DEVELOPMENT OF A MULTI-PLATFORM HOSPITAL APPOINTMENT MANAGER

(CASE STUDY OF JOS UNIVERSITY TEACHING HOSPITAL)

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2013/1/46756CI

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November, 2019

ABSTRACT

Appointment scheduling is a common procedure in businesses, organizations and establishments. Healthcare institutions are not left out; patients book for appointments in order to consult medically trained personnel based on agreed upon time or schedule. This is not the case observed in the Jos University Teaching Hospital, Jos, Plateau State where patients queue up as early as six o'clock just so they can see a physician on time. This procedure of coming to the hospital without prior arrangement with the hospital or physician often results in long waiting times for the patients. To solve this long waiting time, an automated online booking system is proposed in this thesis.

The proposed system (web and mobile) will enable patients book appointments online and receive a reminder notifications concerning their pending appointment.

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CHAPTER ONE

INTRODUCTION

This chapter introduces the substance (reduction of waiting time for patients) of the project to be undertaken, the problem identified with the present system in operation, the importance or significance of the incremented solution proposed, how the solution will be realized and achieved, its boundary or scope, organization of the study, and definition of terms relevant to the study.

1.1 Background of the Study

Clinic appointment booking system has been one of the main obstructions for hospitals to increase the quality of their service (Zhan & Liu, 2013). Particularly for those high-level tertiary hospitals having large turnouts of patients at the outpatients' department. Congestion in the outpatient especially in public (government owned) hospitals is considered a common phenomenon (Mohebbifar et al., 2014). Online appointment registration system to see a doctor has been implemented and is getting popular in some developed countries. The rising population and health-need due to adverse environmental conditions have led to escalating waiting times (Derlet, Richards, & Kravitz, 2001).

Queuing theory is used extensively in engineering and industry to analyse and model processes involving waiting lines. In appropriate systems, it aids managers in calculating the optimal supply of fixed resources necessary to meet a variable demand. In the past, attempts have been made to apply queuing analysis to a variety of hospital activities, including cardiac care units, obstetric services, operating rooms and emergency departments, as a means of directing the allocation of increasingly scarce resources. Recently, health policy researchers have also sought to apply these techniques more widely across entire healthcare systems (Olorunsola & Adeleke, 2014).

A queue is described by the way in which customers (i.e. procedures) join in order to wait for service, and by the way in which customers already in the queue are selected for servicing. Queuing is an integral part of any service delivery system (Chowdhury, 2013), a queue is formed usually when the demand for a service is higher than the supply of the service (Kandemir-Cavas & Cavas, 2007). Queues become inevitable in our everyday lives especially when the demand exits the supply of a service or product (Augustine & Agu, 2013); its most essential form realizes the benefits of evenhandedness to customers/patients based on the order of their arrival. Customer or patient service oriented organizations are currently challenged with persistent queues. We queue when we get to the bank, at the bus stop, at shopping malls, in hospitals, airports and even virtually on the internet when many users bombard a computer server with loads of requests. These queues become most intense during peak hours. Failure to manage such queues efficiently often leads to mounting pressure on both employees and customers. This often results in customers migrating to other companies or organizations to seek better service, and of course it decreases employee job satisfaction (Biju, Faisal, & Naeema, 2011).

A hospital, to a lay man is a healthcare organization that is concerned with the restoration of health and the preservation of life in some cases (Mosadeghrad, Ferlie, & Rosenberg, 2011). It is defined comprehensively as an institution for the treatment, care, and cure of the sick and wounded, for the study of disease, and for the training of physicians, nurses, and allied health care personnel (Farlex, 2012).

Long waiting queues are a major issue in healthcare institutions, even with a good measure of resources dedicated to hospital finance (Siciliani, 2005). The time a patient spends waiting in the system is the space of time between when the patient is joins the waiting list and when he is served or attended to (Rotstein & Alter, 2006). This waiting list is the list of patients enrolled in once they decide to follow an elective procedure given that this procedure cannot be performed immediately (Conner-Spady, Sanmugasunderam, & Noseworthy, 2004). Waiting queues are becoming a norm in hospitals (General Hospitals in particular), it is now a common thing to see patients queuing for hours before gaining any sort of medical attention or service. In standard business institutions, this will often result in the loss of customers and customer dissatisfaction for those who still remain (Yechiali, 2007). In the health institution however, prospective patients often have no choice but to continue waiting especially in public hospitals due to the high cost of obtaining medical services in private situations.

1.2 Statement of the Problem

It has become a common occurrence at the Jos University Teaching Hospital (JUTH) to have consultation queues forming up at the General Out Patient Department as early as six o'clock in the morning. This often leads to a very long waiting time for the patients, with the result that some of these early arriving patients are still not able to see a physician within the day. It is no longer headlines that some patients spend days before receiving any medical attention. These existing queuing system — if it qualifies to be called a system at all — is grossly inefficient in respect to time and resources and ultimately it puts the health of the waiting patients at great risks. Cases of patients passing out while on such queues have been recorded (Owoseye, 2018).

It is in view of the above that this thesis proposes the development of a queue management system (queue manager) that will greatly reduce the waiting time at the JUTH General Out Patient Department (G.O.P.D) and the problems associated with it.

1.3 Significance of the Study

This study is undertaken to bring to minimise the silent hardships and challenges faced by patients as they seek medical attention in hospitals or health care centres in general. The worth or importance of implementing a hospital queue manager will achieve the following:

i. Reduction of patients' waiting time through its appointment booking function. This means that patients will now receive medical attention at specified times.
ii. It will increase the effectiveness of service delivery in the hospital.
iii. It will improve patients' satisfaction to the credit of the healthcare system.

1.4 Aim and Objectives

The aim of this project is to deal with indefinite patient waiting time by developing an online hospital queue manager. To realize this aim, the procedure outlined below will be followed faithfully:

i. To gather data from the hospital (JUTH) on the existing system of appointment booking.
ii. To use queue theory to determine the appropriate queuing model for the system.
iii. To apply the model in designing an automated hospital appointment system with a web- and mobile-based solution.
iv. To realizing the system through the use of PHP, CSS, HTML, SQL and Java Scripting technologies.
v. To test-running the system for effectiveness.

1.5 Scope and Limitation of the Study

This project is intended to solve the problem of patients having to wait indefinitely in hospitals as part of the appointment process to see a medical officer or a consultant as the case may be. It is designed to be a subset of a Hospital Record Management System and as such does not cover or include patient record management operations. This system will enable patients to book appointments or join a queue electronically – what is termed a virtual queue technically.

1.6 Organization of the Study

This thesis is divided into five chapters. Chapter one introduces the background of the research, identifies the problem of the research and captures the aim and objectives of the research. It gives an overview on why and how important the research topic is. Chapter two is a collection of research on important concepts that relate to the thesis and up to date reviews on existing works that are closely related to the project topic. Chapter three contains the system analysis and its design. It shows clearly the scheme of work leading to the implementation. Chapter four contains the result of the inputs from Chapter three. It shows the use of various software or technologies employed in the system implementation and the developed system itself and shows some important interfaces of the solution. Chapter five is a recap of the entire project, discussing the fully implemented solution and outlining its limitation for future improvements. The references or bibliographies are also contained in Chapter five.

1.7 Definition of Operational Terms

Appointment: An appointment is any meeting expected or arranged for in advance with the attributes of date, time and venue well specified.

Patient: A patient is any person who requires any form of medical attention from a healthcare institution.

Queue: A queue is defined as a line of people waiting for a service.

Waiting time: This is the total time it takes a patient to wait before seeing a physician.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter is logically divided into two sections; the first is dedicated to reviewing of important concepts in the design and development of queuing systems. The second presents an analysis and review of related works on hospital queuing systems, their developments (if any), weaknesses and loopholes.

2.1 General Information

Modern queuing systems have their background and foundation in a branch of System Operations Research (SOR) known as queueing theory.

2.1.1 Queuing Theory

Queuing theory has emerged as an established body of knowledge entirely within the twentieth century. Its initial impetus was derived from the study of congestion in telephone traffic, and its nourishment from the theory of stochastic processes (Sahu & Sahu, 2014). Queuing theory deals with one of the most unpleasant experiences of life, waiting. It is concerned with the mathematical study of waiting lines in order to predict waiting time. Queuing is quite common in many fields, for example, in telephone exchange, hospitals, in a supermarket, at a petrol station, at computer systems, etc.

Though healthcare organizations differ in scope and scale, they can be seen as queuing systems where patients arrive, wait for service, obtain service, and then depart (Imahsunu, 2014). While they differ in complexity and scope, they are made up of medical and non-medical procedures and activities that patients must pass through before receiving treatment. According to Imahsunu (2014), the servers are the trained personnel and specialized equipment that are required in the procedures and activities.

2.1.2 Queuing Models in Hospitals

There are four queuing models that are commonly seen in hospitals – even in JUTH. They will be discussed below.

2.1.3 Single Queue, Single Server Model

This model is one where one healthcare personnel or specialized equipment attends to patients on a single line. An example is a clinic or any healthcare organization with just one consultant for which all patients queue up to consult, another example is where there is just one x-ray machine that serves an entire hospital. Figure 2.1 represents the single queue, single server model.

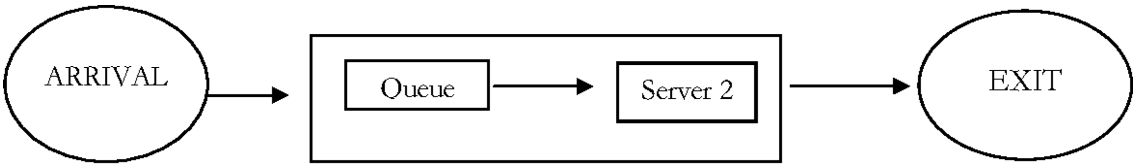

Figure 2.1. Single Queue Single Server Model

2.1.4 Single Queue Multi-Server Model

This model is where you have patients joining in a single queue but are being attended to by a group of doctors in a large hall or closed office. The patients are called in by any doctor who is available or who has just finished seeing another patient on the queue. Figure 2.2 represents the single queue, multi-server model.

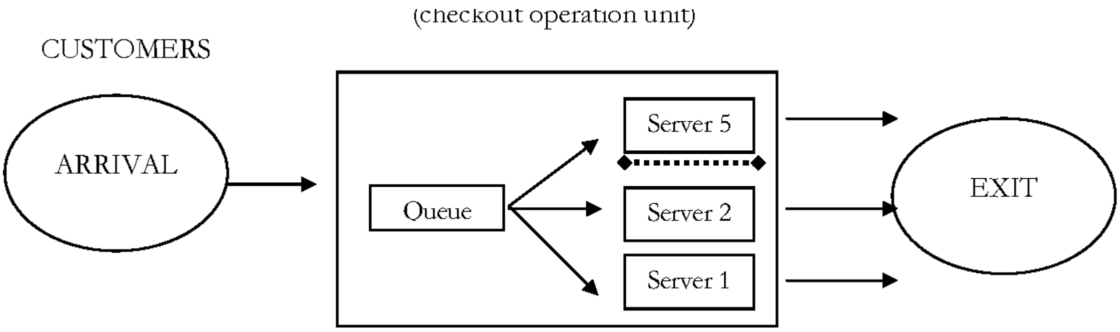

Figure 2.2. Single Queue Multi-Server Model

2.1.5 Multi Queue Multi Server Model

This model is one where there are two or more queues for which patients can join in and are attended to by multiple servers (Trained Personnel or Specialized equipment) that attend to the patients in the queue. Figure 2.3 below is an illustration of how this model operates.

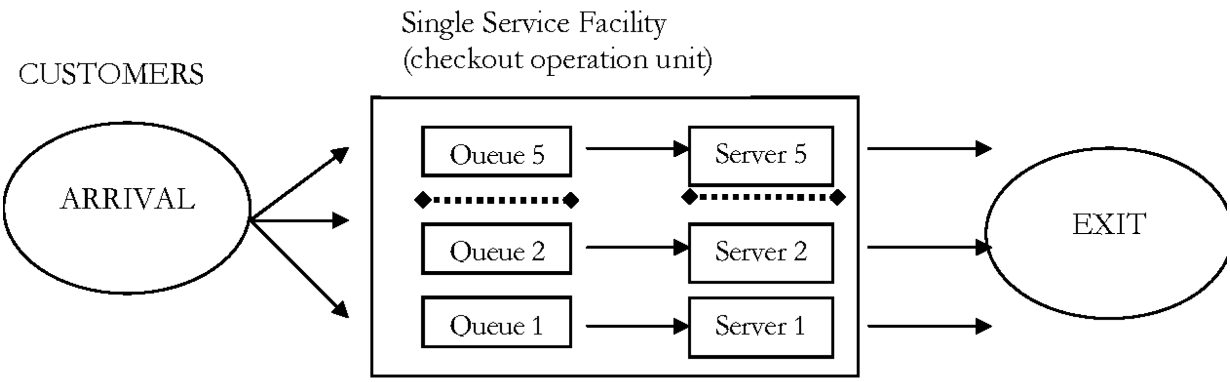

Figure 2.3. Multi Queue Multi Server Model

2.1.6 Characteristics of Queue Management

The fundamental components of any queuing system are the arrivals, the actual waiting line and the service facilities.

2.1.6.1 Arrival Process of Customers

Arrival rates could be either constant in which case there is exactly the same period between successive arrivals or variable where there are random arrival distributions (Rao, Gunasekaran, Goyal, & Martikainen, 1998). In most queuing systems, customers' inter-arrival times may not be independent and with a common distribution as it is usually assumed. The arrivals are according to a Poisson stream in many practical situations. Patients may arrive one after the other or in batches (Dobson, Lee, Sainathan, & Tilson, 2012). An example is the emergency department of the hospital where more than one patient involved in an accident arrives at the hospital.

2.1.6.2 Waiting Lines

This is the center of queuing analysis; it refers to the queue itself. The lines or queues are formed depending on the nature of the arrival and service processes (Willig, 1999).

2.1.6.3 Service Mechanism

This is the description of how customers are being served. "In a single server system, each customer is served by exactly one server, even if there are multiple servers" (Singh, 2006). It is not unusual for service times to be random and varying. Service Mechanism also considers the number of servers. A single server or more than one parallel servers may be used in a queue system (Beasley, 2004).

2.1.7 Appointment System

Appointment system for hospitals is an early practice in healthcare. Appointment scheduling is an administrative obligation that ensures that a system runs smoothly, especially the healthcare system. Appointment systems have an organized patient (customer) arrival pattern. Healthcare appointment system has traditionally considered the time of the doctor to be more valuable to that of the patients. This was the belief and practice in most hospitals owned by the Nigerian Government, where doctors don't keep to working hours so much that they often take several break times before their shift is over. This old practice has led to long waiting time for patients in these hospitals due to the increase in idle time of the doctors and inadequate queuing system.

Modern development of the appointment system focused on crucial time factors for patients and doctors. Therefore, it is possible to schedule appointments in two ways; static and dynamic (Cayirli & Veral, 2003). A static appointment schedule system is a system of scheduling appointments used in the outpatient clinics where a dedicated number of appointment slots are reserved for each patient type each week. An instance is where a clinic may choose to reserve the first 10 slots for new arrivals after which 20 slots are reserved for follow-up patients (Laan & Boucherie, 2018). The dynamic appointment scheduling is the opposite of the static system, this system includes reservation of capacity for “urgent or walk-in patients, or obtaining policies that describe how many patients of each diagnostic group should be admitted into the hospital from a waiting list to optimise utilisation and access times” according to Laan and Boucherie (2018).

According to Luo (2012), the patient appointment system management recorded early work and development in the queuing model. People have busy lifestyle as such cannot bear the waiting especially in hospitals for treatment. Using a mathematical model, it is also possible to reduce patients waiting time and to evaluate the waiting time interval for patients and doctors (Thomopoulos, 2012). Building a queuing system for hospital appointments increases patient satisfaction and reduces the burden on staff having to control the calling population, relying on manual processes for selecting a patient's appointment time and makes it easier to schedule appointments in the various departments of the hospital.

2.2 Related Works

Musa (2018) in a thesis titled “Automated Hospital Queue and Appointment Management System” proposed an appointment system for the General Out Patient Department in the General Hospital of Niger State, Minna. According to the author, the system will improve patient satisfaction by reducing the indefinite waiting time associated with medical consultation in the hospital. Musa outlined a design that will make it possible for a web based solution to capture the booking of appointments online although the implementation required that patients have to come to the hospital to be registered first. It is after such registration that appointments can then be made.

Barretto (2017) proposed a system called “Efficient Doctor Patient Portal” for doctor patient handling. The author stressed that the long waiting hours for patients in the Out Patient Department of hospitals increases chances of patients contracting other diseases. The journal discussed the system as a managing system that will aid medical personnel’s in their work routine and enables patients to book appointments with doctors and access medical reports or progress reports online. The system provided the functionality for doctors to fill in their booking slots so patients could make their booking. In this system, doctors are able to access patient’s medical history from the records section even before the patient arrives at the hospital. Reports and prescription were uploaded subsequently by doctors to patient’s dashboards.

Akinode (2017) in a paper titled “Design and Implementation of a Patient Appointment and Scheduling System” presented a system for the online allocation of surgery rooms for cases coming from local clinics and also booking of appointments for medical check-ups. The thesis also captured patients’ registration of details online as a way of ensuring data consistency. Akinode emphasized on how the system will greatly reduce patient waiting time increase overall doctor efficiency. The system however did not automate the booking process as the receptionist (record staff) was required to manually change booking status from pending to approved each time an appointment was to be made.

Zhao et al (2017) in a journal article entitled “Web-based medical appointment systems: a systematic review” discussed extensively on the implication of using web based solutions for medical appointments. The journal stated that having these systems implemented in the health sectors will reduce staff labour, improve patient satisfaction, reduce no shows, reduce waiting time, increase revenue, reduce cost, balancing patient load and reducing wrong appointment type. They suggested that web web-based solutions should be adopted to enhance work flow in the hospitals.

Obulor and Eke (2016) in a journal paper titled “Outpatient Queuing Model Development For Hospital Appointment System” discussed the delayed hospital attendance rate in specialist, teaching and general hospitals in Nigeria. The authors stated that “cases in which patients may not be attended to on time, while others may end up going home without medical care” has become a common experience in medical institutions. A queuing model deemed efficient for proper appointment system was proposed to solve the long waiting times in the aforementioned hospitals. Obulor and Eke used their proposed queue model in developing a web based appointment system for the University of Port Harcourt Teaching Hospital (UPTH). The system enabled doctors to manage patient records electronically and it equally allowed patients to book appointment online before coming to the hospital.

Daini (2015) designed and developed an “Electronic Queue Management System” (E-QMS). It enabled customers/persons to be on a queue without having to stand in line, with an alerting system (device), an alert was sent to inform the next customer or person to approach the service counter. Using the First Come First Serve method of attending to queues, the author stressed on how the developed system will bring about “fairness and comfort to persons based on the order of their arrival”. Daini’s system also provided a means of tracking the number of customers served in the system thereby improving system efficiency calculation or throughput analysis. The project implementation was found to be useful in banks, public dealing offices, airports, ticketing offices and places where customers stood in queues in order to receive service. It however does not provide for virtual queuing or account for how many customers are in the system at any point in time.

Gowthem and Kaliyamurthie (2015) proposed a smart appointment reservation system. An “electronic paper less application” designed with high suppleness and ease of use, patients can book their appointment according to their preferences within the scheduled appointment slots. The system helps organize appointments and enables patients to cancel or reschedule appointments by incorporating decentralized medical systems into a collection of reliable and easy resources that are available through a web browser. Furthermore, patients can receive regular notifications on changing appointments, delayed appointment schedules or doctor's unavailability. The system attempts to improve patient satisfaction or experience by providing patients the opportunity to provide input on the system to improve services.

Idowu, Adeosun, and Williams (2014), in a paper titled “Dependable Online Appointment Booking System For NHIS Outpatient In Nigerian Teaching Hospitals” developed a web based medical appointment system. The system was designed to give patients coming to the Obafemi Awolowo University Teaching Hospital the option of booking an appointment online with the doctors in the hospital. Patients could view appointment status after booking and doctors were able to see the appointments they had before ever seeing the patients. Although their system allowed for online booking of appointment, appointment handling itself was not automated as the System administrator had to approve any booking request before it changes on the patient dashboard from pending to booked.

Zhan and Liu (2013) developed a clinic appointment registration system. Its sole aim according to the thesis was so appointments for medical consultation could be done online.

Although the authors intended for the system to include an online credit card payment functionality for consultation fee, it was not implemented due to “inadequate teaching equipment”. Patients could choose the doctor they wish to see and view his schedule in order to get information on doctor’s availability. The system was deemed suitable to be deployed only in “small and medium-size hospitals for managing their outpatient online appointment registration and to be used for managing outpatient medical records for data mining”.

Kerdvibulvech and Win (2012) in their paper developed a web based Dentist Online Reservation System. The paper stressed how most business sectors today use network services and offer online web services in order to create more ease and convenience for their stakeholders and for themselves, this convenience according to the authors, includes how people make reservations. To extend this modern way of doing business to the health sector, they proposed an online patient-dentist appointment system. The system allowed patients to schedule appointments with dentists (only) of a particular clinic and equally pay for services offered electronically.

2.3 Summary of the Review

The various literatures reviewed have shown how an automated booking system for medical consultation thrives over the existing manual or adhoc consultation system employed in the General Out Patient Departments of Hospitals. Table 2.1 presents a summary of the reviewed literatures.

Table 2.1. Tabular Summary of Related Works

Related Works	Scope of system	Web-based solution	Automated	Mobile Solution
Idowu et al. (2014)	NHIS Outpatient In Nigerian Teaching Hospitals.	Yes	No	No
Zhan and Liu (2013)	small and medium-sized hospitals.	Yes	No	No
Daini (2015)	Banks, public dealing offices, airports, and ticketing offices.	Web based with led indicator for queue service count display.	Yes	No
Barretto (2017)	General Out Patient Department of Clinics	Yes	No	No
Akinode (2017)	Local clinics	Yes	No	No
Obulor and Eke (2016)	Specialist, teaching and general hospitals in Nigeria.	Yes	No	No
Kerdvibulvech and Win (2012)	Patient-dentist appointment system.	Yes	Yes	No
Gowthem and Kaliyamurthie (2015)	General Hospitals.	Yes	No	No
Musa (2018)	General Out Patient Department in the General Hospital of Niger State, Minna	Yes	No	No
(Zhao et al., 2017)	Medical Institutions in Nigeria.	Not applicable	No	No

CHAPTER THREE

SYSTEM ANALYSIS AND DESIGN

Introduction

This chapter captures in great details the methods, design, schematics and software structures employed in order to achieve the aim and objectives of the system being developed.

The focal point of this chapter is to complement the architecture of the system, providing useful and necessary information and data for implementing system elements. It defines the system's components, modules, interfaces and data to meet specified requirements. The chapter consists of the various modules, interfaces and data required for the design of the proposed appointment system.

3.1 System Analysis

The proposed system – JUTHAM (Jos University Teaching Hospital Appointment Manager) is a multiplatform (Web and Mobile) system that gives patients the convenience and comfort of booking hospital appointments from the comfort of their homes or wherever they are located while providing doctors with a way of handling patient flow. It provides for automated booking of available doctor schedule slots which indirectly enforces that doctors are present during their work shift hours or days.

3.1.1 Analysis of the Existing System

Queuing for medical appointments in the Jos University Teaching Hospital is such a tedious time tasking exercise even for a healthy person, not to talk of the unwell. The existing system based on observations and interviews with the unwell at the General Out Patient Department revealed that for a potential patient to see a physician, the person leaves home as early as 06:00am to get a good position on the consultation queue should they hope to be attended to in good time. Other patients who arrive much later in the daytime have a very slim if not zero probability of being able to see a doctor. Patients including those that will not end up seeing a physician due to closing hours will normally queue up for as long as the physician is available. Many cases have been recorded where patients leave without being able to see the physician and others due to how far their destinations are away from the hospital opt to spend the night in the hospital to increase their chances of seeing a doctor the following morning. This showing up before official working hours and waiting indefinitely before seeing a physician has become the norm for almost all the patients who come to the hospital's General Out Patient Department. Below is a flowchart of the existing system as shown in Figure 3.1

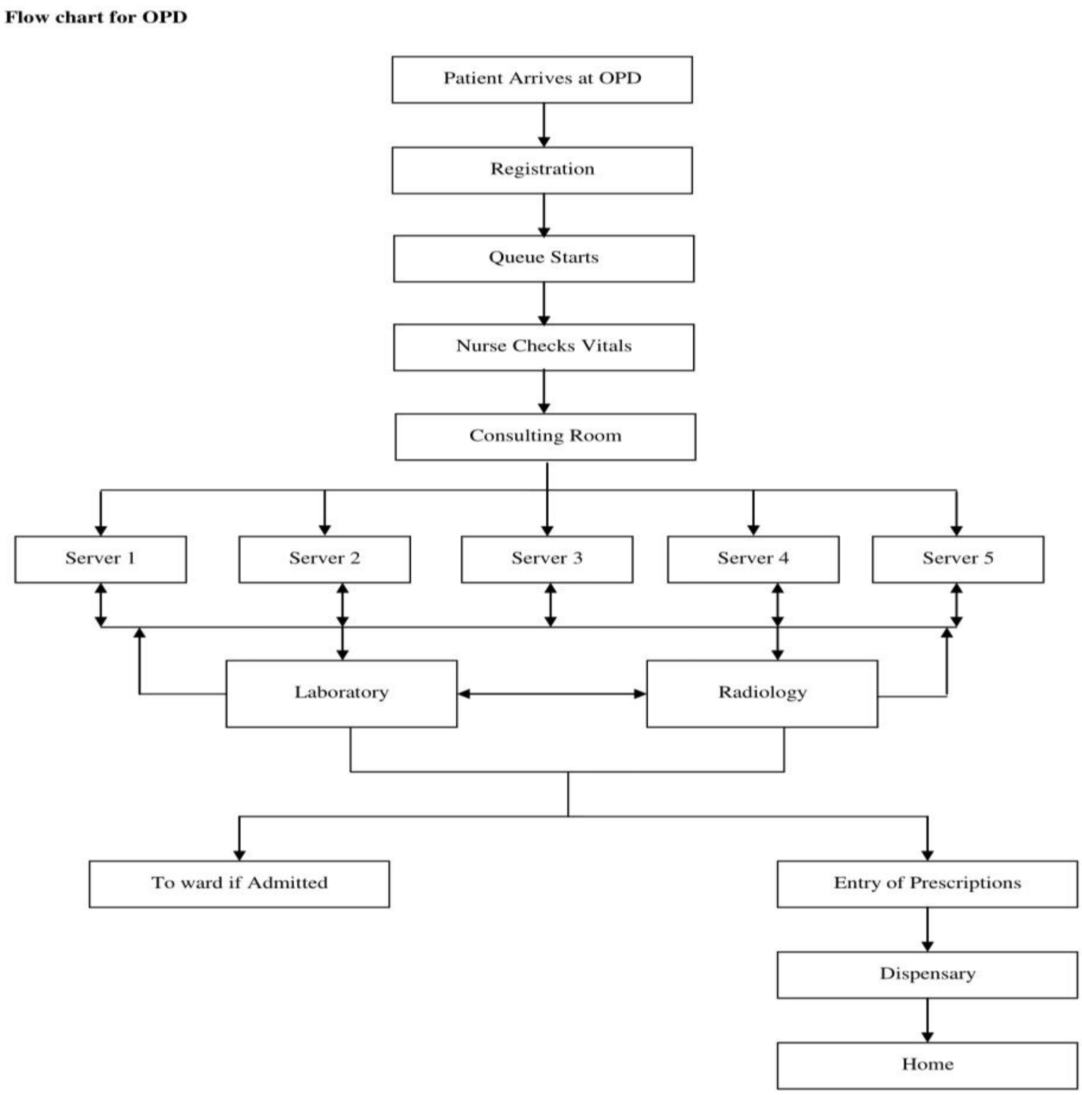

Figure 3.1. Out Patient Department Flow Chart

3.1.2 Limitation of the Existing System

The existing system of appointment booking has no regard for the patient in terms of time efficiency – waiting time. It has been more of a disservice as cases of patients collapsing and even dying has been recorded of due to the stress experienced while standing on the queue indefinitely.

3.1.3 Justification for the New System

The new system being developed otherwise known as the hospital queue manager or appointment system will reduce to a very high degree the waiting time of patients in the Hospital. Patients will be able to join a queue or otherwise book an appointment from wherever they are provided there is internet connectivity and will only bother showing up just in time to see the doctor. While response time will still depend largely on the hospital staff and administration, patient satisfaction will however be elevated when the proposed system is installed.

The system will also as a byproduct put pressure on the physicians to report to work on time so as to meet up with their appointments.

3.1.4 Description of the New System

JUTHAM will be implemented on two platforms – web-based solution and the android mobile platform. Except for the differences in the interfaces of the appointment system, both the android mobile and the web based solution will share the same application logic and data. The following flowcharts presents a pictorial description of the system.

3.1.4.1 General System Flowchart

In figure 3.2, any user of the system will be required first of all to be registered in the system before login to the system. If a user is already registered, then providing the valid login credentials will give access into the system. You are either logged in as a doctor in which case you have access to functions available to the doctors or you are logged in as a patient and are able to perform booking functions.

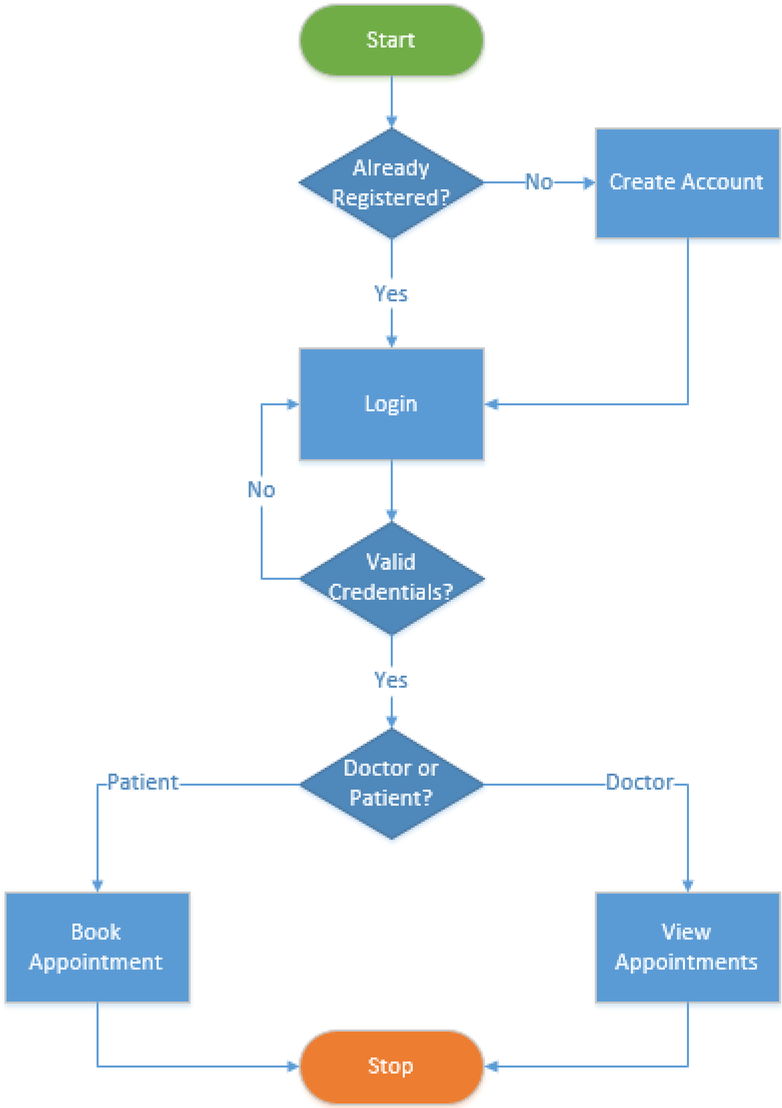

Figure 3.2. General System Flowchart

3.1.4.2 Flowchart for Patients

Figure 3.3 shows the flow diagram for patients. Patients are required to login to their account before they can book appointments.

3.1.4.3 Flowchart for Doctors

As shown in figure 3.4, doctors are required to login also in order to access their dashboard and view or make changes to appointments.

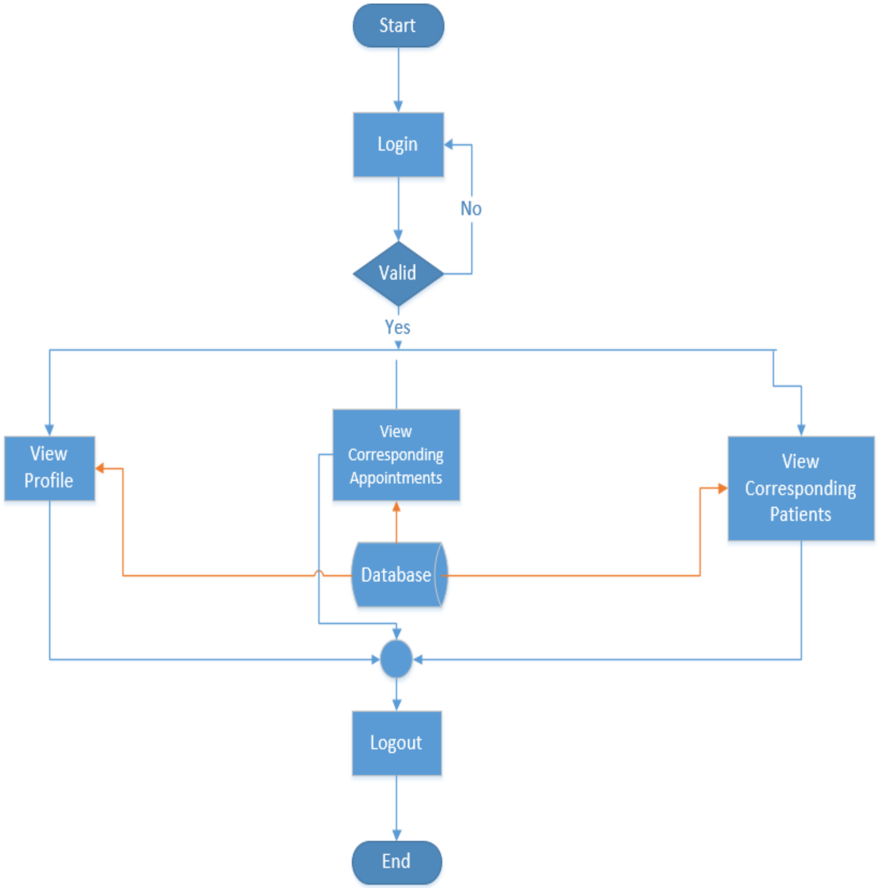

Figure 3.4. Doctor Flow Diagram

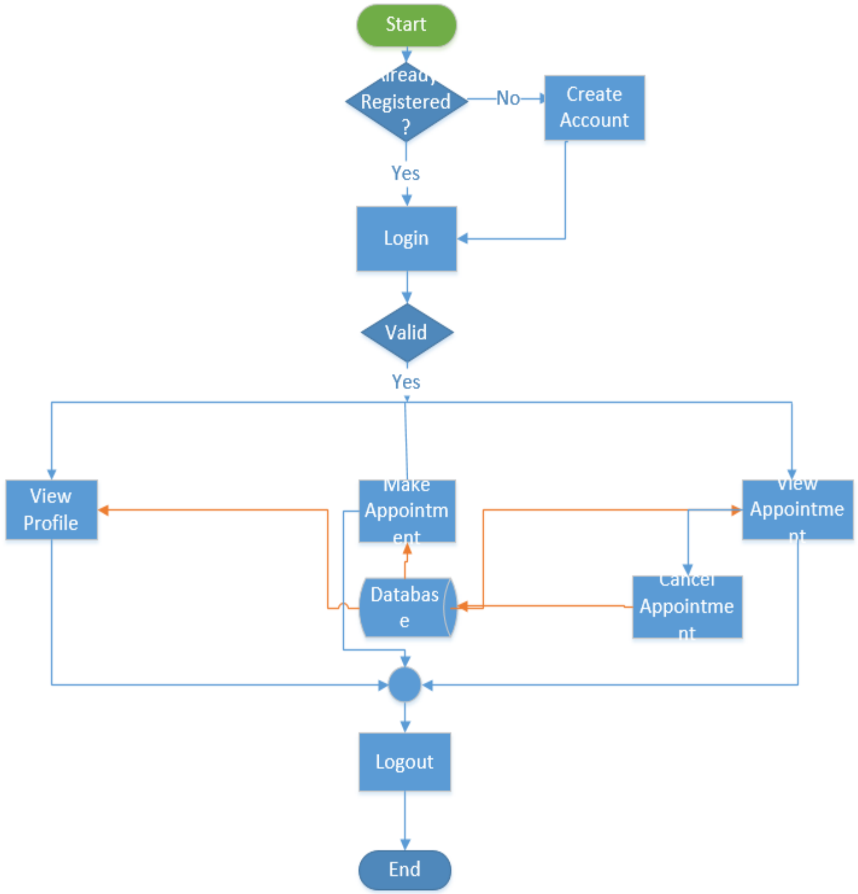

Figure 3.3. Patient Flow Diagram

3.2 Design of the Proposed System

The design of a system consists of the architecture, modules, components and their various interfaces, and how data is handled or its flow in the system. The proposed system will be implemented on a three-tier client-server structural design. The presentation, application and the data tier. The presentation tier containing the graphical user interface, the application tier which handles the business logic, and the data tier to store data.

3.2.1 Data Model

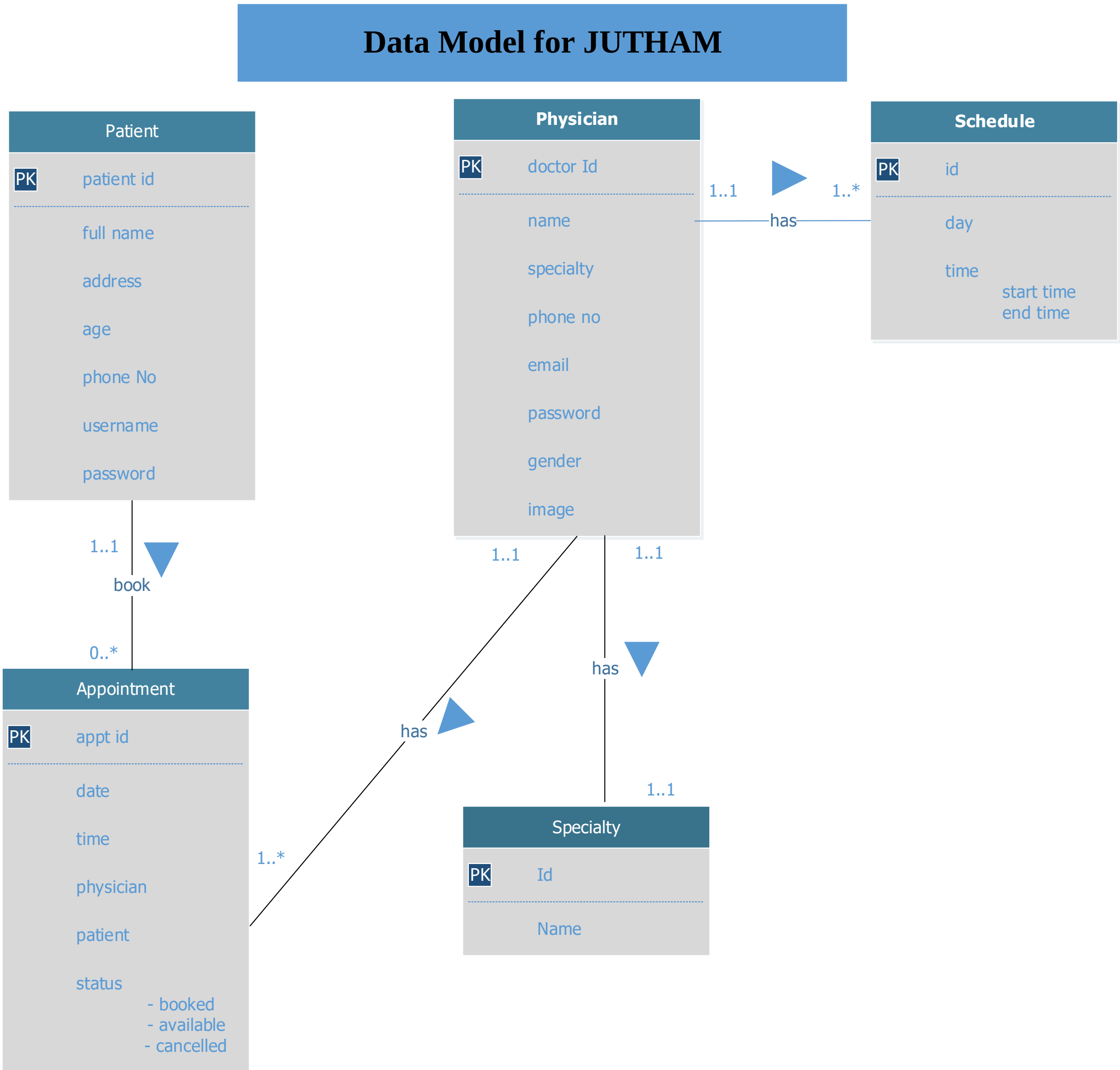

Figure 3.5. Data Model of JUTHAM

The data model above presents the representation of the various entities in the system and their relationships. Working with a data model is imperative in the design of any system in order to ensure data consistency and prevent data redundancies. A data model clearly shows entities, their relationship, attributes and multiplicity. Multiplicity is defined as "the number (or range) of possible occurrences of an entity type that may relate to a single occurrence of an associated entity type through a particular relationship" (Thomas Connolly, 2005). An entity, as defined by Connolly (2005) is "a distinct object (a person, place, thing, concept, or event) in the organization that is to be represented in the database". The attributes of an entity or relationship is its defining properties, it gives a description of the object that we want to record, and a relationship is the connection between the entities that are being modelled.

In this thesis, five (5) entities are involved, the patient, physician, appointment, schedule, and specialty entities. Detailed information on the entities, their relationships and the data they use is represented in the next sub headings.

3.2.1.1 Dictionary of Entities

Table 3.1. Dictionary of Entities

ENTITY	DESCRIPTION	ALIASES	OCCURENCE
Physician	Physician refers to a doctor or any trained medical personnel in the hospital.	Doctor	A physician attends to one or more appointments. A physician has one or more schedules.
Patient	A patient is the person in need of medical attention.	_	A patient can book many appointments.
Appointment	An appointment is a scheduled meeting to see a physician.	my_appointment	Many appointments can be booked by one patient.
Specialty	Specialty refers to the field of medicine a physician is based.	_	One physician has one area of specialization.
Schedule	Schedule refers to the doctors time allocation for patient consultation	appointment	Many schedules can be assigned to one doctor.

Table 3.1 above shows the various entities and their description as they appear in the data model.

3.2.1.2 Dictionary of Relationships

Table 3.2 shows all the entities involved in the data modeling process, their relationship and their multiplicity.

Table 3.2. Dictionary of Relationship

Entity	Multiplicity	Relationship	Multiplicity	Entity
Patient	1..1	Books	0..*	Appointment
Physician	1..1	Has	1..*	Appointment
Appointment	1..*	Booked	1..1	Patient
Physician	1..*	Has	1..1	Specialty
Physician	1..1	Has	1..*	Schedule

3.2.1.3 Dictionary of Attributes

Table 3.3 captures the dictionary of the entities in the data model, it gives a description of each entity and what role they play in the model.

Table 3.3. Dictionary of Attributes

Entity	Attribute	Description	Domain	Null	Simple	Single-valued	Derived
Patient	Username	Identifier	Text	No	Yes	Yes	No
	Fullname	Profile username	Text	No	Yes	No	No
	Dob	Date of birth	Date	No	Yes	Yes	No
	home_address	Residency of patient	Text	No	Yes	Yes	No
	mobile_number	Mobile phone number	Text	No	Yes	Yes	No
	Email	Identifier	Text	No	Yes	Yes	No

	Password	Password for login	Text	No		Yes	No
Physician	doctor_id	Identifier	Integer	No	Yes	Yes	No
	Name	Full name	Text	Yes	Yes	Yes	No
	Specialty		Enumeration	No	Yes	Yes	No
	mobile_number	Mobile phone number	Text	No	Yes	Yes	No
	Email	Email address	Text	No	Yes	Yes	No
	Gender	Sex	Enumeration	No	Yes	Yes	No
	Password	Login password	Text	No	Yes	Yes	No
	profile_picture	Path to the image passport	Text	No	Yes	Yes	No
Appointment	Id	Identifier	Integer	No	Yes	Yes	No
	Date	Date of appointment	Date	No	Yes	Yes	No
	Time	Time of appointment	Time	No	Yes	Yes	No
	Physician	Doctor’s name	Text	No	Yes	Yes	No
	Patient	Patients name	Text	No	Yes	Yes	No
	Status	Booking status of a slot	Text	No	Yes	Yes	No
Schedule	Id	Identifier	Integer	No	Yes	Yes	No
	Day	Available doctor days	Text	No	Yes	Yes	No
	Time	Time slots	Time	No	Yes	Yes	No
Specialty	Id	Identifier	Integer	No	Yes	Yes	No
	Name	Specialty name	Text	No	Yes	Yes	No

3.2.1.4 Dictionary of Tables (Normalized)

Table 3.4 is a representation of the appointment table.

Table 3.4. Appointment Table

COLUMN_NAME	ALIAS	INDEX	DATA TYPE	LENGTH	NULL
ID	-	PRIMARY KEY	INT	15	NO
Appointment_id		-	INT	15	NO
Appointment Date	apt_date	-	VARCHAR	10	NO
Status		-	VARCHAR	10	NO
Patient		FOREIGN KEY	VARCHAR	100	NO
Doctor		FOREIGN KEY	VARCHAR	12	NO

Figure 3.5 is a representation of the schedule table.

Table 3.5. Schedule Table

COLUMN_NAME	ALIAS	INDEX	DATA TYPE	LENGTH	NULL
ID	-	PRIMARY KEY	INT	15	NO
Doctor_id	-	FOREIGN KEY	VARCHAR	10	NO
Day	-	-	VARCHAR	15	NO
Start_time	-	-	VARCHAR	10	NO
End _time	-	-	VARCHAR	10	NO
Status	-	-	INT	1	NO

Figure 3.6 is a representation of the patient table.

Table 3.6. Patient Table

COLUMN_NAME	ALIAS	INDEX	DATA TYPE	LENGTH	NULL
First_name		-	VARCHAR	25	NO
Last_name		-	INT	25	NO
Middle_name	-	-	VARCHAR	25	NO
Dob	Birth_date	-	VARCHAR	10	NO
Home_address	-	-	TEXT		NO
Mobile	-	UNIQUE	VARCHAR	15	NO
Username	-	PRIMARY KEY	VARCHAR	20	NO
Email	-	UNIQUE	VARCHAR	70	NO
Password	-		TEXT		NO

Figure 3.7 is a representation of the physician table.

Table 3.7. Physician Table

COLUMN NAME	ALIAS	INDEX	DATA TYPE	LENGTH	NULL
Dictor_id	-	PRIMARY KEY	VARCHAR	10	NO
First_name	-	-	VARCHAR	25	NO
Last_name	-	-	VARCHAR	25	NO
Middle_name	-	-	VARCHAR	25	NO
Specialty	-	FOREIGN KEY	VARCHAR	50	NO
Mobile	-	UNIQUE	VARCHAR	22	NO
Email	-	UNIQUE	VARCHAR	70	NO
Gender	-	-	VARCHAR	10	NO
Password	-	-	TEXT		NO
Profile_pic	-	-	TEXT		NO

Figure 3.8 is a representation of the specialty table.

Table 3.8. Specialty Table

COLUMN_NAME	ALIAS	INDEX	DATA TYPE	LENGTH	NULL
Id	-	PRIMARY KEY	INT	13	NO
Specialty_name	-	-	VARCHAR	50	NO

Figure 3.8 is a representation of the notify table.

Table 3.9. Notification Table

COLUMN_NAME	ALIAS	INDEX	DATA TYPE	LENGTH	NULL
Id	-	PRIMARY KEY	INT	13	NO
Patient	-	FOREIGN KEY	VARCHAR	50	NO
Reminder	-	-	VARCHAR		

3.2.2 Functional Requirement

Figure 3.6 represents the functional requirement of JUTHAM.

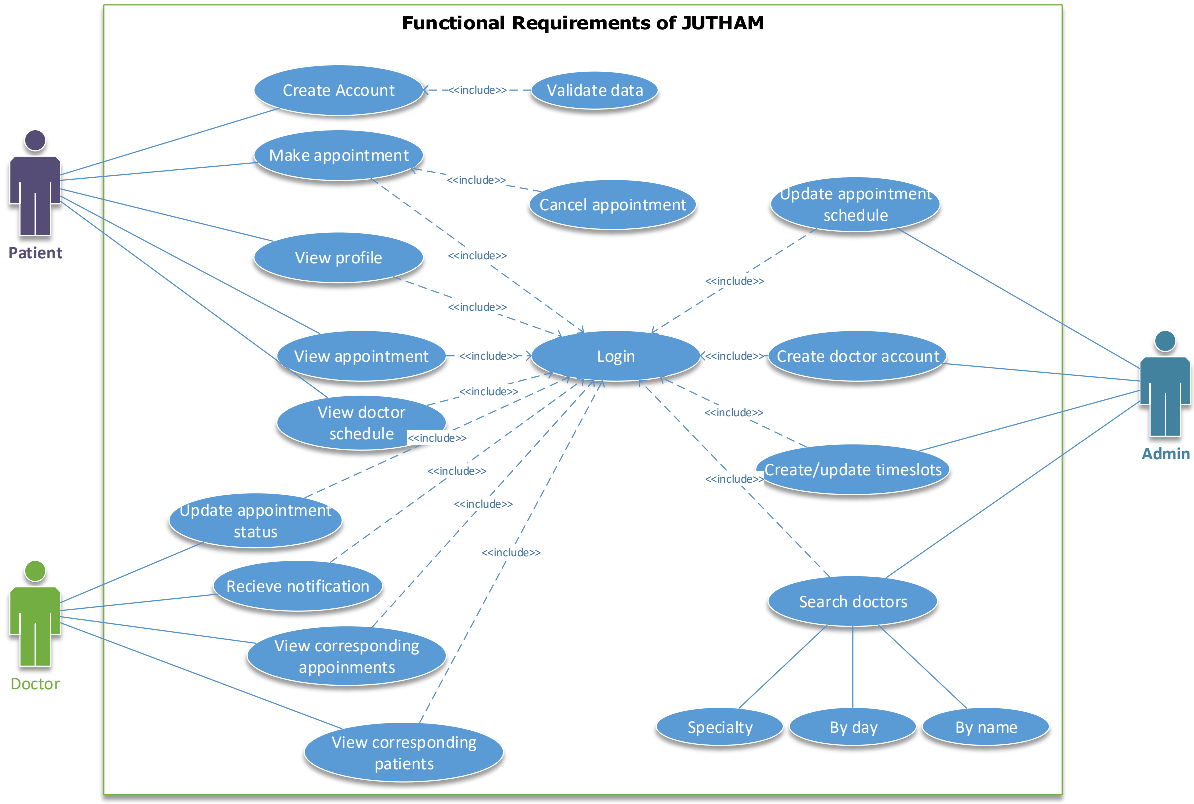

Figure 3.6. Functional Requirements of JUTHAM

The functional requirement of a system are requirements that must be active (functional) in a system in other to meet the needs of its intended users. It includes all the possible interaction between the system and the actors (users).

The Patient has the following use cases:

1. Create account by providing valid data.
2. View doctor schedule in order to help them decide when to book appointment
3. Make appointment and cancel appointment after login to their account.
4. View their booked appointment.

The Doctor has the following use cases:

1. Update appointment status through login to their account.
2. View the patient they are going to be attending to beforehand.

3. Receive notification of the list of appointments they are looking forward to.

4. View corresponding appointments in his schedule.

The Administrator has the following use cases:

1. Create doctor account
2. Create and update doctor time slots for their appointment schedule
3. Update appointment schedule
4. Search for doctors through name, specialty search of day on duty search to see their schedule.

3.2.3 System Architecture

The system architecture gives a description of the components of a system and their communication. Figure 3.7 shows the deployment diagram of the system and shows the high level system architecture of the new system.

The patient with a mobile phone (JUTH Appointment System Installed) or computer communicates with the application through the web server, the mobile phone user reaches the web server through the application server while the user with the traditional PC communicates directly to the web server through the HTTP (Hyper Text Terminal Protocol), when this connection succeeds, the patient can then book for an appointment and receive confirmation as well.

The doctor will as well through any browser enabled device (PC or Mobile phone) connect to the web server and receive appointment notification as well.

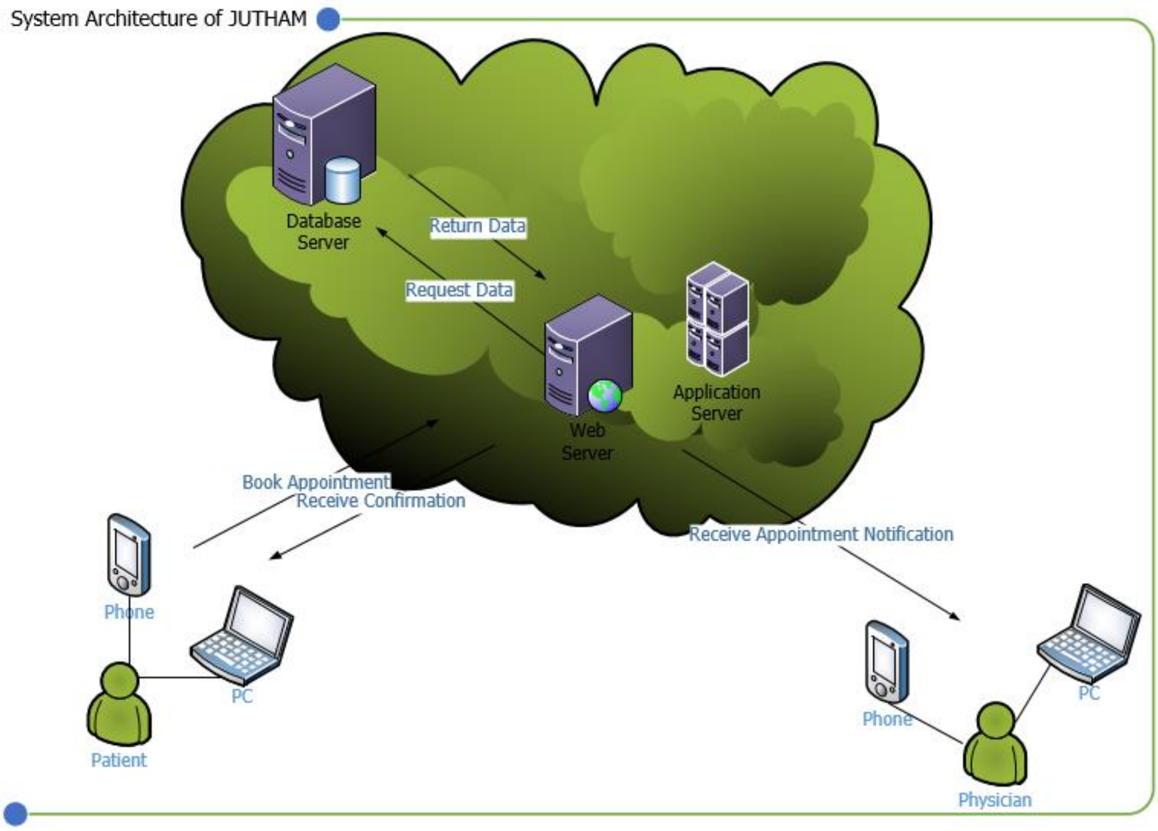

Figure 3.7. System Architecture of JUTHAM

3.2.4 Software Structure

Figure 3.7 illustrates the class diagram of JUTHAM. The class diagram is a type of static structure diagram which explains the system's structure by showing the classes of the system, its attributes, operations (or methods) and object relationships.

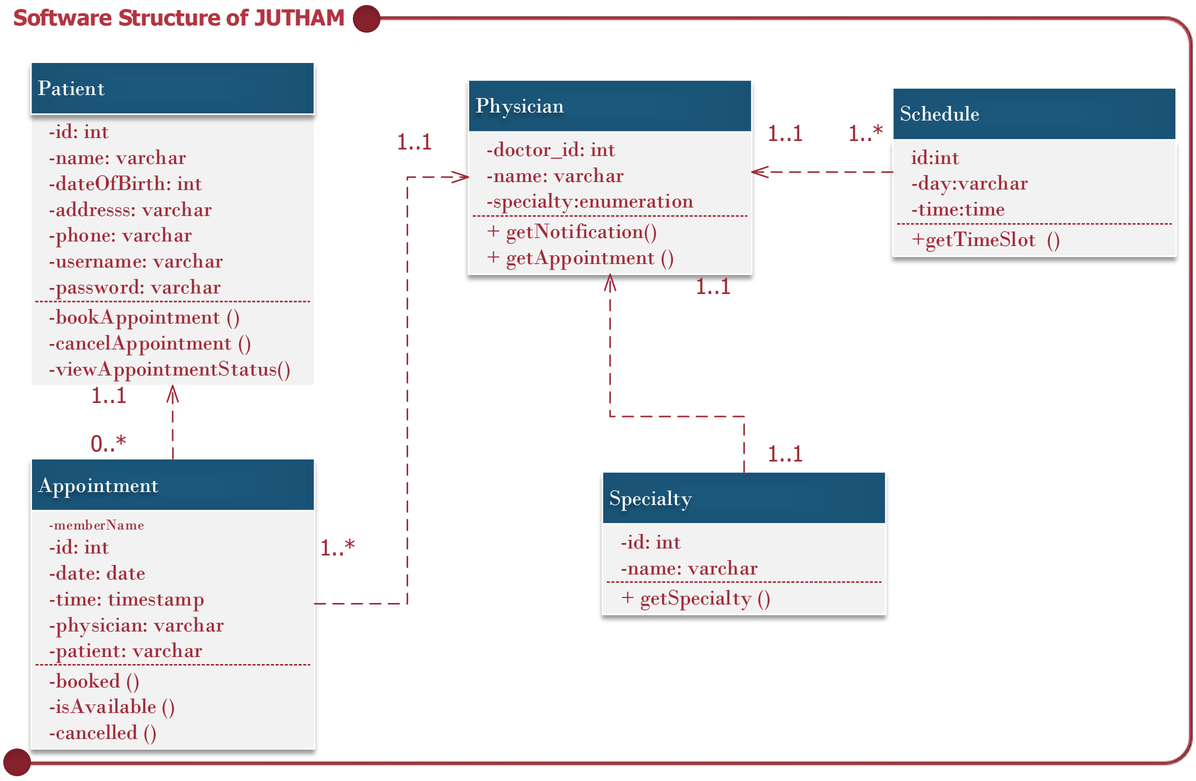

Figure 3.8. Software Structure of JUTHAM

3.2.4 Workflow of Use Cases

The activity diagram presents the workflow of the various use cases (functional requirement) in the system. It gives a roadmap to how the actors or users of the system relate to the system. Figure 3.9 is a visual representation of the workflow of functional requirements in the system. It also captures all the possible actions the users of the system can perform or functions they can execute.

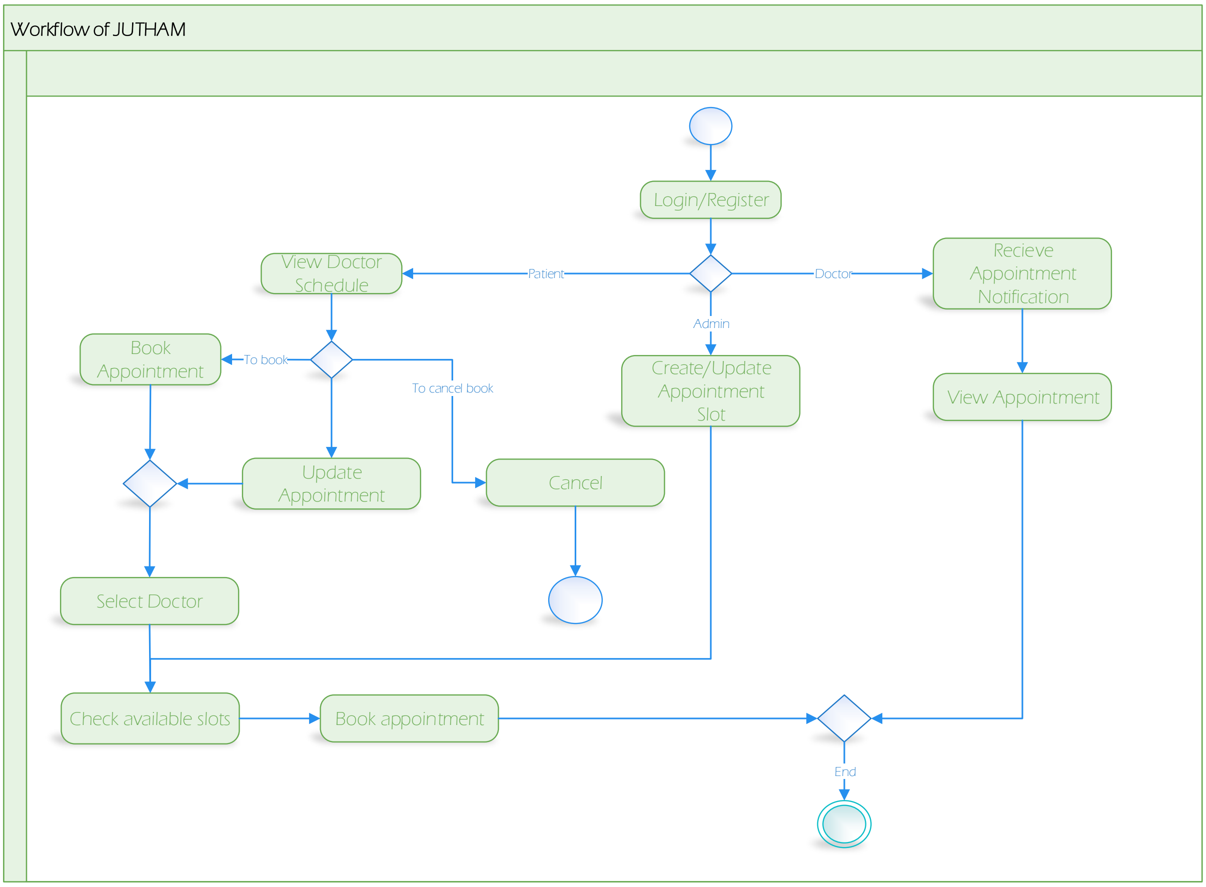

Figure 3.9. Workflow of JUTHAM

CHAPTER FOUR

IMPLEMENTATION AND DISCUSSION

Introduction

This chapter presents the software product of the thesis – the deliverable of the implementation phase. It talks about how the design prototype in chapter three was realized, especially how the functional requirement of the system was implemented and what hardware and software were utilized.

4.1 System Requirement for Development

The system requirement for development consist of certain criteria that must be satisfied by the software or hardware used in realizing the implementation of the system. They include the software and hardware components of a computer system. It also requires a smartphone for the mobile phone users.

4.1.1 Hardware Requirement

The hardware is the tangible component of a computer system, it includes the monitor, processor, memory, and the peripheral devices connected to the computer. The combination of the input and the output devices simply make up the hardware. The hardware requirements for JUTHAM are presented in table 4.1.

Table 4.1. Hardware Requirement

Hardware	Description
Computer	Hp Pavilion TS 15 Notebook PC and any other laptop or desktop
Processor	INTEL Pentium 4, with a processor speed of 1GHZ and above.
Android Phone	Samsung Galaxy J7 Pro
Memory (RAM)	1.00GB and above.

4.1.2 Software Requirement

The Software requirement for developing the system are captured in table 4.2 below.

Table 4.2. Software Requirements

Software	Information
Server Environment	
Operating system	Microsoft Windows 10 Pro
IDE's	Android Studio and Vs code
Web Server	Apache
Relational Database Management System	MySql
Programming Languages	PHP, SQL
Web Technologies	HTML, JavaScript, Bootstrap with CSS
Client Environment	
Internet Browser	Google Chrome, Firefox, UC Browser

4.2 System Menus Implementation

This section presents the code snippets that were employed (written) in realizing some of the important user interfaces (front end) in JUTHAM. The interface was designed using HTML, CSS and the Bootstrap framework as mentioned in the system development requirement. Some of the core interfaces of the system and their classes are shown subsequently.

Figure 4.1 is a screenshot of the home page (landing page) showing both the web implementation (on the right) and the android mobile application (on the left). The home page is the first point of interaction for any user who launches the application or searches the web address of the system.

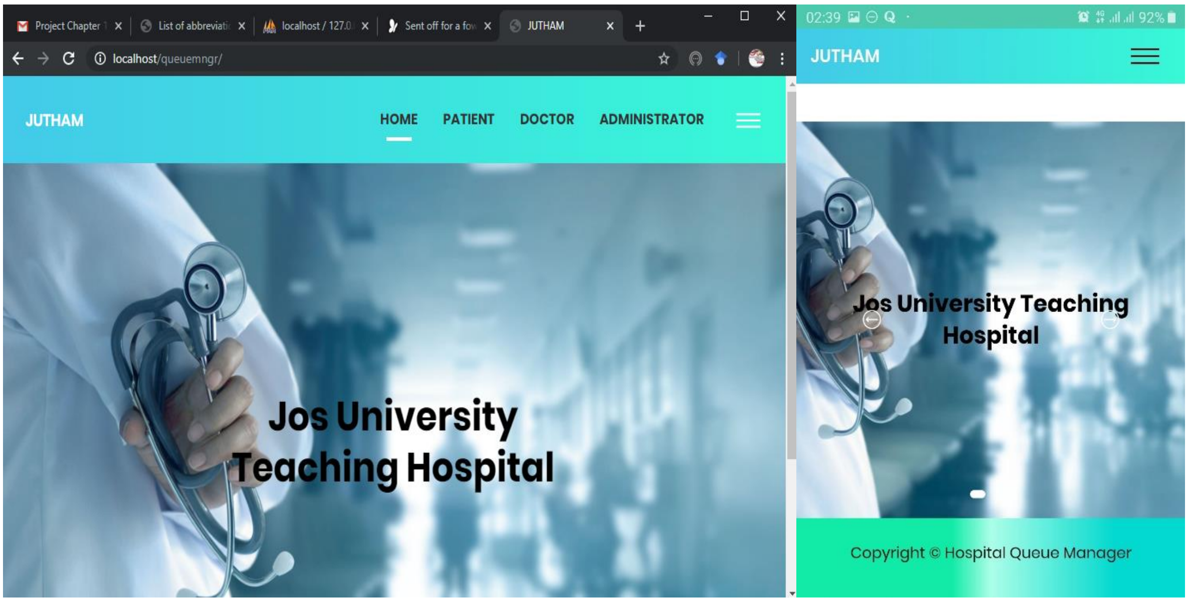

Figure 4.1. Home Page

Figure 4.2 shows the registration page of the patient entity JUTHAM. The doctors are registered exclusively into the system by the system administrator.

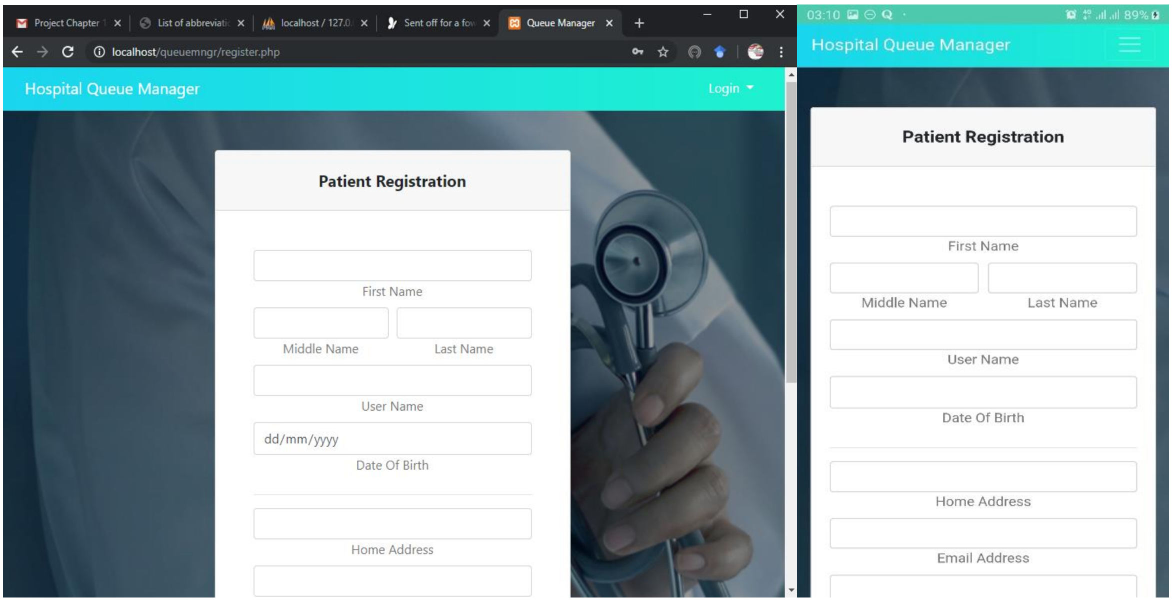

Figure 4.2. Patient Registration Page

Figure 4.3 shows the login interface of the system. Patients are required to enter their emails here and their passwords in order to login. The doctor's login is also similar except they are required to use their hospital id as username.

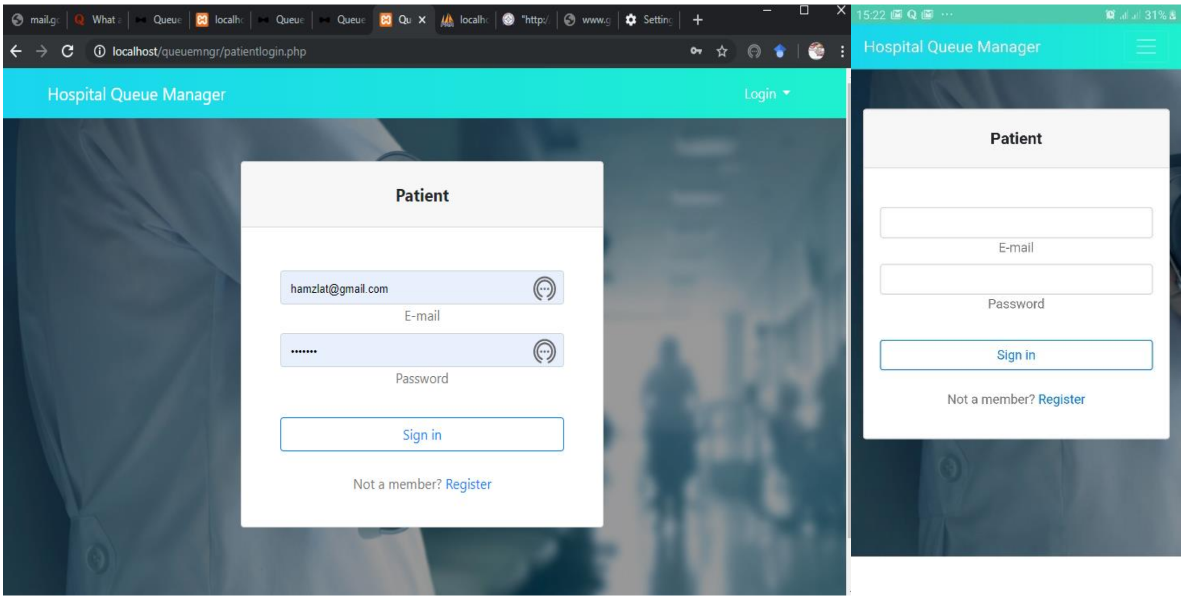

Figure 4.5. Login Interface

The admin panel (interface) of the system is illustrated in figure 4.6 below. It features the registration of doctors and their specialties. Through the "view" button, the admin begins to enter the schedule for each doctor.

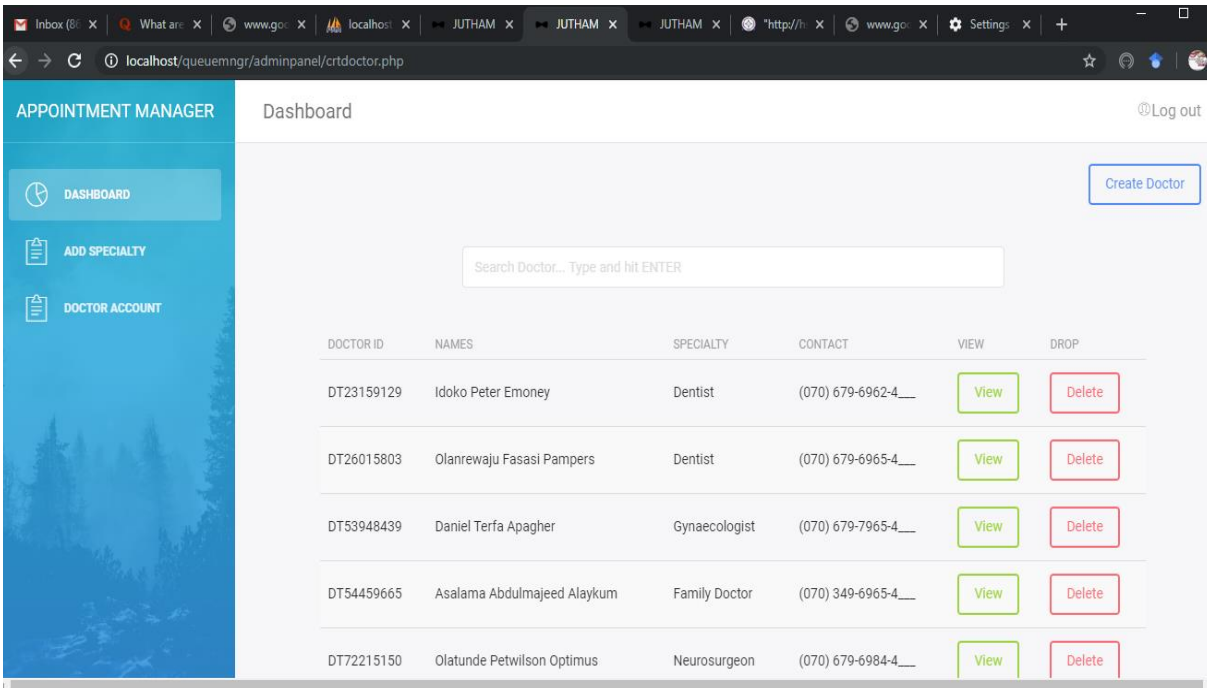

Figure 4.6. Admin Panel

Figure 4.7, 4.8 and 4.9 below features the ‘doctor search’, ‘doctor schedule view’ and ‘appointment booking’ interfaces respectively. The patient will first of all have to select the doctor category, then check the doctors schedule before booking for an appointment.

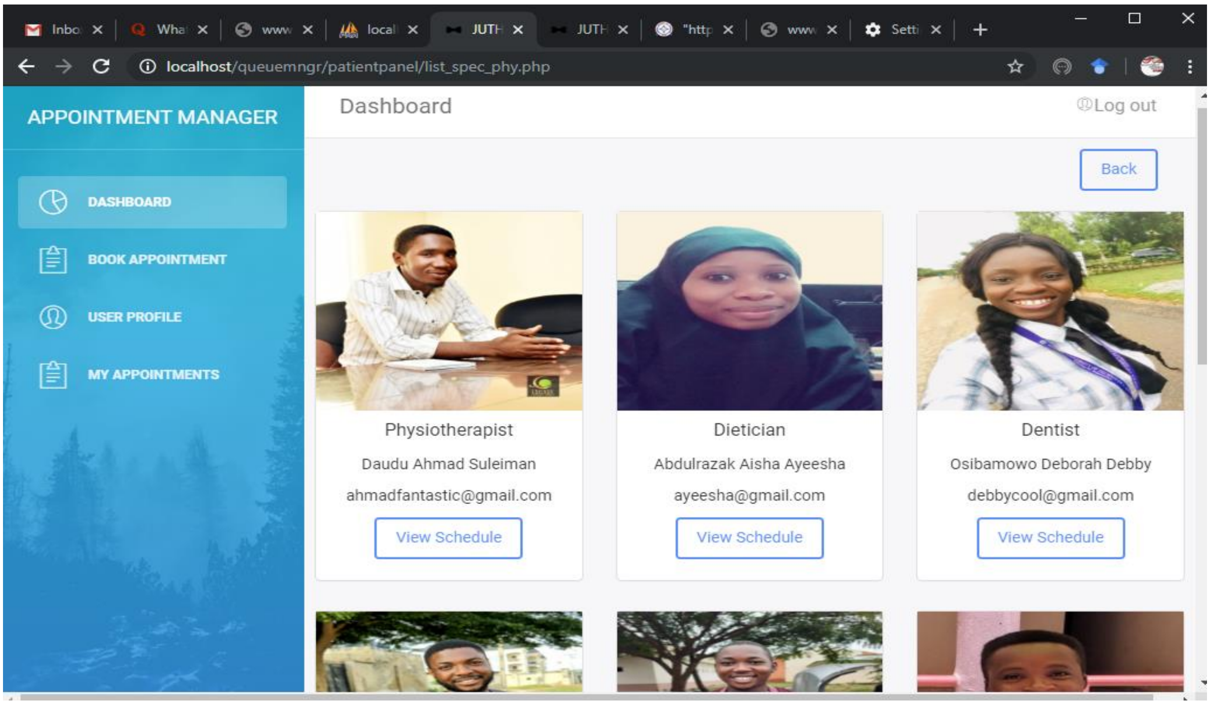

Figure 4.7. Doctor Search Interface

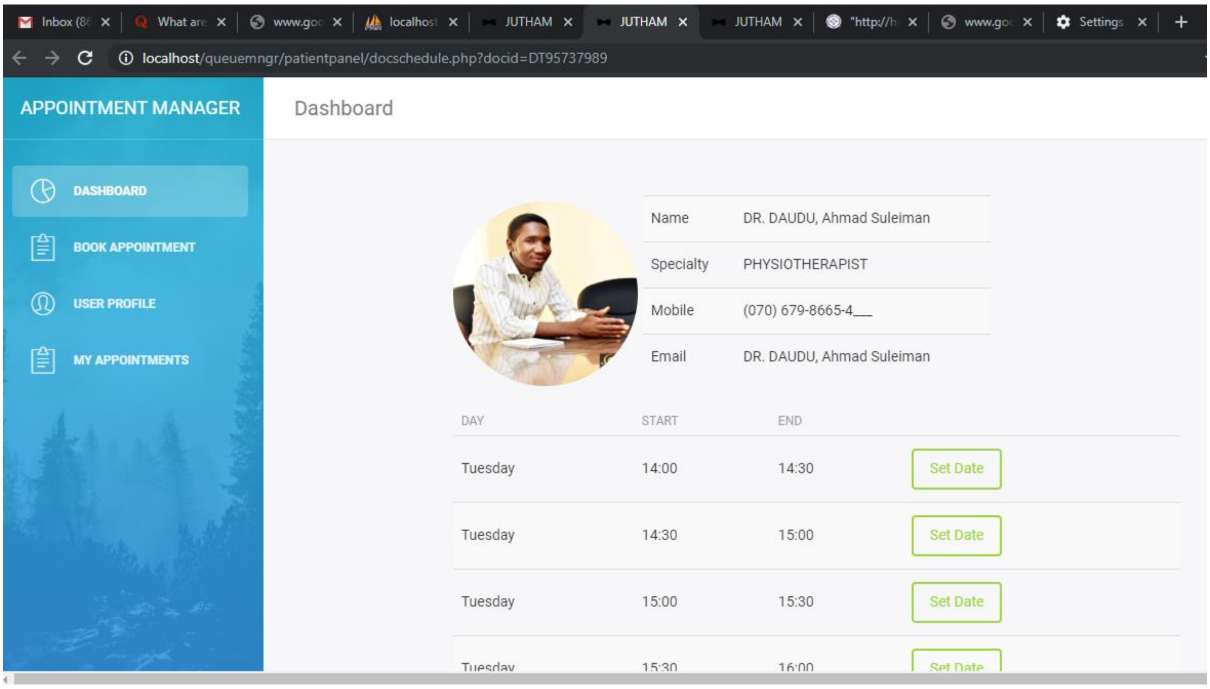

Figure 4.8. Doctor Schedule Interface

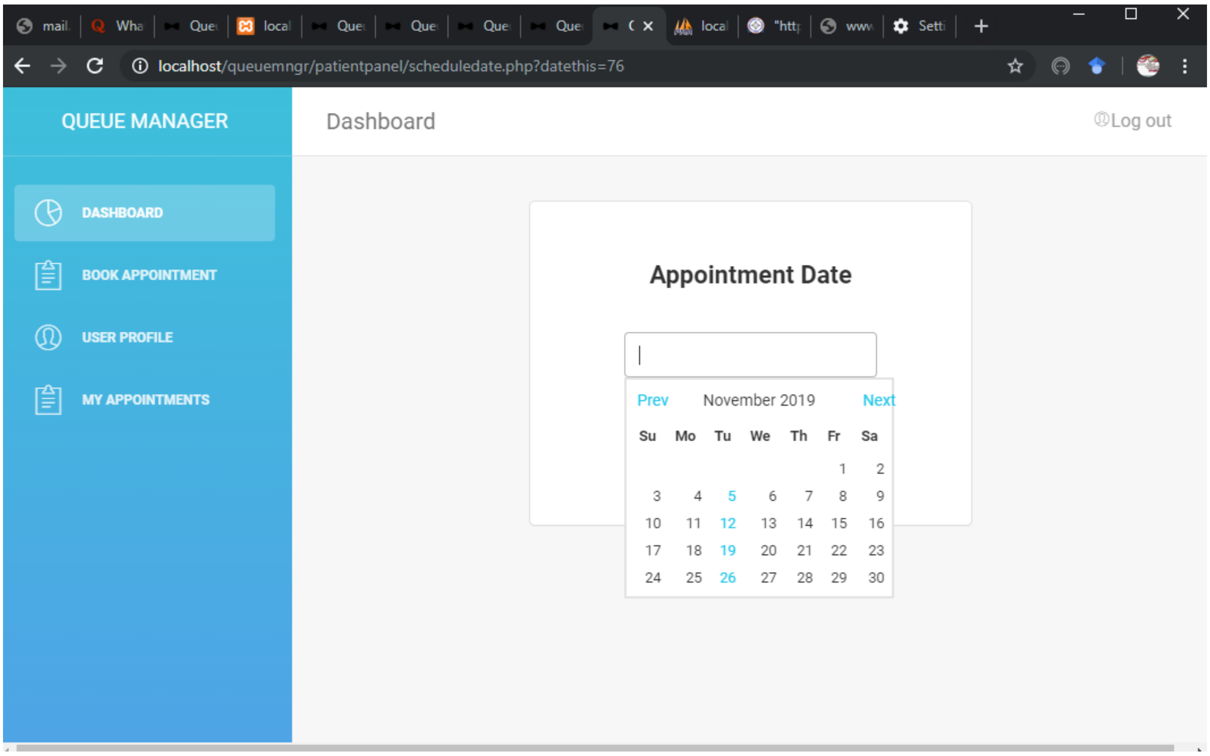

Figure 4.9. Book Appointment Interface

Figure 4.10 Shows the doctor list of appointment interface where he receives notification of pending or new appointments.

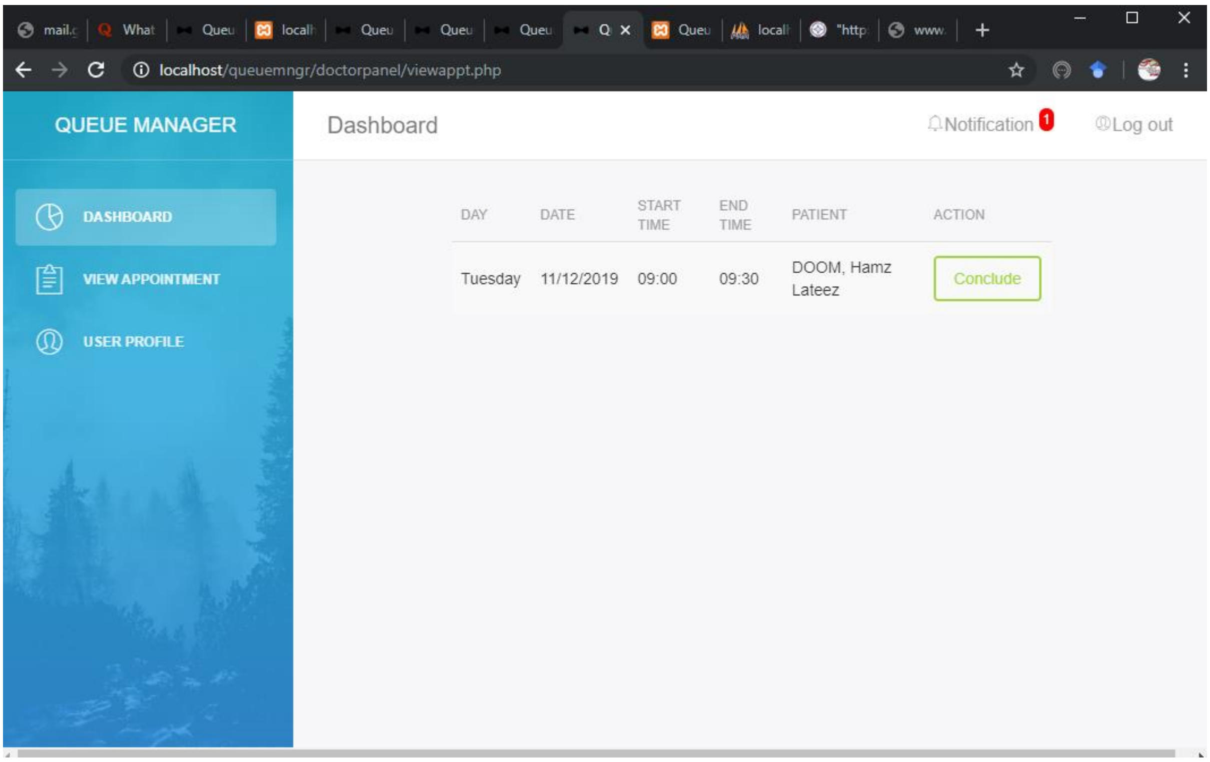

Figure 4.10. Appointment List and Notification Interface

The codes responsible for the implementation of the booking function are shown below.

```
<?php
$fetchquery = "SELECT * FROM `my_appointment` WHERE `patient` = '$patient_id' ORDER BY `id`
DESC";
if ($runfetchquery = mysqli_query($connect, $fetchquery)) {
	while($data = mysqli_fetch_assoc($runfetchquery)) {
		$id = $data['id'];
		$appt_date = $data['appt_date'];
		$appointment_id = $data['appointment_id'];
		$status = $data['status'];

		$fetch_appt = "SELECT * FROM `appointment` WHERE `id`= '$appointment_id'";
		if ($runfetch_appt = mysqli_query($connect, $fetch_appt)) {
			if ($appt_data = mysqli_fetch_assoc($runfetch_appt)) {
				$day = $appt_data['day'];
				$start_time = $appt_data['start_time'];
				$end_time = $appt_data['end_time'];
				$doctor_id = $appt_data['doctor_id'];

				$get_doctor = "SELECT * FROM `physician` WHERE
`doctor_id`='$doctor_id'";
				if ($runget_doctor = mysqli_query($connect, $get_doctor)) {
					if ($doc_det = mysqli_fetch_assoc($runget_doctor)) {
						$doc_fname = $doc_det['first_name'];
						$doc_lname = $doc_det['last_name'];
						$doc_mname = $doc_det['middle_name'];
						$doc_mobile = $doc_det['mobile'];
						$f_doc_lname = strtoupper($doc_lname);
					}
				}
?>

				<tr>
	<td scope="row"><?php echo $appt_date; ?></td>
	<td scope="row"><?php echo $day; ?></td>
```

```
<td scope="row"><?php echo 'DR. '.$f_doc_lname.' '.$doc_fname.' '.$doc_mname; ?></td>
<td scope="row"><?php echo $doc_mobile; ?></td>
<td scope="row"><?php echo $start_time; ?></td>
<td scope="row"><?php echo $end_time; ?></td>
<?php
if ($status == 0) {
?>
<td><form method="post" action=""><button class="btn btn-danger" name="cancel_btn"
value="<?php echo $id; ?>">Cancel</button></form></td>
<?php
}elseif ($status == 1) {
?>
<td scope="row"><span class="text-warning">Cancelled</span></td>
<?php
}elseif ($status == 2) {
?>
<td scope="row"><span class="text-success">Concluded</span></td>
<?php
}
?>
</tr>
<?php
}
}

}
}
?>
```

4.3 Database Implementation

This section presents query statements that were written to realize the database end (back end) of the system. The data base was realized with the use of MySQL, a relational database management system (RDBMS). The database was implemented using MySQL, an open source relational database management system (RDMS). The database was named queuemngr (short for Queue Manager) with a cumulative of six (6) tables. The names of the tables were given to be appointment, patient, physician, schedule, specialty and notify table. The code snippets below show how these tables were created alongside a screen shot of their demo.

Figure 4.1 creates the 'queuemngr' database.

```
Create database queuemngr;
```

Figure 4.11. Database

The following Structure Query Language (SQL) statements in Figure 4.12 realized the 'schedule' table shown in figure 4.13.

```
CREATE TABLE `schedule` (
  `id` bigint(15) NOT NULL PRIMARY KEY,
  `doctor_id` varchar(10) NOT NULL,
  `day` varchar(15) NOT NULL,
  `start_time` varchar(10) NOT NULL,
  `end_time` varchar(10) NOT NULL,
  `status` int(1) NOT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

Figure 4.12. Schedule Table

Table structure   Relation view

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	**id**	bigint(15)			No	*None*		AUTO_INCREMENT	Change Drop More
2	**appointment_id**	bigint(15)			No	*None*			Change Drop More
3	**appt_date**	varchar(10)	latin1_swedish_ci		No	*None*			Change Drop More
4	**status**	varchar(10)	latin1_swedish_ci		No	*None*			Change Drop More
5	**patient**	varchar(100)	latin1_swedish_ci		No	*None*			Change Drop More
6	**doctor**	varchar(12)	latin1_swedish_ci		No	*None*			Change Drop More

Figure 4.13. Schedule Demo

Figure 4.14 shows how the Table 'patient' was created and Figure 4.15 shows its demo.

```sql
CREATE TABLE `patient` (
  `first_name` varchar(25) NOT NULL,
  `last_name` varchar(25) NOT NULL,
  `middle_name` varchar(25) NOT NULL,
  `birth_date` varchar(10) NOT NULL,
  `home_address` text NOT NULL,
  `mobile` varchar(15) NOT NULL UNIQUE,
  `username` varchar(20) NOT NULL PRIMARY KEY,
  `email` varchar(70) NOT NULL UNIQUE,
  `password` text NOT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

Figure 4.14. Patient Table

Table structure | Relation view

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	**first_name**	varchar(25)	latin1_swedish_ci		No	*None*			Change Drop More
2	**last_name**	varchar(25)	latin1_swedish_ci		No	*None*			Change Drop More
3	**middle_name**	varchar(25)	latin1_swedish_ci		No	*None*			Change Drop More
4	**birth_date**	varchar(10)	latin1_swedish_ci		No	*None*			Change Drop More
5	**home_address**	text	latin1_swedish_ci		No	*None*			Change Drop More
6	**mobile**	varchar(15)	latin1_swedish_ci		No	*None*			Change Drop More
7	**username**	varchar(20)	latin1_swedish_ci		No	*None*			Change Drop More
8	**email**	varchar(70)	latin1_swedish_ci		No	*None*			Change Drop More
9	**password**	text	latin1_swedish_ci		No	*None*			Change Drop More

Figure 4.15. Patient

Figure 4.16 shows the implementation of the 'physician' table and Figure 4.17 shows a demo.

```sql
CREATE TABLE `physician` (
  `doctor_id` varchar(10) NOT NULL PRIMARY KEY,
  `first_name` varchar(25) NOT NULL,
  `last_name` varchar(25) NOT NULL,
  `middle_name` varchar(25) NOT NULL,
  `specialty` varchar(50) NOT NULL,
  `mobile` varchar(22) NOT NULL UNIQUE,
  `email` varchar(70) NOT NULL UNIQUE,
  `gender` varchar(10) NOT NULL,
  `password` text NOT NULL,
  `profile_pic` text NOT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

Figure 4.16. Patient Table

Table structure | Relation view

	#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
	1	doctor_id	varchar(10)	latin1_swedish_ci		No	*None*			Change Drop More
	2	first_name	varchar(25)	latin1_swedish_ci		No	*None*			Change Drop More
	3	last_name	varchar(25)	latin1_swedish_ci		No	*None*			Change Drop More
	4	middle_name	varchar(25)	latin1_swedish_ci		No	*None*			Change Drop More
	5	specialty	varchar(50)	latin1_swedish_ci		No	*None*			Change Drop More
	6	mobile	varchar(22)	latin1_swedish_ci		No	*None*			Change Drop More
	7	email	varchar(70)	latin1_swedish_ci		No	*None*			Change Drop More
	8	gender	varchar(10)	latin1_swedish_ci		No	*None*			Change Drop More
	9	password	text	latin1_swedish_ci		No	*None*			Change Drop More
	10	profile_pic	text	latin1_swedish_ci		No	*None*			Change Drop More

Figure 4.17. Doctor Table

Figure 4.18 shows the implementation of the ‘specialty’ table. Its demo is shown in Figure 4.19.

```
CREATE TABLE `specialty` (
  `id` bigint(13) NOT NULL PRIMARY KEY,
  `specialty_name` varchar(50) NOT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

Figure 4.18. Specialty Table

Table structure | Relation view

	#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
	1	id	bigint(13)			No	*None*		AUTO_INCREMENT	Change Drop More
	2	specialty_name	varchar(50)	latin1_swedish_ci		No	*None*			Change Drop More

Figure 4.19. Specialty Table

Table ‘appointment’ was created using the following SQL statements in Figure 4.20 and is demonstrated in Figure 4.21.

```
CREATE TABLE `appointment` (
  `id` bigint(15) NOT NULL PRIMARY KEY,
  `appointment_id` bigint(15) NOT NULL,
  `appt_date` varchar(10) NOT NULL,
  `status` varchar(10) NOT NULL,
  `patient` varchar(100) NOT NULL,
  `doctor` varchar(12) NOT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

Figure 4.20. Appointment Table

Table structure | Relation view

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	**id**	bigint(15)			No	*None*		AUTO_INCREMENT	Change Drop More
2	**appointment_id**	bigint(15)			No	*None*			Change Drop More
3	**appt_date**	varchar(10)	latin1_swedish_ci		No	*None*			Change Drop More
4	**status**	varchar(10)	latin1_swedish_ci		No	*None*			Change Drop More
5	**patient**	varchar(100)	latin1_swedish_ci		No	*None*			Change Drop More
6	**doctor**	varchar(12)	latin1_swedish_ci		No	*None*			Change Drop More

Figure 4.21. Appointment Table

Table ‘notify’ was created the following SQL statements as shown in Figure 4.22 and demonstrated in Figure 4.23.

```sql
CREATE TABLE `notify` (
  `id` bigint(15) NOT NULL PRIMARY KEY,
  `patient` varchar(70) NOT NULL,
  `reminder` varchar(150) NOT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

Figure 4.22. Notify Table

Table structure | Relation view

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	**id**	bigint(15)			No	*None*		AUTO_INCREMENT	Change Drop More
2	**patient**	varchar(70)	latin1_swedish_ci		No	*None*			Change Drop More
3	**reminder**	varchar(150)	latin1_swedish_ci		No	*None*			Change Drop More

Figure 4.23. Notify Table

4.4 System Testing

The system will be tested alongside two metrics:

i. Usability

ii. Functionality

Usability in system testing refers to the system nonfunctional requirements, this deals more with the efficiency of the system. Functionality is aimed at answering the question of whether or not the functional requirements of the system are met, its effectiveness is the focal point in functionality test. The system was evaluated by ten (10) users in the case study hospital through a system test evaluation shown in Table 4.24 below.

Table 4.24. System Test Evaluation Table

		5 (Very Good)	4 (Good)	3 (Satisfactory)	2 (Fair)	1 Poor
Functionality	**Function Suitability**					
	Automated scheduling of appointments	5 users	3 users	2 users	None	None
	Support for doctor schedule	4 users	5 users	None	1 user	None
	Support for doctor time slot allocation	5 users	2 users	None	3 users	None
	Support for appointment reminder (to patients)	4 users	4 users	2 users	None	None
	Support for appointment notification (to doctors)	3 users	5 users	2 users	None	None
Usability	**Understandability**					
	Appropriateness of icons and/or labels	2 users	4 users	None	4 users	None
	Ease of recognition of icons and/or labels	3 users	None	4 users	1 user	2 users
	Clarity and conciseness of instructions to the intended audience	1 user	6 users	None	3 users	None
	Learnability					
	Ease of learning to use the system	3 users	5 users	2 users	None	None
	Amenability to use with little/no assistance	None	4 users	4 users	2 users	None
	Appearance/Attractiveness					
	Conformity of the colours and appearance to the Hospitals's colour code	6 users	1 user	3 users	None	None
	Aesthetic perception	7 users	None	3 users	None	None

From the table above, the overall result indicates that the system passed the usability and functionality test.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

Introduction

This chapter presents the conclusion drawn from the thesis, possible limitations observed and relevant recommendations for subsequent research on the proposed topic.

5.1 Summary of the study

This thesis fundamentally x-rayed the existing system of appointment scheduling in JUTH and discovered the long waiting times experienced by patients in the General Out Patient Department of the hospital. This research demonstrated how this waiting time has burdened many patients. It was proposed therefore that an automated online appointment system (JUTHAM – web and mobile system) would solve this problem by eliminating the physical queueing process, which was found to be highly inefficient especially as regards to the time spent in such queues before seeing a physician. It is expected that with this system deployed in, waiting time of patients in the hospital will no longer be a challenge as it has been before this thesis.

5.2 Conclusion and Recommendation

Finally, the developed system (JUTHAM) was tested and found to have achieved the aim of the research which was to design and implement a multi-platform hospital appointment manager.

5.2.1 Limitation

JUTHAM is not a standalone system but is designed to be integrated into the existing hospital management system. Without this, patients will still experience long waiting times as the manual (paper-based) process of retrieving patient record is still time consuming.

5.2.2 Recommendation

For future developments, I recommend the development of an appointment system that will solve tandem queues (queues in series) in the hospital.

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