Development of a Multi-platform Outpatient Appointment System with Automated Interactive SMS Service

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Abstract - The accessibility to healthcare services is of utmost importance in any country. However, faced with increasing cost, limited capacity and expanding demand, outpatients face main dissatisfaction in terms of access and waiting times. In an attempt to solve this, appointment systems were developed to allow patients communicate and book an appointment with their health care providers at any time. While these medical appointment systems reduce waiting and access times, they do not offer full flexibility in terms of ways of booking an appointment. These systems tend to only cater millennials (born 1981-1996) and Gen X (born 1965-1980) who are adept in tech devices. Older patients (Baby Boomers, born 1946-1964) are left doing walk-in appointments. The researcher developed a cross-platform outpatient appointment system with automated interactive SMS service. This project aims to address the limitations of existing appointment systems. This project provides a multi-platform means for booking an appointment. The system allows outpatients to book their medical appointments using a web browser, mobile app or through SMS. To accomplish the project, the researcher started with identifying the functional and non-functional requirements of the system. From these requirements, the researcher was able to identify the system's four modules: the administrator, secretary, doctor and patient. The researcher used different design tools to create the logical and physical design of the system. The design served as a blueprint to develop the system. The system was developed using different web and communication technologies and frameworks such as Laravel, VueJS and Twilio. Tests were done to make sure the system's completeness. The system was deployed in a web server. Minimum hardware and software requirements were identified. Installation and user manuals were also created to provide thorough guide in using the system..

Keywords: *multi-platform outpatient appointment system, booking by SMS, interactive SMS*

1. INTRODUCTION

Health has been a priority in the Philippines. In the National Objectives for Health 2011-2016 of the Department of Health (DOH), it is projected that the average life expectancy of Filipinos will increase to 70.38 years from 2010 to 2015 and 71.59 years from 2015 to 2018 through improved national health insurance program, health support systems, improved access to quality hospitals and health services. The DOH budget trend from 2010-2018 shows increasing budget allocation to support its national objectives for health. There is a 13% increase of budget from PhP 151 Billion in 2017 to PhP 171 Billion in 2018. This increase in

yearly budget is due to factors such as new advances in expensive treatment technologies and pharmaceuticals, unfavorable trends in population demographics such as aging, obesity and chronic disease, and legal expenses resulting from medical errors and malpractice. Faced with this environment of increasing costs, limited capacity and expanding demand, many hospitals in the Philippines, public and private, are emphasizing shorter lengths of stay and are shifting care from inpatient to outpatient facilities. This, in turn, results to requiring outpatient medical facilities to reassess their operations and processes to match the quality of healthcare access of outpatients to that of inpatients. Access to these outpatient facilities is

controlled through scheduling of medical appointments.

The term "medical appointment" is defined as a pre-scheduled duration of time allocated to a patient's visit and time to be spent with a medical practitioner (Irin Sherly, et. Al., 2016). When scheduling medical appointments, patients prefer to have a short waiting time, while physicians and other medical practitioners aim to have as little idle time as possible, and to finish on time (Kaandorp and Koole, 2007). The current outpatient departments depend on first-come, first-served basis where a patient can schedule a consultation in two ways: (1) walk-in appointment and (2) appointment scheduled by calling in. Sickinger and Kolisch (2009) stated that the appointment scheduling is a trade-off between doctor's and patient's waiting times. While outpatients may have longer waiting times, doctors or providers can have frequent idle times. Gaps in the appointment schedules also cause underutilization of the doctor's time (Sickinger and Kolisch, 2009). Even if there are appointment scheduling techniques in place, there are still many challenges being experienced.

Patients who scheduled appointments face several issues on access and waiting times. In outpatient clinics, the access and waiting times are patients' main dissatisfaction with hospital services (Huang, 1994)(Wang and Gupta, 2011). Access time is the time between the patient's request for an appointment and his arrival at the outpatient clinic (Cayirli et al., 2003). A patient's waiting time is the period between the scheduled starting time and the actual starting time of his consultation. Problems in access time is caused by schedulers and phone lines availability. In addition, when the outpatient facility or clinic is working close to its capacity, the earliest schedule tends to be fully utilized and appointment slots might not be available for many weeks or months. This situation is problematic because when the appointed time does arrive, some patient's needs could have changed significantly and the previously booked medical service may not already apply because patient could have recovered, moved, forgot or died. The same

problems were encountered in Nigeria, when National Health Insurance Scheme (NHIS) was introduced (Iloh et al., 2012). There is long waiting time before an NHIS outpatient can have access to see the doctor.

For medical service providers, late arrival, unexpected number of walk-in appointments and no-show appointments are the most common problems. No-show appointments refer to appointments for which patients did not show (Balik et. al., 2018). There is a reported 5% - 55% no-show rates in medical outpatient facilities (Festinger et. al., 1996) (George, et. Al., 2003). No-shows have negative impacts including wasteful use of clinic resources, medical practitioners time, decrease in the quality of care and productivity, escalation of costs and reduced accessibility for all patients (Moore, et. Al., 2001). In addition, the current manual process entails problems such as more paper-based, huge stack of patient files and records for health history, provider notes, appointment records, admission and discharge information, laboratory and radiology report information, index of summary and patient hospital visits. In the Philippines, the same problems were being encountered by providers and patients. In a study conducted by J. Banawol, et. Al. (2013), patients' satisfaction to a Level IV private hospital's Outpatient Department (OPD) in Baguio City. There were 125 patients that participated in their study conducted last December 2013 at SLU-Hospital of the Sacred Heart Outpatient Department. It is worth noting that in their study, 40% of patients are not satisfied when it comes to the waiting time until they get to see a doctor.

Noting these challenges here in the Philippines and abroad, there has been a vast number of techniques and methods that were introduced to solve the underlying challenges. One is Open-access scheduling. It is "when participants were able to schedule an appointment for the next day" (Bundy et. al., 2005; Kopach et al., 2007; Lacy et al., 2004). Another effective solution to no-show appointments are no-show policies (Van Dieren et al., 2013, Schmalzried & Liszak, 2012) and appointment reminders. An appointment-

reminder system uses phone calls, emails and texts to remind the outpatients for their medical appointment. In addition, several technology-based solutions have been introduced to solve long waiting times.

Information and Communication Technology (ICT) and the Internet have made innovations to almost any sector worldwide, including the healthcare industry. Through these two main enablers of innovation, numerous medical appointment systems were developed. These medical appointment systems are either web technology-based applications or native applications. The most popular web-based medical appointment scheduling systems in the market today are provided and maintained by health and IT companies such as InQuicker, ZocDoc, Appointy and others.

Cao, et, Al. (2011) presented a web-based appointment system to reduce waiting time for outpatients in China, especially in tertiary hospitals. The results of their study showed that use of a Web-based Appointment System (WAS) can effectively increase patient satisfaction by reducing the waiting times, increase and reduce non-attendance (no-show) rates. This reviewed literature will help the researcher to note that promotion and reminder systems are essential components of a medical appointment system.

Idowu, et. Al. (2014) presented an online National Health Insurance Scheme (NHIS) Outpatient Medical Appointment Booking System where NHIS patients can access and view any available personnel or doctor schedule in order to book an appointment with the corresponding time as specified by the available doctor. The system was developed using PhP, Macromedia Dreamweaver, Apache and MySQL. This literature will help the researcher to consider the technologies used to ensure that the application is robust, cheap and is able to run on different platforms.

In the Philippines, a technical report of Sarmiento, et. Al. (2011), discussed the Community Health Information Tracking System (CHITS) with SMS-based enhancements. The

said enhancement used SMS technology and SMS-based applications to improve the delivery of health unit services of urban health centers. A monthly comparison report shows that the use of the reminder system significantly influenced the number of monthly follow-up visits to the health centers. This literature will help the researcher to note that SMS-based appointment reminder module can be integrated to the proposed system to improve the number of follow-up medical check-ups.

While these medical appointment systems help reduce the occurrence of the problems imposed by the traditional systems, other useful features can still be integrated and improved. While Millennials and Gen X are adept in using gadgets, Baby Boomers prefer to use basic phones. And this generation comprises the greatest number of visits in an outpatient facility. However, none of the reviewed systems offer full flexibility in terms of ways to book an appointment, particularly to Baby Boomer's age group. Most of them are using browser-based systems that require the patient to have a computer with an active Internet connection. The reviewed systems were not able to provide multi-platform mechanism to allow patients to book appointments. In this study, the researcher aims to develop a multi-platform outpatient medical appointment system that offers full flexibility on how patients book their appointments. It is an on-demand scheduler for medical appointments for roster of medical practitioners, clinic administrators and secretaries. This system will allow outpatients book their medical appointments online using a web browser with an active Internet connection. This system will also allow the outpatients to book using SMS messages through their basic phones. This makes booking without the need of Internet connection, smartphone or a computer. Its functionalities include easy-to-follow appointment scheduling, finding available doctors according to the medical services they offer, email and SMS notifications for upcoming appointment reminders, email and SMS notifications of any change in appointment and in queue, user roles

and management, calendar view for the clinic secretary, reporting, and security.

2 METHODOLOGY

The researcher chose the Waterfall Model as its software development methodology. The researcher chose the Waterfall Model because requirements were clearly laid out, and very well understood.
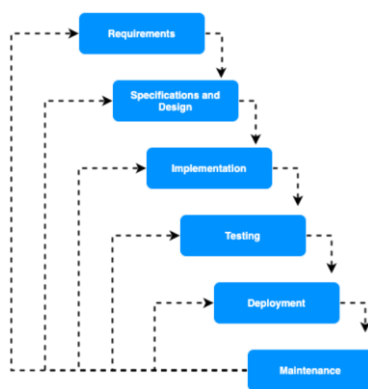

Figure 2.1 Modified Waterfall Model

2.1 Identifying functional and non-functional requirements

In order to determine the functional and non-functional requirements, different techniques in data gathering were done such as interviews and observations. The functional requirements were identified from scheduled structured and unstructured interviews with people in Outpatient Department of the hospitals in Pangasinan. Through interviews and reading of related literatures, the researcher was able to collect information about the business process related to medical appointment booking. From the arrival of patients, service process, queuing process, up to the process of receiving actual health care services. Another data gathering technique used to obtain data is through the observation method. Through this, the researcher was able to observe the process of scheduled and unscheduled appointments, as well as the problems that occur

in the current manual process of getting an appointment.

The non-functional requirements for the system were identified through interviews with some clinic secretaries, medical service providers and outpatients about their preferred aesthetics and features. The researcher also considered the list of non-functional requirements of a typical appointment system by reviewing and considering different medical appointment applications available in the market today and analyzed their applicability to the project that was developed. To group the non-functional requirements, the researcher used the categorization stipulated in FURPS+ (Functional, Usability, Reliability, Performance, Supportability) model.

The modules of the system were identified by analyzing the requirements. The researcher also reviewed number of medical appointment systems available in the market today and examined their existing modules. The result of the review helped the researcher to choose the appropriate modules to be added into the system. The interviews with different secretaries of outpatient clinics also helped the researcher to determine the modules with their corresponding features and functions.

To visualize the modules of the system, the researcher used a top-down strategy. In this strategy, the main module is identified. The main module is subdivided into submodules or segments based on the tasks performed by each module.

2.2 Creating the Design of the System

This section discusses how the researcher created the logical and physical design of the system. Section 2.2.1 discusses how the database and schema was designed. Section 2.2.2 discusses how the use cases were designed. Section 2.2.3 discusses how the system architecture was designed. Section 2.2.4 discusses how the process flow diagram is designed.

2.2.1 Defining the Database Design

The forms and actual data that were collected during the data gathering phase in Section 2.1 were used as a basis for the creation of the database design. The diagram and schema are created to represent the database design of the system. Entity-Relationship Diagram (ERD) was created to represent and visualize the entities and their relationships to each other. The forms that were shown during the interviews was used by the researcher as one of the bases for selecting the entities present in the Entity-Relationship Diagram (ERD). While the modules helped the researcher to outline the relationships between the entities. After the creation of the ERD, a database schema was created to show and represent the skeleton structure of the whole database. The database schema was also used to show how will the data be organized and how the relations among them are associated. In addition, foreign keys, foreign key constraints, primary keys and alternate keys for each entity are also identified in the database schema.

2.2.2 Creating the Use Case Diagram

The identified functional and non-functional requirements and modules from Section 2.1 and Section 2.2.1 were used as bases in making the Use Case Diagram. The researcher created the Use Case Diagram to visually model the system's dynamic behavior when it is operating and deployed. The diagram illustrates internal and external agents as actors. with their main flow of events as well as their alternate flows to have a model of the interactions between the users of the system. The Use Case Diagram was created by defining the actors that are involved in the system. The functional requirements that were gathered in Section 2.1 is used to illustrate use cases. Use cases are drawn to capture the functional requirements of a system and represent the activities to be performed by the actors.

2.2.3 Defining the System Architecture

The defined functionalities, features, modules, database design and use case diagram in the previous sections served as the basis in creating the System Architecture Diagram. The System Architecture Diagram shows the structural design of the system. It shows the important processes and how those processes behave in the system. The diagram shows a mapping of functionality onto hardware and software components. The diagram also shows the technologies and services that were used and their relationship with the functionalities, features and modules.

2.2.4 Creating the Process Flow Diagram

The Process Flow Diagram is created to show an improved business flow when an outpatient center implements the online outpatient appointment system. The diagram illustrates new and improved business processes when an outpatient center uses the system. The Process Flow Diagram shows an improvement from the current Process Flow Diagram presented and discussed in Section 1.1. The outputs from Section 2.2.2 and 2.2.3 were used to build the new Process Flow Diagram. The diagram also illustrates the automated processes, including the functions of each module that can be done by the user, from the moment a patient registers until the reports were generated by the secretary or the administrator.

2.3 Development of the System

This section discusses the development of the system. This section is subdivided into two sections, Section 2.3.1 and Section 2.3.2. The first section discusses the technologies that were used in creating the system, from choosing the appropriate web technologies, frameworks, Integrated Development Environment, and other libraries needed for the successful development of the online outpatient appointment system. The second section, Section 2.3.2, discusses the development of the actual system and showing a process cycle for each of the modules identified.

2.3.1 Selecting Technologies to be used in the Development of the System

The researcher has reviewed and considered several existing technologies before selecting the ones that were used in the system. The selection web technologies, languages, frameworks, and IDEs were also based in several criteria such as popularity, community size, sustainability, support, documentation, license, speed and reliability. These criteria were used to create a checklist of technologies used in the development of the system.

2.3.2 Selecting Technologies to be used in the Development of the System

Mockups or prototypes were created after having the requirements gathered from previous sections and were shown to potential clients for comments, suggestions and feedbacks. The researcher developed the system based on System Architecture Diagram, Use Case, Process Flow Diagrams, Entity-Relationship Diagram, and by using various web technologies in making the web applications.

3 RESULTS AND DISCUSSION

3.1.1 Functional Requirements

The functional requirements aim to show specific functionalities of the system that defines what a system is supposed to accomplish. The researcher was able to build the list of functional requirements through observation, experience, interviews and review of literatures regarding the appointment process. Table 3.1 shows the functional requirements. It is classified by the system's base functionalities.

Table 3.1 Functional Requirements

Base Functionality	Functional Requirement Description
User Accounts	The system must allow users to register or create accounts through the web application and mobile application.
	The system must provide password protection to each user account.
	The system must allow users to reset their passwords through emailed reset password links.
	User accounts are classified according to their level of access to the system: outpatient, secretary, medical provider, administrator.
	User accounts tagged as medical providers are tied to medical services.
	The system must only allow Administrator accounts are to add and manage other outpatient, secretary and medical provider accounts.
Data Accessibility	Authorized users must be able to manage appointments, medical services, and other users' data.
	Appointments, medical services and other users' data should be searchable by authorized users in the system.
	Appointments, medical services and other users' data should be exportable to PDF or Excel spreadsheets by authorized users in the system.
Appointment	The system must allow outpatient accounts to reserve their own medical appointment

Base Functionality	Functional Requirement Description
Management	scheduled not later than the current date.
	The system must allow secretary, medical provider, administrator accounts to create/view/edit/cancel/search /move appointments scheduled not later than the current date.
	The system must provide a calendar view for booked appointments. This calendar view can be toggled by day/week/month. Appointments shown in this calendar view are color-coded according to status. Types of appointment status are 'Reserved', 'Confirmed', 'Finished' or 'Canceled'.
	The system must initially set the status of newly created appointments as 'Reserved'. Authorized users should be able to change this status to 'Confirmed', 'Finished' or 'Canceled'.
	The system must allow appointments to be booked according to a medical service, then by a medical provider.
	The system must not allow appointments of the same outpatient in a single day.
Notification System	The system must send email and SMS notifications to outpatients and medical providers to confirm that an appointment has been successfully received. The notification shall include the status, date/time, service

Base Functionality	Functional Requirement Description
	availed and the name of the medical provider.
	Succeeding changes to the appointment status/schedule shall also trigger email and SMS notifications to outpatients and medical providers.
	The system must send queue updates as SMS notifications to outpatients on the day of their appointment.
	Upon mass movement of appointments, the system must send SMS notifications that contains the reason of such action.
Interactive SMS Appointment Management	The system must allow outpatients to book appointments via SMS.
	Using keywords, the system must be able to list available services, medical providers and time availability via SMS to the outpatient.
	The system must be able to handle incorrect format or keywords and send appropriate SMS response.

3.1.2 Non-Functional Requirements

After determining the functional requirements in Section 3.1.1, the researcher had established the non-functional requirements which are criteria that can be used to judge the operation of the system. These requirements are in contrast with the functional requirements in Section 3.1.1 that define specific behaviors of the system. Table 3.2 shows the specific characteristics or attributes

that would meet the non-functional requirements of the system. The table presented the non-functional requirements through the FURPS+ model. The description column provides a generic explanation of each non-functional requirement.

Table 3.2 Non-Functional Requirements

Non-Functional Requirements	Description
Usability	The system should be user-friendly.
Reliability	The system should ensure that the user actions are performed with low chance of failure and should react robustly with the errors.
Performance	The system should be efficient in performing user tasks and should be able to provide service to users simultaneously.
Supportability	The system can be easily maintained due to model and code simplicity.
Non-Functional Requirements	Description
Availability	The system must be readily available anytime. The system must provide appointment booking through multiple platforms.
Security	The system should provide user authentication and proper roles and permissions.
Portability	The system should work on any operating system with a GUI internet browser installed.
Interoperability	The system should work correctly on different web agents (browsers).

3.1.3 Features and Modules of the System

The decision to reinforce the outpatient appointment system with SMS technology, has several motivational sources. The main motivation in adding the SMS technology is from the analysis of positive results of related literatures regarding the use of SMS technology to solve no-show problems. Specific scenarios show that appointment reminders done through SMS are more effective than that of traditional reminder methods. Several studies suggest that SMS reminders are suitable means for improving patient attendance. In addition, when the initial project was proposed to panel members, SMS integration was suggested for patients. The SMS technology integration shall allow the outpatients to book for appointments using their basic mobile phones. While the outpatient appointment system also allows booking through a browser with Internet connection, it was emphasized by the panel members that most people visiting outpatient facilities are old people with basic mobile phones. With the use of SMS technology, the patient will have an automated way to book for medical appointment even without a smartphone or a computer with Internet connection. In addition, SMS is available and can be sent from almost any part of the Philippines, thus, giving a patient the ability to book a medical appointment anywhere.
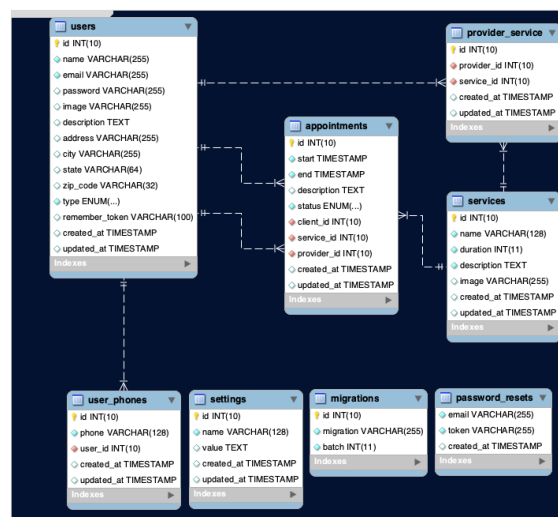
Figure 3.1 Module and Functions Chart

flow after implementation of outpatient appointment system.

3.2.1 Database Design

Figure 3.2 Entity Relationship Diagram

3.2 Design of the System

This section contains several design tools that were used in the system. Section 3.2.1 shows the database design. It includes the Entity Relationship Diagram to show the relationship between entities. The database schema is also included. Section 3.2.2 shows and discusses the Use Case Diagram which depicts the different internal and external agents as actors with their corresponding roles, actions and main flows of events. Section 3.2.3 discusses the System Architecture to show the overview of the structural design of the system. The last section, Section 3.2.4 discusses the Process Flow Diagram to show the new and improved business

Figure 3.6 shows the Entity Relationship Diagram (ERD) of the system. The database schema is also shown after the Entity Relationship Diagram (ERD) to support the entire database design. The database schema shows foreign key constraints of an entity. Primary keys, alternate keys and attributes are also presented.

3.2.2 Use Case Diagram

This section shows the use case diagrams of the outpatient appointment system. The researcher used the use case diagram to explain better the functionalities of the system. It also explains the way the user interacts with the system.
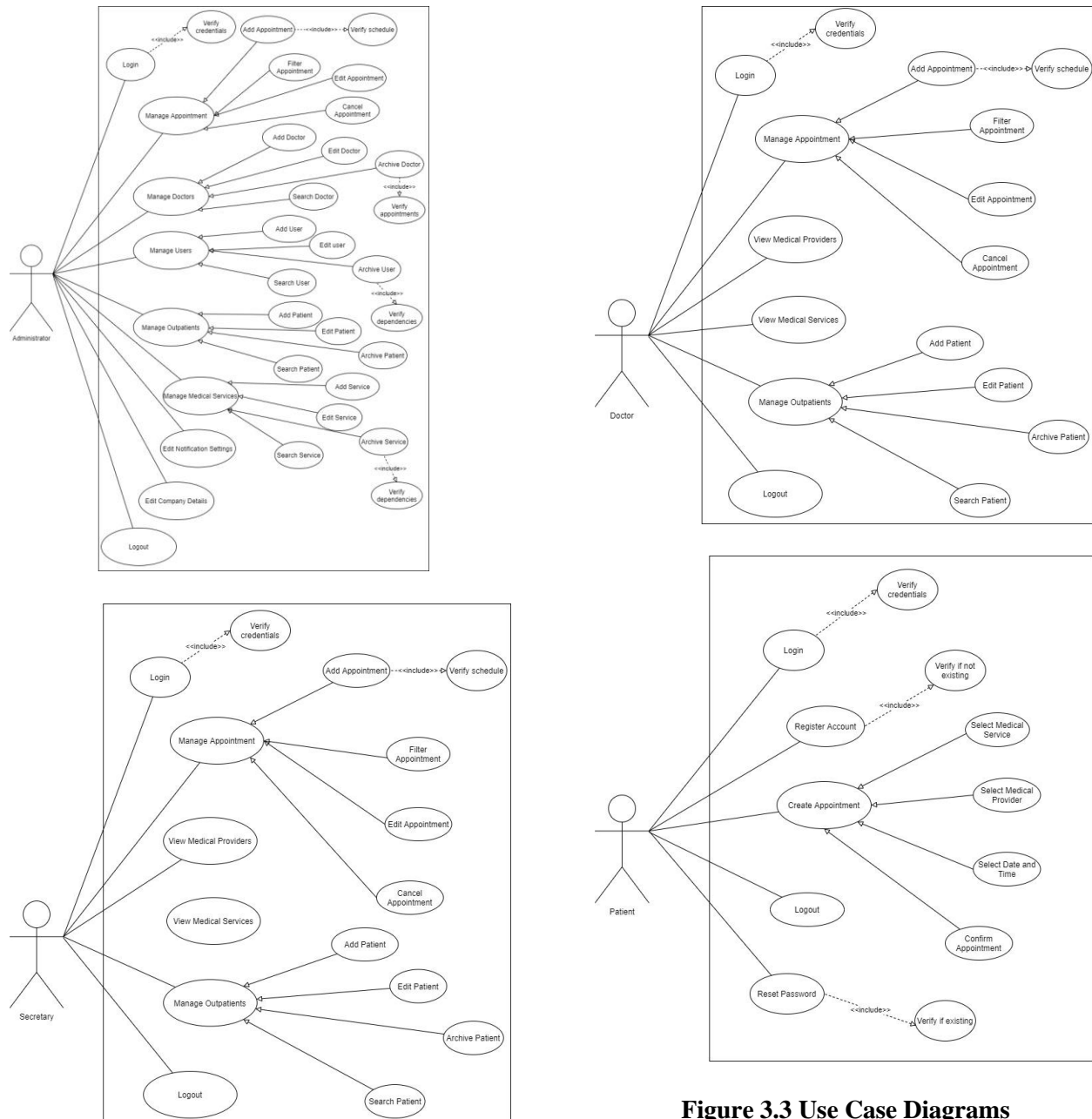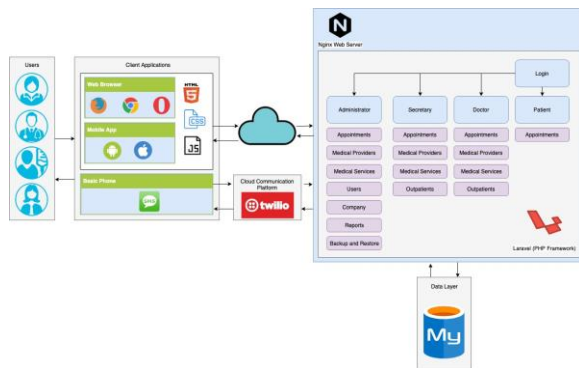
Figure 3.3 Use Case Diagrams

3.2.3 System Architecture

Figure 3.11 shows the System Architecture diagram of the outpatient appointment system. The diagram shows how the system will operate on an architectural level from the users to the browser to the web application and to the servers. The users will see and interact with the front-end side of the web application using a browser with

an active Internet connection. The front-end is made possible with different web technologies like CSS, HTML, JavaScript and other frameworks. In the backend, a PHP framework called Laravel is used to make the web application. The application is deployed on a Nginx Web Server. The data is fetched and stored in MySQL database. Twilio is used as a cloud communication platform for processing appointments and notifications via SMS.

Figure 3.4 System Architecture

3.3 Development of the System

This section discusses how the system was developed following the outputs of the design tools in Section 3.2 such as ERD, Use Case, System Architecture and Process Flow Diagram. This section also introduces the actual system through series of screenshots of the system. Section 3.3.1 discusses the different web technologies, frameworks and tools that were used in the development of the system's front-end and back-end. Section 3.3.2 shows the actual interfaces of the system. The interfaces are presented individually per module.

3.3.1 Technologies Used in the Development

This section discusses the technology stack used in the project. Technology stack refers to the

web technologies, frameworks, libraries and tools that were used in the development of the system. The first part of this section discusses the criteria in the selection of technology stack. The second part of this section discusses the final web technologies that were used as programming language for back-end development and as scripting language for the front-end side. The Integrated Development Environment (IDE)s are also presented.

As previously defined, technology stack is a combination of components like frameworks, tools and technologies used for software development. Basically, this web and mobile project needs a backend, frontend and a database. In addition, this project will also utilize SMS gateway for the system's notification system and interactive SMS appointment booking system. The following criteria were considered in the coming up with the final list of technology stack to be used:

Table 3.3 Criteria used in Technology Stack selection

Criterion	Brief Description
Licenses	In choosing parts of the technology stack, it is important to consider open-source solutions because these are free of cost and does not require licenses for future revisions or changes. All of the chosen technologies, except for Twilio, were license-free because it is important to reduce initial development expenses in this unfunded study.

Criterion	Brief Description
Developer Community and Documentation	Web development is a challenging area for the researcher. Most of the web technologies in the stack, the researcher has no prior experience with. Therefore, during the conduct of this study, it is very important for the researcher to have an extensive and readily available documentation and a large, ready to help developer community in case of problems that the documentation is of no help.
Time to Market	This factor refers to the capability of a framework in a technology stack to auto-generate available to all features such as an authentication system. This makes shorter time to market period. This criterion is equally important to this project because of time constraints.

After careful consideration of the criteria presented in Table 3.3, the final technology stack is presented in the next section.

The outpatient appointment system is a web application and is written using web technologies. HyperText Markup Language (HTML) was used for the general web content. It is used for the content structure of each page of the system. In addition to HTML, CSS3, Bootstrap and VueJS were also used for the front-end side of the system. The said technologies

were used to enhance the appearance of the system. The backend is generally written in PHP. PHP was used to construct the logic of the system's functionalities. For faster development, Laravel has been used as the PHP framework. The researcher has used several IDEs for coding. Table 3.4 lists the different web technologies. Table 3.5 shows the IDEs that were used in the development of the project.

Table 3.4 Web Technologies used for System's Front-End and Back-End

Web Technology	Brief Description
HyperText Markup Language (HTML)	This web technology is the basic building block of all websites and web apps. This technology was used to create the basic structure of all web pages of the system.
Cascading Style Sheet 3 (CSS3)	This technology was used by the researcher to provide better appearance and aesthetics to the HTML web pages. It is also used to control the colors, fonts and different layouts of the pages and make them uniform across the system. The researcher used modular approach in creating the CSS files to enable web pages share the same file for styling, thus reducing repetition and complexity.

Web Technology	Brief Description
VueJS	This technology was also used for the front-end side of the system. VueJS was used for the controls and components within the system. It was used for modal dialog boxes, forms, settings page, calendar and date and time pickers.
Bootstrap	This technology was used to improve the system's interface. The researcher used the layouting tags/ids of Bootstrap as they are shorter and concise as compared to defining the layouts in plain CSS.
PHP	This technology is the most language in building web applications. This web technology was used by the researcher for the system's logic on all functionalities. It is used for viewing, storing, and retrieving data from the database. It is used to provide dynamic content to the web pages.
Laravel	This technology is a PHP web framework. It is considered as one of the best PHP frameworks. The researcher utilized the framework by using its libraries for user authentication, session

Web Technology	Brief Description
	management and password reset. The researcher also took advantage of Laravel's structure that uses Model–View–Controller (MVC) architecture. This made the structure of the system's code clear between logic and presentation. This also improved the system's performance compared to a cluttered generic PHP application. The MVC architecture has also made the system easily documented and troubleshooted. The researcher also used the security features of Laravel. It was used to automatically hash saved passwords. And since Laravel uses prepared SQL statements, the system is protected from SQL injection attacks.

Table 3.5 IDEs used in Programming

IDE	Brief Description
Visual Studio Code	This tool was used for coding and loading the project files. It was selected because it is lightweight and fast. This improved the coding efficiency of the researcher. In

	addition, it also supports Lint for all of the web technologies that have been used. The said tool has also a built-in terminal to easily compile resources for production and for easy launching of local server.
PhpStorm	This tool was used for coding and loading the project files. It was selected because it has built-in code completion function. This improved the coding efficiency of the researcher. In addition, it also supports Lint for all of the web technologies that have been used. The said tool has also a built-in terminal to easily compile resources for production and for easy launching of local server.

Table 3.6 Technologies and Tools for Data Management

Name of Technology	Brief Description
MySQL	This tool was used to access, add and modify contents in the database. The tool was selected for its flexibility, reliability, high-performance and

Name of Technology	Brief Description
	ease-of-use. In the system, this tool has been used to manage data related to users, appointments and medical services.
MySQL Workbench	This tool has been used for visual database design. It is used for viewing and verifying entries to the database. It was also used for generating the ERD diagram direct from the database. It was also used to backup data.
MySQL Server	This tool has been used to host the MySQL database of the system in the local environment. It was selected because MySQL Server is open-source and was made specially for MySQL.

Table 3.7 Other Technologies and Tools used in Development

| Name of Technology/Tool	Brief Description

|	
Twilio	Twilio is a cloud communications platform that provides APIs for SMS, Voice, Video and Authentication. The researcher used this platform to send SMS messages to notify user that their appointments have been changed. This platform was also used for booking an appointment through SMS.
MailTrap	MailTrap is a fake SMTP server for testing emails in the development and staging environments. This tool was used by the researcher to test the email notifications being sent by the system.

3.3.2 The System

Mockups or prototypes were created using Adobe XD to provide the researcher a visualization of what the system would look like and how would be the flow between pages. The prototype was used to get feedback from potential clients. Changes are made to conform to initial test results and feedbacks gained. The four modules identified in Section 3.1.2 were Administrator Module, Secretary Module, Doctor Module and Patient Module. These modules were followed in the construction of prototypes. The developer created a parent prototype for the Administrator Module which is of highest roles and permissions. Then the prototypes for the other modules were constructed by removing contents from the parent prototype.

This section presents the actual system created by the project developers. It also presents a complete process flow diagram for each module. The process flow diagram shows the actual system and what functionalities are available to users. It will also show the complete process from successful login up to generation of reports.
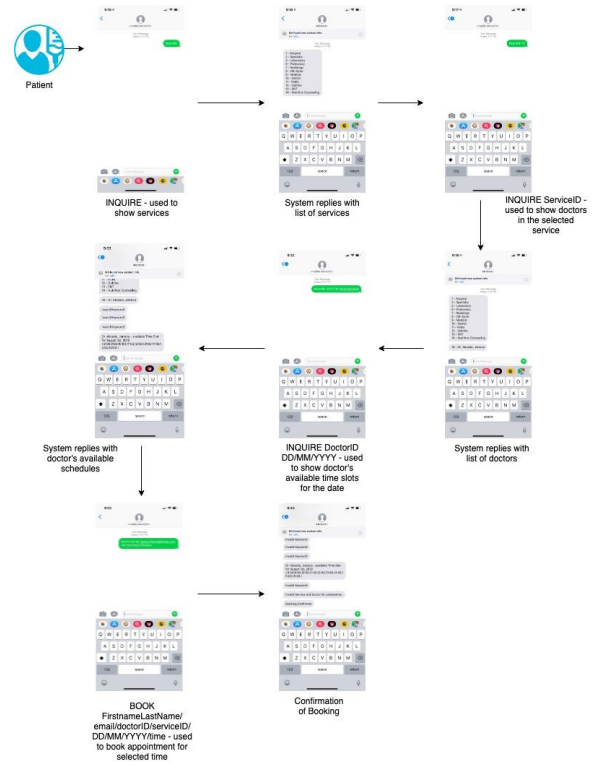
The succeeding diagrams shows the functions and screenshots for each of the four modules, Administrator Module, Secretary Module, Doctor Module, and Patient Module. It also includes screenshots of the SMS keywords sent to successfully book an appointment via SMS.
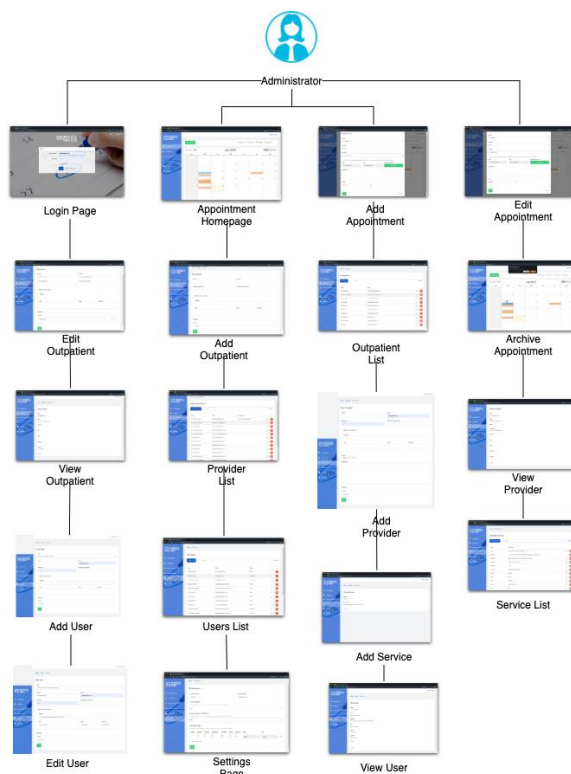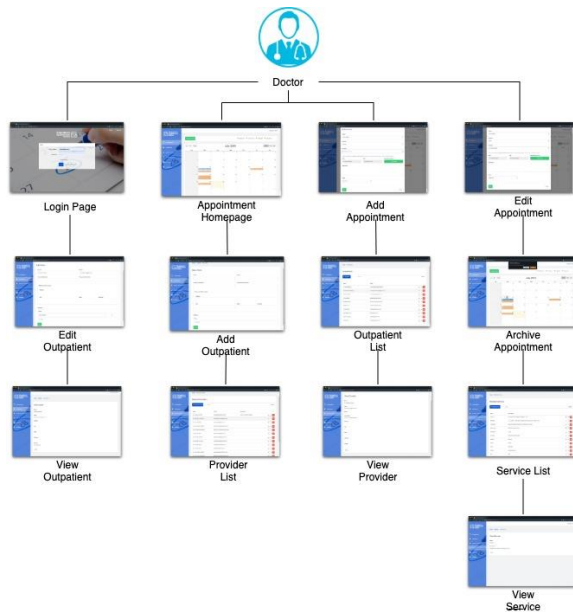

Figure 3.5 Administrator Module Process
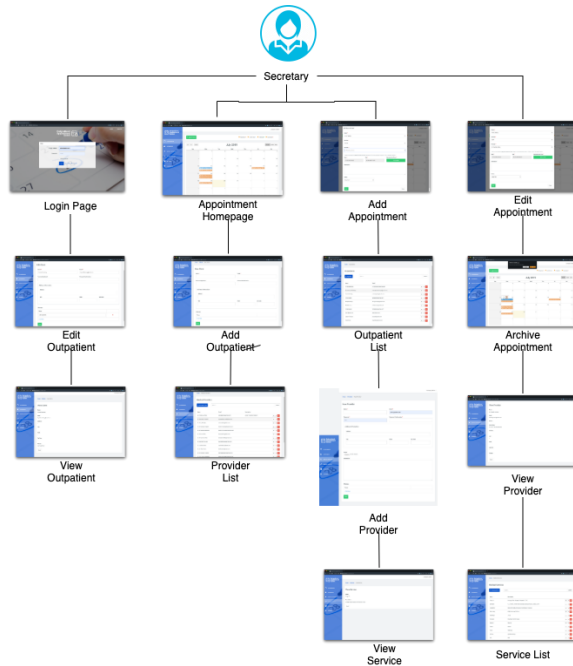
Figure 3.6 Secretary Module Process

Figure 3.7 Patient Module Process

Figure 3.7 Doctor Module Process

4 CONCLUSION

The multi-platform outpatient appointment system with automated interactive SMS service was developed to achieve the functional and non-functional requirements gathered through interviews and literature reviews. The identified functional and non-functional requirements of the system have established the characteristics, functionalities and modules of the system. The functional requirements were divided according to the base functionality of the system: User Accounts, Data Accessibility, Appointment Management, Notification System and Interactive SMS Appointment Management. On the other hand, the identified non-functional requirements are usability, reliability, performance, supportability, availability, security, portability and interoperability. Using

the identified requirements, the researcher was able to determine the modules as well as the features for each. The modules of the Outpatient Appointment System are Administrator Module, Secretary Module, Doctor Module and Outpatient module. The Administrator Module is designed to be used by the clinic's administrator. It has the highest level of roles and permissions. The administrator can manage appointments, outpatients, medical services, medical providers and system users. The administrator has the ability to add another user with administrative privileges. The Secretary Module is designed for the clinic's secretary. The main role of this module is to manage appointments across doctors. The Doctor Module is designed for the clinic's medical providers. The main role of this module is to enable the doctors to manage their own appointments. The Outpatient module is designed for the clinic's clients. This module enables the outpatients to book their appointments online through a browser with an active Internet connection. SMS technology has been integrated into the system. The said technology is used for notification purposes. When appointment time and date were changed, SMS message will be sent to notify the user. It is also used to notify clients when the status of appointment is changed. SMS notifications work hand-in-hand with email notifications. Both settings are configurable through the Administrator Module. In addition to notifications, SMS technology has also been used to enable outpatients to book for an appointment using their basic phones. Specific keywords are used to select medical services, providers and date and time.

The system was designed by specifying the Entity-Relationship Diagram (ERD), Use Cases, Process Flow Diagrams and System Architecture. These were identified through interviews, literature reviews and review of existing appointment applications. The technologies used in the development of the system were carefully selected to allow efficient development. The selection of the technologies was based on the following criteria: Licenses, Developer Community and Documentation, Time to Market.

The system was developed based on the functional and non-functional requirements, features, modules and technologies that were previously identified. The system will run on 3 platforms: web, mobile and through SMS. The system's core is a web application in which the mobile application and the SMS module are connected. The system's core was built using Laravel for the back-end and VueJS and Bootstrap for its front-end. The system used a cloud communication platform called Twilio to send and receive SMS messages from patients. This platform is then hooked to the system's web application to provide results.

Several testing methods were accomplished to ensure the correctness and quality of the system. Basic functionality and validation were done through an open-source automated testing tool, Selenium. Black-box testing were done by creating test cases for the web, mobile and SMS modules. The minimum software and hardware requirements were identified and organized according to the components of the recommended infrastructure. Approximation of cost for the deployment were also presented. In addition, businesses who will implement this system will start to pay a monthly recurring fee. An approximation of this monthly cost was also presented. Installation and user manuals were also created for the project.

To further improve the system, the researcher recommends adding an online payment mechanism for outpatients. It will also be helpful if patients can directly send their feedbacks through the system's built-in customer support. It will also be beneficial for the outpatients to have online prescription records. It is also recommended to integrate data analytics together with couple of queueing algorithms to furtherly decrease the waiting and access times. An iOS version of the app can also be developed in the future.

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