patients and health workers hence slow response time in addition to lack of real time interaction between patients and doctors.

The proposed intelligent phone based system is aimed at rectifying that problem by providing cheap real time interaction and faster feedback to the patients about their appointments, dates, time and doctors that will be attending to them as soon as the appointment is scheduled. Due to the fact that it is mobile based, the system will be much more accessible, customizable and adaptable compared to existing systems. The study targeted one health center but is intended and can be used by any health facility that permits its use.

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

This chapter presents the methods that were used in realizing the study objectives and the development methodologies. It includes data collection, research design, system testing and implementation.

3.1 Research Design

User Centered design (UCD) was used in this research. User centered design was chosen because it helps in creation of applications that are user friendly and meet the needs of the end user. Rigsbee and Fitzpatrick (2012) define user centered design as an iterative design process that focuses heavily on the user and applies a top-down systems engineering approach that categorizes the overall system and user requirements into their various functions, sub functions, and tasks.

The purpose of User-Centred Design is to involve end users in the development process of the product or system in a way that the prototypes and designs, and finally the products or systems would meet the needs and requirements of the users as well as possible (Heinila et al,2005). The UCD work is multidisciplinary, joining together the expertise of different stakeholders, such as UCD experts, programmers, graphical designers and any other stakeholders.

3.1.1 User Centered Design Process

User-centered design in the whole product development cycle is an iterative process where feedback from end users is brought into design in different stages of the development cycle (Heinila et al 2005). It has the following steps;

Step 1: Define user requirements and context of use

Step 2: Visualise design ideas

Step 3: Carry out user evaluations of design ideas

Step 4: Create concepts and prototypes

Step 5: Evaluate concepts and prototypes

The Iterative User-Centered Design Process

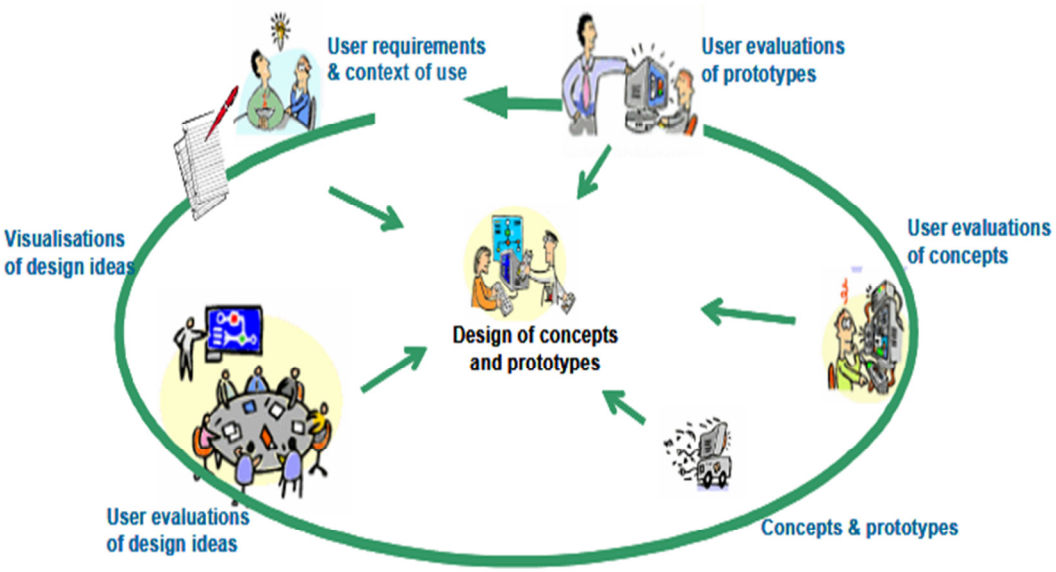

Figure 3.1: The iterative User-Centred Design process

[Source: Nomadic Media http://www.vtt.fi/inf/julkaisut/muut/2005/UCD_Guidelines.pdf]

Iterative design should be employed throughout the entire product development cycle, as well as within each step of the UCD process. This principle recommends that requirements are collected and the product is designed, modified and tested repeatedly. Usually it is neither possible nor meaningful to go through the development cycle once; one has to continue to iterate and fine-tune with each cycle until the final user requirements are specified with the help of different methods in different steps of the product development process. For example, interviews may be carried out in the step1, gathering phase of initial requirements. They may be used to begin the user requirements collection.

3.1.1 Target Population

The UCD process emphasizes user needs focus and in order to achieve this, there has to be a clear understanding of the target users so that no one is left out in the design process. The proposed system runs on mobile phones therefore there was need to understand who the users were going to be and to first understand what problems they found with the current system. The

researcher used Zion Medical Centre Kitebi as a case study and the study population included doctors working at the medical Centre, the patients, nurses and management.

3.1.2 Sampling Procedures

Sampling is the process of selecting a number of individuals for a study in such a way that the individuals selected represent the large group from which they were selected (Slideshare.net, 2014).

3.1.3 Sampling Technique

Purposive sampling was used to select some of the respondents especially the health workers and patients. Crossman (2016) defines purposive sample as a non-probability sample that is selected based on characteristics of a population and the objective of the study. Purposive sampling is also known as judgmental, selective, or subjective sampling. Purposive sampling is a form of non-probability sampling in which the subjects selected seem to meet the study's needs. This type of sampling can be very useful in situations when you need to reach a targeted sample quickly, and where sampling for proportionality is not the main concern (Crossman, 2016). This technique was also selected because it enabled the researcher to focus on the main stakeholders for whom the application was going to be designed. The total sample size was thirty two (32) respondents inclusive of doctors, medical officers, nurses and patients.

3.1.4 Systems Requirements Gathering and Analysis

This is the process of determining user expectations for a new or modified product. These features, called requirements, must be quantifiable, relevant and detailed (TechTarget, 2007). Following the UCD process the initial user requirements are refined during the design process on the basis of continuous feedback from the users. In most cases, the user requirements cannot all be fixed at the beginning of the project. The initial user requirements were collected using data collection tools like document review, questionnaires, Interviews, observation and informal discussions, were administered to the study population.

3.1.4.1 Document Review

Existing data collection instruments and documents were reviewed and these included patient records, physical doctors' schedules, formal policies formal policies and guidelines, and contract

agreements were reviewed too. The purpose of conducting document reviews was to obtain balanced information that would be used when conducting interviews and answering questionnaires. The document review provided a broad coverage and helped in collecting all the necessary information and variables required for the new system, giving opportunity to discover gaps and problems with the existing system as well as possible improvements. Due to the availability of data, this technique was cheap and easily implemented.

In addition existing literature related to the proposed system was reviewed especially the technologies and designs, to find out how the previous systems were developed and designed to meet the required user specification and which functionalities could be included into this one to make it better.

3.1.4.2 Interviews

Unstructured, Face to face interviews were conducted with the key users of the system. This data collection technique was used to collect information from stake holders (staff) as well as selected patients found in Hospitals because the more unstructured the interview, the more it is expected that the main issues will emerge from the interviewee, rather than being imposed by the structure of the interview. Interviews are important in following up unexpected results or confirm interpretations generated by other methods of data collection and analysis. They mainly helped in making clear issues not openly understood in the questionnaires.

3.1.4.3 Observation

Observations involved physical presence at the hospital. This allowed us to observe and take notes pertaining to the situation in the hospital i.e. doctors' schedules, patient management system, and other observable activities, etc. This method was used to see how patients make appointments, how cancelled appointments are communicated to the doctor and patient, how long the patients wait to make appointments and what happens if they cannot. Five observation sessions were carried out to confirm the answers obtained from other methods. The observation method brought many requirements into light and provided original information for determining functional requirements of the proposed system.

3.1.4.4 Questionnaires

Questionnaires were given to the health workers, patients and hospital administrators who all were considered potential users of the proposed system. They came in handy in a way that key questions were put forward and answered in precise statements. This made data analysis easy. Fortunately the response time was also short as all respondents were able to return them within one week.

3.1.4.5 Data Analysis and presentation

The data collected, from interviews, questionnaires and informal discussions, was analysed using Microsoft word 2010 and the Statistical Package for the social Sciences (SPSS). The major aim was to document requirements for the proposed system. Diagrammatic explanations were also drawn using Visio paradigm after making use of information from the data analysis.

3.1.5 Prototyping

When user requirements have been identified in the UCD process, concepts and demonstrations can then be created and in this case a prototype was used. A prototype is a representation of all or a part of a product or system that, although limited in some way, can be used for evaluation (ISO 13407:1999). In the user-centred design approach, prototypes are not simply demonstrations to show users a preview of the design, but they are developed to collect user feedback that is then used to drive the design process.

Paper prototyping was employed. This technique was used because it minimized development costs and allowed the researcher to receive quantifiable user feedback and because there was need to keep the design as simple as possible for all levels of users. It supported the development of a high quality system with end-user input in the process through their suggestions on refinements and improvements to each iterative development of the system (prototype) until a satisfactory system was constructed. The researcher was able to do more in a shorter period of time while allowing quality development.

3.2 Development Platforms

3.2.1 Operating system

The researcher intends to use the Microsoft Windows operating system with Microsoft Office packages such as Microsoft Word and Microsoft Visio in additional to Visual Paradigm

3.2.2 Programming Toolkits

JADE: This is a multi-agent toolkit capable of creating agents that can execute on a mobile device with limited resources.

Eclipse: JadeLeap was integrated with Eclipse which was then used in implementing the Grapical user interface due to its compatibility with JadeLeap.

3.2.3 Database Management Systems

MySQL was used to implement the database because it is free open source software, and can run on many operating systems. It is also easy to use, fast, and is scalable and hence accommodates large amounts of data thus providing high level security for the stored information.

3.3 System Implementation and Testing

System implementation and testing involves transferring logical models into a working/ functional system which is then tested against various standards and requirements.

3.3.1 System Implementation

When the design was completed, major decisions about the system were made and what was left for this stage was to translate the designs of the system into code and scripts in a given programming language to implement the design in the best possible manner. During this phase, the main focus was on developing programs that were easy to write, simple, clear, and documented so as to avoid high costs of maintenance and testing. The researcher implemented the system designs using the model view controller ease for editing parts of the system and the following technologies;-

a) JADE, a development framework and toolkit for implementing agents and multi agent systems on mobile devices.

b) Java, a programming language used for both our frontend and backend

c) MySQL Server, a server hosting the database where all the data regarding different transactions are stored.

3.3.2 System Testing

During system design, a paper prototype was used. This prototype was un executable therefore there was need for testing the system before deployment so that any errors can be uncovered and corrected. System testing was done against technical system requirements to see if all functional and non-functional requirements were met.

3.4 CONCLUSION

The research methodology chapter is basically explaining the methods both research and development and the development process that were used in this research to design and implement of an intelligent mobile phone based appointment management system. Chapter three was a summary of the following chapters.

CHAPTER FOUR

SYSTEM ANALYSIS AND DESIGN

4.0 Introduction

This chapter presents the study, analysis criteria used and design for implementation of the Intelligent Mobile phone Based Appointment Management System. The results and data obtained from the interviews, questionnaire and observation methods are discussed in detail. Data and process models, system architectures were also developed in this chapter. These were based on the analysis of results thus depicting what the new system will require and how it will function.

4.1 System Analysis

According to Shelly and Rosenblatt (2012) the purpose of the systems analysis phase is to build a logical model of the new system. The first step is requirements modeling, where you investigate business processes and document what the new system must do to satisfy users. To understand the system, you perform fact-finding using techniques such as interviews, surveys, document review, observation, and sampling. Therefore the following section is going to exhaust the strengths, weaknesses and requirements for the new system.

4.1.1 Analysis of Data Results

The data and information gathered from data collection phase was critically categorized, coded and analysed to come up with system requirements. Purposive sampling was used to select some of the respondents especially the health workers and patients. The total sample size was thirty two (32) respondents. Twenty (20) patients, three (3) doctors, medical officers, seven (7) nurses and two(2) administrators. The analysed data is shown in the tables below;

Table 1: Sex of respondents

Sex	Number of Participants	Percentage %
Male	**12**	**37.5**
Female	**20**	**62.5**
Total	**32**	**100**

Table 1 indicates that the more females visit the health centre more than males 25% Sex of respondents. This shows that women are more likely to be patient with the waiting durations but may also use the application more.

Table 2: Age of Respondent

Age	Number of Participants	Percentage %
18 to 30	**8**	**25**
31 to 49	**15**	**46.88**
50 to 65	**5**	**15.63**
66 or older	**4**	**12.5**
Total	**32**	**100**

Table 2 illustrates question two that was about age of respondents. From the percentages, it is clear that people within the age bracket of 31 and 49 visit more frequently and form the biggest part of the system users. This question was included to determine how usable the system will be and the acceptance rate. Further in the data it is clear that some age groups are not very open to new technology while others are.

Table 3: Position or status in the hospital

Position/Status	Number of Participants	Percentage %
Doctor	**3**	**9.38**
Patient	**20**	**62.5**
Nurse	**7**	**21.88**
Administrator	**2**	**6.25**
Total	**32**	**100**

Table 3 indicates that patients are the majority users of the system. It also shows the doctor patient ratio clearly showing that the doctor patient ratio is too high because patients make up 62.5% whereas doctors only make up a 9.38%. Also the percentage of administrators is 6.25% which is too low compared to the number of patients. This is a positive indicator that an intelligent system that assists their scheduling will be welcome venture.

Table 4: Appointment scheduling frequency

How often do you make appointments?	**Number of Participants**	**Percentage %**
Very often	**12**	**37.5**
Often	**17**	**53.1**
Rarely	**2**	**6.3**
Very rarely	**1**	**3.1**
Total	**32**	**100**

Table 4 indicates that many of the system users do make appointments. 90.6% of the respondents make appointments and often. There is no respondent who does not make an appointment therefore appointment scheduling is an important activity in any hospital. It is usually impossible to see a doctor without first getting an appointment given their heavy schedules and limited time

Table 5: Forgetting appointments by health provider

How often does your health provider forget your appointments?	**Number of Participants**	**Percentage %**
Never	7	21.86
Sometimes	5	15.63
Usually	14	43.75
Always	6	18.75
Total	**32**	**100**

Table 5 indicates that there is need for a reminder system since it is often that appointments are forgotten by the health care providers. 43.75% of the respondents confirm that their

appointments are usually forgotten while 15.63% say their appointments are sometimes forgotten and 18.75% claim their appointments are always forgotten making a high percentage of 78.13%

The patients were asked how often their appointments were cancelled by the health provider and not informed. This question was asked to find out if the current system was effective towards putting patients' priorities first. The results are shown in table 4.6 below

Table 6: Cancellation without notification

How often does your health provider cancel your but not inform you?	**Number of Participants**	**Percentage %**
Never	2	10
Sometimes	6	30
Usually	10	50
Always	4	20
Total	**20**	**100**

The above table brings to conclusions that when appointments are cancelled due to change in the doctors' schedules, the patients may not be informed which is very inconveniencing to them.

Table 7: Forgetting appointments by Patients

How often do you forget your appointment ?	**Number of Participants**	**Percentage %**
Never	4	20
Sometimes	6	30
Usually	9	45
Always	1	5
Total	**20**	**100**

Table 7 Depicts that it is not rare for patients to forget appointments that they made themselves. 45% of the respondents accept that they usually forget their appointments and 5% always forget them. This shows a need for usually and tirelessly reminding users of their appointments.

Table 8: Usage of Smart phones

Do you own a smart phone?	Number of Participants	Percentage %
Yes	21	65.6
No	11	34.4
Total	32	100

In order to implement the proposed system the researcher had to first find out if people actually owned mobile phones. Table 8 shows that more than half of the users already had smart phones therefore making the system implementable.

Table 9: Experience with mobile appointment systems

Have you used a mobile based appointment system before?	Number of Participants	Percentage %
Yes	6	18.75
No	26	81.25
Total	32	100

Question 10 asked users if they thought a mobile based appointment system would be better than the current system. The analysis looked at the responses in regards to the age group. From the analysis, it was observed that people between ages of 18 and 49 were more open to the idea of the proposed system unlike the older age groups. However the younger groups make up the bigger user population showing that the system will be well accepted by users. This is shown in table 10

Table 10: Acceptance of Intelligent Mobile phone based appointment management system according to age group

Age Group					Number of participants	Percentage%
Option	18 to 30	31 to 49	50 to 65	66 or older		
Yes	7	11	3	1	23	71.87
No	1	4	2	3	9	28.13

Total	**8**	**15**	**5**	**4**	**32**	**100**

Table 11: Adaptability to Intelligent Mobile phone based appointment management system.

Age Group					**Number of participants**	**Percentage%**
Option	**18 to 30**	**31 to 49**	**50 to 65**	**66 or older**		
Yes	6	9	2	0	17	53.13
No	2	6	2	4	16	46.88
Total	**8**	**15**	**5**	**4**	**32**	**100**

Question 11 asked users if it would be easy for them to learn using an intelligent mobile phone based system. As with adaptability, acceptance of the proposed system was analysed in comparison to age group. More than 50 percent expressed ease of learning the new system and most of these still from the younger age groups.

From the analysis in all the above tables, it is clear that the proposed system will be well accepted and improve appointment management.

4.2 Existing Appointment Scheduling System at Zion Health Centre Kitebi

The research was based on a case study which was Zion Health Centre located in Kitebi Kampala district. The Centre has seven departments comprising of Outpatient, Inpatient/Admissions, Maternity, Dental, Pharmacy, Laboratory and Administration departments. Having been in existence for five years, it has acquired a clientele of approximately one hundred fifty (150) patients. Unfortunately this ever growing number isn't equally matched by the number of health personnel who are twenty two inclusive of doctors, nurses, laboratory technicians, dentists and administrators. This has caused strain on their ability to deliver quality services and timely. This was observed by the researcher that many patients wait for hours before they are attended to due to failure to make appointments of lack of knowledge of cancellation of earlier made appointments since the administrators are overwhelmed by large numbers and often forget to efficiently perform

The current system is paper based but the administrator has excel documents where she later transfers daily activities, patient details and appointments at the end of the day. These are entered in summary just for accounting purposes. At the start of the day, each doctor reports to the administrator and briefs her about his days' schedule and the time he will be or not be available. The administrator records these details to later be used for making appointments. On reaching the hospital, a patient provides their details to the administrator alongside the reason for visitation. The administrator then checks through the doctors' schedules and assigns the appropriate doctor and time slot. The patient is given a card and told to wait.The first come first served system is usually applied and only interrupted in case of emergencies and causalities. If a patient cannot see the doctor that day, they are requested to come back the following day but if they come late, then one has to wait in line.

The researcher asked the users how what they expected from a mobile appointment system and major expectations from the patients included ability to know availability of the doctor even before they came to hospital, notification on appointment cancellation, personalized information about their common ailments, history of their bookings and being able to get routine medical advice that could reduce need for consultations. On the other hand the administrators expressed a keen interest in a system that could reduce their workload. They voiced that a mobile application that could make daily reminders without their input would be a welcome change. The health workers were intrigued too since forgetting of appointments would be reduced as from their expectation.

4.2.1 Analysis of Current System

The research involved system analysis. It is essential that the existing system is analysed to find the loopholes, how they can be fixed and how the good practices can be adopted in the new system.

4.2.1.1 Strength of existing system

The system is cheap to implement; given that most of the work is paper based there is limited consumption of utilities like electricity, hardware and software costs that may increase operational costs.

The System is easy to adapt to; anyone who is literate can use the system. There is no additional training or special expertise required to draw up schedules and update them. The

administrator enters patient details against their names and each patient has a page dedicated to their visits.

Majority of patients and doctors are familiar with the system; this is a system that has been in place ever since the establishments opened and is the same system used in many health facilities such that even new employees have used it before and easily adapt and operate it.

4.2.1.2 Weakness of existing system

Despite the above mentioned strengths, the researcher identified the following problems with the existing system.

The patients cannot know appointment status before reaching the hospital: whether the doctors are available or not, whether the doctor is fully booked and there is no possibility of seeing him, the patient can only find out when they reach the hospital. This causes frustration especially if one cannot secure an appointment after travelling to the health centre.

The retrieval of patient records is slow and tedious: every patient is recorded in the book and if they come back, the book has to be checked until their dedicated page is found. This slows down the operation of services and very tiring as reported by the administrator.

The system does not provide efficient real time services; Users do not receive real time information or feedback especially patients.

The system does not have a reminder function for either patients or doctors: Failure to remember appointments mostly stems from forgetfulness of patients. If they aren't reminded, chances of forgetting are very high making it a disadvantage of the existing system.

The administrators are overwhelmed with keeping track of patients schedules with doctors: Coordinating hospital activities sometimes becomes too taxing for the limited employees. It is therefore not a surprise that the administrator may sometimes forget to call clients to cancel appointments or even remind them of their upcoming appointments. Sometimes there are so many patients giving them appropriate time slots and doctor becomes tricky given the dynamic nature of doctor's visits.

The system does not have a reliable backup mechanism for the patient and doctor information: The researcher observed that excel documents are kept as inform of a summary of all the day's transactions and activities is stored in these but mainly for accounting purposes. In case of fire or any disaster, chances are that there may be no data left

The system is mainly manual and an administrator is needed to coordinate doctors and patients.

4.2.1.3 Solutions to the weakness of the current systems

The proposed system envisions solving the above problems by providing the following solutions;

i. The Intelligent mobile telephone based system will provide real-time feedback to the patients, making the response time faster.

ii. It will ensure there are no clashing schedules

iii. It will also ensure reliable interaction between the patients and the doctors through messaging and direct calls for reminders of appointments mechanism to ensure maximum coordination

iv. Being a mobile application, it will be much more easily accessible and portable compared to the above systems that require the use of a computer or old fashioned box filling systems.

v. The system will minimize the work load and burden on the administrators since the appointments and any reschedules will be made without input from the administrators.

4.3 System Requirements

As mentioned earlier, doctors, medical officers and nurses were interviewed while patients were given questionnaires and subjected to informal discussions. Whatever information wasn't got from the above methods was derived from extensive document review, both from the internet and physical books together with paper records of the medical centre. The data collected from respondents through interviews, questionnaires and literature review enabled the researcher to provide a description of the current system and extract its weaknesses. This then informed requirements for the proposed Intelligent Mobile Phone based appointment management system as specified below.

4.3.1 Functional Requirements of the system

These describe what the system is meant to do, inputs that the system accepts, outputs produced, data stored, and what computations the system should perform.

I. The system should be able to register a user with a password.
II. The system should possess adequate intelligence to schedule the appointments on behalf of the patient and doctor.
III. The system should be able to schedule appointments according to the priority of the patients.
IV. The system should provide automatic system reminders before the appointment time begins.
V. The system should be able to cancel appointments and notify the users.
VI. The system should store patient records and appointments for future reference.

4.3.2 Non Functional Requirements of the system

Non-functional requirements are global constraints on a system for example, development costs, operational costs, performance, and reliability.

I. The system should allow access to only authorized users who are expected to have a username and password.
II. The system should be easy to learn and use by its user.
III. The system should be able to store the user content in a database
IV. The system should be fast and efficient even on low end phones (low computing power).
V. The system should be expendable for further development in future.

4.3.3 Software Requirements

The system requires minimum software to be Android 2.2 and above

4.3.4 Hard ware Requirements

The system requires minimum hardware requirements as listed below;

Processor: dual core 300 MHz or higher

Memory: 64 MB of RAM or higher

Hard Drive space: 15 MB or higher

4.4 System Design

The purpose of the systems design phase is to create a physical model that will satisfy all documented requirements for the system (Shelly and Rosenblatt 2012). In this section, system architecture, design specifications and logical designs of the user interface are shown.

4.4.1 Proposed System Design

The architecture of the proposed system is composed of agents and users. The Agents that comprise of hospital, Doctor and Patient agent negotiate appointments with each other while referring to the available time slots in the Mysql database running on Apache Server. The Front end is composed of a mobile application installed on the User's Android Phone. Users include Doctors, Patients and Systems administrator.

Architecture of Intelligent Mobile phone Based Appointment Management System

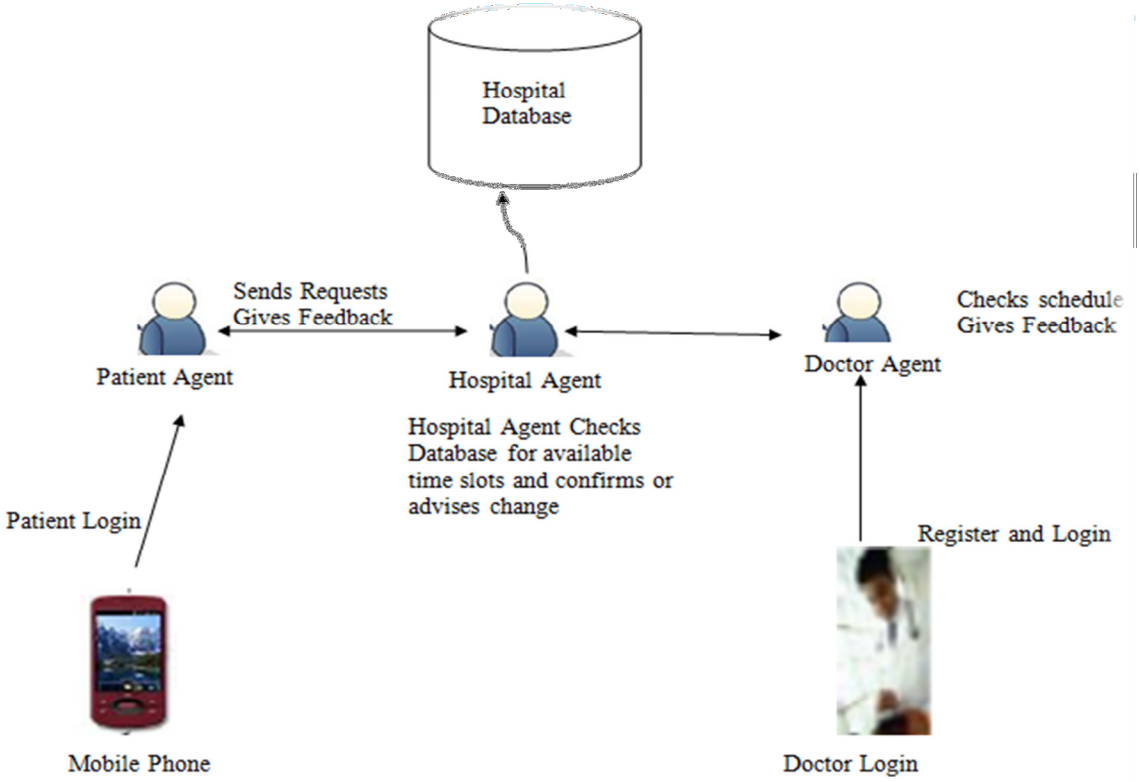

Figure 4. 1: Architecture of Intelligent Mobile phone Based Appointment Management System

4.4.2 Use Case Diagrams for the Intelligent Mobile based appointment management system

A use case diagram visually represents the interaction between users and the information system. In a use case diagram, the user becomes an actor, with a specific role that describes how he or she interacts with the system (Shelly and Rosenblatt, 2012).

The system has two major actors that, is the patient and doctor;

The Patient Actor: The patient is anyone who has the intent to see the doctor at any given time. The patient can register, login, make appointments and cancel appointments. The patient can also check their appointment history and details.

The Doctor Actor: The doctor can log in and view his appointments and make cancellations where he feels he cannot make the appointment.

The Administrator Actor: The administrator controls who is a doctor within the system and edits the health categories within the hospital but has no control over the schedules.

4.4.2.1 Use case Diagram for the entire System

The use case diagram depicts the user requirements that were collected during the study.

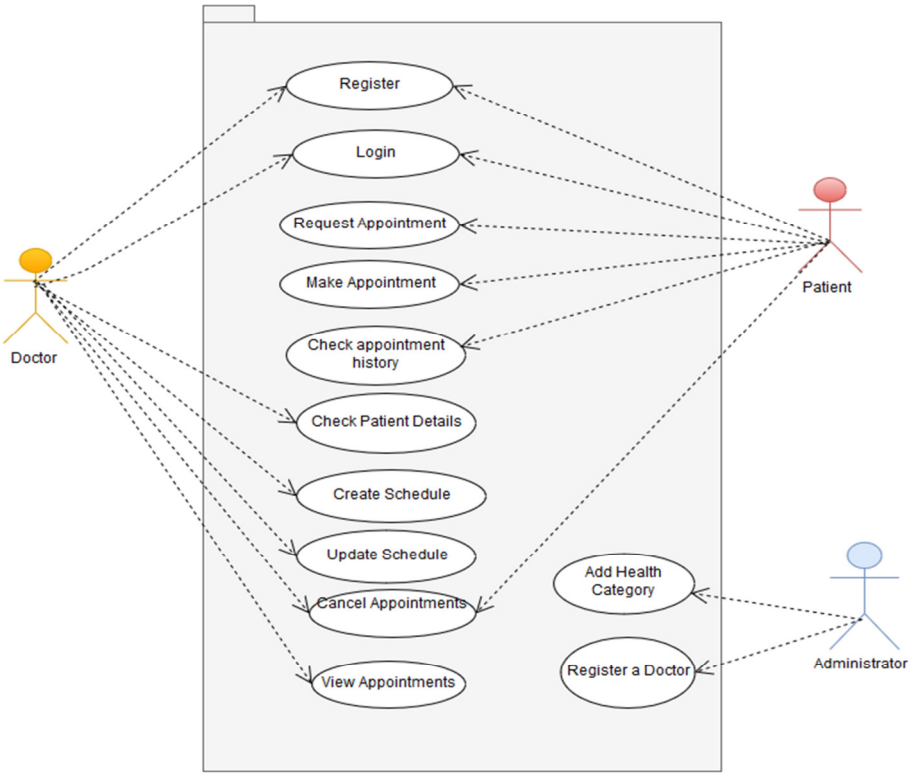

Figure 4. 2: Use case Diagram for the System

4.4.2.2 Use Case for Patient making and cancelling appointments

Actor: Patient

The use case begins when the Patient registers into the system. If they are already registered, they can log in directly. If they aren't registered, the user is required to enter their details after which they can become a registered user. On successful login, the patient can then make an appointment to see a doctor within a given time period. If the user wishes to cancel the appointment they can do so and that slot is then assigned to another patient. This is shown in figure 4.3

Use case Diagram for the Patient making and cancelling appointments

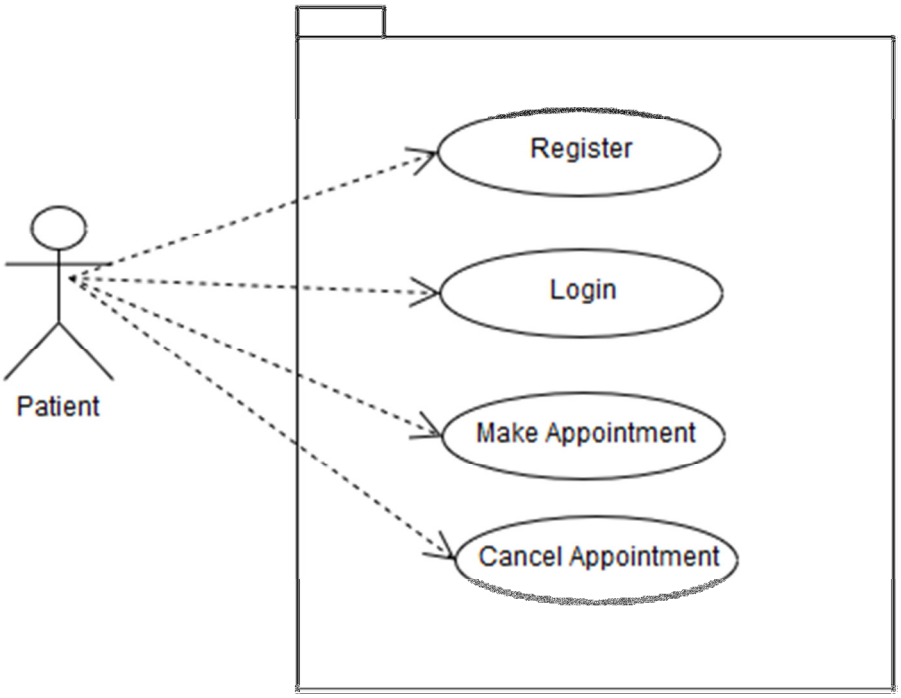

Figure 4. 3: Use case Diagram for the Patient making and cancelling appointments

4.4.2.3 Use case for Doctor Checking appointments

Actor: Doctor

The use case begins when the Doctor registers into the system. On Registration, the administrator has to first confirm that the user is a doctor. Once the account has been registered as one for a doctor he can then log in. When the doctor logs in, he can view his appointments with patients

and also cancel appointments that he feels he might not be able to fulfill. As illustrated in figure 4.4.

Use case Diagram for Doctor Checking appointments

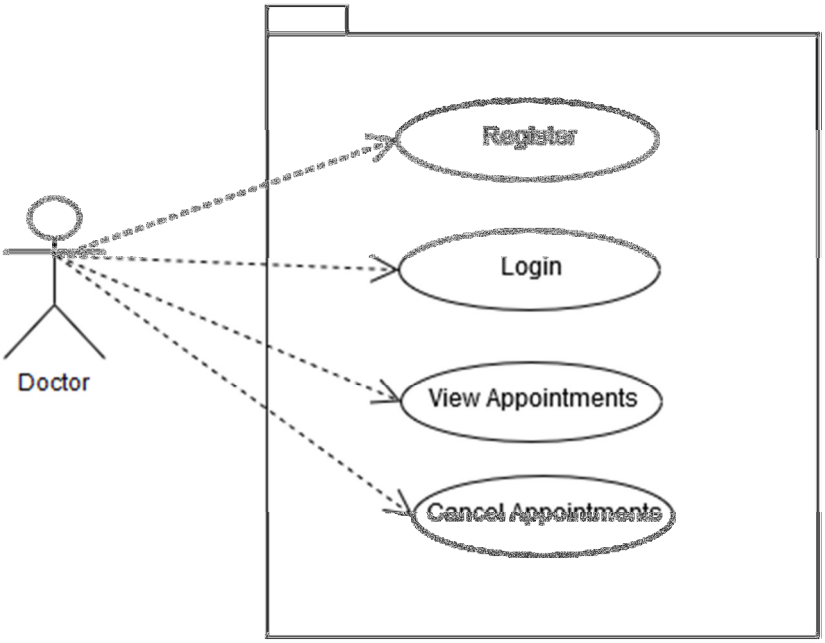

Figure 4. 4: Use case Diagram for Doctor Checking appointments

4.4.3 Sequence Diagram for the appointment request scenario by Patient

A sequence diagram shows the timing of interactions between objects as they occur. Below is figure 4.5 showing a scenario of a patient making an appointment.

Sequence Diagram for the appointment request scenario by Patient

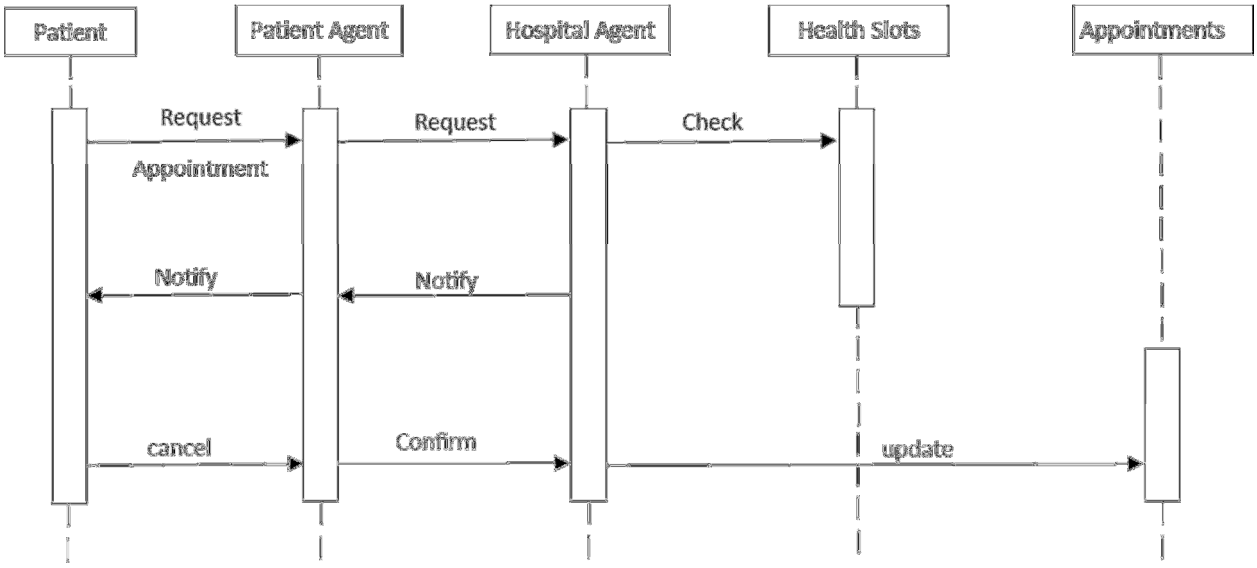

Figure 4. 5:Sequence Diagram for the appointment request by Patient

The Patient initiates the process by requesting for an appointment. The horizontal arrows show the messages exchanged among the objects.

4.4.4 Activity Diagram to show events in adding a health category by Administrator.

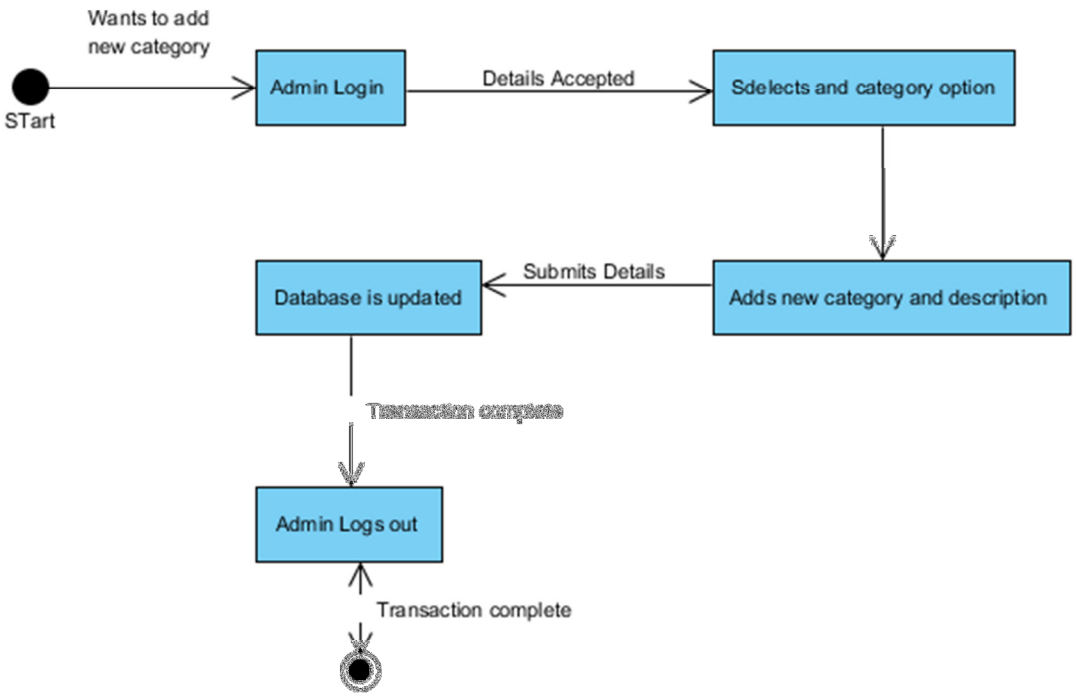

Figure 4. 6:Activity Diagram to show events in adding a health category by Administrator.

4.4.3 Process Flow diagram for the entire system.

The process flow diagram shows the core steps followed by the agents to check schedule, schedule appointments or cancel them.

Process Flow Diagram

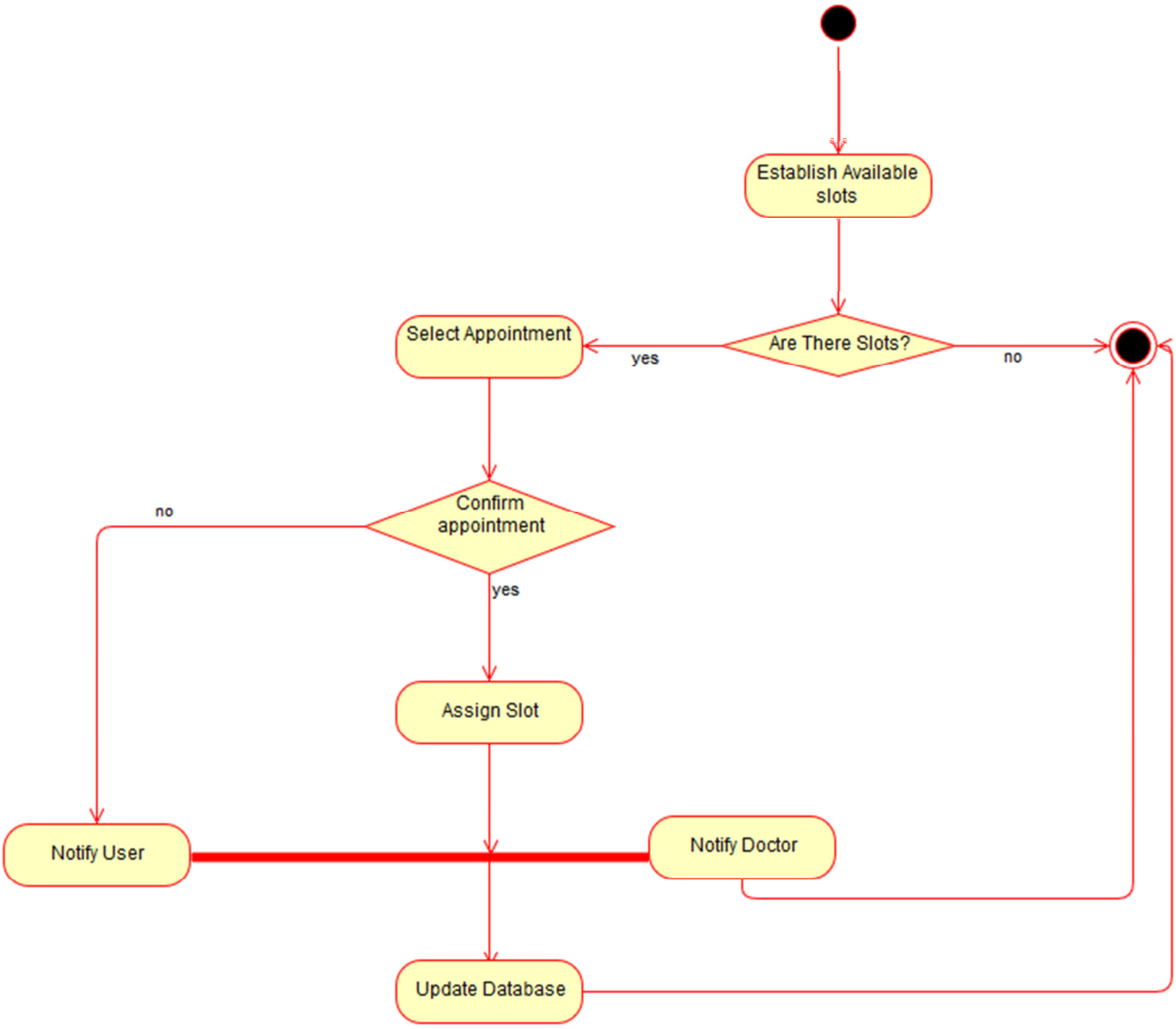

Figure 4. 7: **Process Flow Diagram for Appointment Scheduling.**

From the Figure above, we can see that when the user requests for an appointment, the patient agent establishes whether there are available slots and if none notifies the user. If slots are available then the selected slot can be allotted to the patient. On successful assignment of a slot the system then notifies both patient and doctor. The system has to notify the user of all outcomes of the agent negotiations that is if the appointment has been scheduled or the user needs to ask for another slot.

4.5 Conceptual Agent Model and Design.

Agent design is defined by Foundation for Intelligent Physical Agents (FIPA) standards and is illustrated as below

The Agent System Design

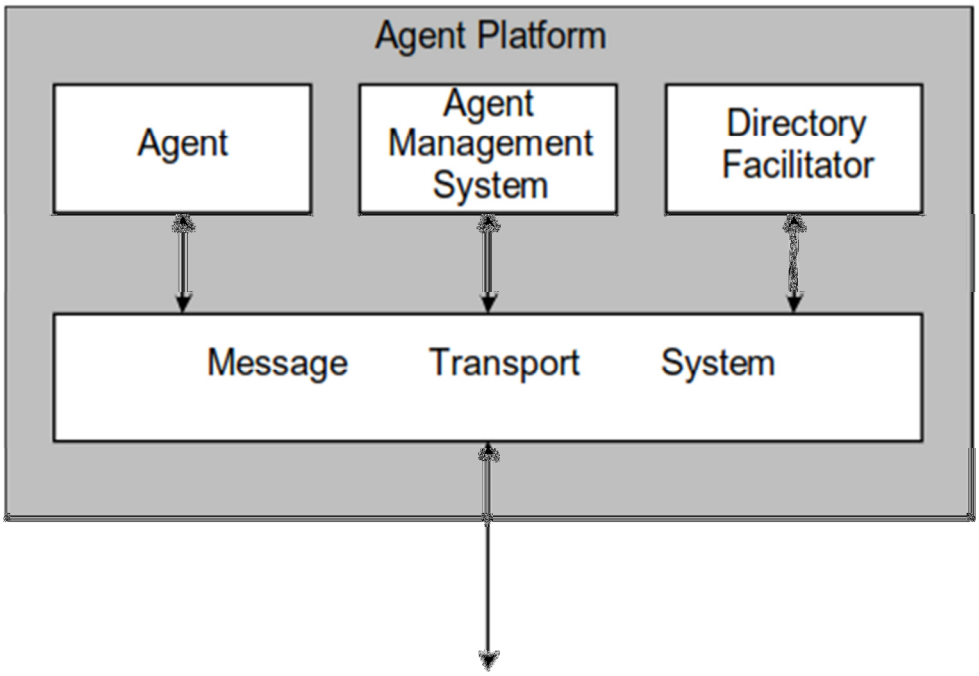

Fig 4.6: Agent System design

This is a representation used to understand how the agents in the system will communicate and achieve tasks. The Agent Management System (AMS) is the agent who exerts supervisory control over access to and use of the Agent Platform. Only one AMS will exist in a single platform. The AMS provides white-page and life-cycle service, maintaining a directory of agent identifiers (AID) and agent state. Each agent must register with an AMS in order to get a valid AID. The Directory Facilitator (DF) is the agent who provides the default yellow page service in the platform. The Message Transport System, also called Agent Communication Channel (ACC), is the software component controlling all the exchange of messages within the platform, including messages to/from remote platforms. JADE fully complies with this reference architecture and when a JADE platform is launched, the AMS and DF are immediately created. Furthermore the Messaging Service (implementing the ACC component) is always activated to allow message-based communication. The agent platform can be split on several hosts. Typically (but not necessarily) only one Java application, and therefore only one Java Virtual Machine

(JVM), is executed on each host. Each JVM is a basic container of agents that provides a complete run time environment for agent execution and allows several agents to concurrently execute on the same host. The main-container is the container where the AMS and DF lives. The other containers, instead, connect to the main container and provide a complete run-time environment for the execution of any set of JADE agents (Bellifemine et al, 2010).

4.6 Database design

Database design involved coming up with the database structure for the Intelligent Mobile Phone based appointment system. It was comprised of designing the conceptual, Logical and physical database.

4.6.1 Conceptual and Logical Design

An Entity relationship Diagram was drawn to explain the relationships between the attributes as well as the requirements for the system. The Entity Relationship Diagram shown in figure 4.8 below is a representation of the logical database design showing how the various entities connect and interact with each other. It mainly shows the relationships between the entities as well as their attributes.

Entity Relationship Diagram for the proposed system

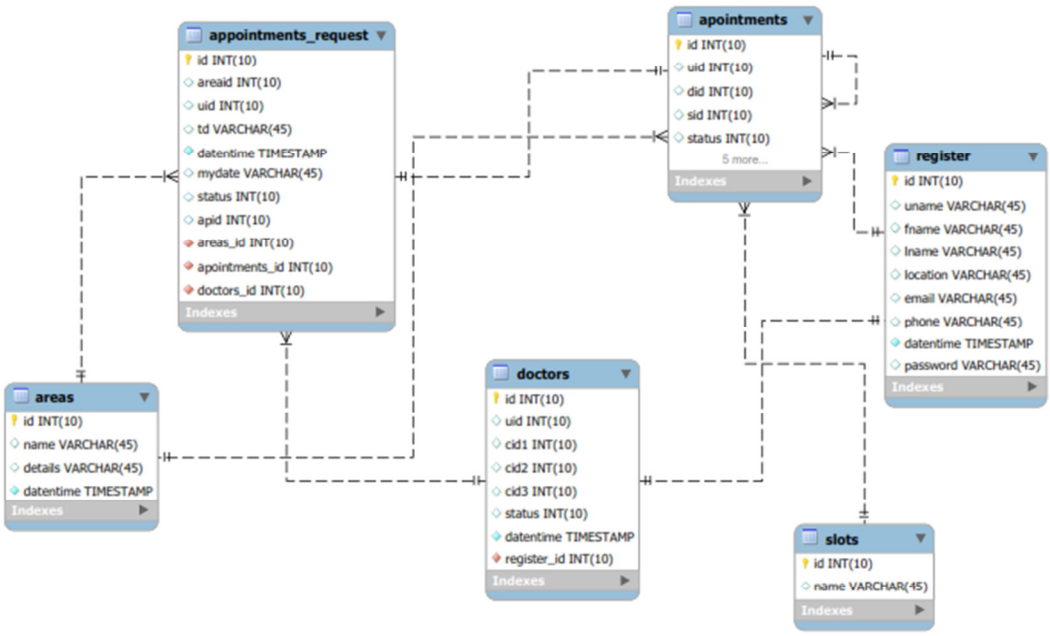

Figure 4. 8: ERD for an Intelligent Mobile Phone Based Appointment Management System

4.6.2 Physical Database Design

The physical database was generated from the logical design to come up with normalized tables as Illustrated in the following tables.

User Registration Table

Table 12: **User Registration**

Field	Type	Null	Default	
id	int(10)	No		
uname	varchar(45)	Yes	*NULL*	
fname	varchar(45)	Yes	*NULL*	
lname	varchar(45)	Yes	*NULL*	
location	varchar(45)	Yes	*NULL*	
email	varchar(45)	Yes	*NULL*	
phone	varchar(45)	Yes	*NULL*	
datentime	timestamp	No	CURRENT_TIMESTAMP	
password	varchar(45)	Yes	*NULL*	

Indexes:

Keyname	Type	Cardinality	Field
PRIMARY	PRIMARY	5	id

Table 13: Appointments

Field	Type	Null	Default	
id	int(10)	No		
uid	int(10)	Yes	*NULL*	
did	int(10)	Yes	*NULL*	
sid	int(10)	Yes	*NULL*	
status	int(10)	Yes	1	1=logged 2=scheduled 3=done
datentime	timestamp	No	CURRENT_TIMESTAMP	

Indexes:

Keyname	Type	Cardinality	Field
PRIMARY	PRIMARY	6	id

Table 14: Appointment Requests

Field	Type	Null	Default	
id	int(10)	No		
areaid	int(10)	Yes	*NULL*	
uid	int(10)	Yes	*NULL*	
td	varchar(45)	Yes	*NULL*	
datentime	timestamp	No	CURRENT_TIMESTAMP	
mydate	varchar(45)	Yes	*NULL*	
status	int(10)	Yes	*NULL*	1=logged 2=scheduled 3=done
apid	int(10)	Yes	*NULL*	

Indexes:

Keyname	Type	Cardinality	Field
PRIMARY	PRIMARY	12	id

Table 15: Appointment slots

Field	Type	Null	Default	
id	int(10)	No		
name	varchar(45)	Yes	*NULL*	

Indexes:

Keyname	Type	Cardinality	Field
PRIMARY	PRIMARY	15	id

Table 16:Hospital Departments

Field	Type	Null	Default	
id	int(10)	No		
name	varchar(45)	Yes	*NULL*	
details	varchar(45)	Yes	*NULL*	
datentime	timestamp	No	CURRENT_TIMESTAMP	

Indexes:

Keyname	Type	Cardinality	Field
PRIMARY	PRIMARY	8	id

Table 17: Doctor's Details

Field	Type	Null	Default	
id	int(10)	No		
uid	int(10)	Yes	*NULL*	
cid1	int(10)	Yes	*NULL*	
cid2	int(10)	Yes	*NULL*	
cid3	int(10)	Yes	*NULL*	
status	int(10)	Yes	*NULL*	
datentime	timestamp	No	CURRENT_TIMESTAMP	

Indexes:

Keyname	Type	Cardinality	Field
PRIMARY	PRIMARY	30	id

CHAPTER FIVE

SYSTEM IMPLEMENTATION AND DISCUSSION OF RESULTS

5.0 Introduction

In this chapter we clearly document how the earlier designs both conceptual and logical were implemented to form a working system. In addition the implementation of the graphical user interface is shown. In this phase, the real coding was done and a feasible system implemented.

5.1 Implementation Plan

This section shows the different activities, deliverables and tools that were carried out during the implementation of the system as listed in the table.

Table 18: Implementation Plan

Activity	**Deliverables**	**Tools Used**
Programming	• Implementing GUI components. • Realizing Agents • Link interface to database	• Eclipse, JadeLeap platform and MySql database.
Testing	• Inspection of code for predictable errors • Perform unit and functional testing • Test with various Android Emulators ranging from low end to high end phones. • Security testing and Authentication	• Eclipses • JadeLeap platform BlueStacks Android Emulator
Performance and stress testing	• Measure response times for key components like Scheduling and schedule prioritization	• Eclipse and Mobile Phone running android

5.2 Database Implementation

The database was created using MySQL and the database is running on the MySQL server.The database and all the defined components were designed and generated using MYSQL server, the tables and their constraints namely, primary keys, unique keys, foreign keys and indices were well defined. Primary keys were used to uniquely identify all records while foreign keys were meant to ensure that data is well represented in other tables.

Screen shot of the database and database tables

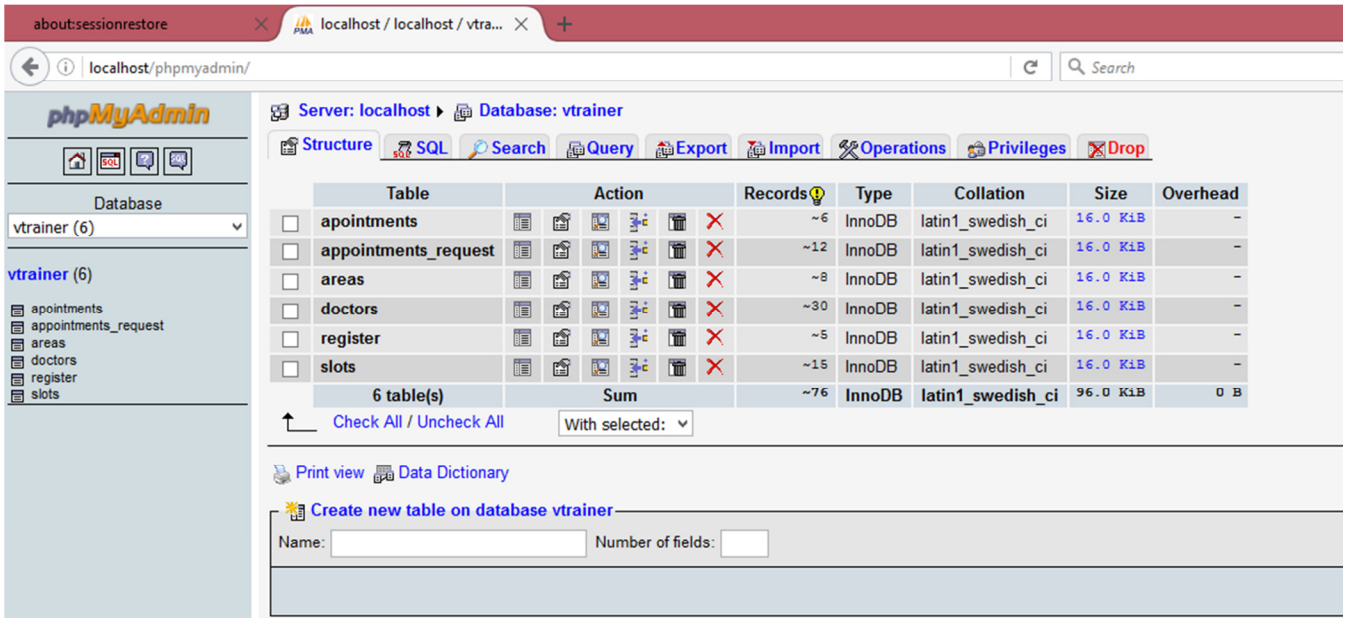

Figure 5. 1: Screen shot of the database and database tables

5.3 System Implementation

The system implementation process included agent implementation, user interface and business logic and implementation of test plans. In the process of coding, the logical, physical design models and specifications were transformed into machine language.

5.3.2 Graphical User interface Implementation

The GUI was developed to run on a mobile phone as an android application. The following figures show the implementation for each system user.

User Registration

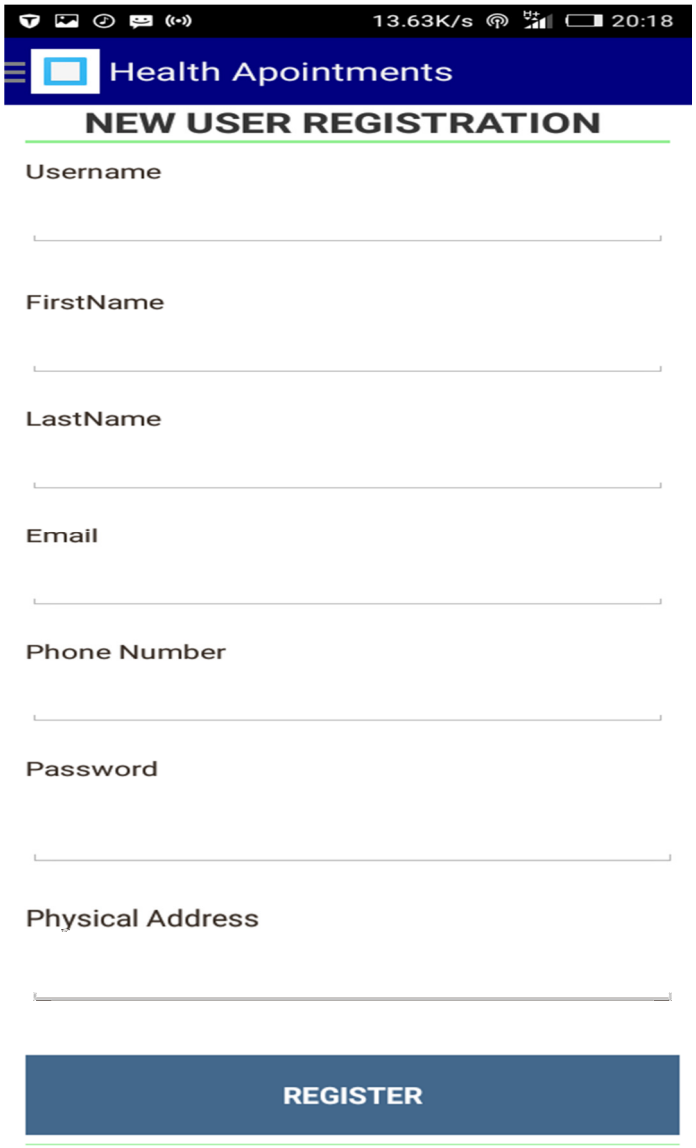

Figure 5. 2:User Registration Interface.

Figure 5.2 shows the User registration page. Before someone can use the system, they hace to register and use it as a member. The user registration page accepts input of data like User name, Email, Phoe number, among details. After succesfull registration one should be able to access the application an time anywhere. All users register as normal users but the administrator remains with the right to select them as doctors.

Interface for User Login

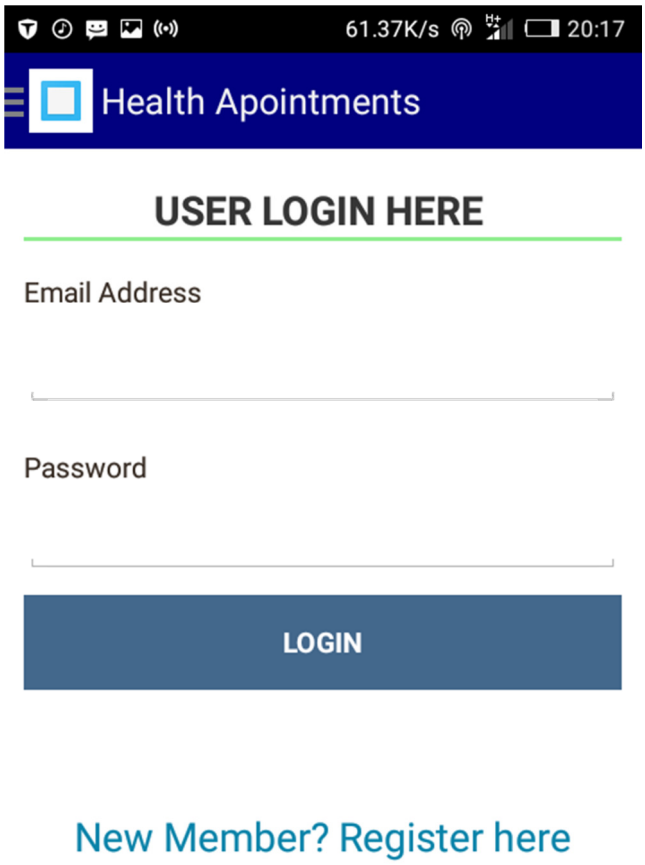

Figure 5. 3: User Login

This interface illustrated in figure 5.3 provides access to the system to registered users. It is generated when the user clicks n the "Login" button. They can enter their user name and password. This accepts all users to login and their views are determined by the administrator's selection of their roles in the system.

Interface for the patient to request for appointment

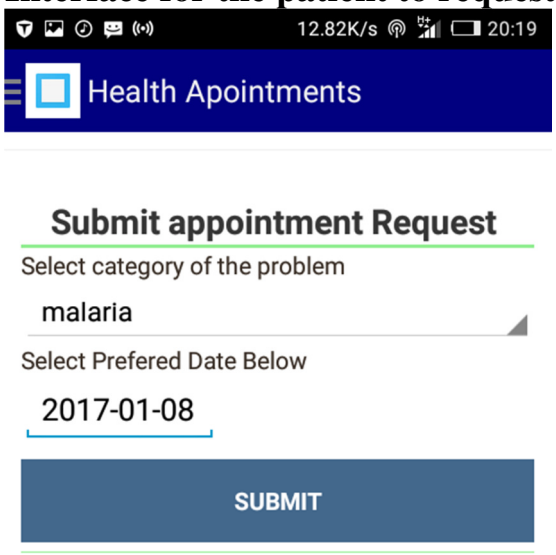

Figure 5. 4: Submit appointment Request

At this point the patient can make a request for an appoitment. The category of the disease is selected as well as the preffered date of appointment. These details are submitted when the patient clicks the submit button.

Interface for user to Cancel Appointment

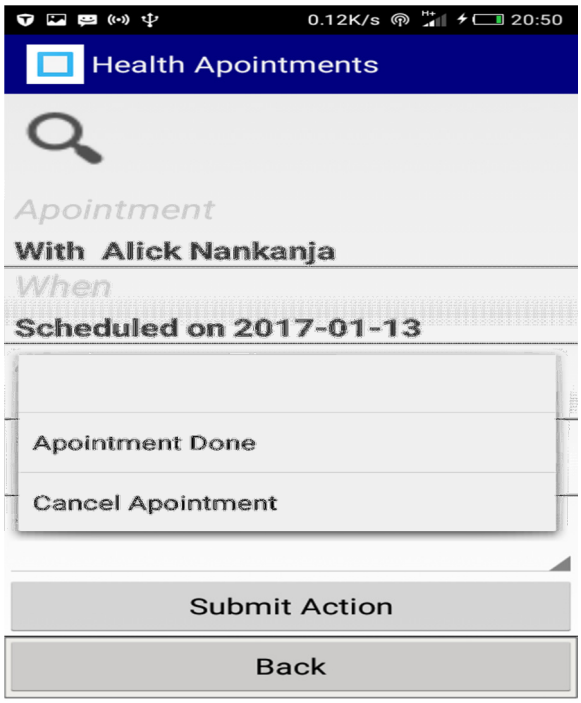

Figure 5. 5:Interface to Cancel appointments

This is used by both the patient and doctor to cancel appointments they aren't going to honor thus creating slots for other patients who may need them.

Interface for Doctor's view of Appointments

Here the doctor can view his upcoming, cancelled or completed appointments. It is useful in helping the doctor plan his day and schedule

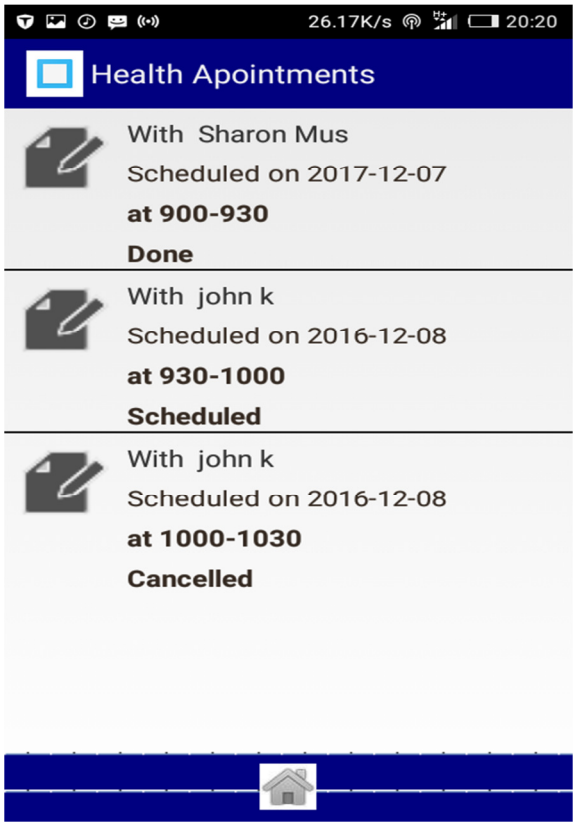

Figure 5. 6: Interface for viewing of appointments by the doctor.

Interface for Administrator tasks

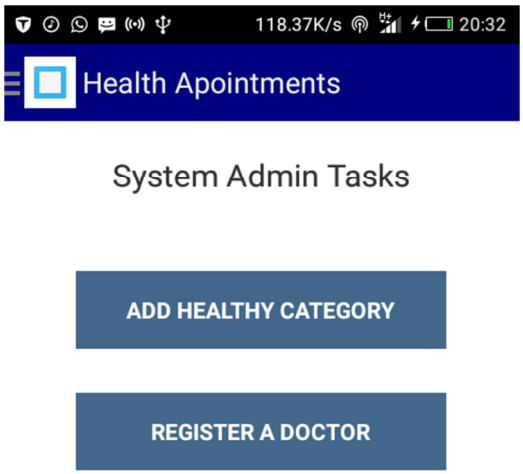

Figure 5. 7: Interface for Administrator Duties

The above interface shows the two major functions of the administrator in the system. That is adding the hospital departments as they are created and also specifying who the doctors are in the system as illustrated in figures 5.8 and 5.9.

Interface for specifying doctors in the system.

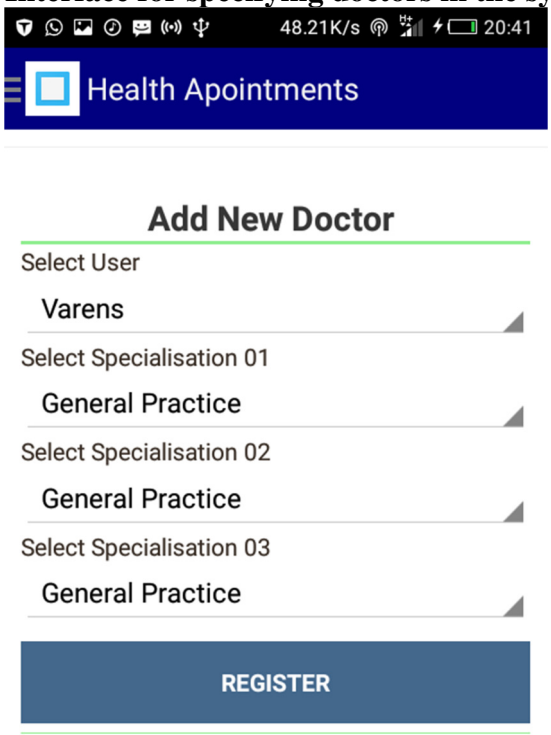

Figure 5. 8: Interface for specifying doctors in the system.

Interface for Adding a Health Category

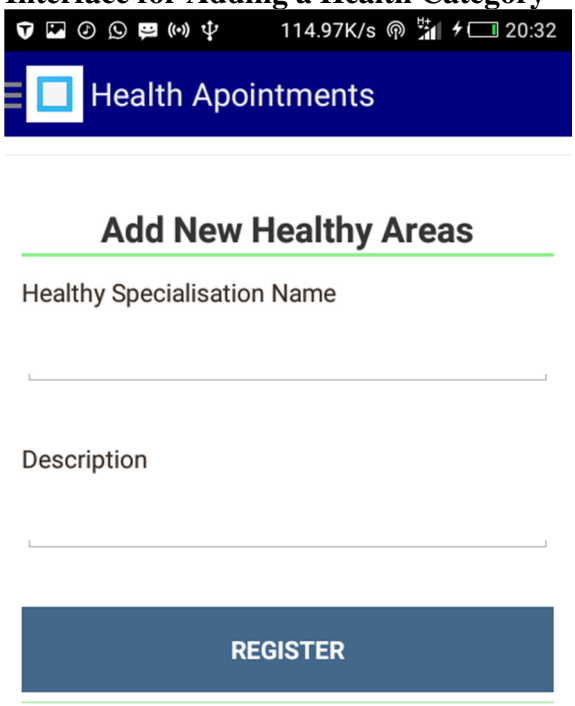

Figure 5. 9: Interface for Adding a Health Category

5.4 System Testing

Before installation on Users' devices, system testing was carried out. Various testing techniques were used to find out faults and errors where the behavior of the system did not match specification. The system was tested for errors and to ascertain that it fulfilled user requirements.

5.4.1 System Test Results

Table 19: System Test Results

Classification	Objective of test	Technique	Outcome
Unit Testing	Identify and eliminate errors at runtime	Sub-testing of all user functions to find errors	Doctor and patient able to make and cancel appointments
Integration Testing	Confirm that transactions depending on each other communicate seamlessly	Updating user's status and login users to confirm change of	Doctor and patient have different functionalities as

		status	specified by the administrator
Systems Testing	To find out if all system components meet all defined specifications	Inputting valid and invalid data	System capable of handling all transactions appropriately valid or invalid
Compatibility Testing	To evaluate the application's compatibility with various computing environments	Installation of APK on different mobile telephones with different versions of Android and emulators	The application was able to run on phones with Android version 2.2 and above

5.5 System Evaluation.

System evaluation was done using prototyping. A system with core components was given to the target users acting as experts. They were trained on how to use the system and user feedback was collected. Validation was done using the following principals.

i. Usefulness

Users were encouraged to give their views on how applicable the system was to appointment scheduling and what features were really useful or could be added.

Table 20: Usefulness of the system designed based on questions provided to the users

Question	Yes(%)	No(%)
1. Is the system Useful?	86	14
2. Do you like the appointment functionality of the System?	90	10
3. Can it be adopted for use?	75	25

ii. Usage

This was used to determine how the system is likely to be adopted for use, it was used to validate whether the provided guidelines of the newly developed system are clear and was also used to

show how users feel when using the system and to determine whether users feel comfortable with the system

Table 21: Usage of the System designed based on the questions provided to the users

QUESTION	Yes(%)	No(%)
1. Do you think the system will be adopted?	70	30
2. Are the guidelines of the system clear?	83	17
3. Are people comfortable using the system?	62	38

iii. Usability

This was used to check whether the system interface is easy to navigate, what users really like most about the system and was used to validate whether the interface is easy to navigate

Table 22: Usability of the System designed based on the questions provided to the users

QUESTION	Yes(%)	No(%)
1. Is it easy to navigate the system?	78	22
2. Do you think any improvements should be made in the system?	57	43
3. Is it easy to understand the system?	95	5
4. Do you like the responsiveness of the system?	85	15

Based on the above analysis carried out to validate the system, we verified the urgent need for the system from the users. Using the principles of usability, usefulness and usage, we were able to ascertain that over 80% of all users who answered the questionnaires, had positive responses towards the developed system.

5.6 Discussion of results and Conclusion

The main objective of the research was to develop an intelligent mobile phone based appointment management system to improve hospital schedule management. Testing was done

as shown in table 22 and the system fully satisfied the functional, non-functional and system requirements. Therefore, it can be anticipated that research project was successful since the system fulfilled the user requirements. Given the fact that Agent technology on mobile platforms is growing rapidly and simplifying human functions whereas being highly adapted across different areas of computing like robotics and Engineering, it is essential that we use it to our advantage to improve daily tasks while reducing human errors. (similarities between my work and other works)

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This chapter provides a summary of what has been achieved by the implementation of this research project. In it, the researcher provides what was achieved, the challenges faced during the entire process of coming up with the Intelligent Mobile Phone Based Appointment Management System as well as recommendations for future work on the system.

6.1 Report summary

This sub-section presents a summary of the study that was aimed at solving the appointment scheduling problem in health centres. It presents the aim of the study, objectives, and how these were achieved, the challenges and successes which were all presented in six chapters as shown below.

For fixing appointments in respect of health applications, we normally employ a human agent to get the work done at the appropriate health care facility. The study was to improve hospital schedule management but to achieve this; research was carried out to find out how this can be improved. To achieve this objective, the researcher had to study other existing and related systems through extensive document review as well as field work that involved interviewing the target audience directly, distributing questionnaires, among others. This put into light what the exact problem was and what others had done to try to solve the scheduling problem. The researcher then sought for a feasible methodology on how hospital scheduling would be simplified in chapter three. As a result of collecting data and information about the current system, requirements for the new system were derived and its design as elaborated in chapter four. The implementation was then done in chapter five basing on the guidance got from chapter three and four. This chapter provides a summary of the research report and shares the challenges that were encountered during the research. It also provides recommendations of how to improve hospital schedule management and pointers for further research.

6.2 Challenges

Many challenges were faced by the researcher when undertaking the research. They were personal, political and institutional. Getting in touch with respondents proved difficult for most of them had limited time to respond to cause of system analysis.

Understanding the operation and implementation of smart agents proved to be taxing since related systems are more or less non-existent in Uganda and most work was found online. This was most evidenced when no solution would be found for an error.

The patients were sceptical on the use of their details by the health centre. Fortunately they later consented after explanation as to how data will be secured from unauthorised access. The older patients believed their details maybe used wrongfully.

The researcher had to learn new Technologies like JadeLeap and this took a lot of time to get familiar and efficient with these techniques. Advanced Java had to be learnt too since Jade had to be implemented with a Java Development Environment to fully perform the proposed functions.

6.3 Recommendations

The healthcare industry providers globally are experiencing increasing pressure to concurrently reduce cost and improve the access and quality of care they deliver. Any healthcare institutions are confronted with long waiting times, delays, and queues of patients. Effectively managing patient flow in an outpatient unit is a key to achieving operational excellence as well as ensuring clinical quality and customer satisfaction. Therefore all stakeholders should always be looking at better and easier ways of achieving these goals.

There is a great need to educate health workers on the need for appointment scheduling using current technologies since they will come to appreciate how easily they cut down their workload. Mobile agents can replicate the job of the human being. Hence helping the health workers in the long run.

6.4 Suggestions for future research

The study outcome was an intelligent mobile telephone based appointment management system that that was implemented using intelligent agents. The Agent gathers the information from the user and schedules appointment with the doctor. The Agents here possess adequate intelligence to schedule the appointment.

However more research should be done to see how if no available doctors, a patient can be redirected to another hospital. AIso, more work should be done to integrate other hospital functions in addition to scheduling but using smart agents for example follow up checkups, Duty rotas for the hospital staff and prescription reminders.

6.5 Conclusion

This chapter summarized the whole report by breaking down what was done in each of the chapters. It further discusses the experiences and challenges faced by the researcher as the study was being carried out. It also made recommendations and suggestions for future research.

The study did not cover all hospital activities but concentrated on appointment scheduling for patients and doctors.

APPENDICES

Appendix 1: Questionnaire

Survey questionnaire filled in by Zion Medical Centre staff and patients.

Objective: To collect data which will be used to determine the applicability of mobile telephone based appointment management system in hospital scheduling.

My name is Nankanja Bridget a student of Masters of Information Systems at Uganda Martyrs University. As part of my masters research thesis, I am conducting a survey to identify the need for an Intelligent mobile-phone based appointment management system in hospital scheduling. The results will be used to develop a model and implement said system as well as further studies to better improve hospital scheduling.

Information gathered during this survey will strictly be confidential and only used for academic purposes.

Thank you.

Instruction: Check the correct option(s)

1. What is your sex?
    - Male
    - Female

2. What is your age?
    - 18 to 30
    - 31 to 49
    - 50 to 65
    - 65 and above
3. What is your position in the hospital?
    - Doctor
    - Nurse
    - Patient
    - Administrator

4. How often do you make appointments?
    - Very often
    - Often
    - Rarely
    - Very rarely

5. In the past few months, how often has your doctor forgotten your appointments?
    - Very often
    - Often
    - Rarely
    - Very rarely

6. How often has your doctor cancelled your appointment but not informed you?
    - Never
    - Sometimes
    - Usually
    - Always
7. How often do you forget your appointments?
    - Never
    - Sometimes
    - Usually
    - Always

8. Wait time includes the time spent in the waiting room and exam room. In the last 12 months, how often did you see your health provider within 15 minutes of your appointment time?

    - Never
    - Sometimes
    - Usually
    - Always

9. Do you own a smartphone?
    - Yes
    - No

10. Have you used a mobile appointment system before?
    - Yes
    - No
11. Do you think learning to use a mobile application will be easy?
    - Yes
    - No

Appendix ii Java Code Snippet for creation of the Agents in the system.

```
public class Main {
   public static void main(String[] args) {
    /*****************************************************************/
    Runtime rt=Runtime.instance();
    ProfileImpl p=new ProfileImpl();
    p.setParameter(Profile.MAIN_HOST, "localhost");
    p.setParameter(Profile.GUI, "true");

    ContainerController cc1=rt.createMainContainer(p);

    /**************creation of 5 police agents*****************/
    for(int i=1; i<6; i++)
    {
       AgentController ac1;
    try {
        ac1=cc1.createNewAgent("PatientAgent"+i, "Agents.PatientAgent", null);
        ac1.start();
    } catch (StaleProxyException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    }
      for(int j=1; j<4; j++)
        {
       AgentController ac2;
    try {
        ac2=cc1.createNewAgent("DoctorAgent"+j, "Agents.doctorAgent",    null);
        ac2.start();
    } catch (StaleProxyException e) {
           e.printStackTrace();
     }
     }
       }
      }    }
```

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