Saudi Journal of Engineering and Technology (SJEAT)
Scholars Middle East Publishers
Dubai, United Arab Emirates
Website: http://scholarsmepub.com/

ISSN 2415-6272 (Print)
ISSN 2415-6264 (Online)

Object-Oriented Design (OOD) Consideration in the Design and Deployment of Agent-Based Patient Appointment and Scheduling System (APASS): A Case of University of Calabar Medical Center

Ele, Sylvester I*, Ofem OA, Obono I. Ofem
Department of Computer Science, University of Calabar, Nigeria

Original Research Article

***Corresponding author**
Ele, Sylvester I

Article History
Received: 07.04.2018
Accepted: 18.04.2018
Published: 30.04.2018

DOI:
10.21276/sjeat.2018.3.4.4

Abstract: The University Medical Center which currently runs a manual system for the management and maintenance of its critical information also operate an Outpatient Department in which non-urgent patients arrives for consultation with the problem of patients' long waiting time. This scenario has resulted to certain impediment ion terms of service rendering, including difficulty in accessing data due to improper keeping of patient details; delay in attending to patients on emergency which could lead to case complications as well as death of the patient; Lack of an effective Doctor-Patients appointment coordination; and more so, the few Doctors and Nurses could be overworked. The aim of this research project is to develop an Agent-Based Appointment Management System that will improve the medical center's efficiency in health services provision and reduce outpatient waiting time without adding extra resources. With the introduction of appointment system, the result has shown that average waiting time could be reduced by thirty-seven to forth-four percent as compared to the current status. Object Oriented Analysis and Design Methodology (OOAD) were adopted in the design for the Design and development of the proposed system. The proposed system was implemented using PHP, AJAX, HTML programming technologies. MYSQL was used as the database engine in XAMP server. The hospital appointment and scheduling system was tested using several test data by stakeholders and error correction was carried out.
Keywords: Appointment System, Patient Management System, Intelligent Agent, OOP.

INTRODUCTION

Primary care clinics are under huge pressure to improve access, health outcomes, quality and efficiency of care giving with any amount of available of resources, especially in the current economic situation. The consequence of providing patient-centered care with improved access and stability has been a subject of highlight in a number of studies [1]. Improved access and stability in service delivery are key components of patient-centered care. Studies and researches has proved that quite a number of involvement and interventions by clinics managements and administrators been put place such as providing same day appointments, walk-in services, after-hours care, and group appointments. The primary intention of these interventions in the healthcare systems is to improve access to primary care.

Today, it has become commonplace to come across numerous patients waiting long periods of time to be serviced at a clinic or hospital. As the demand of outpatient facilities rises, more concentration and attention is also being channeled to waiting times of patients, including doctors and other medical personnel [2].

Using open access scheduling allows clinics the ability to minimize the cost of both the patient and the clinic. Regrettably, waiting times for all involved are still apparent [3].

Edward and Sankaranuarrayana [4], noted that Access to the correct healthcare facility is a major concern for most people in today's world. Any average person will need to carry out a search of the hospitals and healthcare facilities within his/her locality to gather information such as skill level of doctors, type of facilities available in the hospital, the environment (cleanliness), the level of customer service provided and the affordability of the services offered.

Since time to be spent for appointment is a major constraint for any individual these days, an electronic computerized scheduling system will most likely solve some inadequacy in the existing manual scheduling and appointment process, especially in the University of Calabar Medical Centre. Computerized scheduling systems manage appointments and meetings. A number of solutions have been put forward as it relates to the use of ICT in making the scheduling of

appointments in education and in healthcare more efficient.

The need to render detailed bills, schedule doctor-patient appointments and reservations has stimulated the formation of fully integrated patient management information system that can record, store and report significant treatment and its associated cost." Based on reports, a 1975 survey of some 6000 hospitals by an American Hospital Association revealed that about 1500 hospitals had in-house computers. The number which has increased proved that with the advent of mini computers and information care systems, the patient management information system will become inevitable in health care. Consequently, the hospital information system has ceased to be a luxury and hence has become a necessity. Current trends have proved that the application of computer technology to health care management is ideal as it is to other sectors of society. This is attributable to increasing demands and expectations for medical services, heavy increase in volume of paper work, the need for rapid transmission of data, increase in hospital admission and emergency care services, increased mandatory report to government bodies etc. When used properly, the patient management information system can disseminate information to the appropriate people at the proper time and thus benefit the patients individually and the society collectively. Thus, the societal trend towards dependence on computers is for the collection, maintenance, storage, management and analysis if patient data appears to present significant opportunities and positive advances in the health care industry.

Appointment reservations and scheduling systems in health care are used to maintain and manage the access to service providers which are the hospitals. In many aspects, it might affect the administration of appointment scheduling systems which includes; the arrival time, time variance in consultation, doctor's preference, dates and other information relating to the technology and maturity level of the administration staff. Hence an appointment scheduling and reservation system is needed considering necessary factors and features which will elevate patient hopes and satisfaction and in turn increase profit margin.

There are existing appointments scheduling system. Some, which are online appointment scheduling systems, also have patient health records management as part of its package. The clinic can create a single point from which patient information can be saved, updated, managed and analyzed. Recording, reporting, and analysis of such information help manage a patient's case file efficiently. All information about the patient recorded regularly, along with a history of checkups and related medical tests, can be used when making educated, carefully considered decisions regarding the patient's healthcare. This can reduce documentation bulk and reduce the time in accessing physical files. Redundant data entries about the same patient can also be avoided. In addition to this, the patient's ongoing records can be updated at each appointment, making information on the patient available in one place for easy and quick access. Non-attendance or no-shows can result in loss of revenue, affected workflow and increased expenses. Not forgetting the inconvenience and annoyance it poses. Online appointment and scheduling systems greatly reduce no-shows or nonattendance, and thus, save revenue.

The university medical center currently uses a manual system for the management and maintenance of its critical information. This requires several paper forms, with data stores littered over the hospital management infrastructure, multiple copies of the same information exist thereby leading to data inconsistency and hampers data integrity. It has been reported that the Nigerian health sector shows that death rate tolls by a high percentage rate yearly due to certain reasons; including inadequate attention to patients, doctors' inability to keep appointments, delay in response to emergency.

The aim of this research work is to develop an agent-based appointment and management system. The goal is to create a database that would support the storage of patient and hospital staff information; and design an agent-based automated system for patient-doctor appointment, scheduling and record.

REVIEW OF RELATED LITERATURE

In the words of Ogbobe [5], Health Care services delivery especially in developing nations such as Nigeria are continually hampered by very weak information infrastructure to support data collection, collation, analysis and interpretation. This has led to a myriad of problems such as poor and inadequate information for clinical care of patients, education, research, and planning, budgeting and report generation amongst others. The burdens of poor information infrastructure are missing and misfiled patients' record which is gradually becoming a norm while data reporting is either absent or delayed to the point of un-usefulness. Hospitals are still groaning with the burden of manual health records, absence of good health library and long patient waiting time for documentation. They are still struggling to benefit from the gains of information and communication technology, hence the need for Hospital appointment and scheduling System.

The application of information technology in health care is unceasingly evolving as the quality of patient care in contemporary times seems to depend on the timely acquisition and processing of clinical information related to the patient. Murray [6], stated that a significant paradigm shift has occurred in health care service delivery from an era of physician centeredness to emphasis on quality of patient care,

from isolationist practices by caregivers to networking in a global world, and from competition to collaboration among practitioners. In tandem with this trend, improvement in technology and advancement in information systems has been adopted in the health care industry as a business strategy to improve the quality of care. Health care service delivery in Nigeria falls short of international standards resulting from poor state of health care infrastructure, shortage of medical professionals, threat of re-emerging infectious diseases, poor sanitation but to mention a few.

According to Sherly [7], Electronic medical record systems help to improve access to health care in remote suburban areas and ensure improved maintenance of long-term care. According to Keenan *et al*., [8], Hospital information systems include strategic decision support systems and clinical documentation systems. Some of the clinical support systems include: Appointment and Scheduling Systems (ASS), Laboratory Information Systems (LIS), Radiology Information Systems (RIS), and Computerized Order Entry (COE). Others are pharmacy information systems and personal data analysis systems with important added feature for messaging between providers and staff, and the ability to share data with other medical facilities.

An intelligent agent is involved in development of the appointment system. An intelligent agent is software that assists people and act on their behalf. Intelligent agents work by allowing people to delegate work that they could have done, to the agent software. Agents can perform repetitive tasks, remember things humans can likely forget, intelligently summarize complex data, learn and even make recommendations [9]. All agents are autonomous, implying that an agent has control over its own actions. All agents are also goal-driven. Agents have a purpose and act accordance with that purpose. An agent could also sense changes in its environment and responds to these changes [10].

The idea of an agent was originated by John McCarthy in the mid-1950, and the term was coined by Oliver G. Selfridge a few years later. According to Kay [11], .an agent would be a 'soft robot' living and doing its business within the computer's world." Though this is one definition, there are so many other definitions or ideas about what an agent is. According to Selker [12], Agents are looked at as "a persistent software entity dedicated to a specific purpose.

In a Multi-Agent System, agents are social, this means that they communicate with other agents. Some agents learn or change their behavior base on their previous experiences. Some agents are mobile, meaning they move from machine to machine to be closer to data they may need to process and do so without network delays. Finally, some agents attempt to be believable, such that they are represented as an entity visible or audible to the user and may even have aspects of emotion or personality.

Object–Oriented Analysis (OOA) is the procedure of identifying software engineering requirements and developing software specifications in terms of a software system's object model, which comprises of interacting objects. Object–Oriented Design (OOD) involves implementation of the conceptual model produced during object-oriented analysis. In OOD, concepts in the analysis model, which are technology−independent, are mapped onto implementing classes, constraints are identified and interfaces are designed, resulting in a model for the solution domain, i.e., a detailed description of how the system is to be built on concrete technologies. Object-oriented analysis (OOA) applies object-modeling techniques to analyze the functional requirements for a system. Object oriented design (OOD) elaborates the analysis models to produce implementation specifications. OOA focuses on what the system does, OOD on how the system does it.

System Design

Use Case Design

A *use case* specifies the behavior of a system or a part of a system, and is a description of a set of sequences of actions, including variants, that a system performs to yield an observable result of value to an actor. An *actor* is an idealization of an external person, process, or thing interacting with a system, subsystem, or class [13]. The Use Case for the appointment system is shown in the figure 1 below.

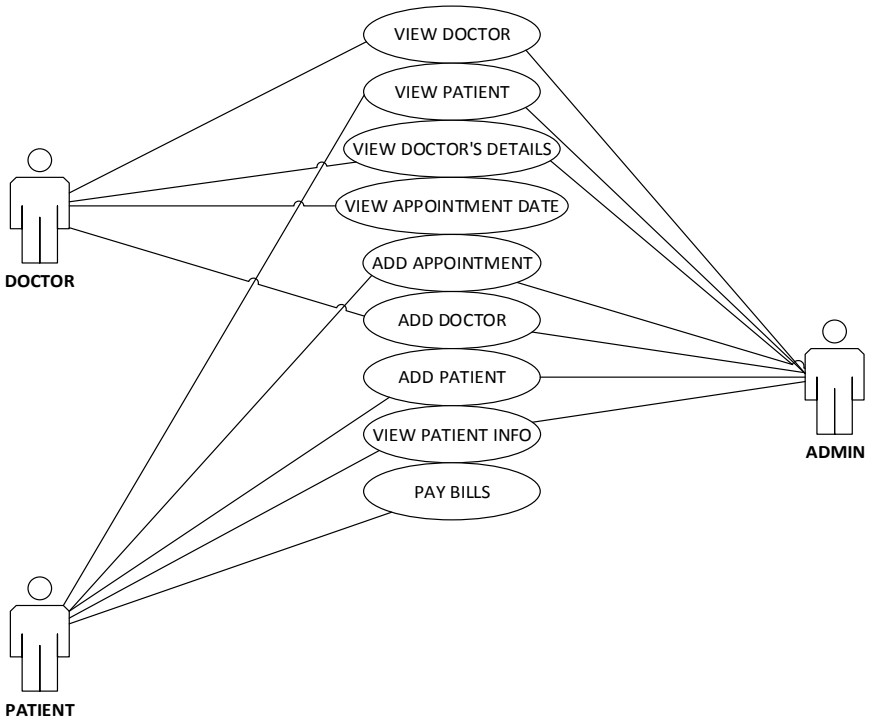

Fig-1: Use Case Diagram of the APASS

Class Diagram

A class is a collection of objects with common structure, common behavior, common relationships and common semantics [13]. The classes identified in this system are *Doctorclass*, *Patientclass*, *AdministrativeClass* and *AppointmentClass*. The class diagram for the Appointment system is represented in figure-2 below.

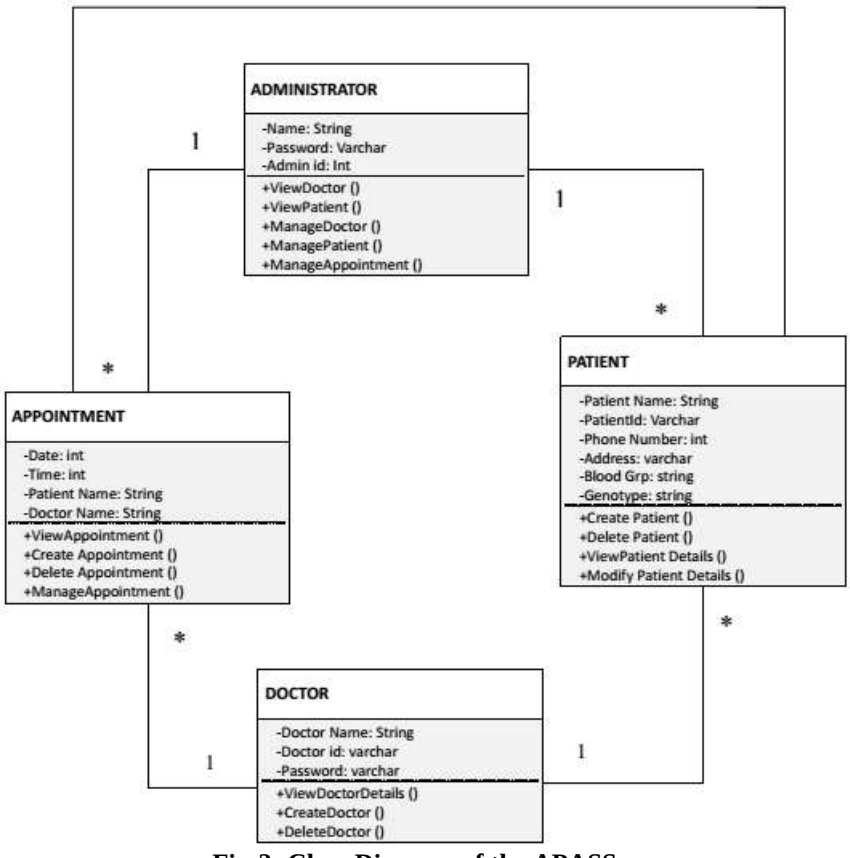

Fig-2: Class Diagram of the APASS

Activity Diagram

The Activity Diagram illustrates the dynamic nature of a system by modeling the flow of control from activity to activity. An activity diagram displays and defines the performances measure of a given system. Actions taken and the results of corresponding actions can be derived from it. Figure-3 represents the activity diagram of the Appointment System.

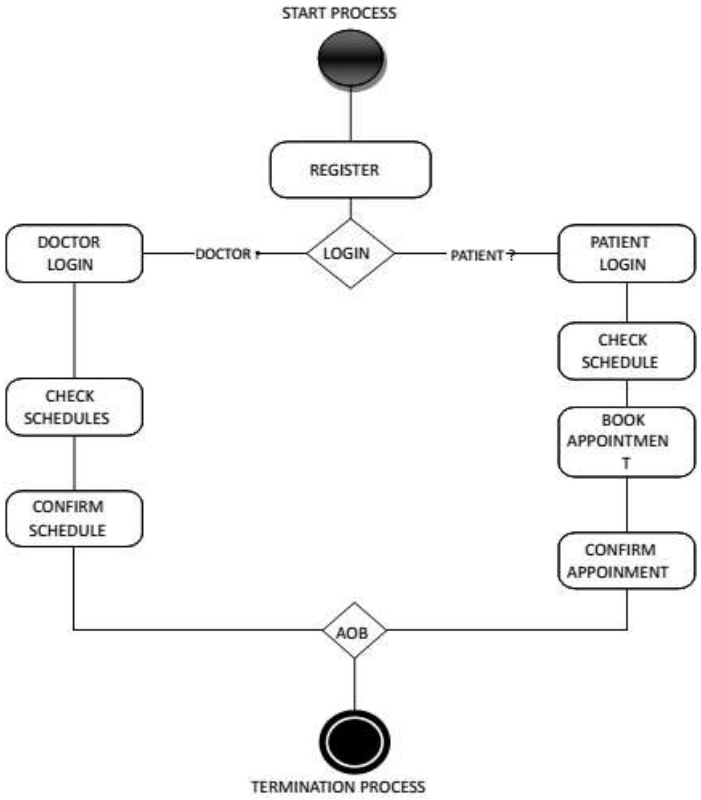

Fig-3: Activity Diagram of the APASS

Database Design

The database is the functionality for storage and record keeping of patient data. In the proposed Patient Appointment System, the objects identified during our analysis and investigation stage are transformed into entities: patient, doctor and administrator and appointment, and tables are defined for each of the entities.

User Login Table

S/N	Field	Data Type	Size	Foreign Key
1	Email	VARCHAR	25	NO
2	Password	VARCHAR	50	NO
3	PATIENT_ID	VARCHAR	10	NO

The Patient Record Table

S/N	Field	Data Type	Size	Foreign Key
1	Surname	Text	15	No
2	First Name	Text	15	No
3	Home Address	VARCHAR	20	No
4	Phone Number	Decimal	13	No
5	Gender	Text	5	No
6	Patient ID	VARCHAR	10	Yes
7	Blood group	Varchar	5	No

The Doctor Table

S/N	Field	Data type	Size	Foreign key
1	Surname	Text	15	No
2	First Name	Text	15	No
3	Doctor ID	VARCHAR	15	No
4	Specialty	Text	20	No
5	Phone Number	Integer	13	No

The Administrator Table

S/N	Field	Datatype	Size	Foreign Key
1	Name	Text	15	No
2	Password	Text	15	No
3	Admin ID	Varchar	10	Yes

Appointment Table

S/N	Field	Datatype	Size	Foreign Key
1	Appointment day	Date	15	No
2	Appointment time	Integer	10	No
3	Schedule Appointment	Boolean	5	No

Database Data Definition

Patient Table Definition

Field Name	Field Type	Constraint	Description
Patiend ID	Varchar	Not null	Patient hospital identification code
Name	String	Not null	Patient's name
Password	String	Not null	Password
Blood group	String	Allow null	Patients' blood group
Genotype	String	Allow null	Patient's genotype
Phone	String	Not null	patient's phone number
Address	Address Array	Not null	Patient's Home address.
Gender	String	Not null	Patient's gender
Email	String	Not null	Patients email address

Doctor Table Definition

Field Name	Field Type	Constraint	Description
Doctor id	Varchar	Not null	Doctor's hospital identification number
Name	String	Not null	Doctor's name
Password	String	Not null	Doctor's Password
Specialty	String	Not null	Doctor's area of specialty
Phone	String	Allow null	Doctor's phone number
Email	String	not null	Doctor's email address.

Administrator Table Definition

Field Name	Field Type	Constraint	Description
Admin id	Varchar	Not null	Administrator's identification number
Password	String	Not null	Administrator's Password

Appointment Table Definition

Field Name	Field Type	Constraint	Description
Admin id	Varchar	Not null	Administrators identity
Date	String	Not null	Appointment date

Architecture of the Patient Appointment System

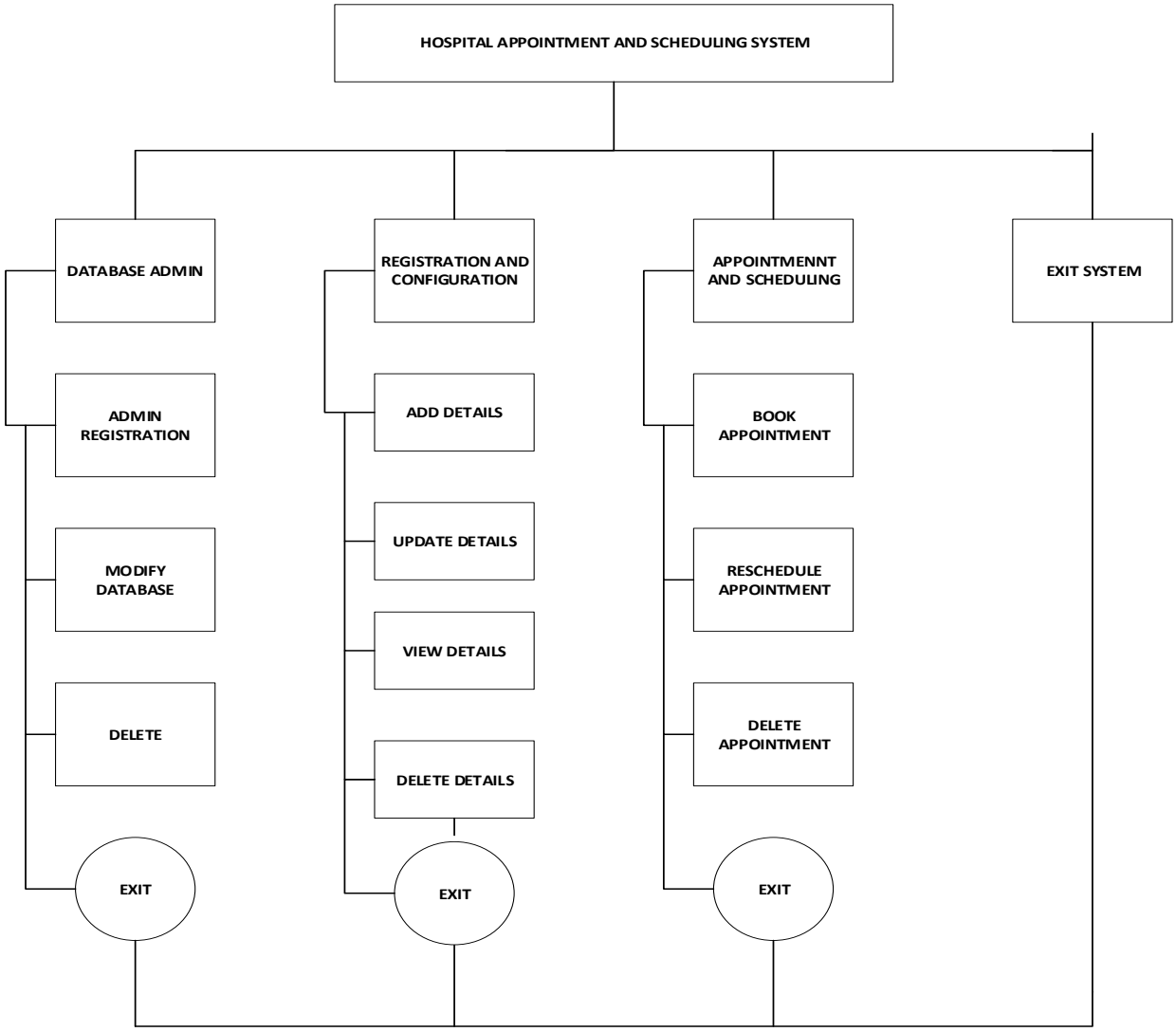

Fig-4: Architecture of the PAS

Implementation and Results

Coding and Choice of Programming Language

Coding and implementation was done using PHP technology with the help of an IDE such as NetBeans, Sublime Text, etc. A local server such as XAMP was also used, this is because it provide effective and dynamic native libraries for the success of the project. The languages employed in the implementation of this system are HTML5, CSS, JavaScript and PHP. Whereas HTML is the basic structure a website, it also describes the structure of the web application, and adds style.

Target System Requirements

Hardware Requirements

- Hard disk: 350GB
- RAM: (2-4) GB
- Processor: Intel core i3, i5, i7.

Software Requirements

- Operating system: windows 7 (32/64 Bit), windows 8 (32/64 Bits), windows 10 (32/64 Bits)
- PHP, MySQL, CSS, AJAX and HTML.
- Sublime Text 3 editor
- PhpMyAdmin

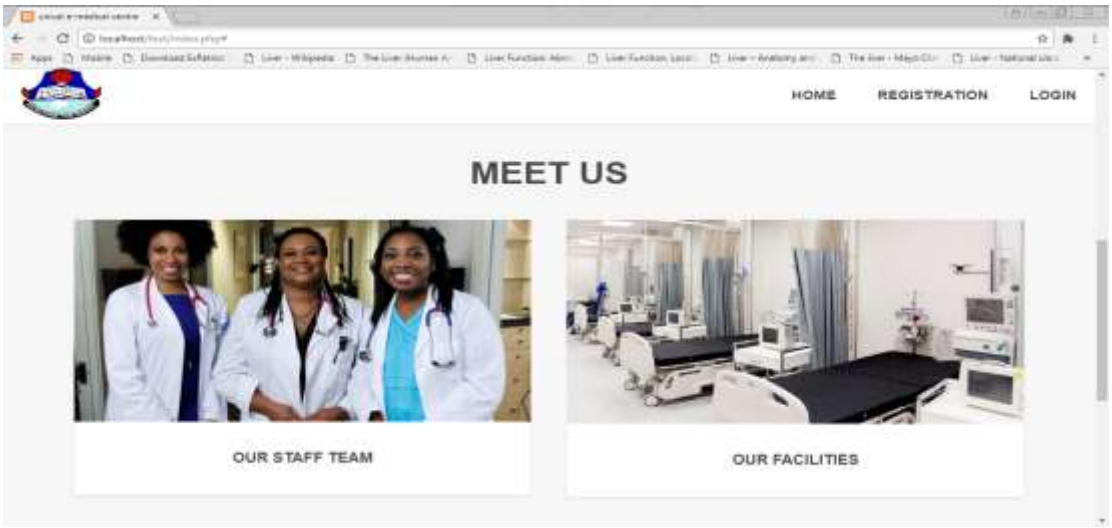

Fig-6: Home Page of the APASS

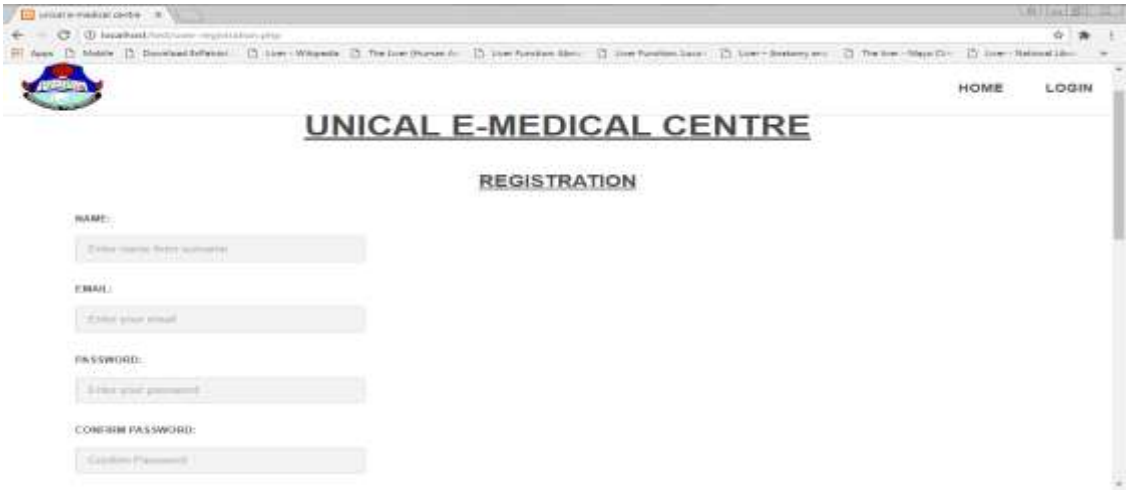

Fig-7: Home Page of the APASS

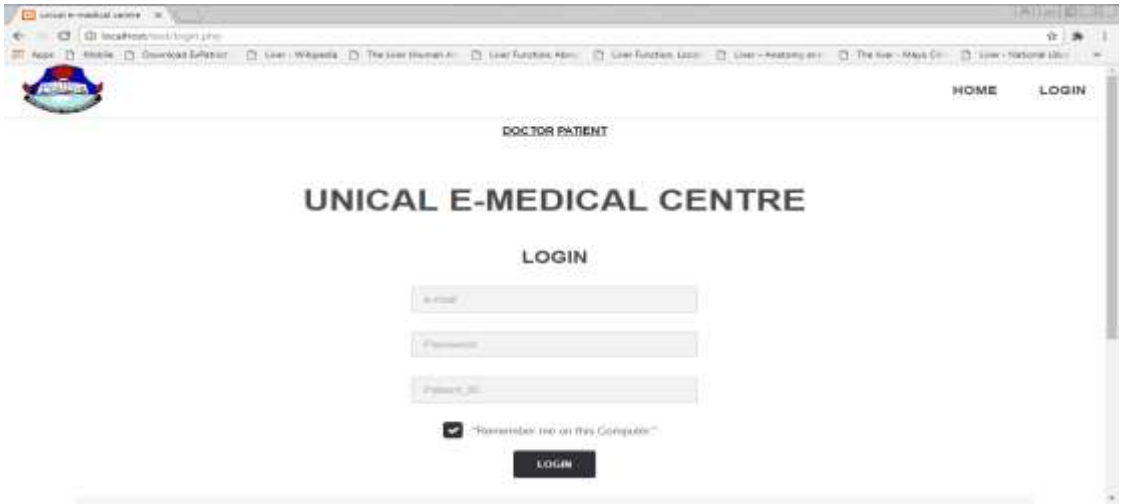

Fig-8: Patient Login Page of the APASS

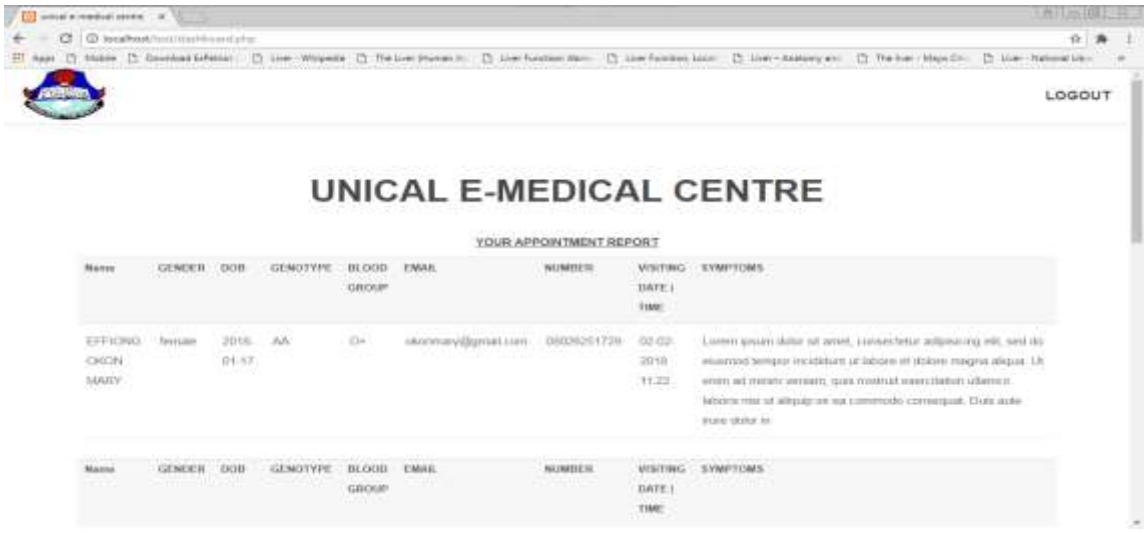

Fig-9: Doctor's Appointment Report Page

CONCLUSION

This research work has been able to implement a prototype System for the Appointment and Scheduling System using the University of Calabar Medical Center as a case area. In the design of the system, the main thrust was on the application and use of Object-Oriented Design approach in the modeling of software such the APASS, using a modern modeling tool such as UML to provide clear notations and pictorial representation of the architecture of the system. The coding stage tried to follow the archetypal representation in the design stage, as modeled in the Class, Use Case and Activity diagrams. From all test results, the system provides appropriate solution to the problem as it eliminates the need for paper-based appointment and scheduling, and record keeping, as currently practiced in the University of Callabar Mrdical Centre. The system still provides room for further improvements and additional functionality.

ACKNOWLEDGEMENT

My special and profound appreciation goes to my student, Eyakndue, Precious Imohowo who provided not only typesetting assistance for this research, but was also helpful in consultations and data gathering. Big thanks to her.

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