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Study and Development of an Information System for Making Online Medical Appointments

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Abstract

To improve the medical care of patients, their relationship with health professionals must be better organized to reduce the gap between the supply and demand for care. In response to the difficulties encountered by patients in Algeria relating to the methods of making medical appointments, this project aims to analyze, design and develop an information system, accessible via the internet, for making medical appointments online. It is a dynamic, simple and easy-to-use website for patients in Algeria to schedule medical appointments online and thus avoid unnecessary travel and waiting time in professionals' healthcare offices.

Keywords: Information system, dynamic website, Health, Medical appointment, patient, health professional

Résumé

Pour améliorer la prise en charge médicale des patients, leur relation avec les professionnels de santé doit être mieux organisée pour réduire l'écart entre l'offre et la demande des soins. En réponse aux difficultés rencontrées par les patients en Algérie relatives aux méthodes de prise de rendez-vous médicaux, ce projet vise à analyser, concevoir et développer un système d'information, accessible via internet, pour la prise de rendez-vous médicaux en ligne. Il s'agit d'un site web dynamique, simple et facile à utiliser par les patients en Algérie pour fixer des rendez-vous médicaux en ligne et éviter ainsi les déplacements et le temps d'attente inutiles chez les professionnels de santé.

Mots clés : Système d'information, site web dynamique, Santé, Rendez-vous médical, patient, professionnel de santé

ملخص

لتحسين الرعاية الطبية للمرضى، يجب أن تكون علاقتهم بالمهنيين الصحيين نظمة بشكل أفضل لتقليل الفجوة بين العرض والطلب على الرعاية. استجابة للصعوبات التي يواجهها المرضى في الجزائر فيما يتعلق بأساليب تحديد المواعيد الطبية، يهدف هذا المشروع إلى تحليل وتصميم وتطوير نظام علومات يمكن الوصول إليه عبر الإنترنت لتحديد المواعيد الطبية عبر الإنترنت. إنه وقع دينا يكي وبسيط وسهل الاستخدام للمرضى في الجزائر لحجز المواعيد الطبية عبر الإنترنت وبالتالي تجنب السفر غير الضروري ووقت الانتظار لأخصائيي الرعاية الصحية.

كلمات دلا ية: نظام علو ات، وقع دينا يكي، صحة، وعد طبي، ريض، صحة هنية

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Dedication

I dedicate this work to

My dear parents Salim and Hayat for their endless advice, encouragement and support as a testimony of my gratitude and affection, in the hope that they will be proud.

My dear brothers and sisters: Wissam, Amine, Mohcine, Moufida, Hanane, Nouzha, Rania.

My dear nephews and nieces: Fadi, Simou, Anes, Baraa, Touline, Lina, Melissa.

The soul of my dear grandfathers.

And finally to my dear ones.

TABLE OF CONTENTS

List of Figures

List of Tables

General Introduction

Nowadays, many types of diseases are increasing due to many factors like pollution, improper food, stress, and daily bad habits, and because of these issues the number of patients is increasing too, and this needs healthcare. Therefore the governments of different countries work continuously on all levels to improve healthcare services, and especially the conditions of patient care. In this improvement's objective, the computer science in general and the information systems in particular play a very important role in providing tools that respond to the expectations of different actors in this field. Among the tools that can be offered to the patients is facilitating the management of their relationship with the health professionals. This Relationship's management begins by reducing the gap between the care's offers and the needs of patients in order to provide quick and efficient patients' medical care for their treatments and medical examinations.

Generally, a medical visit requires a medical appointment to clarify and identify the guidelines and protocol for patient appointment setting so to ensure accurate appointment setting and timeliness of access to care. Scheduling and management of medical appointment consist of using technology, to respond both to the demand of appointments, and the availability of doctors. The tools offering online medical appointment scheduling services play a very important role in accelerating patient's medical care, and they allow professionals to better manage their calendars. The use of such a tool allows patients to have an increased visibility on the available care services in terms of time, places and specialties. As for professionals, they can better manage their relationships with patients by offering them better reception conditions instead of using primitive methods like waiting for a long time on phone call or going to health professionals to take an appointment. Thanks to Internet and its opportunities such as creating a dynamic web site, many countries use web information systems to schedule medical visits.

In this context, this project of final Master year study aims at improving the health services between professionals and patients in Algeria; by realizing an application for the online medical appointment.

This document details the study carried out through this project, which is organized as follows:

The first chapter describes the project and the application's context, and shows the existing methods of scheduling appointments, followed by the second one which represents a preliminary and detailed study of the existing web information systems of online appointments, followed by the third chapter which represents the conception of this application. The fourth chapter which is the last one discusses the implementation and the contribution of this project.

Chapter one

Project Context

1. Introduction

To better organize the patient-healthcare professional' relationship, this project consists of creating a web application for making medical appointments in Algeria. Online medical appointment system relates health professionals and patients, using a phone or a computer and a browser wherever the users are. The use of relevant data allows this application types to offer many services for its users, as specific searches for any doctor, or managing an appointment, so these services facilitate their life and gain their time. Especially for big countries, online medical appointments prevent the patients from travelling for a long distance just for taking an appointment. This application essentially aims to reduce the daily charge of patients by reducing the waiting time when making an appointment. So "an online medical appointment scheduling" is intended for health professionals available 24 hours a day, and 7 days a week, allowing doctors and patients to choose the most appropriate time for their medical examinations, to avoid all the obstacles of the primitive methods of patients' appointment.

This chapter discusses the problematic of medical appointments in Algeria that motivates us to create this application, and the objectives we want to achieve.

2. Problematic

In the Algerian case, there are mainly three types of health professionals, for which a patient may need to make an appointment:

- ➢ Hospital: A public institution which provide medical and surgical treatment and nursing care. It is organized through a set of departments where each department is made up of several doctors.
- ➢ Clinic: a private or a public establishment where outpatients are given medical treatment or advice, especially of a specialist nature. It can contain several general practitioners or specialists
- ➢ Doctor's Office: Is a medical facility in which one or more medical doctors receive and treat patients.

Making medical appointments with health professionals in Algeria is actually related to several problematic:

1. Data Availability

When a patient needs a medical examination for his case of disease, he does not have a prior knowledge about the list of the existing health professionals that he can go, because this information is often not available everywhere and/or it is hard to access. There are many specialized doctors in whole Algeria but there is not a computerized system that contains all their names or information about them intended for patient, so that makes this one always searching for the coordinates of health professionals and asking especially on social media for a good doctor for his case to schedule a medical appointment with.

2. Data Relevancy

Once the patient got the information from social media's users or searching engines, he cannot be sure from what he got, if it is relevant, up to date, and if it contains or not the necessary and complete information like the expertise of each professional, specialty, fees, phone number, and geographic location, this fact obliges him to check these data by himself and go on.

3. Data Completeness

The incompleteness of data about all the health professionals' types is the main reason for ignorance of the offers offered by public healthcare which makes especially poor patients spend a lot of money in the clinics, instead of going to the hospital for free.

4. Communication Lack

Owing to the lack of communication media between professionals and patients, it is not always easy to make an appointment. To schedule a medical appointment, the patient needs generally to go to health professional to fix an appointment, especially when he does not have his phone number, which makes him wake up very early and register in patient appointment's list. So when the doctor is in another state of Algeria this makes the patient travels just to schedule an appointment, and sometimes because of the lack of knowledge of health professionals' working hours and their holidays, he travels there uselessly.

5. Time Management

One of the appointments' problems is the considerable waiting time to get a medical examination, which is a waste of time in professionals' waiting rooms, and an obstacle for the patients' tasks.

For these reasons, we present a project to get rid of these problematic, and below the explanation and the project display.

3. Project Display

In order to present the end of the study project in computer science, Master Two in Information systems, optimization and decision (ISOD), we present this project which intends to provide an easy and reliable information system (a dynamic web application) of communication support. To adequately respond to the needs of patients by offering them services that facilitate their medical care, to reduce no-show rate, decrease staff labor and waiting time, improve satisfaction, and allow professionals to better manage their appointment schedules to be more known, because Flexibility, safety, and integrity are major reasons which discourage patients from switching to Web-based scheduling.

This project is about online medical appointment scheduling, and to get rid of all the obstacles existing in doctors' calendar and patients' appointments. This application is

developed for managing appointment-booking process for both professionals and healthcare establishments, regardless of the type of service they schedule, the practices will have to sign up on the online appointments portal themselves and can view the appointment made by users, the patients. It will help users to book their appointments using the medical appointment application. It will reduce the number of calls for an appointment and avoid the morning rush for an urgent appointment. Also, it will potentially reduce the need for extra reception staff, a significant reduction in labor. Furthermore, it helps users in time saving and avoiding the need to negotiate with the receptionist for a convenient appointment time. This platform can transform the current daunting appointment process and enable them to run more efficiently, effectively and profitably. Not only to schedule an appointment, this application can be intended for analytic studies too, because the data collected by this system can constitute a study base to understand the health needs of the population in Algeria. It suggests to decision-makers the appropriate geographic locations for health professionals through the establishment of the list of populations' needs and the existing healthcare professionals. Precocious detection of disease onset in particular regions through the search lists of patients in the same region for the same doctors' specialty.

4. Project's Objectives

In order to contribute to the process of improving the conditions of patients' medical care, we propose this work which consists of the conception and the realization of a tool dedicated to make online medical appointments. This tool is intended for the patient to allow him to better manage his medical appointments through a set of services designed as part of his medical career. Through out of these services, this tool intends to contribute:

For the patient, to:

- ✓ Avoid unnecessary displacement of patient: no more traveling to make an appointment, to inquire about doctors or to have their phone numbers.
- ✓ Gain time: the patient will no longer be obliged to be absent from his work or lose an entire day for a simple appointment of 15-minutes or wake up at 4am to be at the head of patients' list of the day.
- ✓ Gain comfort: by reducing the lost time in waiting rooms to a quarter of an hour before consultation, the patient will not get tired and face the tedious waiting time again.

✓ Economize money: by avoiding inappropriate travels, unnecessary back and forth, and unnecessary amounts' expense.

For the doctor, to:

✓ Gain visibility: with the current system, a new doctor who settles in a new location does not necessarily have the good visibility close to the patients to start his medical activity. However, with the proposed tool, he will have a similar visibility as former doctors and can take full benefits of real communication support for patients.

✓ Better calendars' manage: choose the reception slots, move if necessary in agreement with patients the appointments in contradiction with his other constraints.

✓ Costs control: he will no longer even need to hire a team of hosts to manage the lists, the waiting rooms for women and men, or to deal with patient dissatisfaction.

✓ Improve doctor image towards his patient: with the often drastic reception conditions and long waits in waiting rooms which sometimes lack the necessary means of patients' comfort, patients get caught as hostage with services that are not always up to their expectations, especially for their state of health, to the human nature of the profession, to their health suffering, the distances traveled and the considerable amounts expensed. With this type of tool, the professional can reserve much more human and personalized reception for his patients. This will help the doctors to regain the confidence of their patients and help them feel that they are in good hands.

More concretely, among the essential services that this application must provide, we can cite:

✓ Search for doctors by their coordinates, their specialty, their location, and their next availability, their attachment's establishment (for hospitals and clinics).

✓ Get the doctors information: consult their general information (address, location, telephone numbers, and working hours) and detailed information (specialty, points of expertise, diplomas).

✓ Appointments' Management: Take an appointment, Move an appointment, Cancel an appointment, approve an appointment.

Before we start the analysis of the online appointment scheduling domain, we should define the primitive methods' processes of booking appointments.

5. Offline Medical Appointment's Methods

There are two methods to schedule an offline appointment for a medical examination in Algeria, either a phone call or physical visit to the health professional (physical appointment).Below the description of each method.

5.1   Phone Call Appointment

The call appointment method requires a prior knowledge of professionals' phone numbers; this issue makes many people ask and look for doctors' telephone numbers to schedule their medical appointments, and this process is repeated whenever the patients need to visit a new doctor and schedule an appointment. The accessibility to the professionals' number can be difficult sometimes, and when calling them, some professionals' assistants answer the call, on the contrary of other professionals, and this is one of the call appointment problems. Moreover, when they change their phone number, the patients call the old and wrong number, because the professionals do not have a computerized system which allows their patients to know their update professional data. During the calls, the medical assistant registers the patients' names in the list of patients' appointments. The patients' examination can be in the same day of the call or for another day. This method of booking appointments may be supported by some professionals and not by others, which makes the physical visit to health professional required to get an appointment.

5.2   Physical Visit Appointment

In physical visit appointment method, the patients should wake up early and go to the professional, to register their names in the list of patients' appointments. This process is very tiring, especially for the patients who come from far distances, which disturbs them from their labors and tasks. The medical consultation can be in the same day or for another day; it depends on the list of the appointments, and the professionals' charge, and the patients' disease case. The medical assistant registers the patients' information, and invites them to wait in the waiting room, until their turn comes in case the consultation is the same day.

6. Conclusion

Population's healthcare is a very critical humanitarian field, and with every creation or development concerning patients' health, which responds to their needs, it gives them a new chance to be healthy. Making medical appointments easier is one of the patients' needs. Therefore, the development of an online application for appointments so necessary to facilitate the patients' and the professionals' tasks and prevent them from the difficult ways (phone call and physical visit) of the appointments' management. Next chapter presents analysis of this domain.

Chapter Two

Analysis

1. Introduction

Medical appointments are an important need for patients, and no one wants to spend hours waiting to book an appointment while there are an online doctors' system which offer equal services with a booking system. This makes appointment scheduling quick and stress-free. Patients want to be taken in charge as soon as they arrive at the professional. The creation of an application for online medical appointment needs a good and a deep analysis to know the imperfections of the existing applications in this field and the needs of patients too. Therefore, we focus on those needs to improve the services of this domain to get the satisfaction of patients and professionals. So, in this chapter and before starting the conception part, it is necessary to understand and analyze the online medical appointment domain, by analyzing the existing way of online appointments, and the necessary data for proper functioning of this application. Besides, we will take a look and analyze the applications already developed in this area to define the user's needs (patients and health professionals), and define the necessary functionalities of this system to achieve them.

2. Online Medical Appointment's Method's Analysis

As most people are internet and tech-savvy these days they prefer to do everything on their smartphones and computers. Therefore most countries over the world opted for the online medical scheduling. In this type of method, patients and healthcare professionals use a common web platform to make and manage medical appointments online. In complement, a phone application can be offered to users instead of using an internet browser. There is no universal platform but generally different websites dedicated to each country.

Making online services available to patient, it shows that the healthcare professionals are following the trend which is allowing patients to reach them via their smartphones and computers using the phone or web application to book their appointments. These systems are very used by huge number of people in developed countries. This fact makes a big difference in terms of offered services and allows these countries to provide carefully better and newer services to satisfy their number of users.

Concerning the online medical appointment in Algeria, there are currently some web applications which are mainly: RdvToubib [1], DZDOC [2], SIHHATECH [3] and eSAHTY24h [4]. There are also other foreign sites such as DabaDoc [5] which covers five African countries including Algeria, Morocco, Tunisia, Nigeria and South Africa. Other sites located outside Algeria such as DoctoMy [6] is located in France but intended for Algerian territory.

According to our researches about these web applications for online appointments we could collect some information about these applications for some criteria. All these apps use approximately the same idea and way of booking appointments; but there are few differences between them. The table in the next page describes the collected information about these platforms, and shows the involvement of their state of advancement.

Application	Company	Innovate year	Coverage	Additional Services
RdvToubib	IdeeOH (Algiers)	2015	Some states	
DZDOC	Khidma Tech (Annaba)	2015	Some states	• A phone phone application (app) for the online patient appointment, • SMS notifications, • Telemedicine, • Electronic prescription, • CRM for pharmaceutical laboratories and Digital marketing, • Advertisements,
SIHHATECH	SARL AFIND (Boumerdes)	2016	Some states	• Home care(consultations)
eSAHTY24h	Not communicated (Algiers, Annaba)	2019	Some data about (6) states	
DabaDoc	Dabadoc (Maroco)	2014	Some states	• A phone application (app) for the online patient appointment, • Offers online consultation, • Rating doctors,
DoctoMy	Unknown company (France)	2019	Some states	

Table 1: Comparison of Online Medical Appointment Applications in Algeria.

According to the analysis of this table, we can say that all these applications are recent, which explains the limited or very limited coverage of health professionals. To overcome this problem of geographical coverage, we find that the use of most of these applications is free, except DoctoMy (from 12000 DZD or free referencing). The DZDOC and DabaDoc applications remain the most advanced than the others in terms of the services offered.

Although five years have elapsed since the creation of most of these applications, they still have a partial coverage only, for example they do not have professional users in Biskra area, it exists just few information about some doctors, and also some of these applications have incomplete data about some professionals like the map location, and doctors' expertise and other information which make unknown doctors in their databases useless.

Another problem is that a healthcare professional cannot register and manage his appointments on several applications due to the lack of interoperability, where each application seeks to dominate the market.

Despite of the existences of these systems, the Algerian patient still use mainly the traditional ways of appointment scheduling, that is due to ignorance of modern methods of this domain, and weakness of broadcast for these applications. The non-maturity of the solutions proposed; the low level of support from health professionals, and incomplete data are factors that favor this observation.

3. Functional and Non-functional Requirements

Through the needs analysis, we must identify the actors of this system.

➢ Patients: connect to choose the appropriate time and doctor for an appointment.

➢ Doctors: connect to manage their calendars (Appointments) according to the work establishments (Hospital, Clinic, and Doctor's Office).

➢ Administrator: he is a responsible for managing all the main functionalities of system.

3.1 Functional Requirements

The below table defines the functional requirements of this application:

Patient's Functional Requirements	Authenticate
	Search for a health professional
	Consult the list of doctors
	Make an appointment
	Confirm an appointment
	Cancel an appointment
	Rate professionals
Administrator's Functional Requirements	Authenticate
	Manage establishments
	Manage health professionals
	Manage patients
Doctor's Functional Requirements	Authenticate
	Consult the list of appointments
	Accept an appointment
	Move (change) an appointment
	Cancel an appointment
	Make an appointment

Table 2: Application's Functional Requirements.

3.2 Non-Functional Requirements

This online application aims to achieve these non functional requirements:

Performance & speed	• Response time does not exceed 10 seconds, get the good functionalities in a few time.
Security	• Use authentication for users to secure their data, and everyone can access just to the allowed information. • Use session duration after every user authentication, which re-requests the users to log in again, cause of no use of the app for a long time from last authentication.
Maintenance	• Develop this system basing on procedures and functions; to facilitate the maintenance, re-use, and maintain the code source.

Table 3: Application's Non-Functional Requirements.

4. Functional Expression

The functional expressions are organized according to the users' interfaces.

4.1 Patient's Functional Interfaces

➢ **Account Management**

- Creation of account: to create an account, the patient enters his personal information like phone number, name, email, and password.
- Authentication: to use this system's services, the patient authenticates, by entering his email and password.

➢ **Search Management**

- Search for a doctor according to one or more criteria: the patient can search for professionals; by the doctor's name, and by specialty if patient wants to know all doctors in a specific specialty and by location if patient wants to search for the nearest doctors to his location. The search can be according to two or more criteria in the same time like location and specialty, or to precise the doctor using professional's name and specialty and location etc.

➢ **Data Consultation**

- Consult doctors' profile: In every professional's profile, there is the following information: the doctor's name, phone number, specialty, expertise, and price. Patient can consult these pieces of information without a registration.

- Rate doctors: this option allows patients to rate the doctors who dealt with them previously, in term of quick response, services and so on. So doctors have in their information's file a rating case.

➢ **Appointment Management**

- Look for appointment: according to patients' searches for professionals, they find the doctors that they need for their medical cases, so the patients can take appointments after subscription for the new users, or connection for the previous users, then they choose the appropriate time for their consultations.

- Confirm appointment: when a patient chooses his appointment's day and time, he should confirm (make) this appointment to list it in the doctor's request appointment list.

- Cancel appointment: The patient has the ability to cancel an appointment if he could not come to the professional, or cause of changing mind about the appointment's time, or in case of the doctors who cancelled or changed the date of the requested appointment, and this date is not suitable for this patient, so this one can delete this appointment, and it will be deleted from the doctors' appointment list, too.

4.2 Doctor's Functional Interfaces

➢ **Account Management**

- Registration of doctor: the professional creates an account to be able to manage his calendar. He should enter the necessary data as: full name, email, password, phone number, specialty and expertise, work location, work time, and prices.

- Authentication: the doctor authenticates to this application to manage his patients and appointments.

➢ **Appointment Management**

- Accept appointment: from the appointments' list, the professional accept the convenient appointment.

- Cancel an appointment: the doctor can cancel an appointment for example, for unserious patients.

- Change an appointment: when the patient chooses the time for his appointment, the professional can move this appointment to have an appropriate time for both of them.

- Make an appointment: the doctor can make appointments for new patients, in case patients could not make it by themselves.

➢ **Data Consultation**

- Consult the list of patient appointments' requests: each professional has a list of the new requests for patients' appointments.

- Consult next appointments: after confirmation and accepting patients' appointments, the doctor can consult his next medical appointments.

- Consult the appointments history: all patients' appointments of professionals are stored in patients' appointments list; this last shows the appointments history for each patient with patients' and appointments' information, which allows the doctors to consult their appointments' history.

4.3   Admin Functional Interfaces

➢ **Account Management**

- Authentication of Admin: the Admin authenticates to be able to manage the system.

➢ **Health Professionals' Management**

- Add doctor: Admin add doctors with their necessary information.

- Delete doctor: Admin delete the doctors who don't have the correct and the newest personal information.

- Update doctor: Admin can update the doctors' data.

➢ **Patients' Management**

- Add patient: Admin add patients with their information.

- Delete patient: Admin can delete the patients who do not use the app seriously.

- Update patient: Admin can update the patients' data.

➢ **Establishments' Management**

- Add establishment: Admin add establishments with doctors' list.

- Delete establishment: Admin can delete the establishments.

- Update patient: Admin update the establishment' data and add the newest one.

5. Application's limits

Generally when people hear about new application that responds to one of their needs, they expect other services which this app can provide too, therefore the use of the following mentioned below are meant to show this application's limits.

➢ This system does not provide the chat with doctors, and the direct call/video call from browsers,

➢ This application does not provide the online consultations, it limits booking appointments,

➢ This system is just used when the user is online, otherwise that it does not work,

➢ This system does not offer medical prescriptions,

➢ This platform is used to schedule an appointment in the doctors' work establishment, it is not a home consultation; the patient should go to the establishment the day of consultation,

➢ This application does not manage the appointments automatically; the users manage their appointments themselves,

➢ This system does not have receptionists for doctors,

➢ This platform does not support people who have an auditory disability; it does not offer a voice guide.

6. Conclusion

This chapter represented the comparison between the online systems for booking appointments in Algeria according to the collected information, the result of these analyses is that even there are some online medical appointments' tools; this domain still contains some gaps and does not cover all patients' needs. The applied and completed analyses of this domain, and the defined necessary data facilitated the conception part; which allows us to know the right way to take and get patients' satisfaction. The next chapter will detail the conception of this application and will show all diagrams used to describe its functioning.

Chapter Three

Conception

1. Introduction

The conception provides a deep understanding of the constraints related to the programming language, the use of components and the operating system. It determines the main interfaces and transcribes them using a common notation. For the conception of this application (app) the Unified Modeling Language (UML) is used to design the app's diagrams to represent the system that we want to develop; its operations, its start-up, the actions susceptible to be carried out by this information system, etc[7]. The tools used for modeling the diagrams of this system are cloud-based collaboration platforms.

2. Modeling Tools Used

➢ **Lucid chart**: is a visual work environment that combines diagram creation, data visualization and collaboration features to facilitate communication. The **Class and Sequence Diagrams, and Data Dictionary** are designed by this tool. [8]

➢ **Creately**: is an online drawing tool provides powerful drawing capacity of all UML diagrams. This environment is used to model **Use Case Diagram and Activity Diagram.** [9]
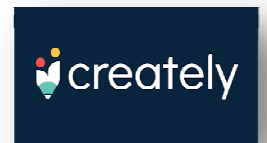
3. Elaborating Application's Diagrams

3.1 Use Case Diagrams

This diagram represents static view of use cases of system's actors and their relationships, which facilitates the organization and modeling the system treatments.
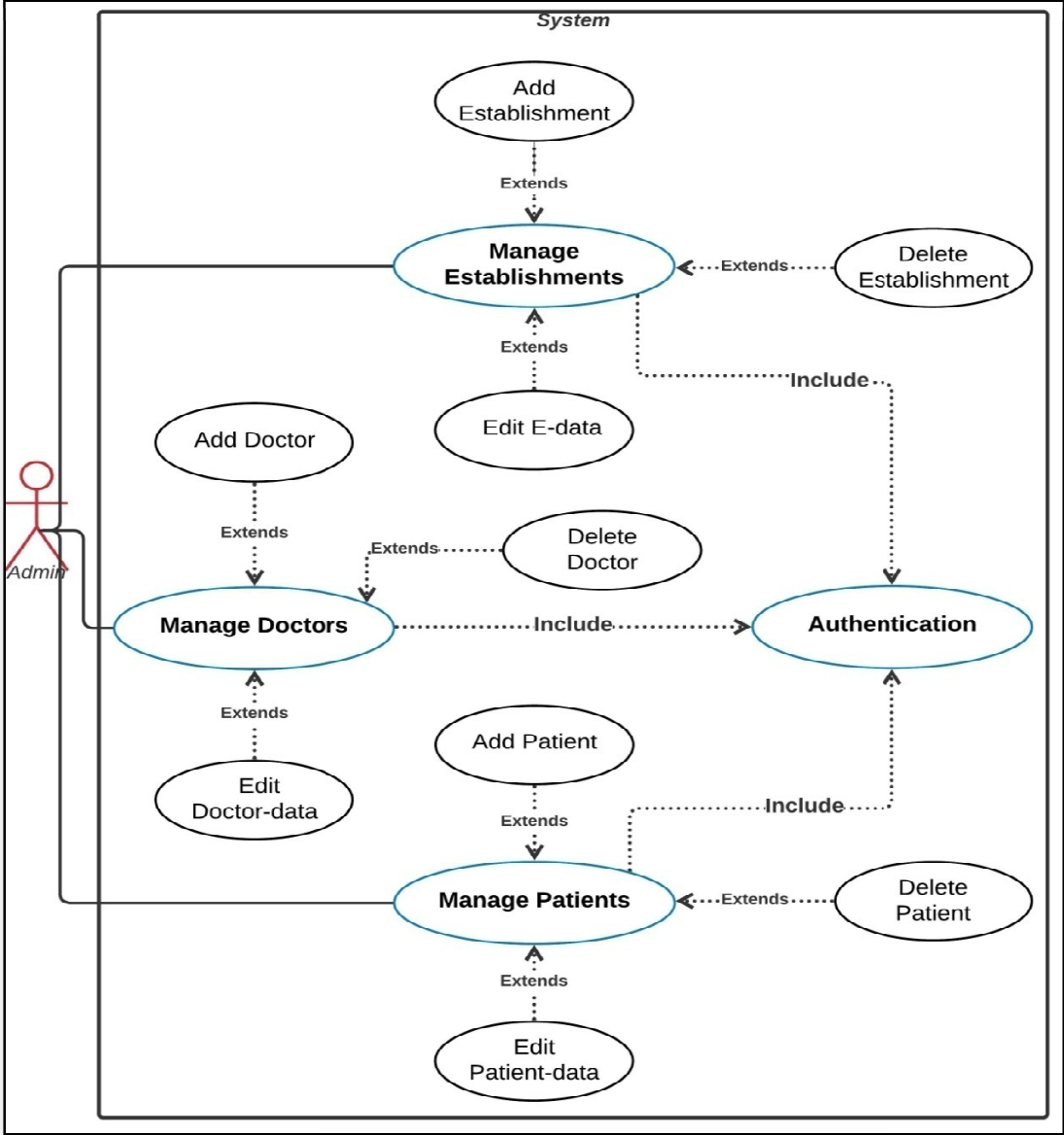
Figure 1: Admin's Use Case Diagram.
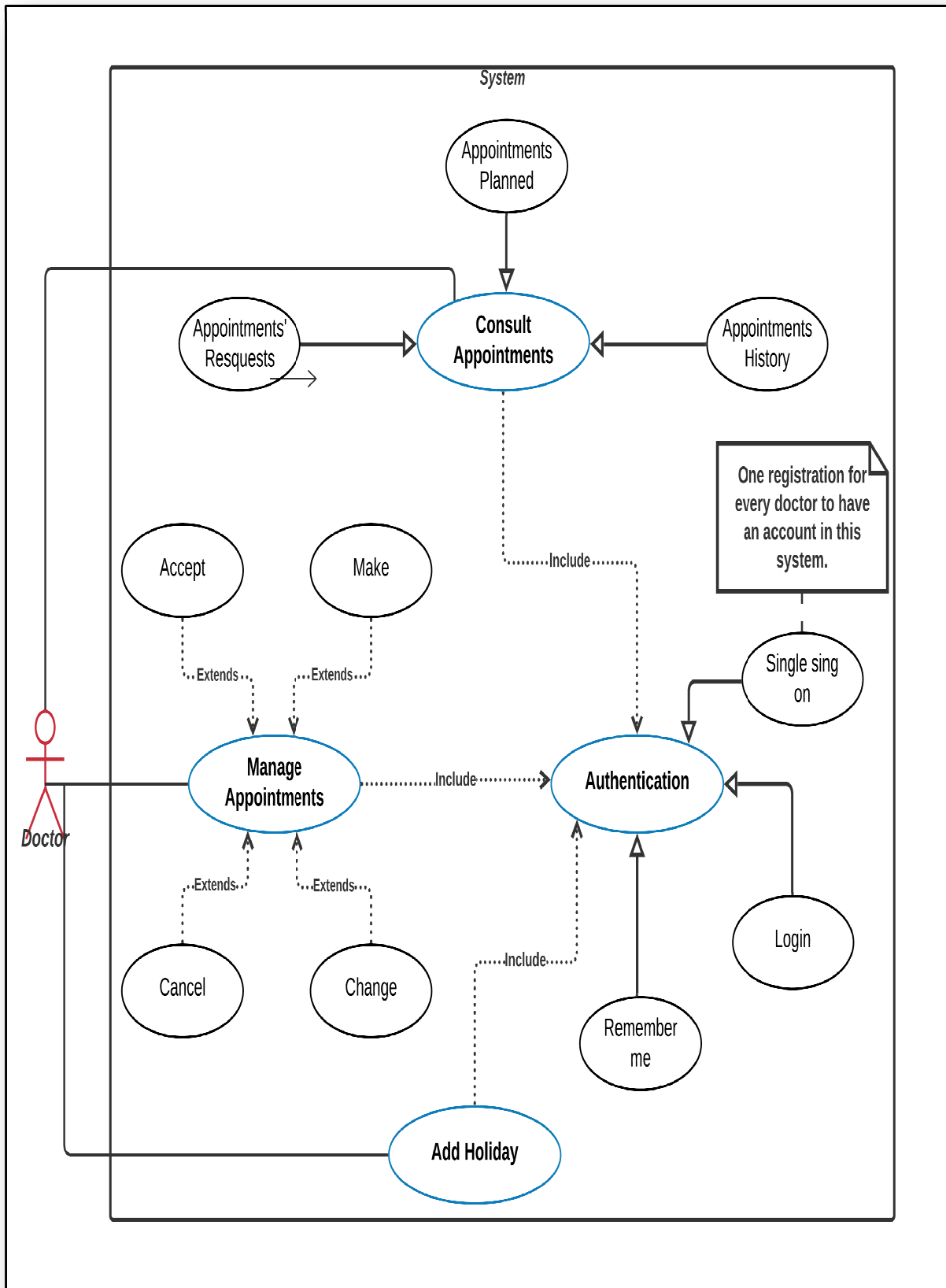
Figure 2: Doctor's Use Case Diagram.
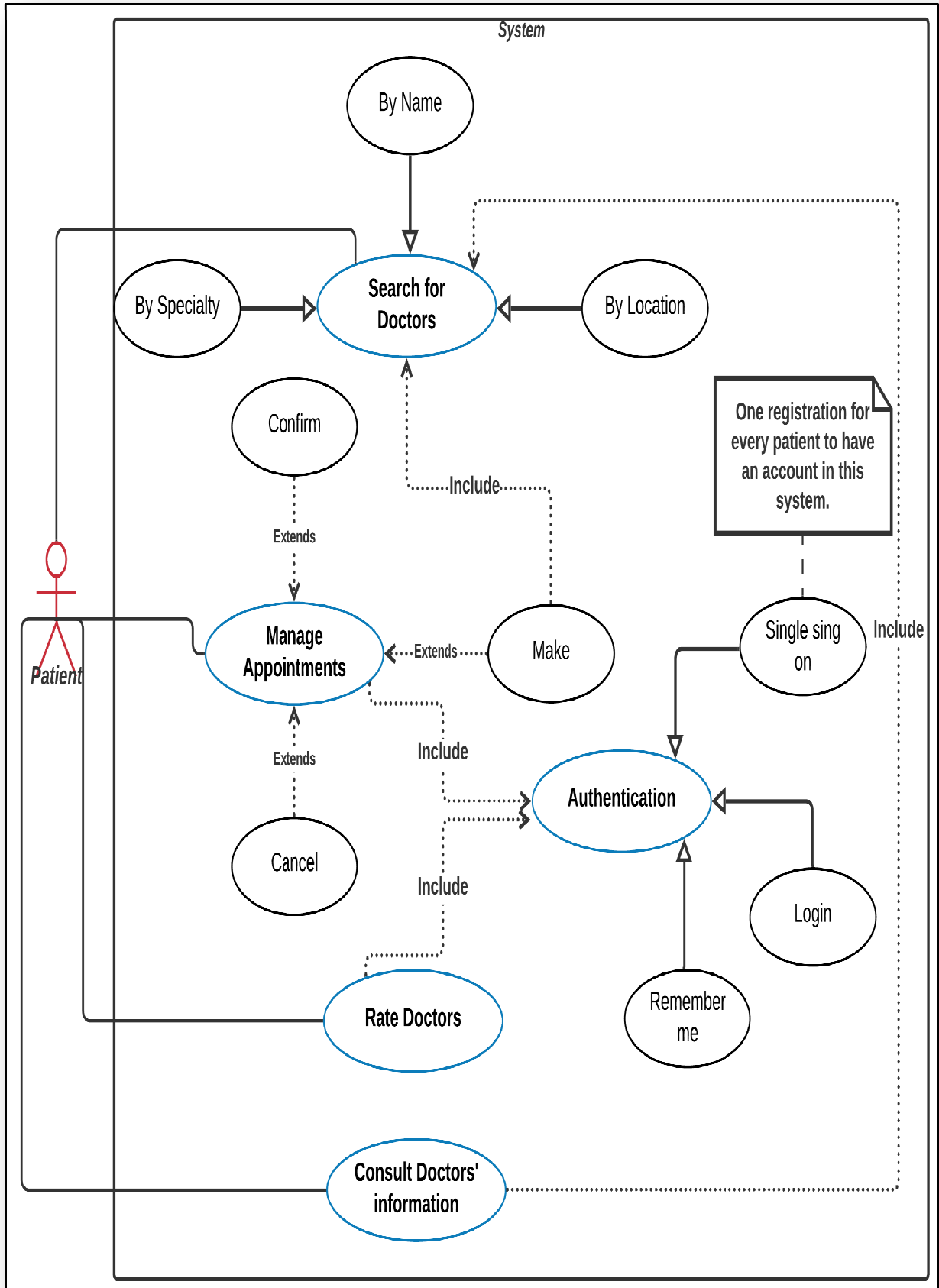
Figure 3: Patient's Use Case Diagram.

3.2 Activity Diagrams

Activity Diagrams are used to describe the dynamic aspects of this system for the important use cases.
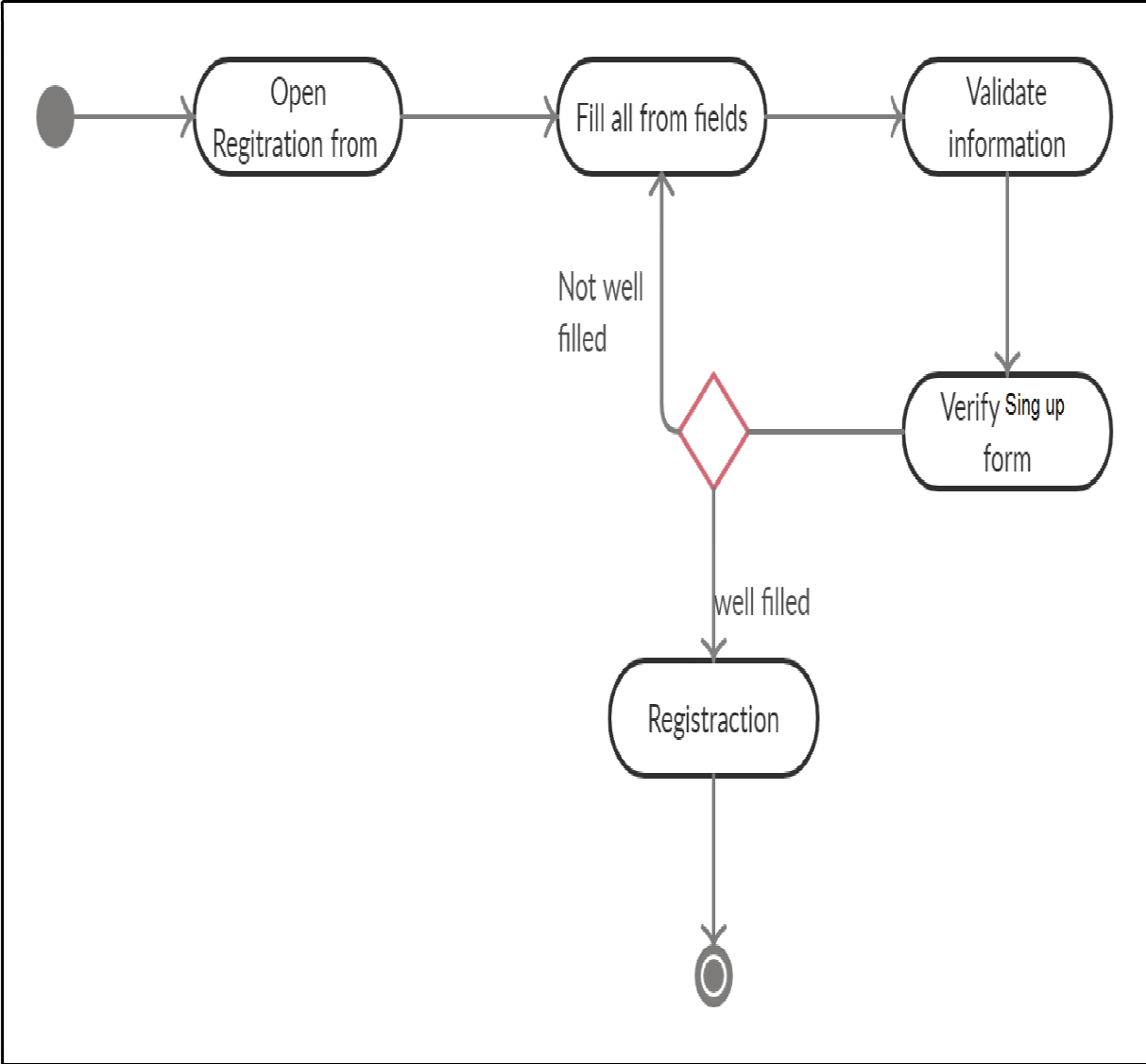
Figure 4: Register Doctor and Patient Activity Diagram.
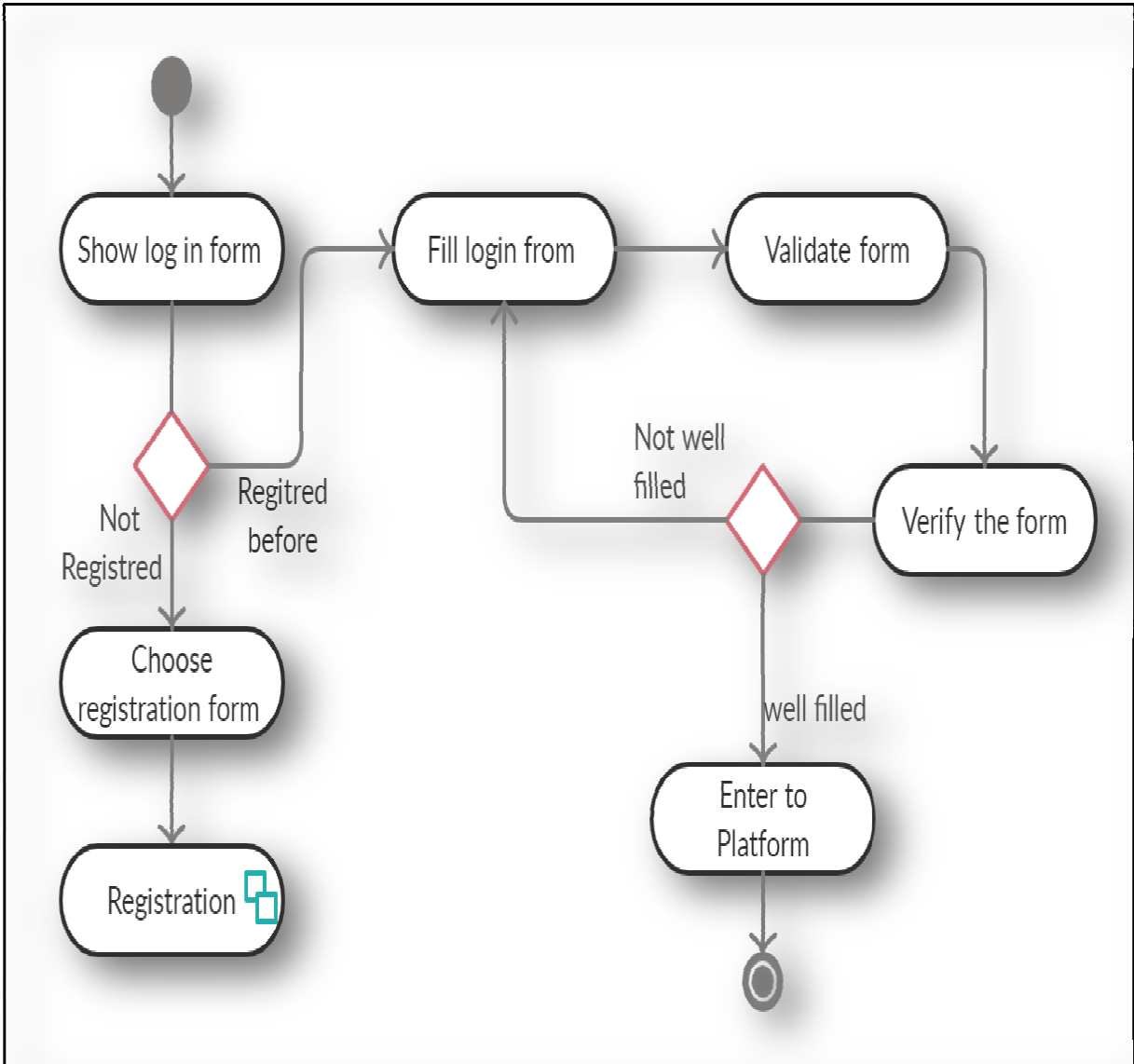
Figure 5: Authentication Activity Diagram for Doctors and Patients.
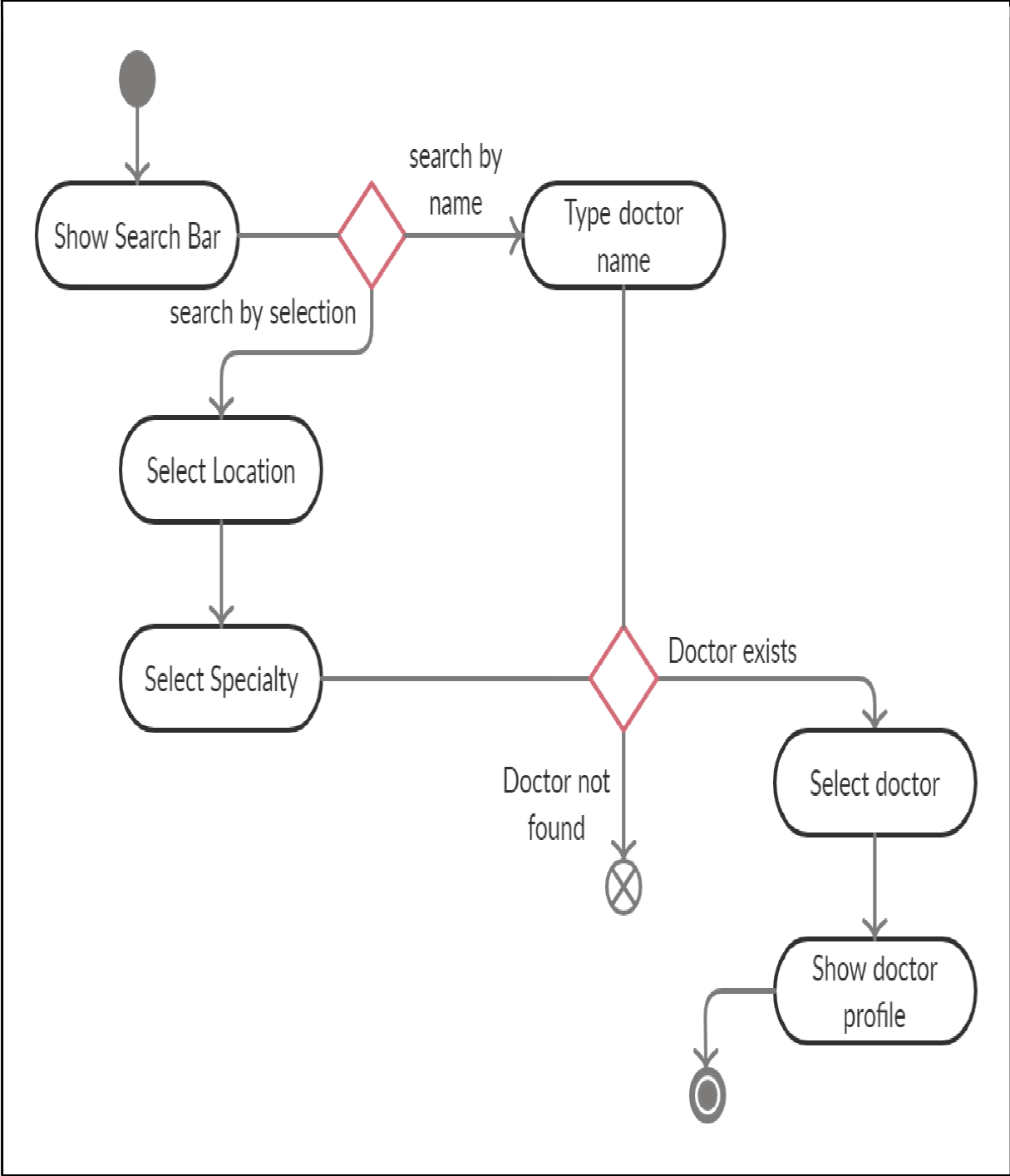
Figure 6: Patient's Search Activity Diagram.
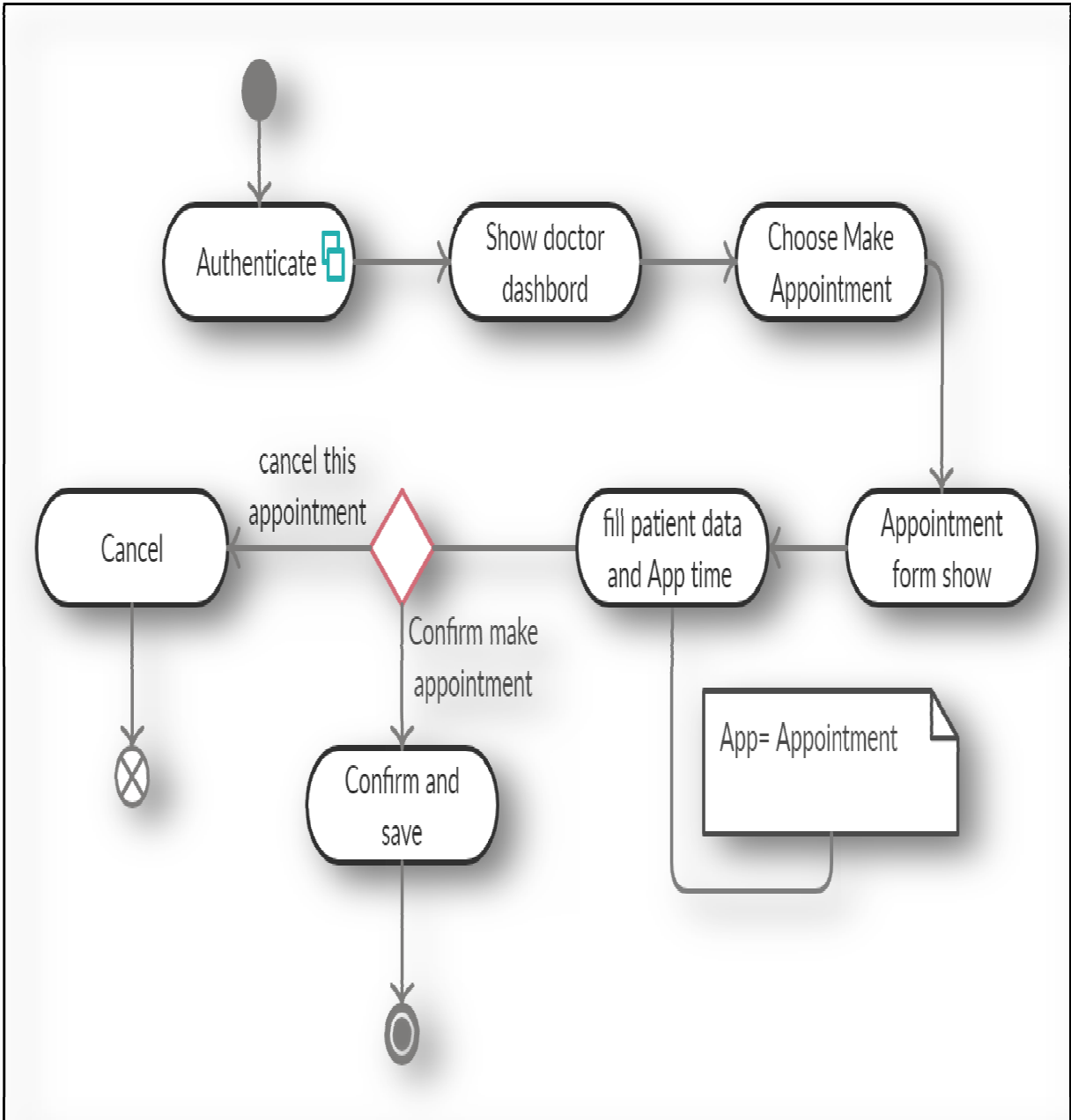
Figure 7: Make Appointments' Activity Diagram for Doctors.
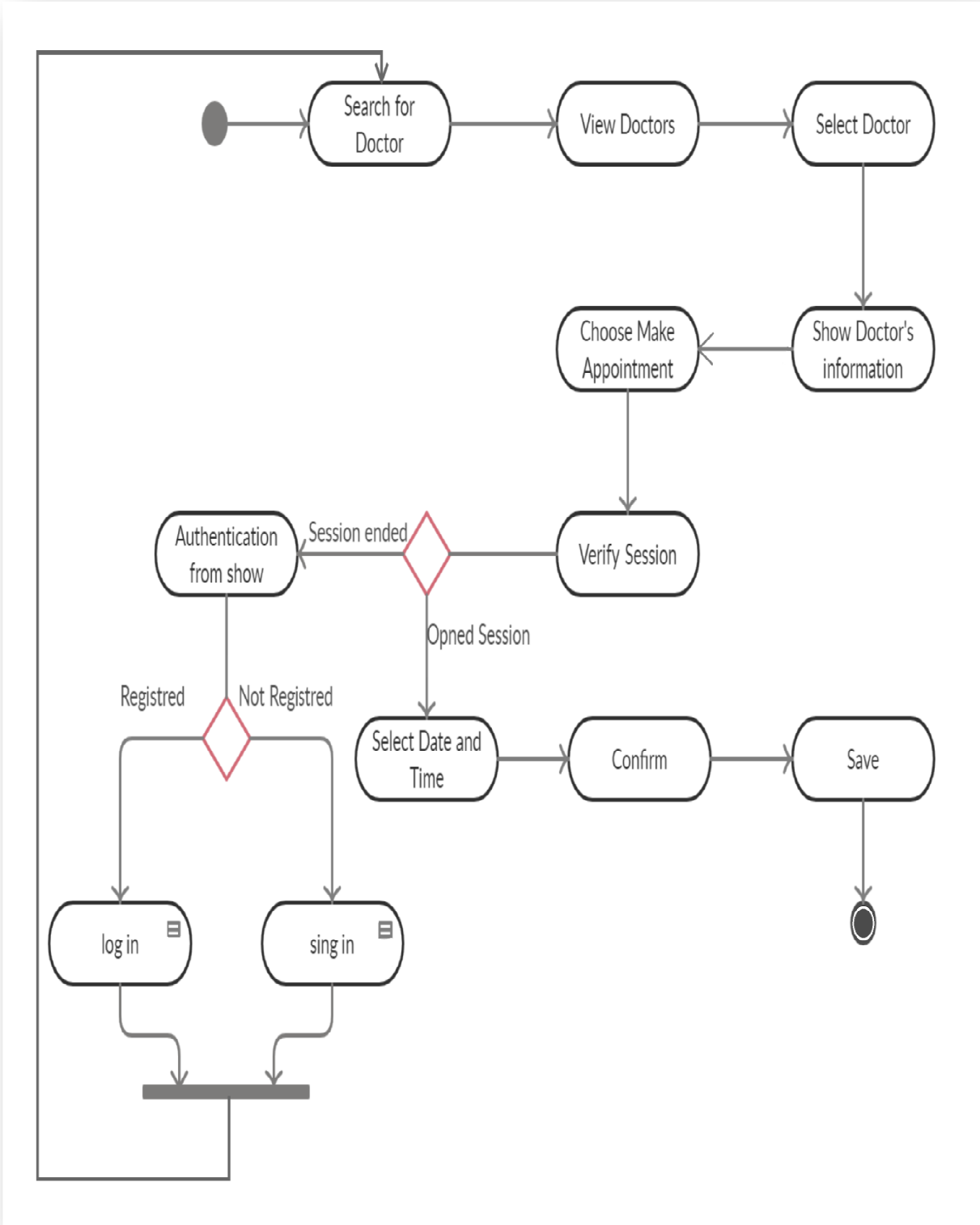
Figure 8: Make Appointments' Activity Diagram for Patients.
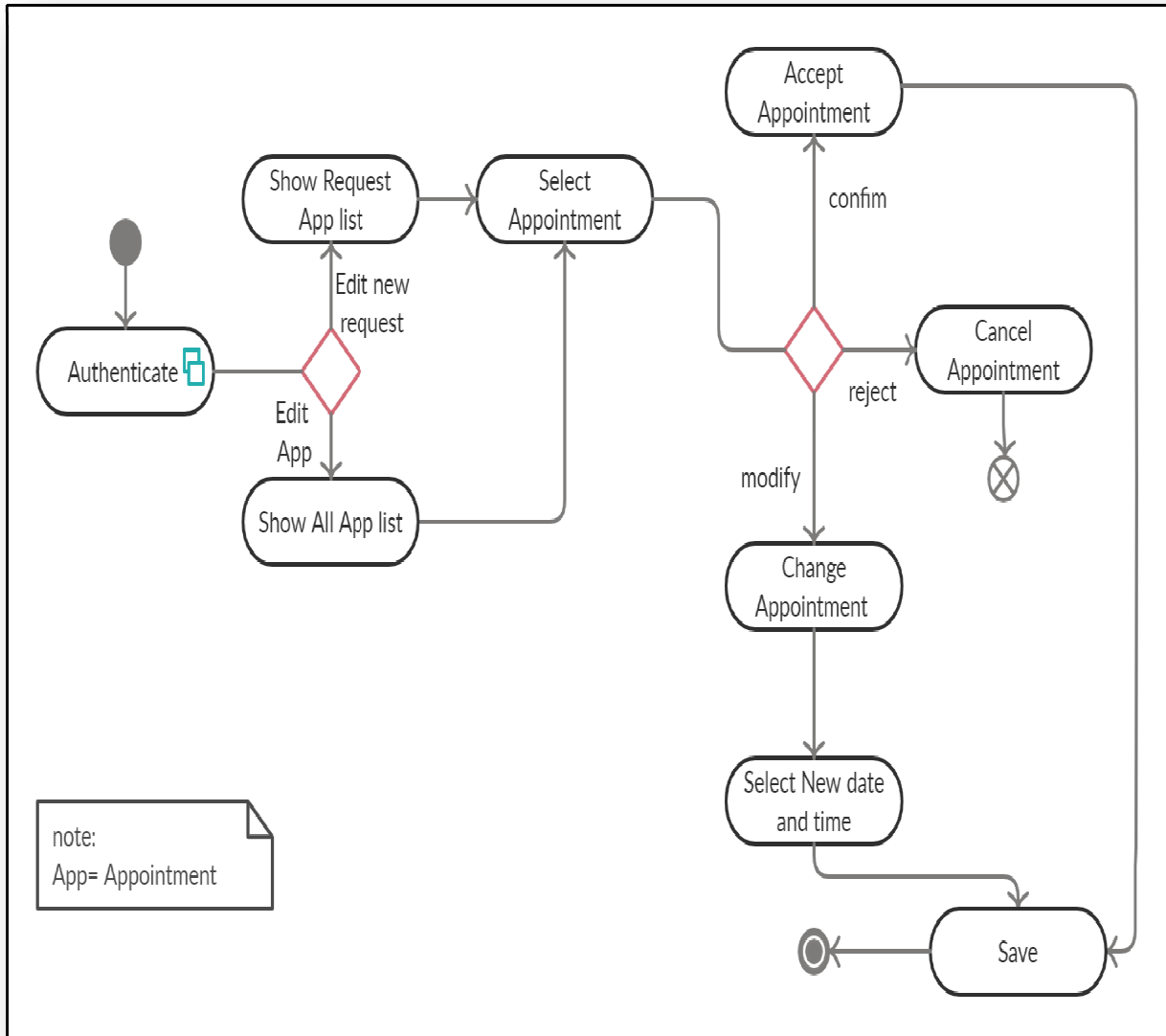
Figure 9: Manage Appointments' Activity Diagram for Doctors.
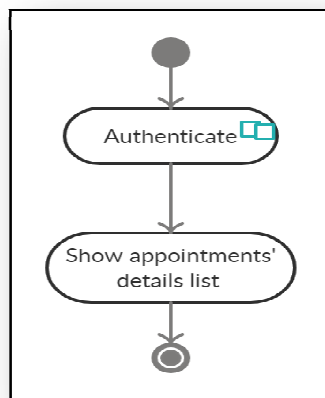
Figure 10: Patients Consult Appointments Activity Diagram.
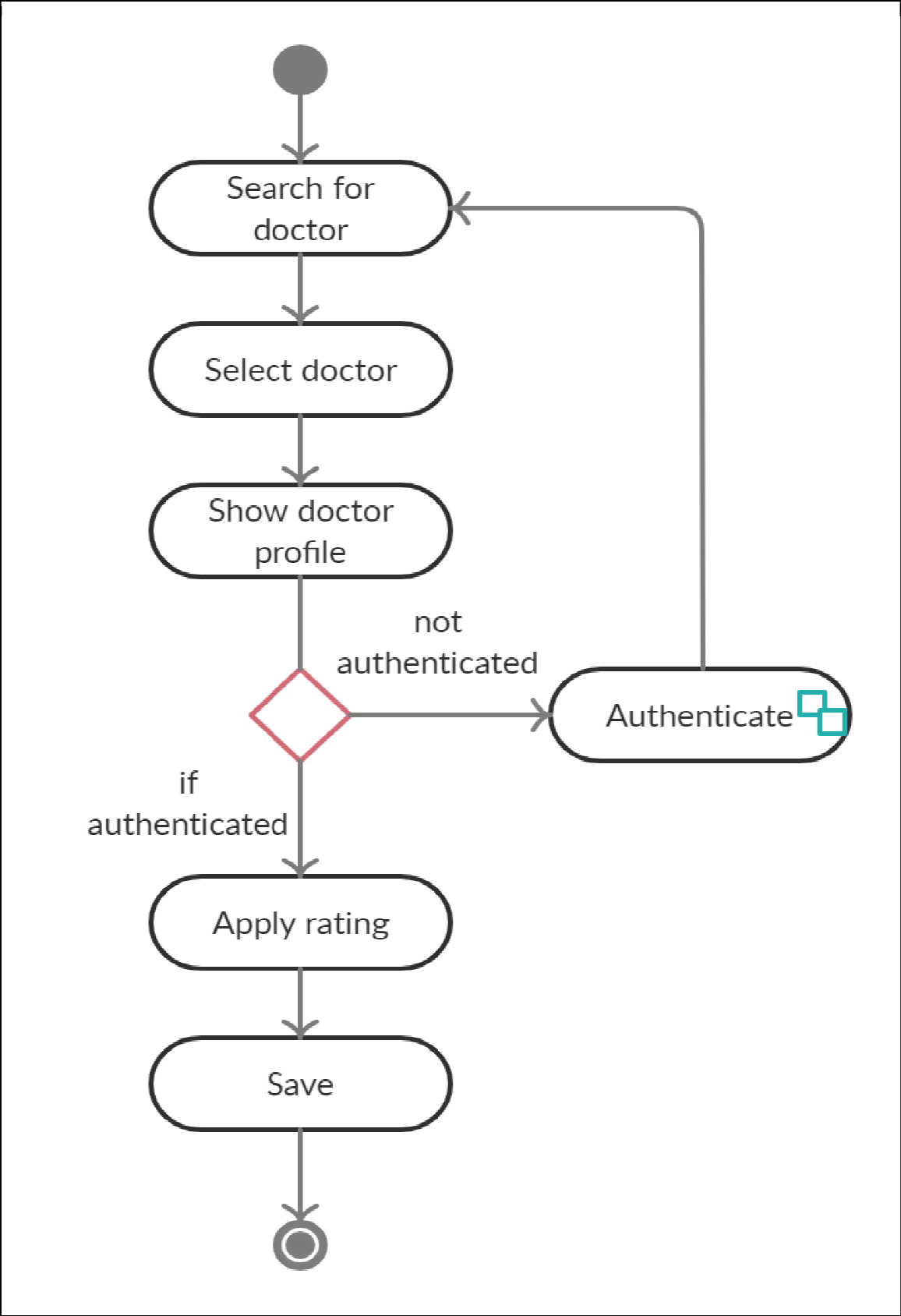
Figure 11: Rate Doctors Activity Diagram.

3.3 Sequence Diagrams

Sequence Diagrams are used to show interactions details and how operations are carried out between the actors and this application.
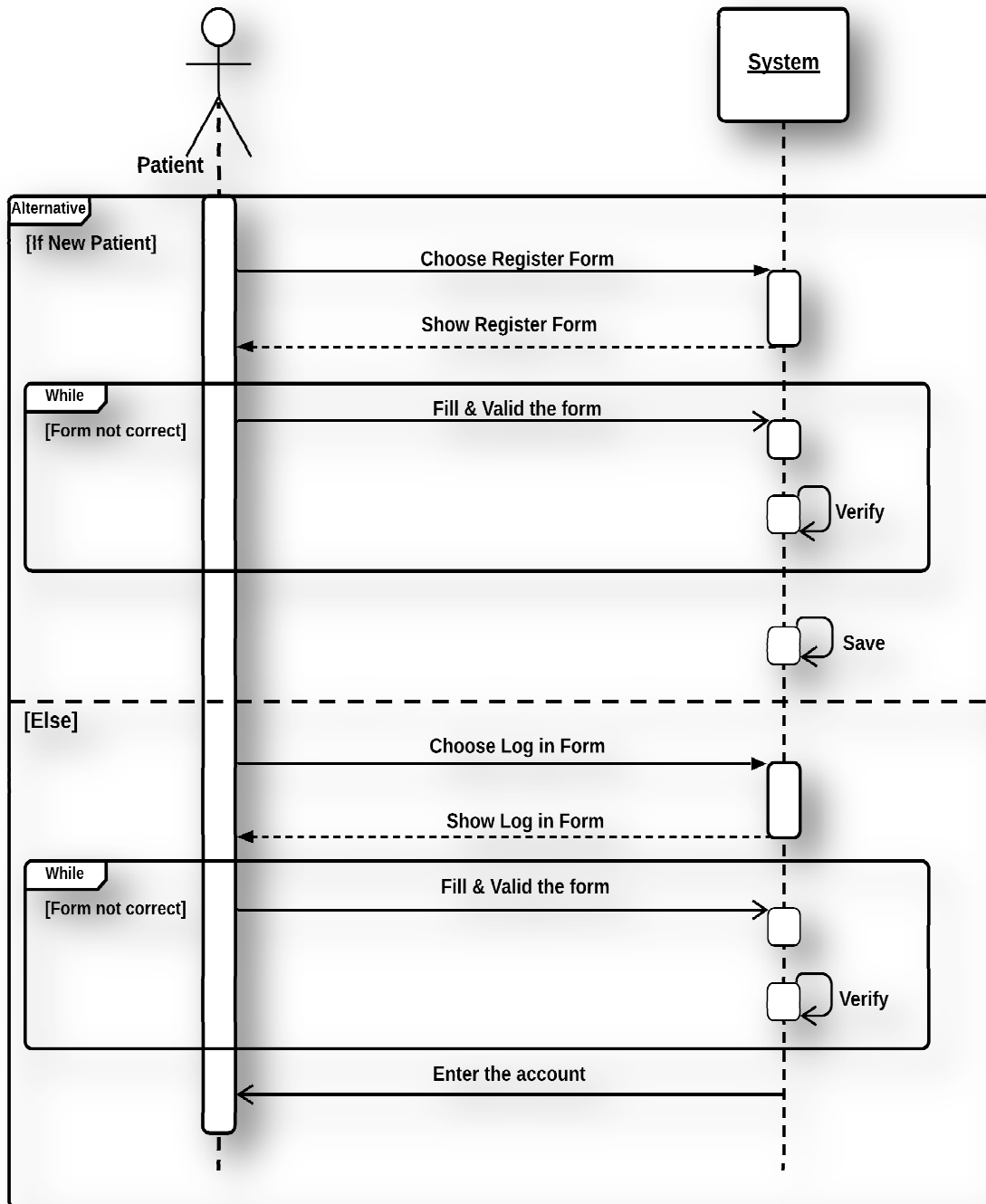
Figure 12: Authentication Sequence Diagram for Patients.
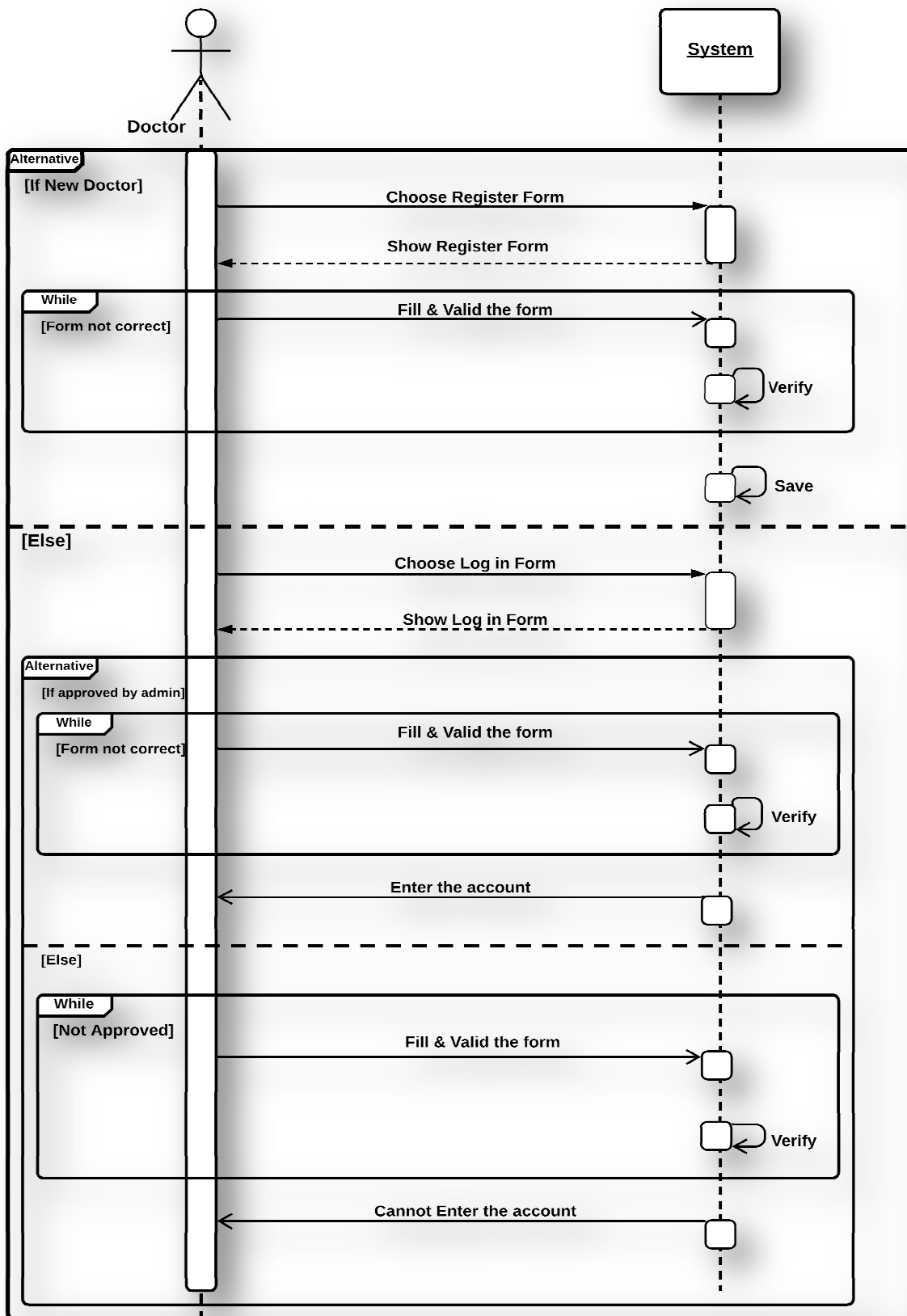
Figure 13: Authentication Sequence Diagram for Doctors.
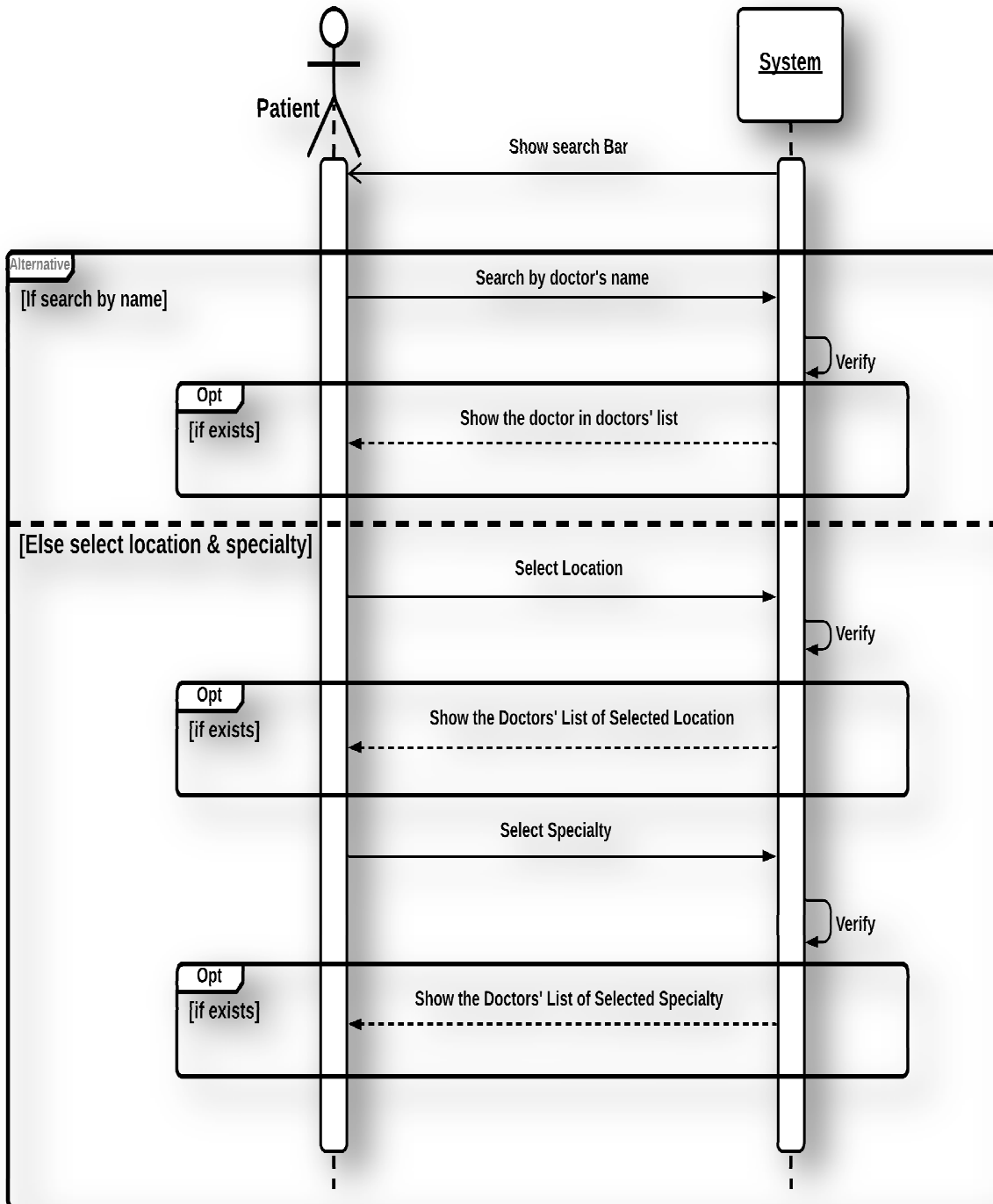
Figure 14: Patients' Search Sequence Diagram.
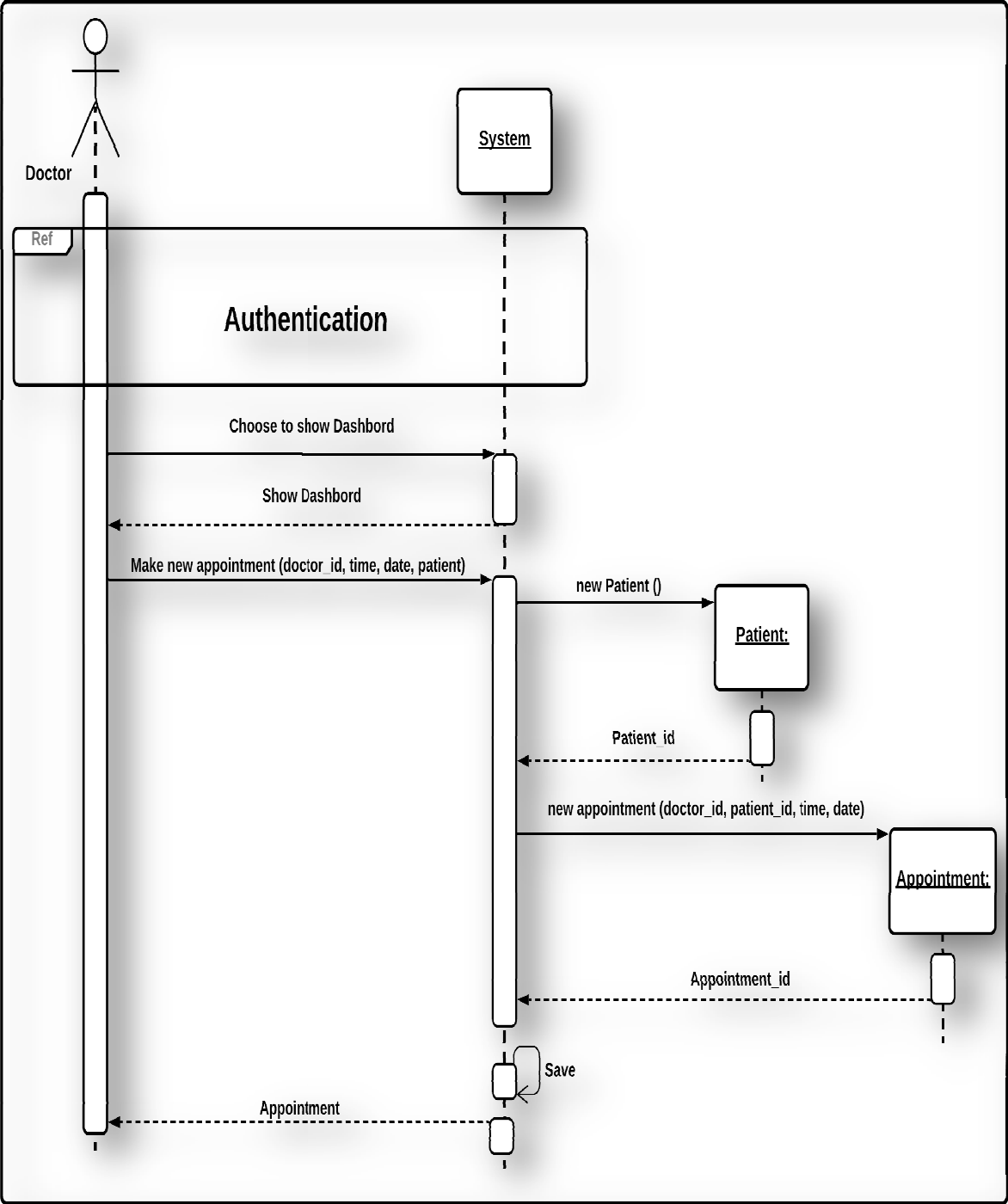
Figure 15: Make Appointments Sequence Diagram for Doctors.
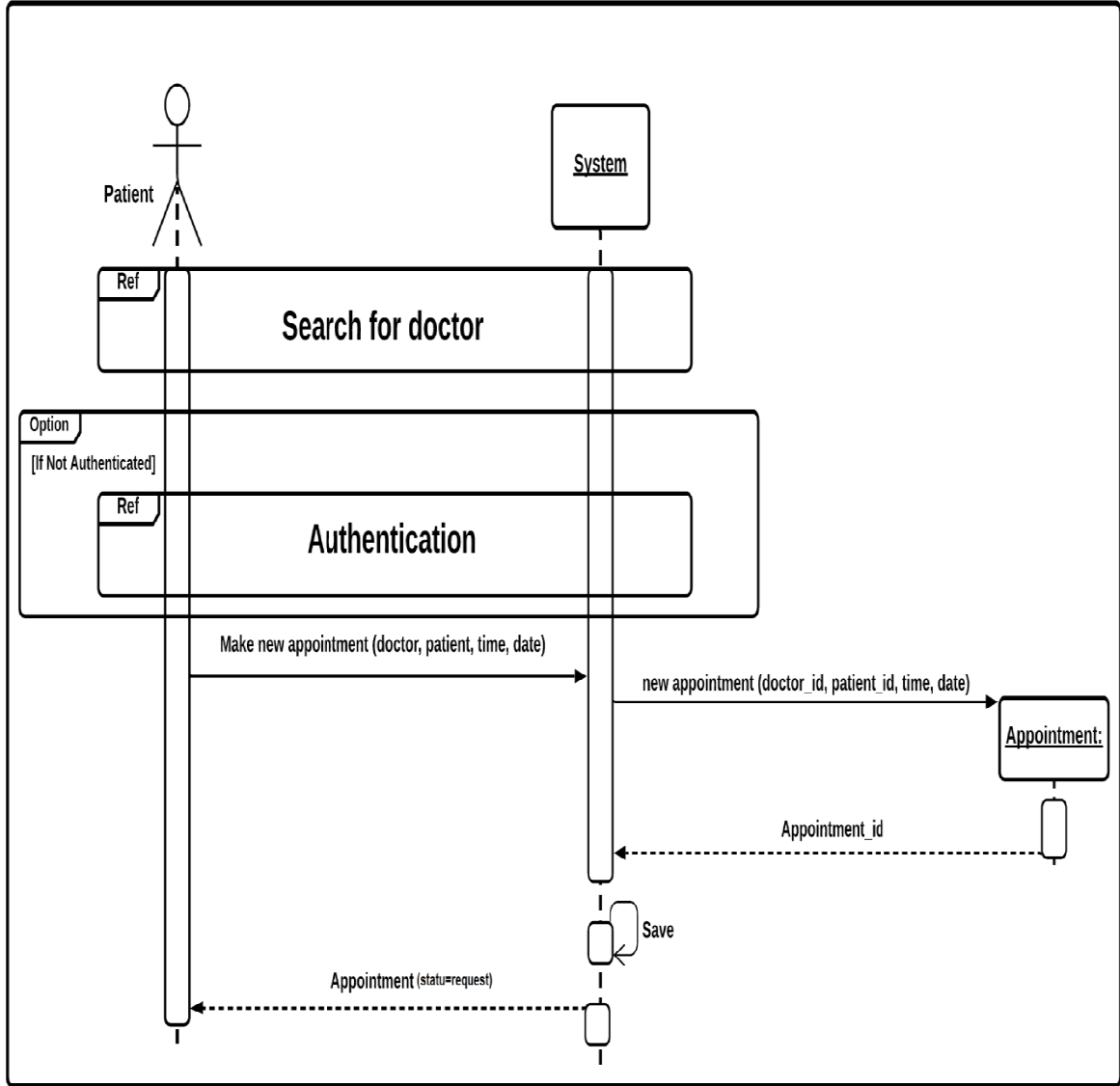
Figure 16: Make Appointment Sequence Diagram for Patients.
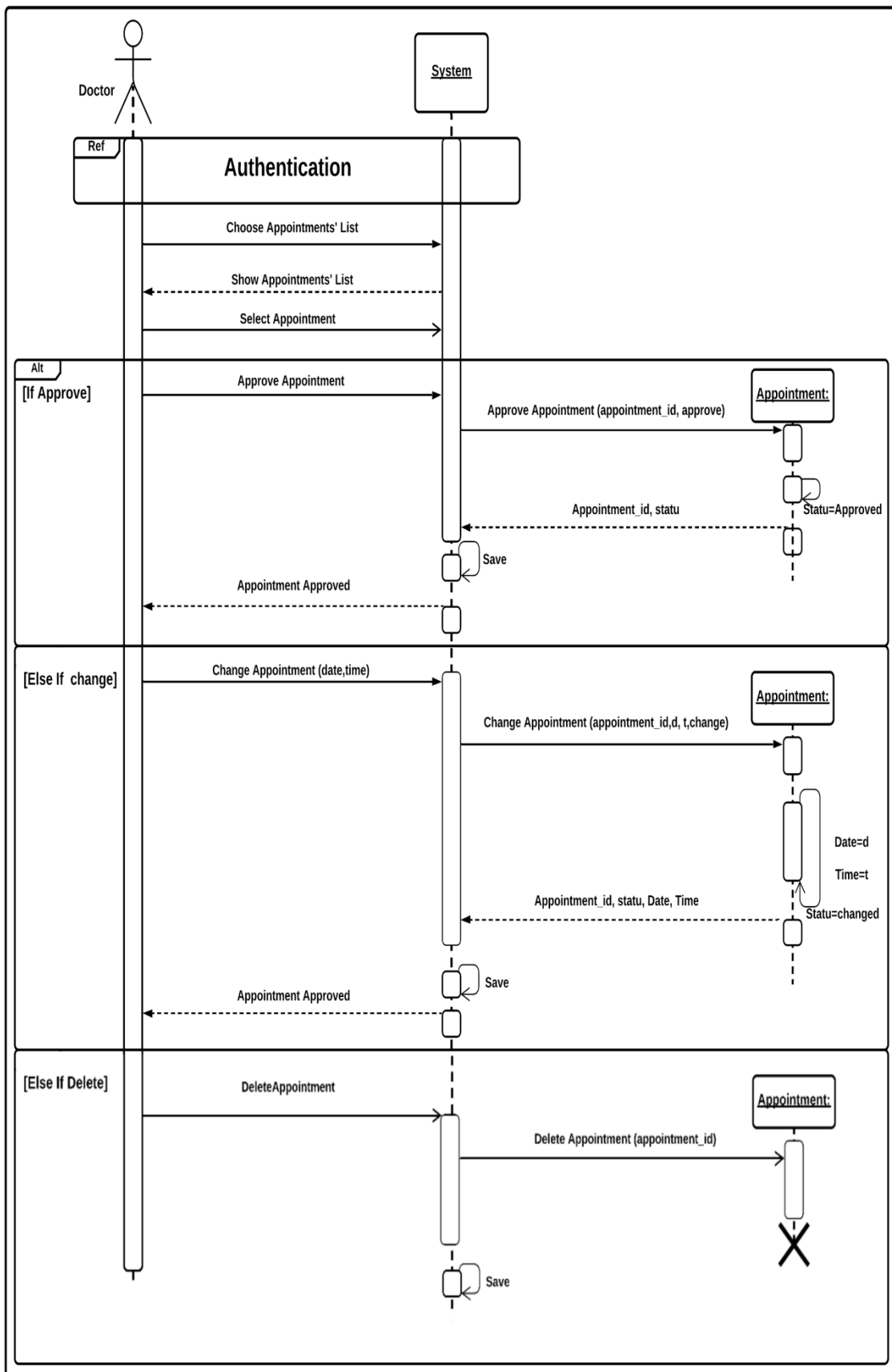
Figure 17: Manage Appointment Sequence Diagram for Doctors.
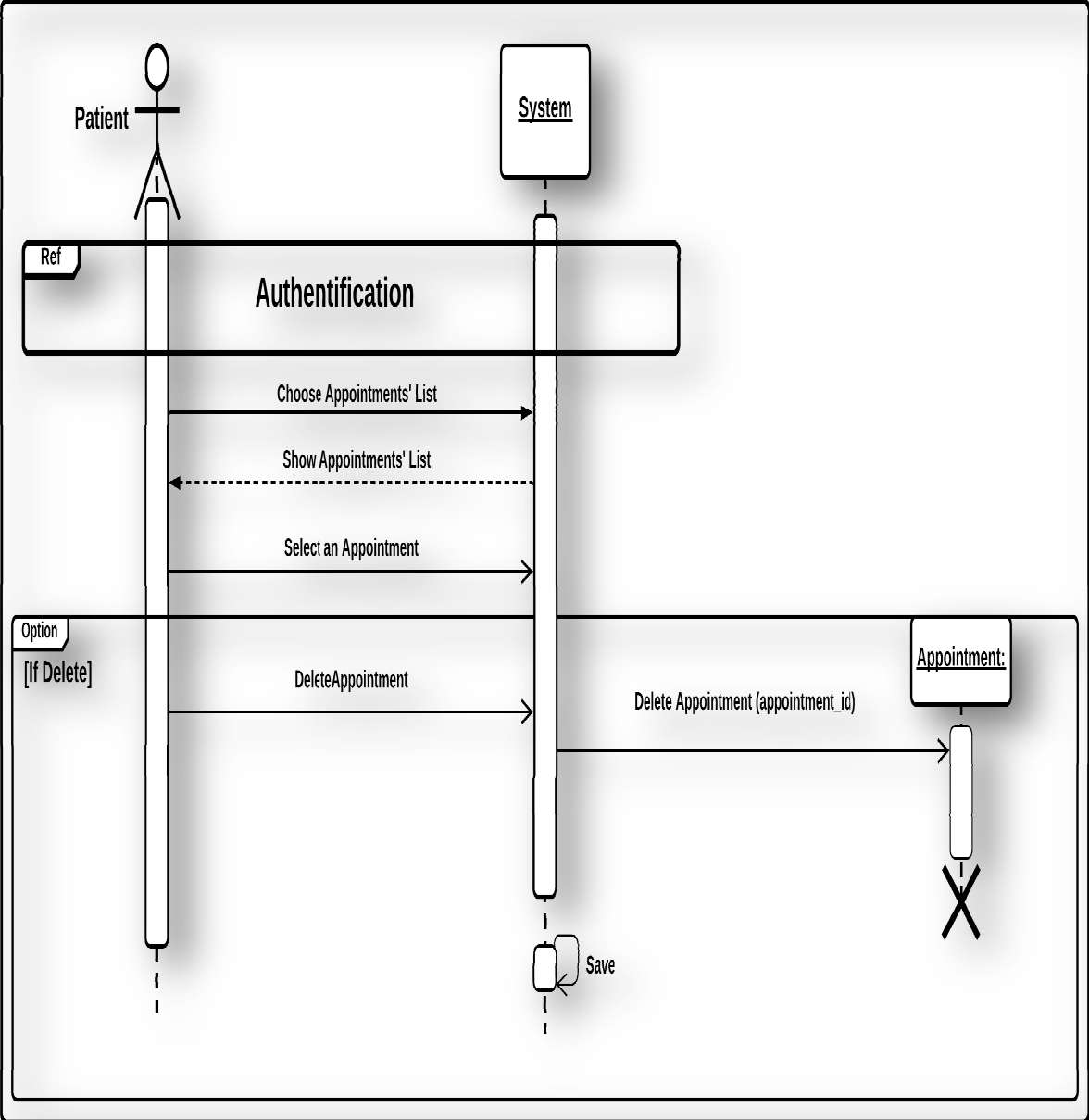
Figure 18: Delete Appointment Sequence Diagram for Patients.
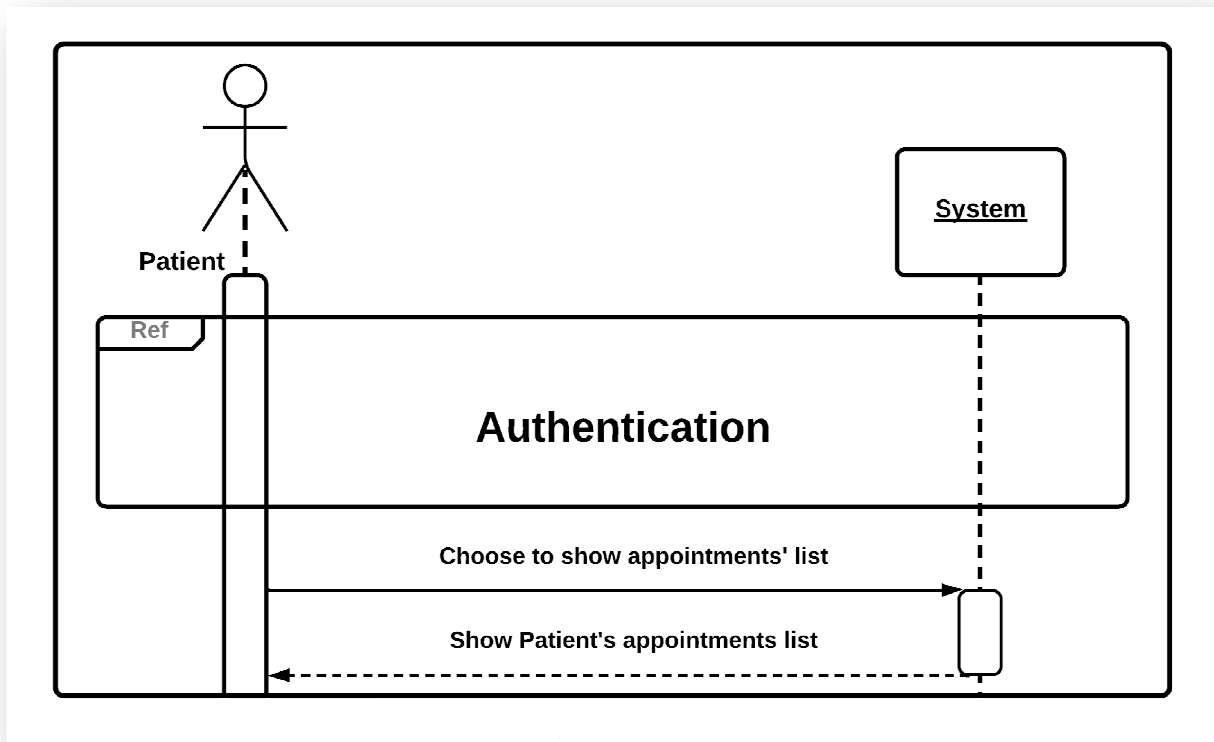
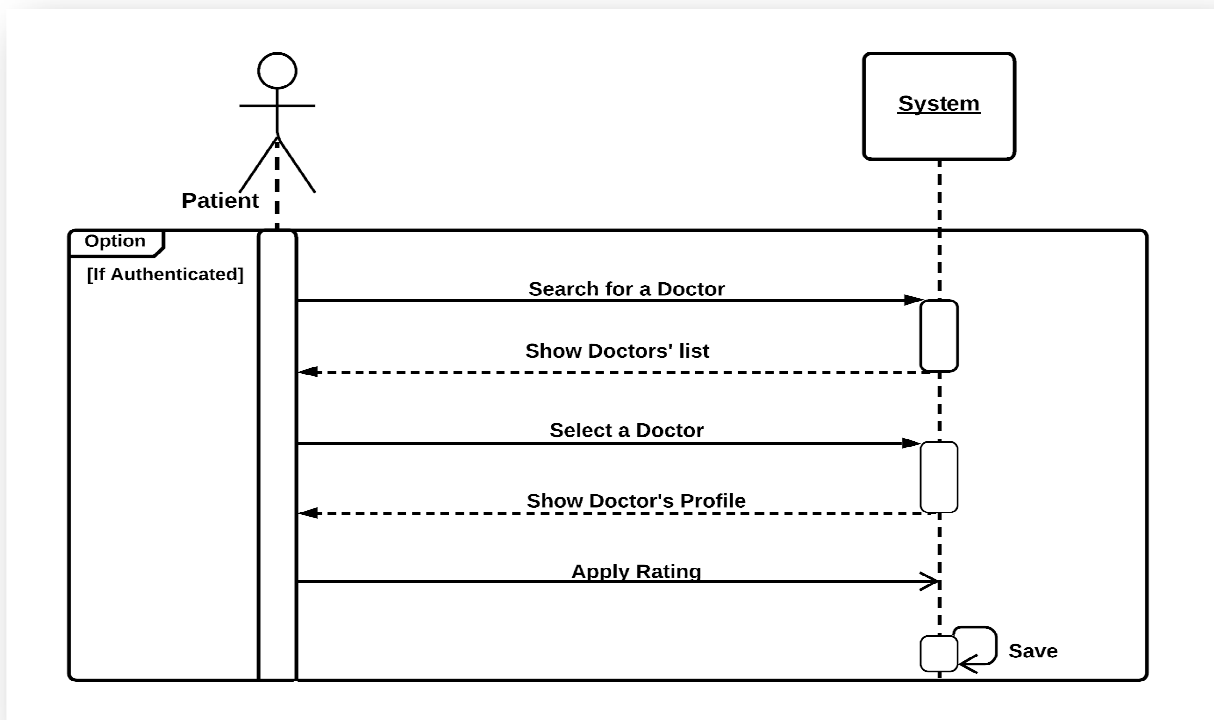*Figure 19: Consult Appointments Sequence Diagram for Patients.*

Figure 20: Rate Doctors Sequence Diagram.

3.4 Class Diagram

Class diagram is used to model and describe data and to identify the database's tables of this system. This figure below represents the class diagram. The attributes of each class are in the next figure.
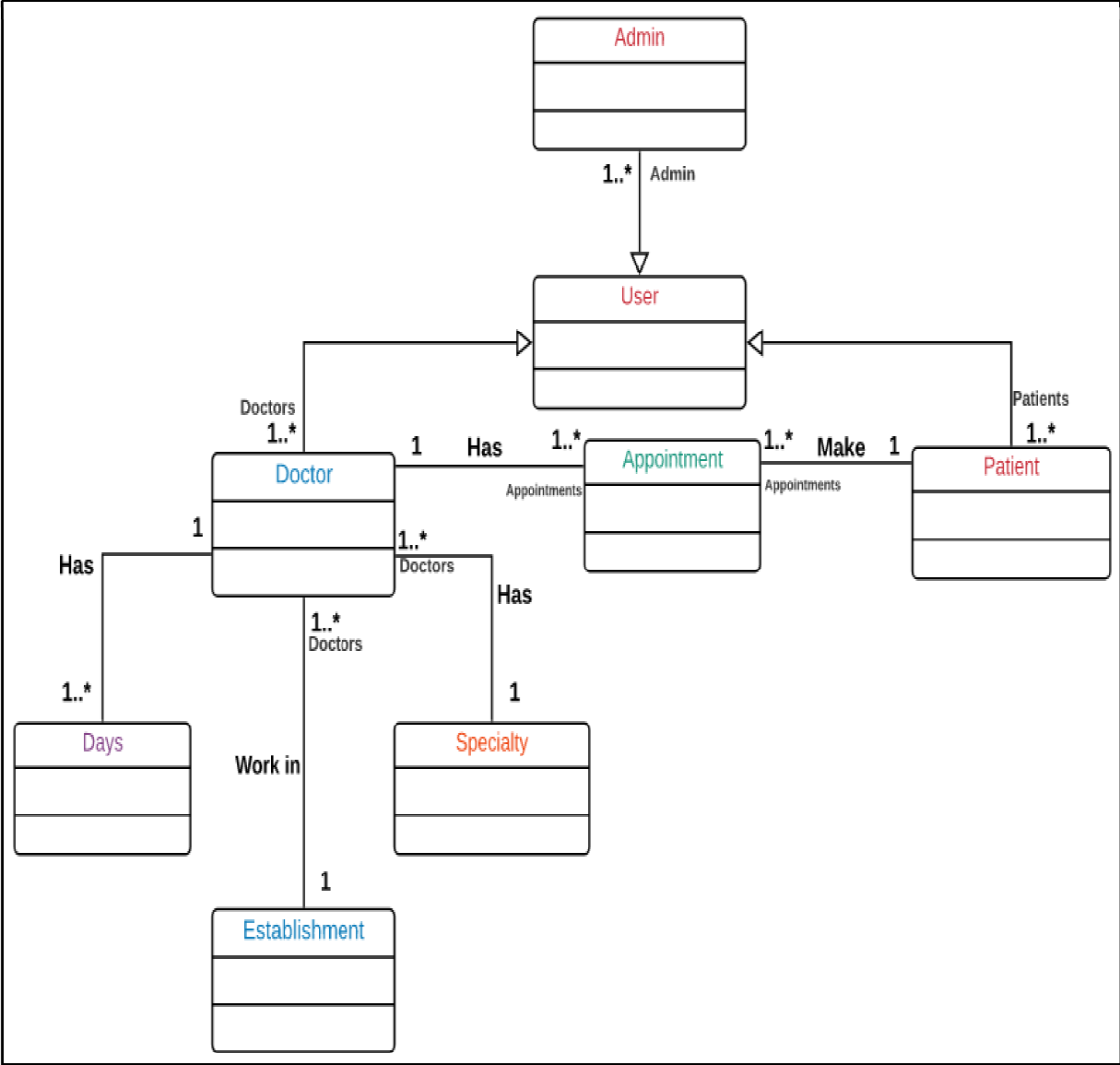

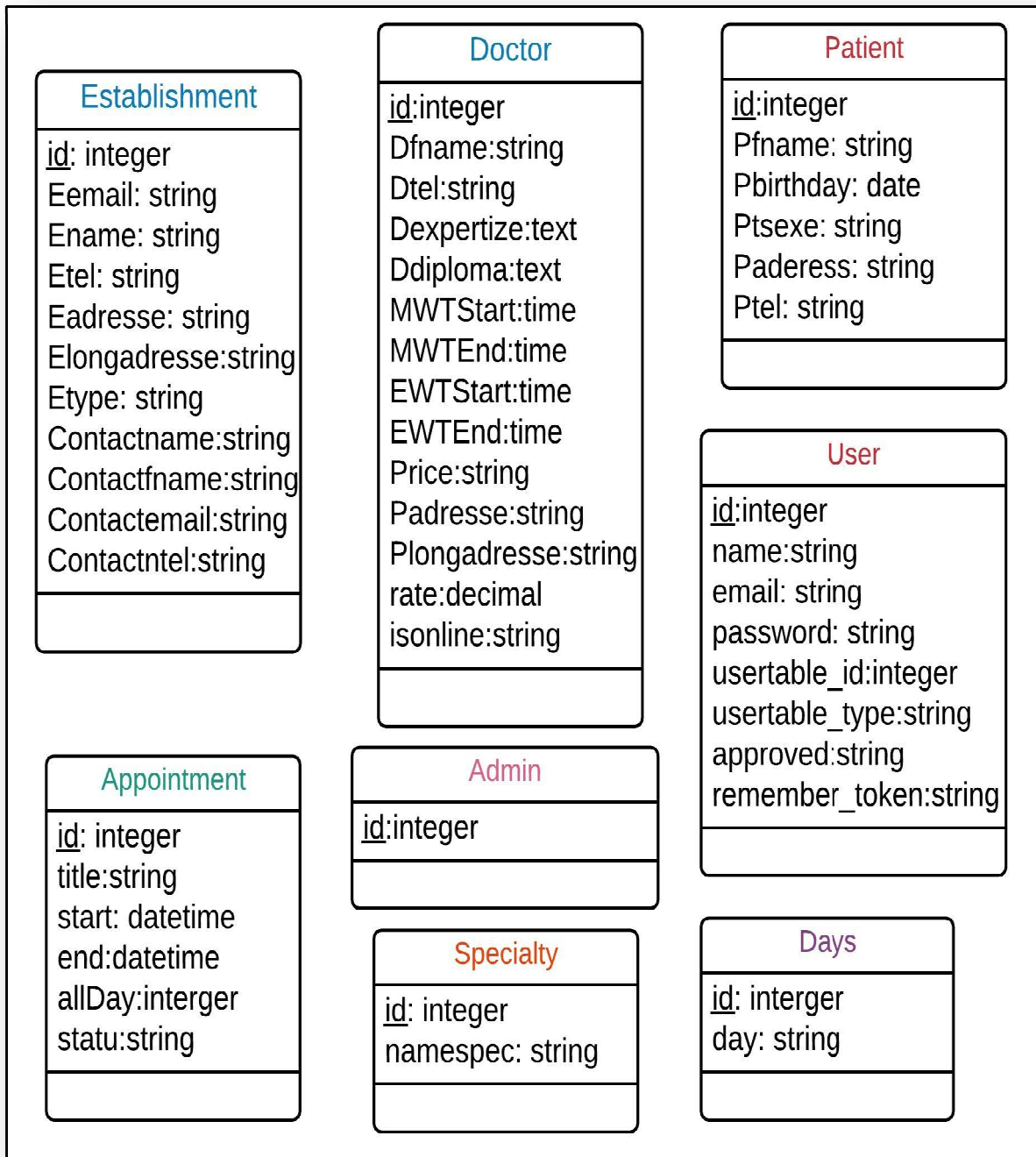*Figure 21: Applications' Class Diagram.*

Establishment

id: integer
Eemail: string
Ename: string
Etel: string
Eadresse: string
Elongadresse:string
Etype: string
Contactname:string
Contactfname:string
Contactemail:string
Contactntel:string

Doctor

id:integer
Dfname:string
Dtel:string
Dexpertize:text
Ddiploma:text
MWTStart:time
MWTEnd:time
EWTStart:time
EWTEnd:time
Price:string
Padresse:string
Plongadresse:string
rate:decimal
isonline:string

Patient

id:integer
Pfname: string
Pbirthday: date
Ptsexe: string
Paderess: string
Ptel: string

User

id:integer
name:string
email: string
password: string
usertable_id:integer
usertable_type:string
approved:string
remember_token:string

Appointment

id: integer
title:string
start: datetime
end:datetime
allDay:interger
statu:string

Admin

id:integer

Specialty

id: integer
namespec: string

Days

id: interger
day: string

Figure 22: Attributes of Class Diagram.

3.5   Relational Schemas

To constitute database's tables, modeling phase of class diagram was followed by the passage from oriented object model to relational model using the passage rules. The relational model is as follow:
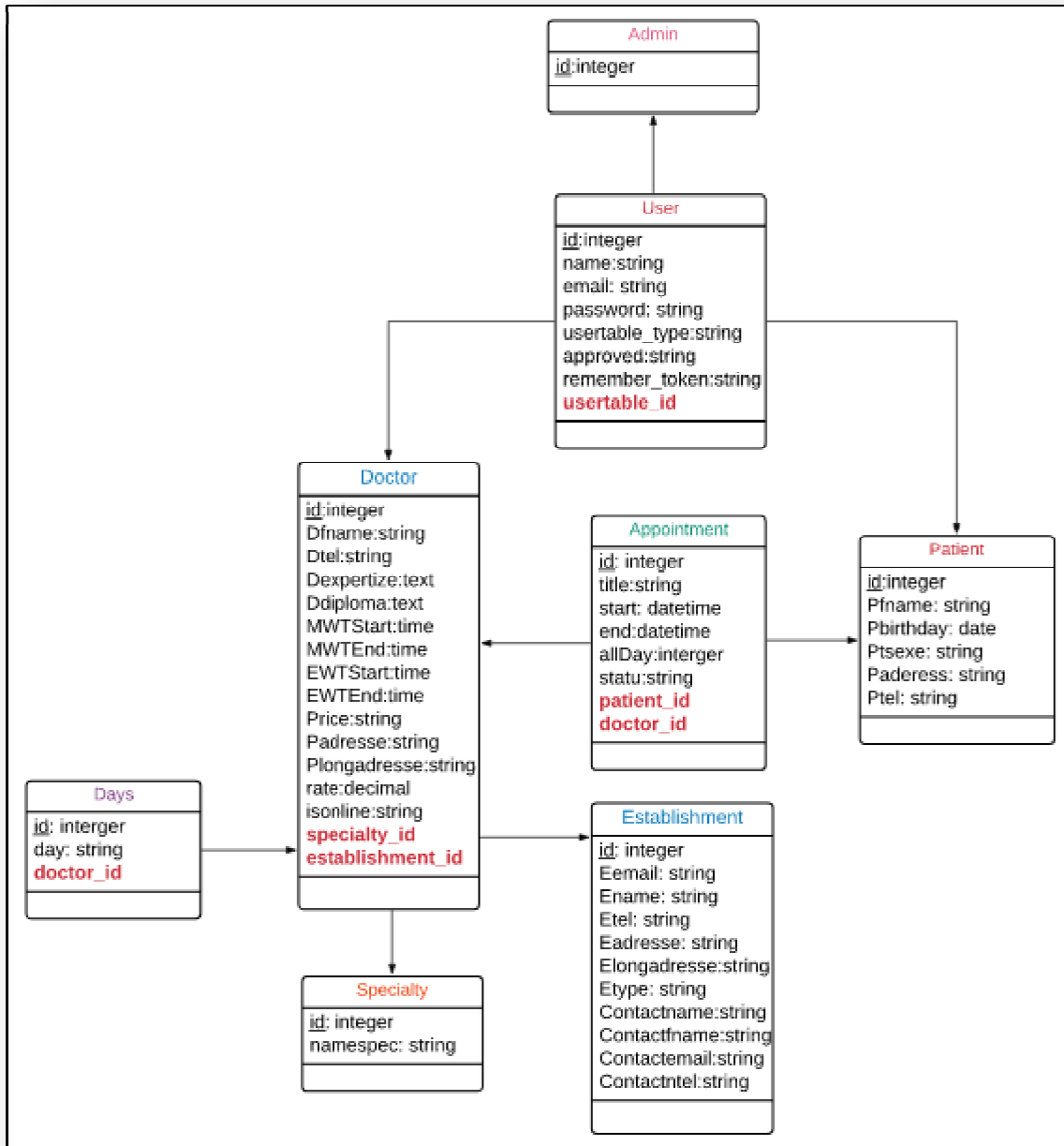

Figure 23: Relational Schema of this Application's Database.

4. Application's Data Dictionary

Data dictionary is a used as Meta data for our database columns, it contains information such as type, default values, relationships and origins. The data dictionary shows details of the relational schemas' attributes. [30]

		Establishment Dictionary		
Column	Type	Null	Default value	Is related to
id (Primary)	bigint(20)	No	/	/
Ename	varchar(191)	No	/	/
Etel	varchar(191)	No	/	/
Eadresse	varchar(191)	No	/	/
Elongadresse	text	No	/	/
Etype	varchar(191)	No	/	/
Eemail	varchar(191)	No	/	/
contactname	varchar(191)	No	NULL	/
contactfname	varchar(191)	Yes	NULL	/
contactntel	varchar(191)	Yes	NULL	/
contactemail	varchar(191)	Yes	NULL	/

Table 4: Establishment's Data Dictionary.

Column	Type	Doctor Dictionary Null	Default value	Is related to
id (Primary)	bigint(20)	No	/	/
Dfname	varchar(191)	No	/	/
Dtel	varchar(191)	No	/	/
Dexpertize	text	No	/	/
Ddiploma	text	No	/	/
Price	varchar(191)	No	/	/
MWTStart	time	No	/	/
MWTEnd	time	No	/	/
EWTStart	time	No	/	/
EWTE	time	No	/	/
Padresse	varchar(191)	No	/	/
Plongadresse	text	No	/	/
rate	int(11)	No	0	/
establishment_id	bigint(20)	Yes	NULL	establishment(id)
spetialty_id	bigint(20)	No	/	specialty(id)

Table 5: Doctor's Data Dictionary.

		Appointment Dictionary		
Column	**Type**	**Null**	**Default value**	**Is related to**
id (Primary)	bigint(20)	No	/	/
title	varchar(191)	No	/	/
start	datetime	No	/	/
end	datetime	Yes	NULL	/
allDay	tinyint(1)	No	0	/
statu	varchar(191)	No	request	/
doctor_id	bigint(20)	Yes	NULL	doctors(id)
patient_id	bigint(20)	Yes	NULL	patients(id)

Table 6: Appointment's Data Dictionary.

		Specialty Dictionary		
Column	**Type**	**Null**	**Default value**	**Is related to**
id (Primary)	bigint(20)	No	/	/
namespec	varchar(191)	No	/	/

Table 7: Specialty Data Dictionary.

		Patient Dictionary		
Column	**Type**	**Null**	**Default value**	**Is related to**
id (Primary)	bigint(20)	No	/	/
Pfname	varchar(191)	No	/	/
Ptel	varchar(191)	No	/	/
Paderess	varchar(191)	Yes	NULL	/
Pbirthday	date	No	/	/
Psexe	varchar(191)	No	/	/

Table 8: Patient's Data Dictionary.

		Day Dictionary		
Column	**Type**	**Null**	**Default value**	**Is related to**
id (Primary)	bigint(20)	No	/	/
day	varchar(191)	No	/	/
doctor_id	bigint(20)	Yes	NULL	doctors(id)

Table 9: Doctors' Works Days' Data Dictionary.

		User Dictionary		
Column	Type	Null	Default value	Is related to
id (Primary)	bigint(20)	No	/	/
name	varchar(191)	No	/	/
email	varchar(191)	No	/	/
password	varchar(191)	No	/	/
approved	varchar(191)	No	/	/
usertable_type	varchar(191)	No	/	/
usertable_id	int(11)	Yes	NULL	/
remember_token	varchar(100)	Yes	NULL	/

Table 10: User's Data Dictionary.

		Admin Dictionary		
Column	Type	Null	Default value	Is related to
Id (Primary)	bigint(20)	No	/	/

Table 11: Admin Data Dictionary.

5. Conclusion

This chapter had allowed us to present our proposed system, particularly its general and detailed designs. We had opted to design our platform using UML diagrams. This modeling language had an important role in making a simple organized software design. The conceptual phase is a fundamental stage for the realization of any project which makes the implementation of this application easier and clearer. Thus it had allowed us to advance rapidly and implement the platform more wisely. The next chapter will present the implementation's overview of this proposed platform, describing different WebPages and the functioning of this application, and determining the frameworks we had used to implement it.

Chapter Four

Implementation

1. Introduction

The implementation of web applications must imperatively be preceded by analyzed and conceptual methodologies, which aim to formalize the preliminary stages of the development of sites in order to make this development more faithful to the needs of the users. The development and creation of apps is the result of the designs. In other word, it is the implementation in the form of components (source code, scripts, executable and other elements of the same type). This chapter discusses the implementation, definitions of some concepts, and justification of the choice of the used programming language, giving a brief overview on the used tools, presenting the results of this application, and some of its contributions.

2. Web Application's Definition

A Web application (Web app) is a set of programs that are stored on a remote server and delivered over the Internet through browsers, and any website component that performs some function for the user qualifies as a Web app. [10]

3. Functioning of the developed Application

To explain how this web application works and the network architecture used, we should define what the network architecture is, and the Client/Server architecture's types.

➤ **Network Architecture**

Network architecture refers to the way network devices (switches, routes) and services are structured to serve the connectivity needs of client devices (end-user devices, servers, and smart things), using types of services (DHCP, DNS). There are three types of network architecture which are: centralized network, peer to peer network, and client/server network. For this web application the client/server network is used, so we focus on this type to define it. [11]

• **Client/Server Network Architecture**

The client-server architecture is a centralized resource system, where the server holds all the resources. The server shares resources to its clients when requested. The client and the server may be on the same device or in a network. [11]

3.1   Types of Client/Server Architecture

3.1.1   Two-tier architecture

In this type's environment, the user interface is stored at client device and the database is stored on the server. In two-tier architecture, there is not any intermediate between a server, and a client when this last is giving an input to the server. For instance, online ticket reservations software uses this two-tier architecture, desktop applications, and desktop games, etc [11]. These are the main 2-tier architecture advantages and disadvantages:

- ➢ **Two-tier architecture advantages**
  - Easy to maintain and modification is easy. [12]
  - Communication is faster. [12]
- ➢ **Two-tier architecture disadvantages**
  - The performance of applications will be degraded upon increasing the users. [12]
  - Ineffective Cost. [12]

3.1.2   Three-tier architecture

In this architecture, there is an intermediate between the client interface and the server, which means the client request goes to the server through that middle layer, and the response of the server is received by middleware first and then to the client. The middleware stores all the business logic and data passage logic. The idea of middleware is to database staging, queuing, application execution, scheduling etc. The Three-tier architecture is split into 3 parts, namely, the presentation layer (Client Tier), Application layer (Business Tier) and Database layer (Data Tier) [11]. These are the main 3-tier architecture advantages and disadvantages:

- ➢ **Three-tier architecture advantages**
  - High performance: because the Presentation tier can cache requests, network utilization is minimized, and the load is reduced on the Application and Data tiers.
  - Security: the client does not have a direct access to database. [12]
  - Easy to maintain: it will not affect other modules. [12]
- ➢ **Three-tier architecture disadvantages**
  - High complexity and efforts. [12]

3.2 Network Architecture Type Used

This application uses 2-tier Architecture; because the web server and the database server is the same; here is how this web application looks like [29]:
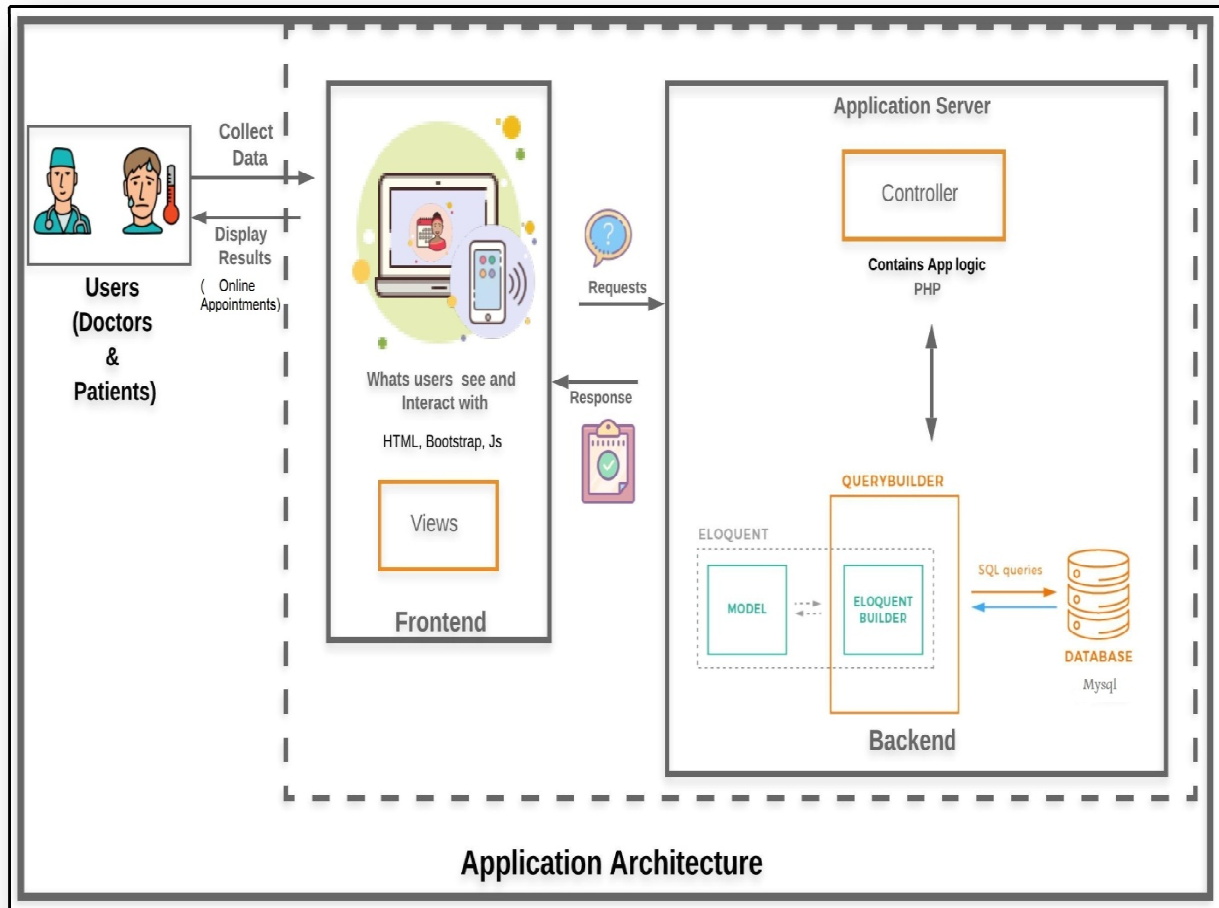
Figure 24: The Used Application's Architecture.

- User triggers a request to this web application server (request the controller) over the Internet, through a web browser or the application's user interface ;
- This application server performs the requested task – such as querying the database or processing the data – then generates the results of the requested data ;
- This application server responds back to the users with the requested information or processed data that then appears on the user's display.

4. Hardware and Software Resources Used

To develop this application the below hardware and software are used.

4.1   Hardware Resources

- **System Model**: Toshiba satellite c660,

- **System Type:** Windows 7 Professional 32-bit,

- **Processor**: Intel(R) Core(TM) i5-2430M CPU @ 2.40GHz (4 CPUs), ~2.4GHz,

- **RAM:** 4 Gb,

- **Hard Disk**: 500 Gb.

4.2   Software Resources

Software tools and programming languages used during development:

Tool	Description	Logo
Markup language HTML5	HTML 5 is the latest Hypertext Markup Language (HTML), the standard programming language for describing the contents and appearance of Web pages. [13]	
Bootstrap	The Bootstrap is a free and open source front-end framework; is used for the design of this web application, based on grid system, bootstrap contains already designed classes with a set of features. [14]	
PHP Language	PHP is a popular general-purpose scripting language that is especially suited to web development. [15]	
JavaScript	The scripting language of web pages, it is used for the application's interactivity. [16]	
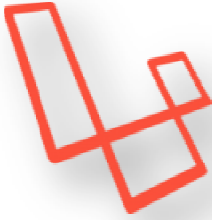
Mysql	Mysql is relational database management system, which uses SQL language. [17]	
XAMPP	XAMPP is a web development platform, for dynamic web applications using the Apache server, PHP scripting language and MySQL database. It also has PHPMyAdmin to easily manage databases. [18]	
Laravel	Laravel is a free, open-source PHP web framework, intended for the development of web applications following the model-view-controller (MVC) architectural pattern and based on Symfony [1]. Furthermore, it provides a powerful expressive database ORM[2]. [19]	
Sublime text	Sublime text 3 is a text editor which is used to write the application's code source, markup and prose. [20]	

Table 12: Software Resources Used

---

[1] Symfony: is a set of reusable PHP components, a web application framework that allows creating websites and controlling web applications more easily. [21]

[2] ORM (Object-Relational Mapping): is a programming technique in which a metadata descriptor is used to connect object code to a relational database.[31]

5. Explanation of PHP Language Use

PHP is the most used language for the development of web applications according to w3techs.com, which makes the existence of a lot of tutorials, courses, and documentations those can facilitate the development, and help any web site developer. [22]
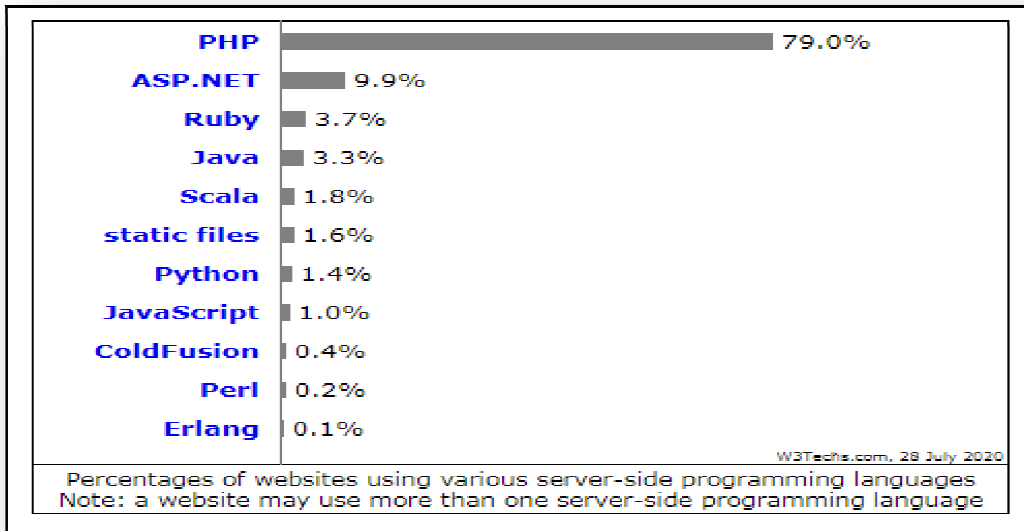
Figure 25: The Percentage of Used Programming languages for websites.

6. Explanation of Laravel Framework Use

Laravel has an architecture known as MVC (Model - View - Controller). The below image shows the logic of this architecture:
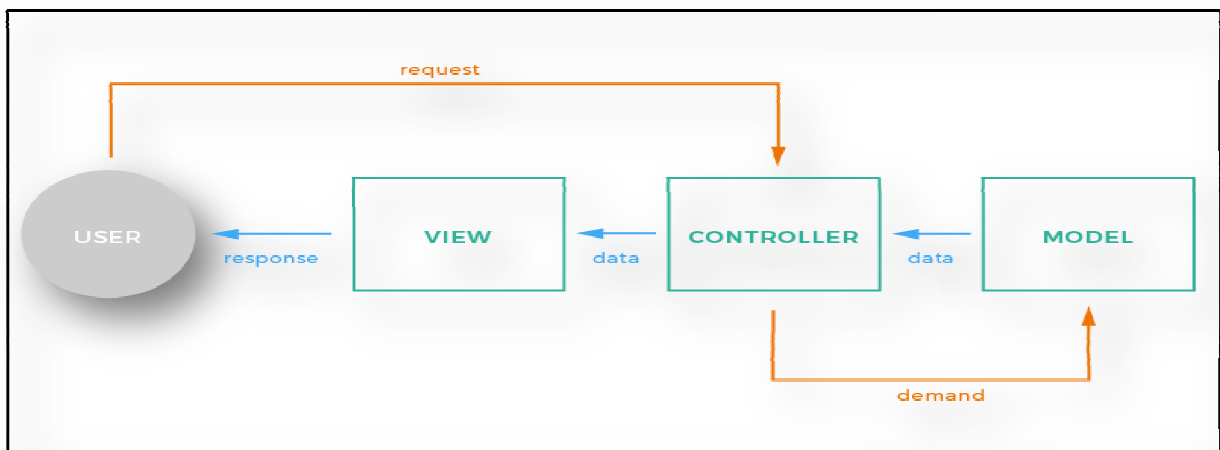
Figure 26: Laravel Architecture (M.V.C).

These three components have different responsibilities:

➢ The model contains the data and its logic.

➢ The view contains the graphical presentation to be returned to the user (what users see).

➢ The controller processes user actions (via queries), asks the model to make changes, and then passes the data to the view.

The controller has a central place in this architecture; everything passes through it in order to control everything. [23]

Laravel Framework offers several services to developers, below some of the offered services:

➢ Laravel provides a very simple way to organize authorization logic and control access to various resources; [24]

➢ Laravel makes programming with PHP easier;

➢ Laravel offers a huge number of documentation that can facilitate its use.

➢ Laravel framework makes database migrations extremely easy;

➢ Laravel has Object Oriented libraries and other pre-installed ones, which are not found in any other PHP frameworks.

7. Application's Presentation

This Application's name is MedApp. These interfaces below are the principal interfaces in MedApp system:

7.1   Home Page

   This page is the home for all users; it contains search bar to search for doctors, and the button of sign up or log in MedApp platform; this page describes some services offered by this app.
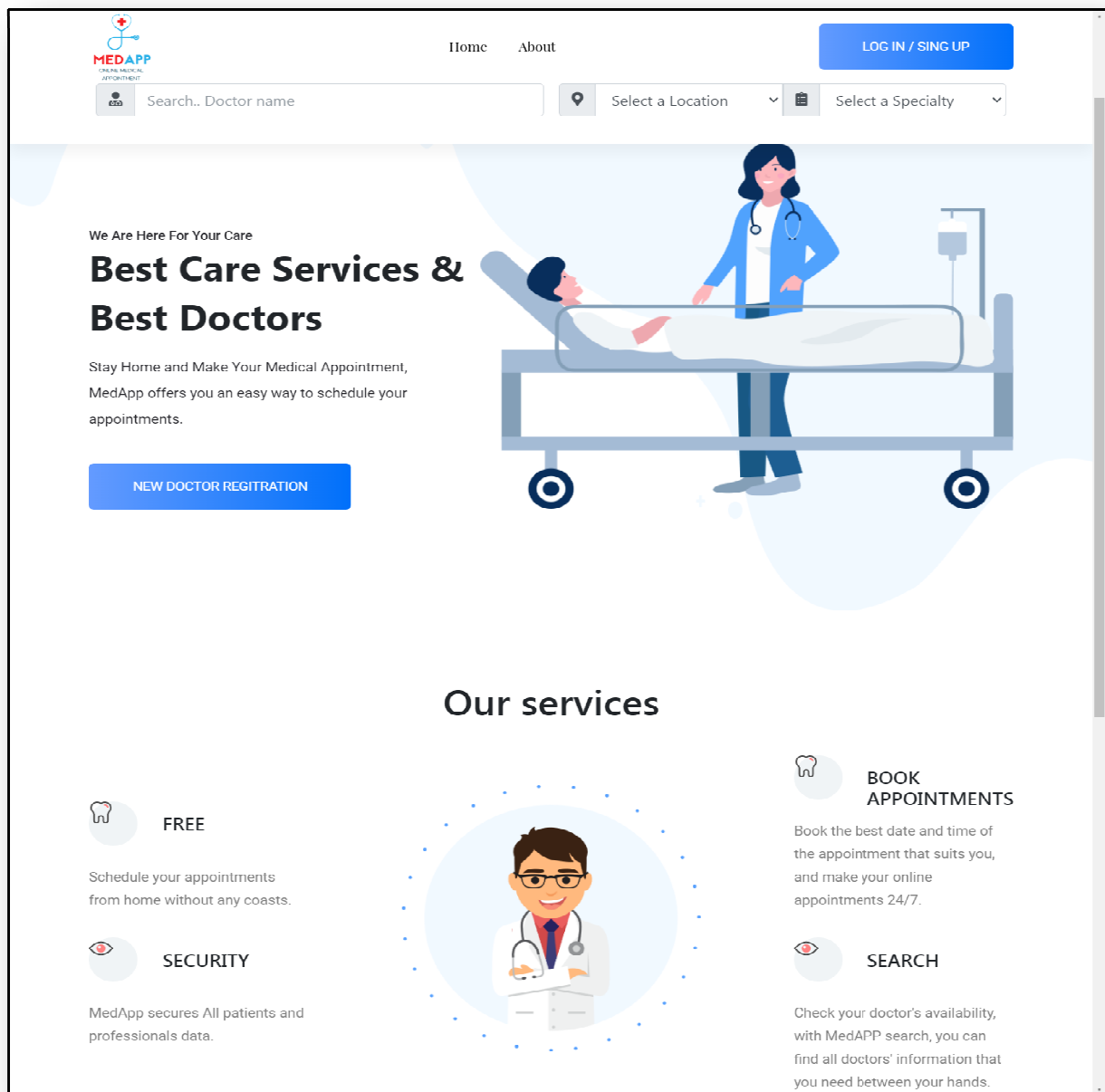
Figure 27: MedApp Application's Home Page.

7.2 Log in and Sign up Pages

Every user should have an electronic mail and password to log in MedApp application, and enjoy its provided services. The users must sign up this platform first; filling up the necessary information; these are the log in and sign up pages respectively.
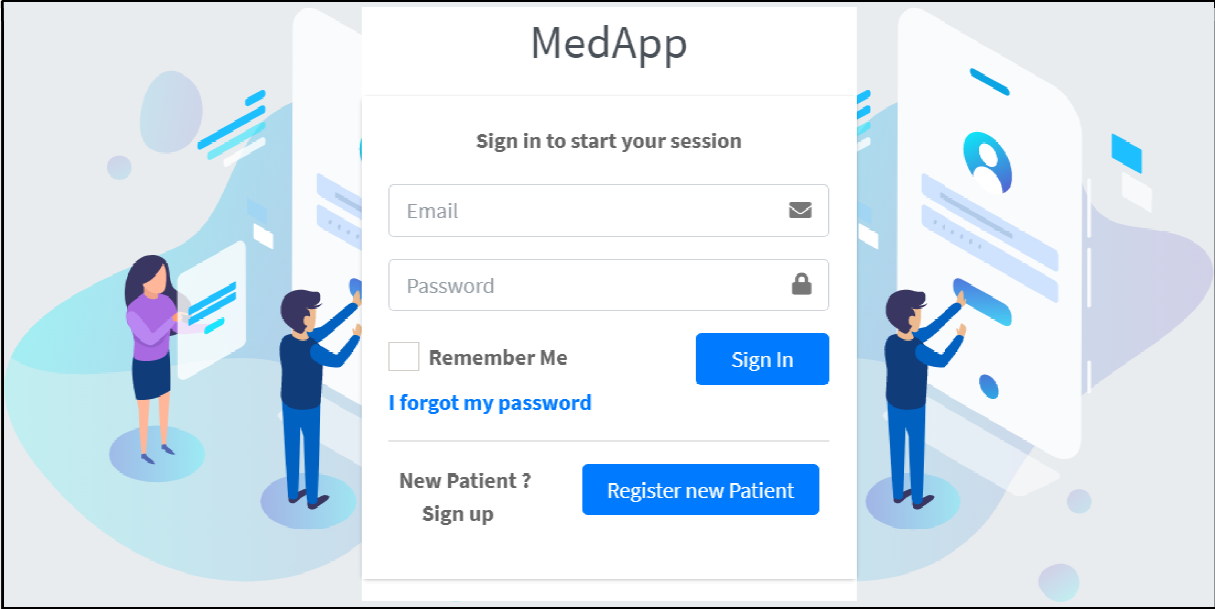
Figure 28: MedApp Application's Log in Page.
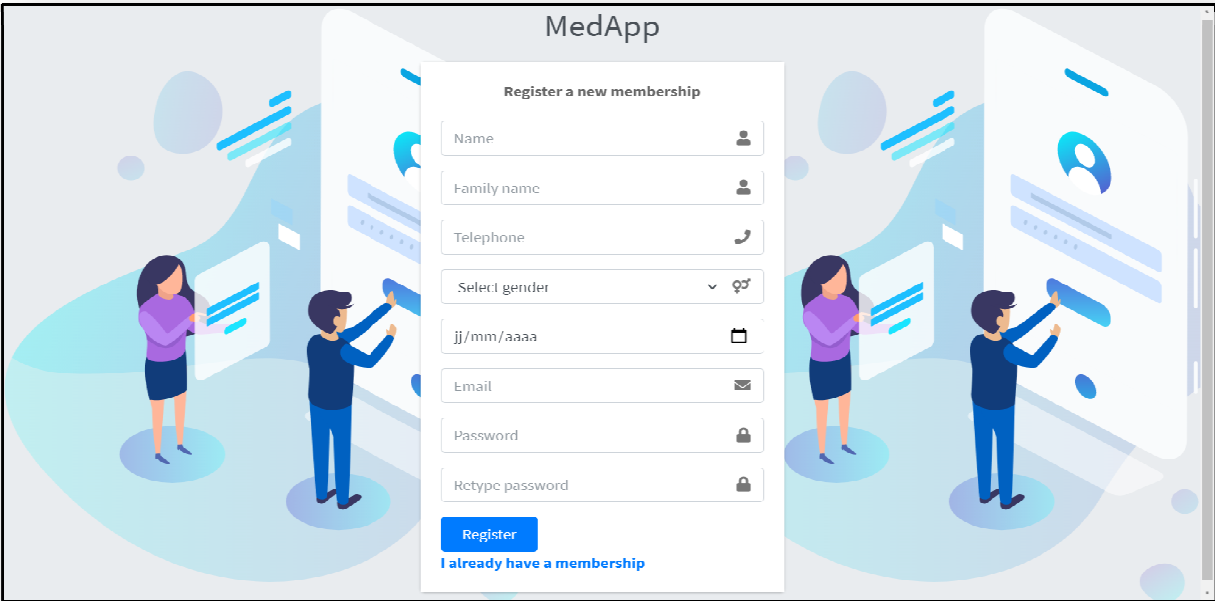
Figure 29: MedApp Application Register Patient's Page.

7.3   Doctor's Registration Page

This page for doctors' registration; they register in this platform by filling up their information. Once the doctors are registered and approved by admin, they can start the online appointments' management.

Figure 30: Register Doctors' Page.

7.4 Doctor's Pages

7.4.1 Doctor's Dashboard

This page contains the doctor's calendar, which allows him to manage his medical appointments; he can add holidays and make appointments for new patients, and view the next appointments. It contains also the Appointments' requests list**.**

Figure 31: Doctor's Dashboard Page.

7.4.2   Doctor's Appointments' List

This page of doctor's appointments list; it contains the patients' names and phone numbers, however, the details of these patients' appointments are in patient appointments' details' page; which shows the necessary patient's information, and the time, the date, and the status of each patient's appointments.
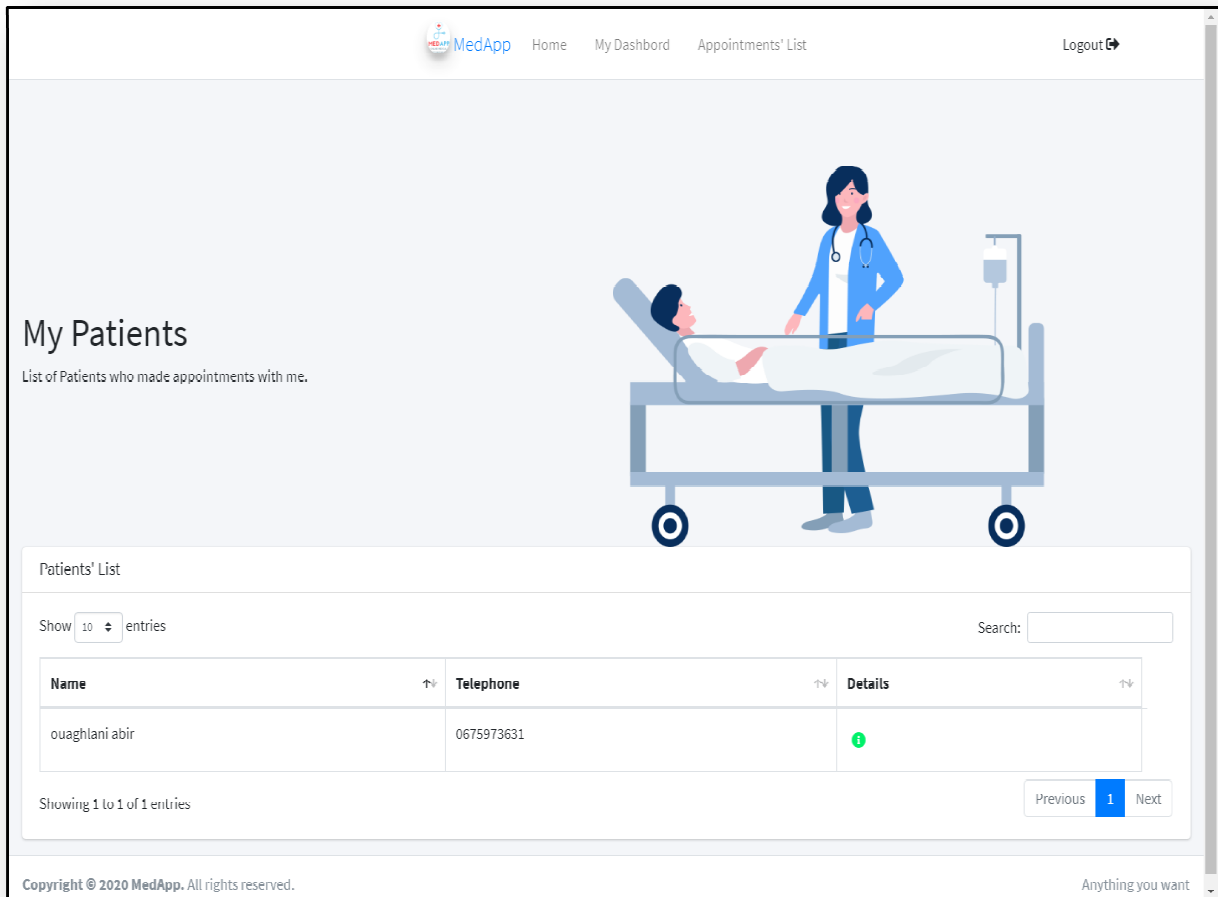
Figure 32: Doctor's Patient Page.
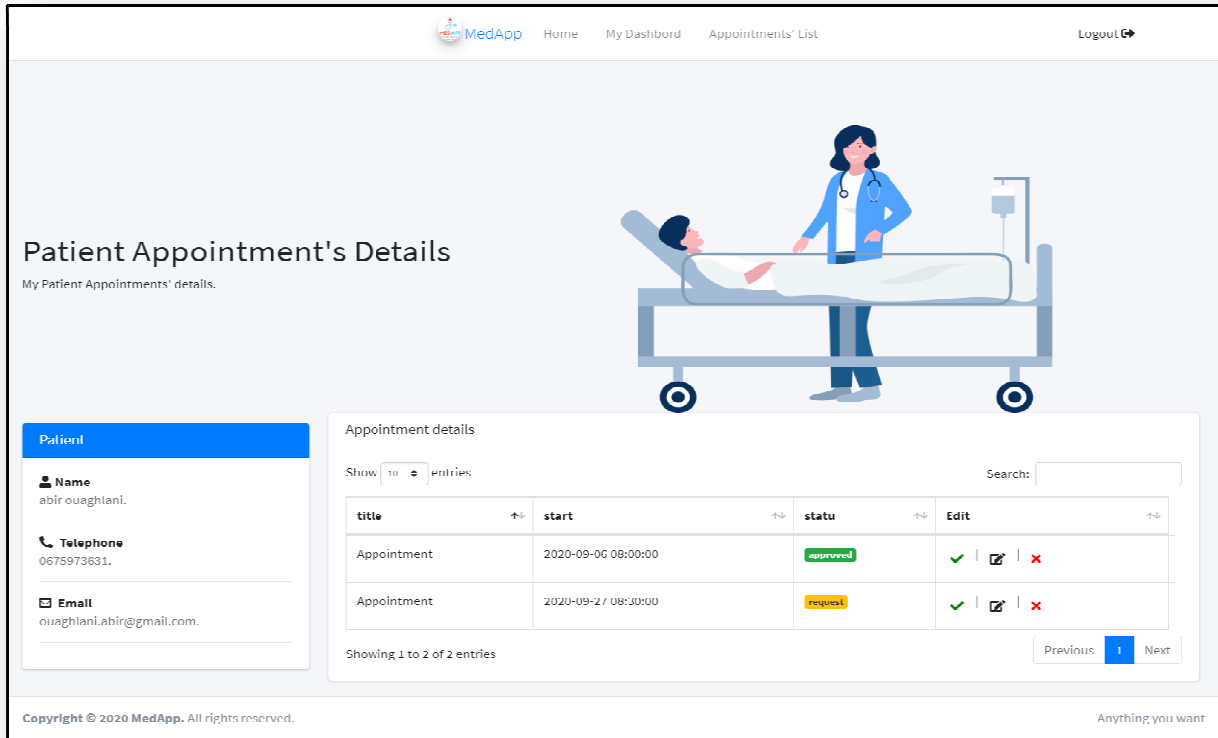
Figure 33: Patient's Appointments Details (1).
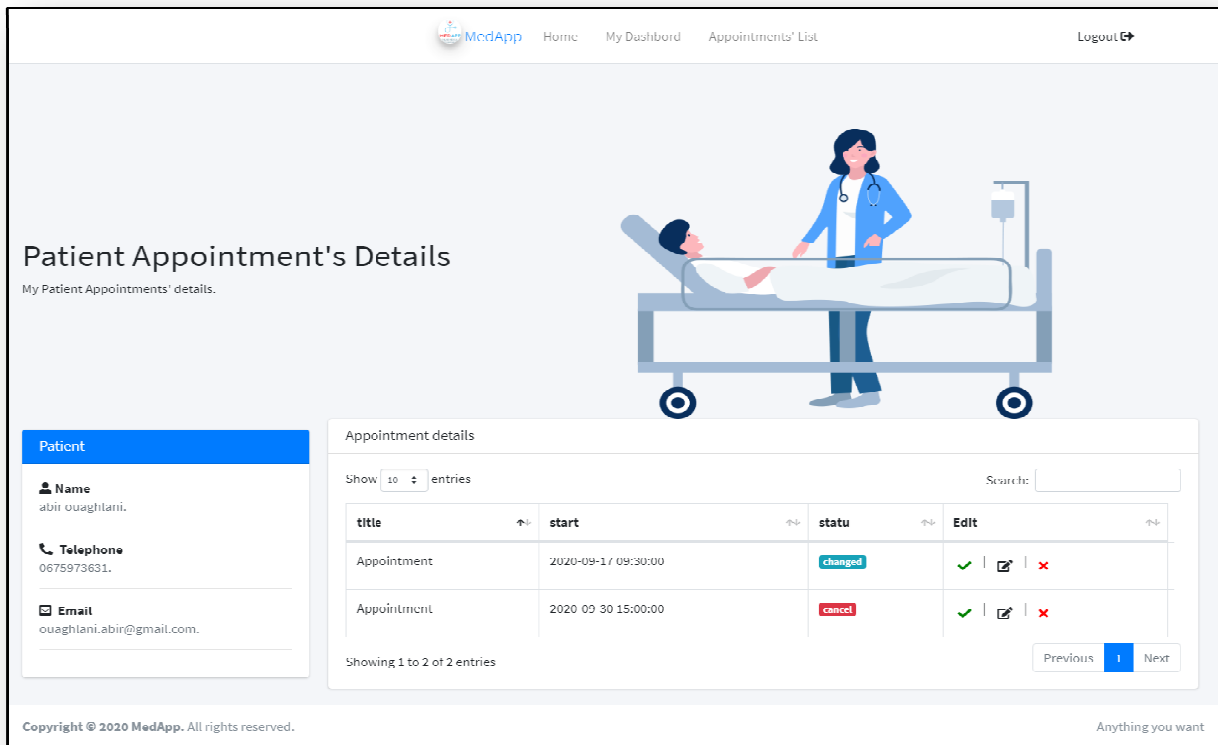
Figure 34: Patient's Appointments Details (2).

7.4.3 Move Appointments' Page

Edit patient appointment's page enables doctors to change the appointments time and date.
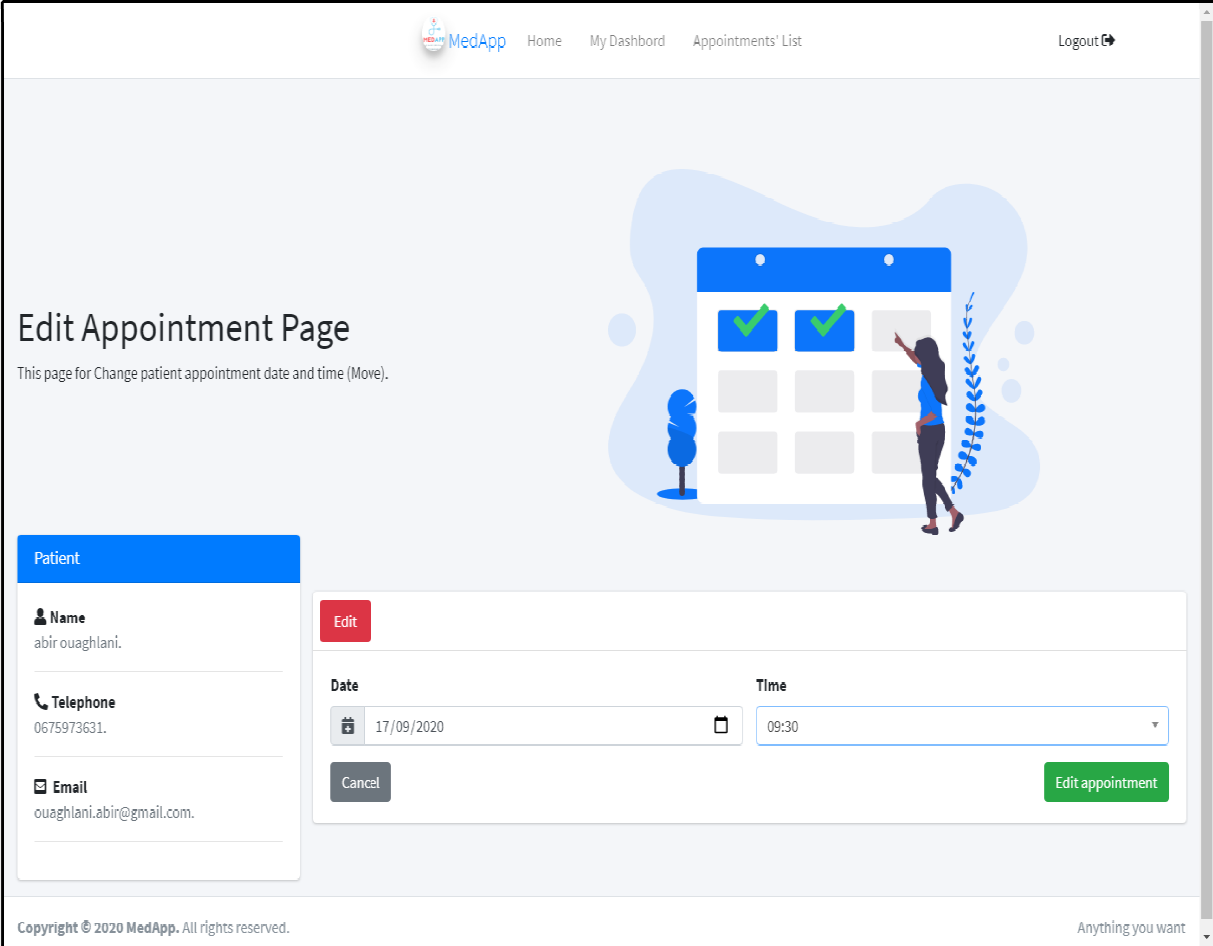
Figure 35: Move Appointments Page.

7.5   Patient's Page

This list holds all patients' appointments.
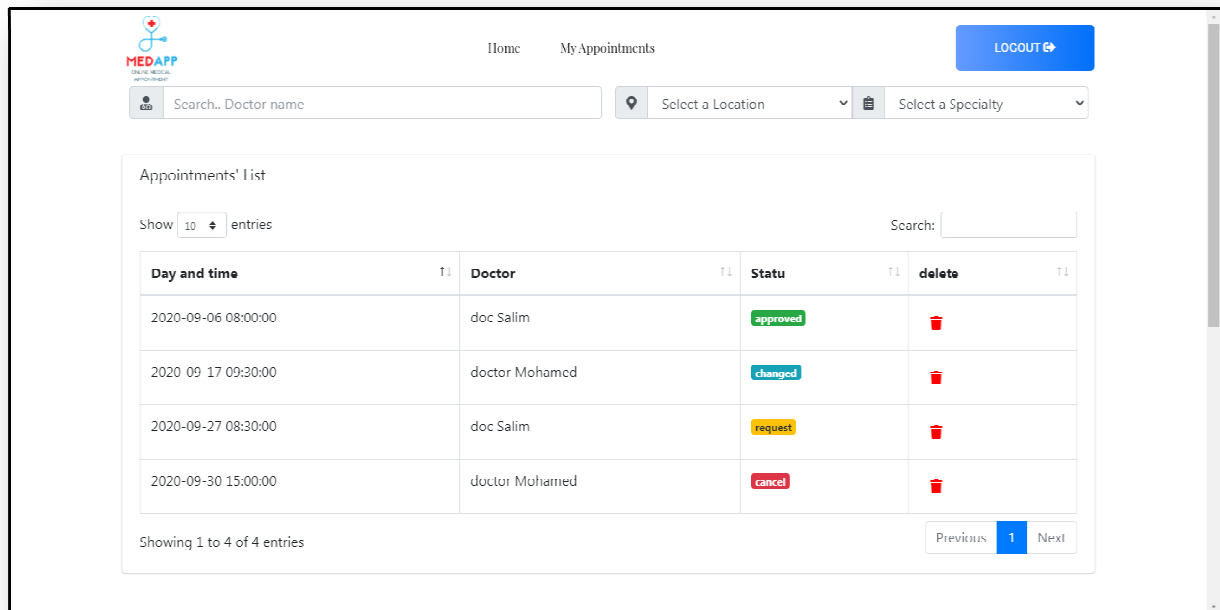
Figure 36: List of Patient's Appointments for Patients.

7.6   Admin Dashboard

Admin have the ability to manage this application; they can add, edit, and delete this platform's users, and they can view all users' lists.
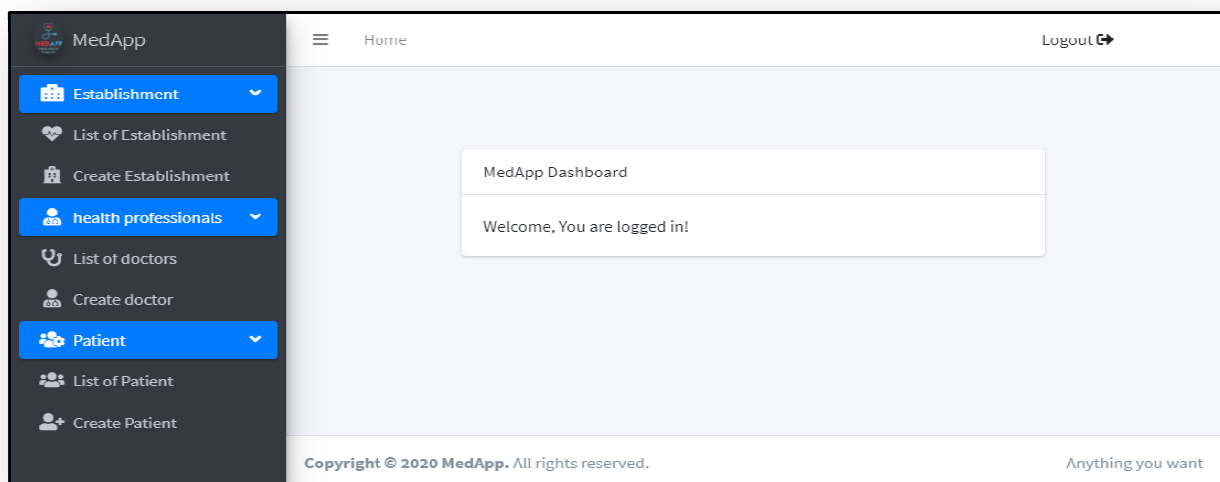
Figure 37: Admin Dashboard Page.

7.6.1 Add Users

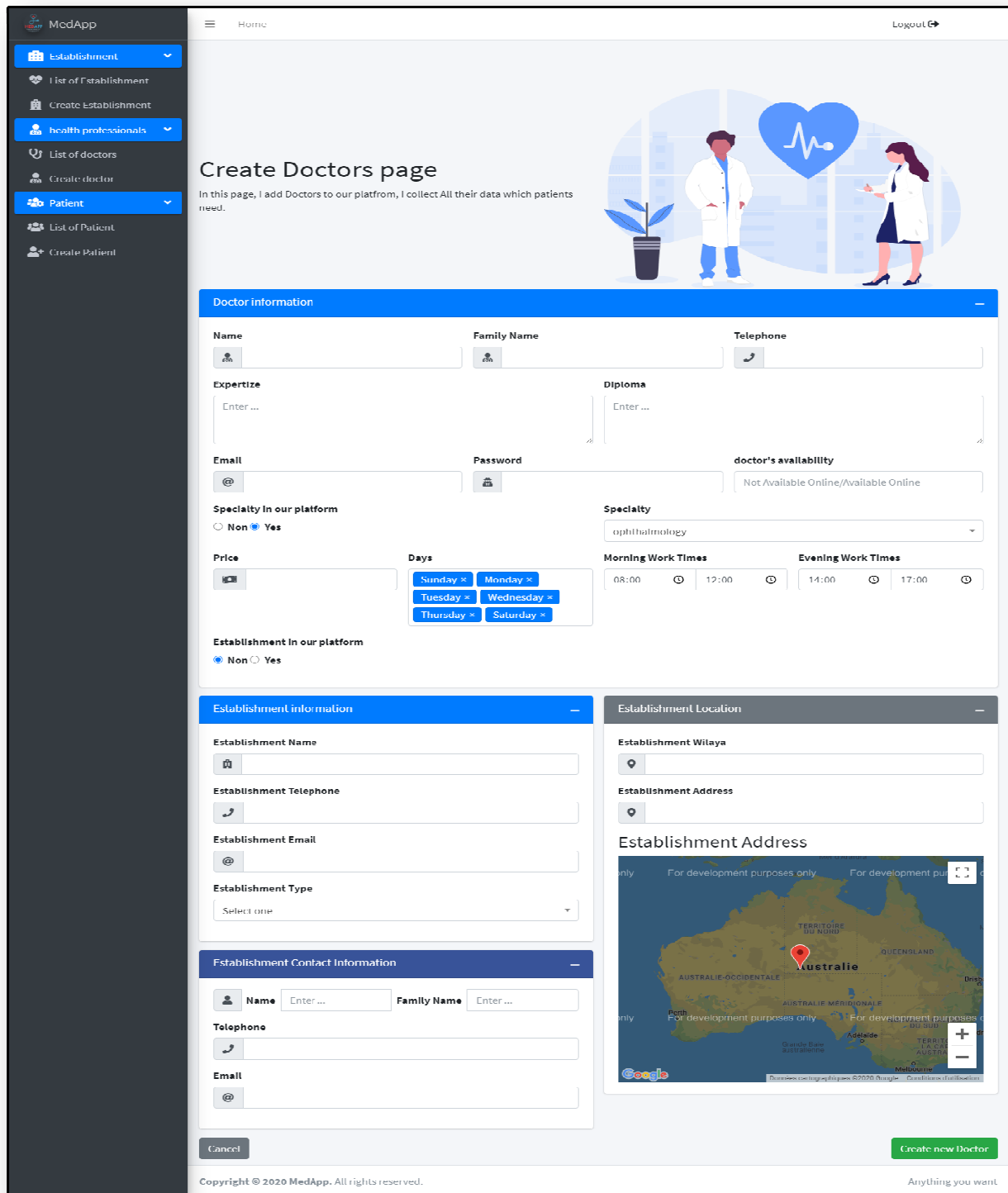Admin add doctors, establishments and patients; filling up their necessary information. This following page of create a doctor example:

Figure 38: Add Doctors Page for Admin.

7.6.2   Edit Users' Data

Admin edit doctors', establishments' and patients' information. This following page of Edit a doctors' Data example:

Figure 39: Update Doctor's Information for Admin.

7.6.3   Users' Lists

Admin view all Users' lists, this following list of the existing doctors' example:

Figure 40: Doctors' List Page for Admin.

7.7   Search for a doctor Result

This Interface below shows search's result for a doctor which views all his information that patients need:

Figure 41: Search's Results for doctor Page.

8. Application's Hosting

Every website has a web host. But not every website is hosted the same way. There are three solutions to host a website: The free alternative, Paid hosting, and Home hosting. [25]

The web host is the company that owns the servers where information related to websites are stored. The types of web hosting using hosting platforms are: Shared hosting, Virtual private server (VPS) hosting, Dedicated server hosting, Cloud hosting, Managed hosting, Collocation, all those types are paid. [26]

> ➢ Companies provide the paid web hosting: Godaddy, dynadot, hover, googledomains, Namecheap, etc. [27]
> ➢ Companies provide the free web hosting: Weboupro, HebFree, Hostinger, 000webhost, alwaysdata, les cigales.org, FirstHEBERG, AWARDSPACE, etc. [25]

For MedApp application, home hosting is used, with a free domain name (**MedApp.mywire.org**) using the site (dynu.com), [3]by following the below steps:

> ✓ Using XAMPP web server;
> ✓ Getting DNS hostname for my computer internet connection;
> ✓ Port forward my router;
> ✓ Test my application from outside my network.

9. Project's Contribution

Unfortunately, because of corona virus this year, we could not make the real test with real doctors, and show the good functions of this application and its contribution for users; in terms of performance, make life easier, and improve the medical healthcare services in Algeria. Moreover, this project was full of experiences in my personal side.

Generally, every new project provides opportunities to learn new skills, or improve the existing ones, among the skills I have acquired from this project on my personal side are:

> ➢ Improve my English; write and speak using this language which enriched my vocabulary, and taught me how to write scientific reports, and expand ideas in English.

---

[3] Dynu.com: is a free, intuitive application which allows management of Dynu's dynamic DNS and other services. [28]

> ➢ I learned how to develop a web application and host it; and this ameliorated my programming level; how to code and how to make the code run.
>
> ➢ I learned that the good developer is the good researcher; who follows the right documentations to gain time and make everything work on a smart way, for example there are amazing sites which helped me like Codepen, Stack Overflow, GitHub, OpenClassrooms, etc.
>
> ➢ I used new tools and platforms to develop this application which I didn't use before.
>
> ➢ I learned how to communicate with new persons, and make conversations, ask for information, and get of my shy shell.

In the background of any successful project, it might be some enfaced and resolved problems which made this success. The problems faced during the development of this app are:

1- Doctors' Calendar: the use of calendar was a little difficulty for me, I used the package FullCalendar.io which works with laraval, and the difficult was in how to integrate this package, and how to get the events (appointments) from database, and view them.

2- Live Search Bar: I used the livewire package for laraval; and the obstacle was when I considered that a doctor has many specialties, this relation (many to many) of cardinalities gets a collection but I needed a query as a result, and collections cannot be converted to queries, therefore, I considered that a doctor has just one specialty to get the search query and respond to patients.

10. Conclusion

Indeed, we have completed the implementation, while respecting the elaborated diagrams. In other words, we hold the final version of this web application offering all the useful and necessary functions for the proper functioning of an online medical appointment booking system. Due to this implementation, I deepened my knowledge in the web domain. I also learned to better master some software. Moreover, I made progress despite of some difficulties.

General Conclusion

After Five consecutive years of studying in which I have assimilated theoretical and practical knowledge; this work is a good reflection of the acquired knowledge.

Managing doctors' appointments is a daily challenge because it requires permanent balance between personnel management, compliance with regulations, and management of operational costs and maintaining patient satisfaction. This is why several Health professionals opt for the integration of technologies to optimize their calendars' management and provide better access and services to their patients; therefore we wanted to produce a dynamic website for managing doctors' calendars, this site allows doctors to manage their appointments with a well organized calendar to automate their appointments.

MedApp functions very well and allows patients and professionals to manage their online appointments without any obstacles, which facilitates their tasks. This system books medical appointment for patients, manage doctors' calendars, rate professionals.

Indeed, this experience was full of learning and application of knowledge acquired during my studies and thanks to this project I have developed my skills. My supervisor was very helpful since he took the time to explain to me all the missions I had to carry out beforehand. He stayed in contact with me to guide me. He allowed me to be able to take initiatives and therefore to be able to propose my ideas.

In order to carry out this project, I used the UML language and in terms of implementation, I used several languages and tools of programming for example: HTML, CSS (Bootstrap), PHP, JavaScript, MySQL, PHPMyAdmin and other several things.

MedApp web Application works properly and responds to the stated needs, but it can be improved and maybe a kernel to develop, we plan to:

➢ Develop the MedApp to manage Online Consultation; Follow-up patients remotely from their homes using video calls.
➢ Develop the MedApp to manage the appointments automatically (Accept, cancel appointments).
➢ Develop phone application for MedApp to manage appointments.
➢ Integrate Voice guide in MedApp phone application for people who have visual handicap.

➢ Develop MedApp for considering; that doctors have many work locations and more calendars.

➢ Cover All Algeria states' doctors.

➢ Host it in a paid server, and get a domain name without extensions.

➢ Use Google map API.

Finally, my ultimate wish is that this project be beneficial for other future works.

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