PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
UNIVERSITY MOHAMED BOUDIAF - M'SILA

FACULTY: MATHEMATICS AND INFORMATICS

DOMAIN: MATHEMATICS AND COMPUTER SCIENCE

DEPARTEMENT: COMPUTER SCIENCE

FIELD: COMPUTER SCIENCE

N°:……..

OPTION: SIGL

Dissertation submitted in partial fulfillment of the requirements for The degree of MASTER

By: Mezrag Islam And Maiche Islam

Subject

Web Application As A Service

Publicly defended before the jury composed of:

Dr. Mohamed Bounif	University of M'sila	Chair
Mr. Hichem Debbi	University of M'sila	Supervisor
Dr. Rabeh Mokhtari	University of M'sila	Examiner

College year: 2019 /2020

PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
UNIVERSITY MOHAMED BOUDIAF - M'SILA

FACULTY: MATHEMATICS AND INFORMATICS

DOMAIN: MATHEMATICS AND COMPUTER SCIENCE

DEPARTEMENT: COMPUTER SCIENCE

FIELD: COMPUTER SCIENCE

N°:……..

OPTION: SIGL

Dissertation submitted in partial fulfillment of the requirements for The degree of MASTER

By: Mezrag Islam And Maiche Islam

Subject

Web Application As A Service

Publicly defended before the jury composed of:

Dr. Mohamed Bounif	University of M'sila	Chair
Mr. Hichem Debbi	University of M'sila	Supervisor
Dr. Rabeh Mokhtari	University of M'sila	Examiner

College year: 2019 /2020

Acknowledgment

First and foremost, heartfelt gratitude and praises go to the Almighty Allah who guided me through and through.

We would like to thank our supervisor teacher, Dr. Hichem Debbi, for his support. Outstanding guidance and encouragement throughout our graduation thesis. We are very grateful to him for making this work reached with the unflagging assistance and participation.

We would also like to thank all the Jury Members, who have agreed to review this work.

We would also thank those who helped me to finish this work whom without their assistance and encouragement it would not have been done.

We would like to acknowledge everyone who played a role in our academic accomplishments.

Thanks to all who helped us

Thanks

Dedication

I dedicate this work to my father layachi and my mather saoudi farida for their ultimate support

To my dear brothers Imad eddin, Farouk, and my sister Nahla

To my uncles, and all our relatives

To these who were a means of help in a way or another

And to all those are precious parts of our lives

Maiche Islam

This dissertation is dedicated to the loving family of Mezrag,

My parents for their encouragement, prayers, motivations, and being there. May God bless them.

To my precious brothers and sisters who've been there for me in my entire journey, all of my nephews and my nieces.

MEZRAG ISLAM

TABLE OF CONTENTS

FIGURE LIST

TABLE LIST

ABBREVIATION LIST

CMS: Clinic Management System.

SaaS: Software as a Service.

***IaaS*:** Infrastructure as a Service.

***PaaS*:** Platform as a Service.

***HMS*:** Healthcare Management Systems.

***HER*:** Electronic Health Record.

***CCR*:** Continuity of Care Record.

***PHR*:** Personal Health Record.

***HMS*:** Hospital Management System

UML: Unified Modeling Language.

***IT*:** Information Technology.

***SQL*:** Structured Query Language.

***GPS*:** Global Positioning System.

***HTTP*:** Hypertext Transfer Protocol.

***IDE*:** Integrated Development Environment.

***ECMA*:** European Computer Manufacturers Association.

***ISO*:** International Organization for Standardization

***IEC*:** International Electrotechnical Commission

***EF*:** Entity Framework

***LINQ*:** Language Integrated Query

***RDBMS*:** Relational DataBase Management System

***IIS*:** Internet Information Services

***MVC*:** Model-view-controller

***HTML*:** Hyper Text Markup Language.

***CSS*:** Cascading Style Sheets

XML: eXtensible Markup Language

***SVG*:** Scalable Vector Graphics.

***XHTML*:** EXtensible HyperText Markup Language.

***JS*:** JavaScript.

Ajax: JavaScript Object Notation

***GUI*:** Graphical User Interface

***MDA*:** Model Driven Architecture

***XSS*:** Cross Site Scripting.

CSRF: Cross Site Request Forgery

***SSL*:** Secure Sockets Layer.

***HTTPS*:** Hypertext Transfer Protocol Secure.

***URL*:** Uniform Resource Locator.

INTRODUCTION

Decades from the industrial revolution, the technology revolution has gained special concern and gave us efficient solutions to the hardest problems and made more advance to patient-centered care. The clinic management system (CMS) has evolved during the past years and made a giant step beyond human capacities. Mechanisms are needed to achieve the optimal management of the clinic. Human resources play an important role, thereafter CMS becomes a cornerstone in this big story, furthermore, one of the ways to provide a CMS is to deploy it as a service, Software as a service (SaaS) is one of three main categories of cloud computing, alongside infrastructure as a service and platform as a service (IaaS and PaaS).

Software as a Service (SaaS) also known as cloud-based software or web-based software is now mainstream. SaaS is a way of delivering applications over the Internet as a service. Instead of installing and maintaining software, SaaS applications run on a SaaS provider's servers. The provider manages access to the application, including security, availability, and performance.

A Clinic Management System is an integrated information system for managing all aspects of a medical clinic's operations such as medical, financial, administrative, and legal issues. It includes electronic health records, business intelligence, and revenue cycle management, and many other features.

The work burden of paper-based records has exhausted the healthcare providers staff, the big challenge of the management aspect of healthcare systems came to reflects the ability to provide treatment and care to patients. To find a solution that helps the medical staff and clinic workers, and to allow them to complete the work in acceptable and satisfactory conditions without possible human errors, the need for digitalizing the entire clinic rises.

We decided to build an application to manage and coordinate the clinic's services. Our practical part took place at the Kalaa Clinic as a case study to implement this work, and then generalize it to the other healthcare providers which share almost the same operations and organization. This application is designed to achieve all the objectives and requirements expected and requested by clinic staff and patients, by facilitating the work and reducing daily tasks time by making smooth coordination between clinic services.

CHAPTER 1: HEALTHCARE MANAGEMENT SYSTEMS

Introduction:

The paper-based record has reduced the efficiency of healthcare providers and increased work burden in the healthcare service delivery system. More challenges inherent in paper-based systems include; no assurance for information backup, no access to patient's medical history, and improper organization of records.

On the other hand, electronic forms of record-keeping have served as a means to reduce memory strain on healthcare providers, improved efficiency and effectiveness in health care delivery, and increased accountability in the health sector.

Furthermore, it has helped in the reduction of medical errors and redundant services, also improved clinical decisions and coordination in healthcare service delivery systems. Although the use of electronic record-keeping systems has been effective, there remain some important concerns associated with its use which include; privacy, data breaches, and medical identity.

Developing efficient and effective healthcare management systems (HMS) has become the most concern area for governments and healthcare decision-makers. So, the emphasis on the management aspect of healthcare systems came to reflects the ability to provide treatment and care to patients.

In this chapter, we will present the concept of Healthcare Management Systems and their impact on individuals. We focus on HMS strategy, importance, and the HMS successful examples in our country, and other countries as well. We will also explore what is HMS software, what functions it performs, and how it helps the healthcare industry be more effective and patient-centric.

Healthcare Management Systems:

1.1 Definition:

Healthcare management system, also known as healthcare information management systems, are designed to help healthcare providers to do various operations including collect, store, retrieve and exchange patient health information more efficiently and enable better patient care, moreover, it can be integrated at hospitals, clinics or any other healthcare provider.

It is frequently stated that the healthcare management system (HMS) is an integrated software that handles different directions of clinic workflows. More interestingly, it manages the smooth healthcare performance along with administrative, medical, legal, and financial control. That is a cornerstone of the successful operation of the healthcare facility.

Healthcare management system (HMS) has a huge demand these days, as it helps in managing hospitals and medical offices. In this regard, (Brailsford & Vissers,2011) states that

(HMS) includes capacity planning, resource allocation, inventory management systems, demand forecasting, scheduling, and other operational activities. To be more specific, it is necessary to determine the types of healthcare management systems we will illustrate them as following.

1.2 Healthcare Management Systems Type:

There are two main types of healthcare management systems: electronic health record (EHR) and practice management, in which medical records are stored on paper-based mediums.

1.2.1 Paper-based Medical Records (Paper Medical Records):

Medical records are a composite of self-reported patient information and clinical diagnostic notes traditionally stored on paper-based mediums.

There are reasons why paper medical records were an industry mainstay for several decades. We cite here some advantages:

- With paper medical records, all you need to get started is paper, files, and a locked cabinet to store all the documents.
- It's easy to pull up information from a file, examine previous notes and medical charts, and record new observations (If the information is written clearly).
- a physical file with all previous charts and medical history neatly sorted in one place. Plus, the data can be physically passed around from one person to another seamlessly. (Of course, all of this depends on the previous notes being neatly written, properly organized, and readily accessible).
- The form is customizable to the requirements of each hospital/doctor without the need for any technical overhaul. Need a new template? Just design one on a standard text editor and you're good to go.

However, with paper medical records, we still have many open problems. We cite here some challenges and drawbacks:

- The information is very difficult to retrieve and to find particular information like to find out about the patient's history, the user has to go through various registers. These results are wastage of time.
- The information generated by various transactions takes time and effort to be stored in the right place. Also, paper medical records need physical space for storage purposes. And it's not just a matter of assigning an empty room and stuffing files there these are valuable repositories of data and require careful handling. you need other mechanisms to ensure data integrity.

- Various changes to information like patient details are difficult to make as paperwork.
- Physical files, once lost, are impossible to recover.
- Manual calculations are error-prone and take a lot of time this may result in incorrect information. For example, the calculation of a patient's bill based on various treatments.
- Paper medical records mean you need a manual written process that is both times consuming and comes with a higher degree of error.
- While paper-based records can be easier to customize, it also means that the layout and format of information can be inconsistent from one record to the next. When paper-based records have different layouts, it extends the time needed to get the (potentially lifesaving) information needed for a patient.
- An element of human error is always possible. Paper records don't have built-in version histories and audit trails. Knowing who made which edits and additions require that the physician signs the records each time. If changes are made, it's not easy to locate where the changes were and who made them.

1.2.2 Electronic Health Record:

"EHR - Electronic Health Record: Currently, this term is the most commonly accepted and used term for storing and accessing patient medical information electronically. EHR encompasses a full range of functionalities and information including patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, radiology reports, scheduling, transcription, e-prescribing, evaluation and management (office visit level) coding, care alerts, chief complaints, evidence-based decision support, and health maintenance. In the future, an EHR will include continuity of care record (CCR) and the personal health record (PHR); standards for these functionalities are still being developed."[1]

"An electronic health record (EHR) is a digital version of a patient's paper chart. EHRs are real-time, patient-centered records that make information available instantly and securely to authorized users. While an EHR does contain the medical and treatment histories of patients, an EHR system is built to go beyond standard clinical data collected in a provider's office and can be inclusive of a broader view of a patient's care. EHRs are a vital part of health IT and can:

- Contain a patient's medical history, diagnoses, medications, treatment plans, immunization dates, allergies, radiology images, and laboratory and test results.

- Allow access to evidence-based tools that providers can use to make decisions about a patient's care.
- Automate and streamline provider workflow."[2]

There are also reasons why electronic health records were an industry mainstay for several decades. We cite here some advantages:

- Electronic medical records are stored on cloud servers. A single cloud server could store hundreds of thousands of patient medical records.
- Electronic records have data backup and storage, so even if a malicious entity manages to infiltrate and get access, there's still a fallback option.
- The electronic system does not have writing problems - records are not handwritten, so the legibility issue isn't an issue at all. Plus, you don't have to search for patient files in a physical cabinet the software does that for you (instantly).
- Electronic records have a consistent format which healthcare providers can get accustomed to, and reduces the time needed to find and analyze information.
- Electronic health records have logs and version records that simplify auditing and tracking.

Installing an electronic health record brings many benefits to healthcare providers (clinics) to provide better patient care and fosters collaboration between hospital departments with fast patient data transfer and seamless accessibility.

EHR offers the provider the following advantages:

- nowadays the healthcare providers get better clinic information about the patient's medical by using EHR.
- The EHR system provides the possibility of maintaining dynamic patient-centered files and give a patient's medical history, this enables superior diagnosis and treatment.
- Digital records allow care providers smooth coordination and tracking of patient care across multiple facilities and practices. For instance, EHRs put in place a one-stop solution that covers services like office visits, tests, surgeries, and hospital visits to reduce time-consuming multiple visits.

  Healthcare providers across disciplines and specialties can utilize EHRs to coordinate on patient outcomes, resulting in better care overall.
- the efficiency and financial savings are one of the most important reasons for using the EHR and to eliminate the paper-based chart storage costs, and retrieval costs.

The EHR ensures that the patients get well health care by making clinical decisions much more accurate for the doctors. EHR plays a critical role in giving safer prescriptions.

EHR is also a technology that facilitates access to the patient's healthcare information by using the internet. Plus, the convenience of using your device to access your test results, order for medication, and even make appointments via a patient portal makes EHR a critical tool for patients too.

EHR offers patients the following advantages:

- the EHR avoids handwritten notes misreading, orders, and prescriptions .and the Patients 'chart information is clear and legible. Health maintenance screenings can be tracked automatically by patient age, gender, past diagnoses, past medical procedures, or even family medical history, which enables the provider to be proactive in inpatient care. The EHR can evaluate the patient information and alert the practitioner regarding tests, procedures, or screenings that are due. With automated medical analysis, the health-care provider can offer more consistent patient care.
- patient care became much better after using the EHR because care is a direct result of the availability of more thorough clinical information which improved the patient's care. Because the EHR provides the health-care practitioner with alerts or notices to better practice guidelines, patients receive the most current standard of care consistently. Patient records in most EHRs have treatment protocols available and recommendations of tests that better inform the health-care provider.
- Eliminates unnecessary paperwork An EHR system increases efficiency and productivity while cutting down on the paperwork and paper charts required. Your staff and patients have fewer forms to fill out, which offers clinicians more time with their patients. Prescriptions and referrals are sent out fast, reducing wait times for pickups and appointments.

  Automatic reminders inform patients when they should come in for their annual checkup and integrated patient tracking makes filing, billing, and insurance claims easy.
- EHR systems ease for patients the access possibility to their health medical records any time they want. Parents can double-check health information on their sick child in case they need to answer questions from a pharmacist or insurance company. Getting lab test results in the comfort and privacy of their home helps reduce a patient's anxiety.

A significant part of the healthcare system is the hospital Management system

1.3 Hospital Management System:

A Hospital Management System (HMS) is an integrated information system for managing all aspects of a hospital's operations such as medical, financial, administrative, and legal.

HMS enables you to develop your organization and improve its effectiveness and quality of work. It becomes one of the most important ways to the success of the hospitals and the healthcare facilities working nowadays.

1.4 Healthcare Management Systems for the patient:

- Make online requests or reservations.
- Allow the patient to search for a clinic-based on distance, specialty, rating, services, availability, and the services price.
- View the working time of each registered clinic.
- View its consultation, operation, and analyses historic.
- Contact the responsible doctor.
- Exchange information with the follow-up doctor.
- Receive the test results.

1.5 Healthcare Management Systems for clinic:

- Manage the patient waiting list.
- Store all the kinds of records (Digital medical records).
- Provide coordination and user communication.
- Implement policies.
- Improve day-to-day operations.
- Arrange the supply chain.
- Manage financial and human resources.
- Provide clinic marketing service.
- Reducing needed time to reach resources.
- Schedule the next appointment.
- Reduces expenses of an organization because of less paperwork.
- Reduced duplication of testing.
- Less time-consuming.

1.6 Healthcare Management Systems for the extern doctor:

- Book an appointment for surgery.
- Inform the patient of the date and place of the surgery.

1.7 Health management system for receptionist:

- Electronic patient registration.
- Accept or reject a patient appointment request.
- Arrange the queue automatically.
- Calculation and display patient costs.
- View and extract patient documents.

1.8 Health management system for lab worker:

- Record the examination information in the patient profile instead of papers.
- Edit the examination information in an instant.

1.9 Health management system for the technical director:

- Scheduling of surgeries.
- View requests for surgeries.
- Accept or reject surgical requests.

Healthcare Management Systems in Algeria and other countries:

In this section, we will set forth the most well known Healthcare Management Systems in Algeria and the rest of the world. We will reveal some of the advantages and limitations

1.10 Santymed :

“Santymed is medical management software designed by an Algerian team to manage patients' medical records. With an intuitive interface”.[3]

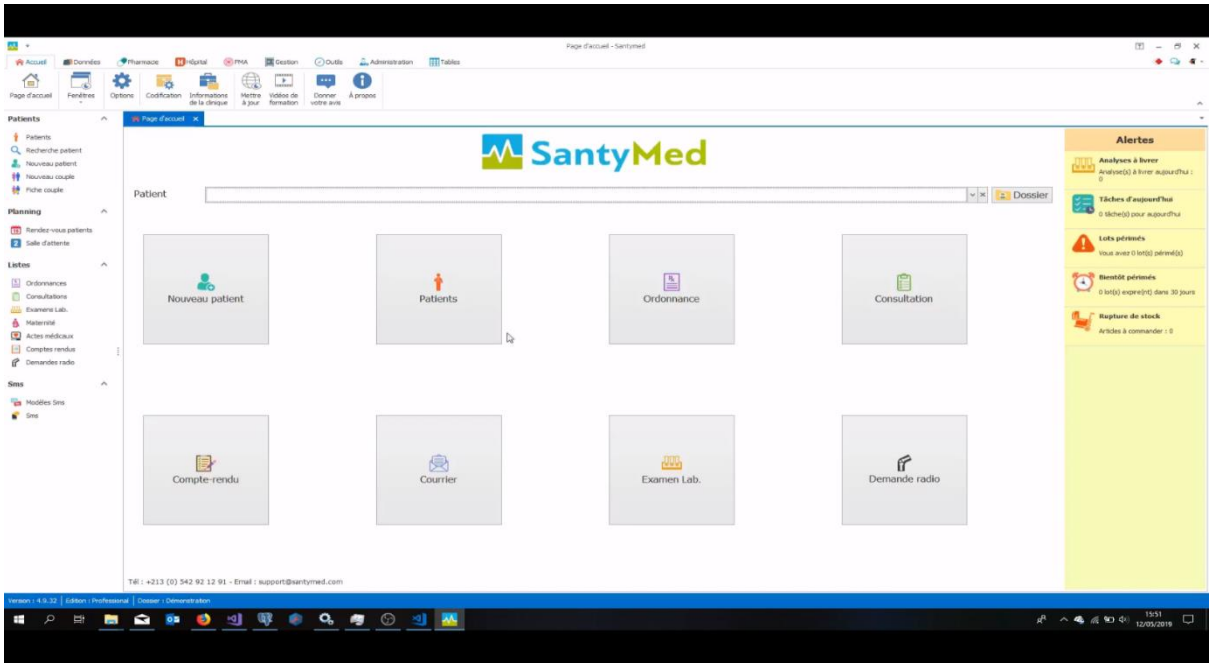

Figure 1. 1: Santymed dashboard

1.10.1 Advantages:

- Easily create and organize the patient's' medical records
- With its rich and extensible medical dictionary, and with the help of standard prescriptions, it is quick to enter and print the patient prescriptions.
- Save all types of documents with the patient file such as images, text documents, or videos.

1.10.2 Disadvantages :

- It can run only on one computer because it is a desktop application and it works offline.
- For every new client, it is necessary to install the application on the client computer.
- There is no backup in case of losing data.
- The application does not integrate the inventory management system.

1.11 eHospital Systems:

"eHospital Systems is a Customizable, Comprehensive, and Integrated Hospital Management System designed to manage all hospital operations. This has Outpatient and Inpatient, Pharmacy, Laboratory, Radiology, Inventory, eClaim, Mobile Apps, Tablet Versions, Online Scheduling, Secured Messaging, Doctor and Patient Portals, Accounting, HR/Payroll, Blood Bank, Mortuary, Alert System, Dietary, Feedback, Lab Machines, and Biometric Integration, HL7/Integrated PACS, and Business Intelligence".[4]

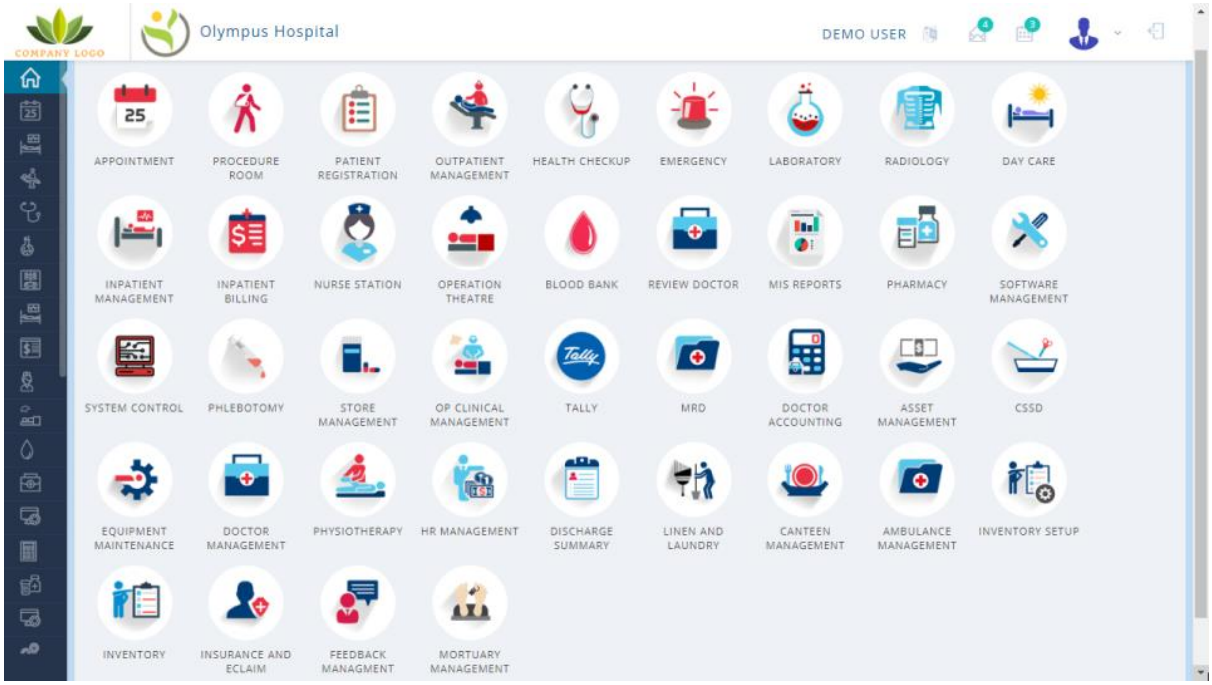

Figure 1. 2: eHospital Systems dashboard

1.11.1 Advantages :

- Server-based software making it easy to scale the number of users without any extra work.
- Features and modules are very comprehensive, simple to understand, and user friendly.
- You do not need prior experience in using hospital systems a little training is enough for the new joiners to understand the software.
- The software is highly customizable to suit the user preference and business process.
- It is suitable both for small and big hospitals.
- It allows integration with other existing software because it is compatible with a large number of systems.
- The entire hospital or clinic is connected and managed in a single system.
- The interface design is simple to understand and userfriendly.
- The software is multi-language.
- The cost is very reasonable.
- Customer support is extremely good.
- It improves the overall performance of the hospital and gives management a clear view of the operation.
- Patients get less queuing time.

1.11.2 Disadvantages :

- Slow internet connection it can be a problem and affecting the solution speed.
- All staff using the software must be trained.
- Users need to understand the application in detail to get the maximum benefit.

1.12 ProMed:

"ProMed, a Cross-Platform Enterprise Application Package for Clinical Data Management and Analysis.ProMed Application Suite, a flexible customizable and cost-effective Health Care Management Solution, precisely Hospital Management System (HMS) that could harness all of your clinical and administrative data, ensuring that it's stored & managed efficiently, intelligently and securely".[5]

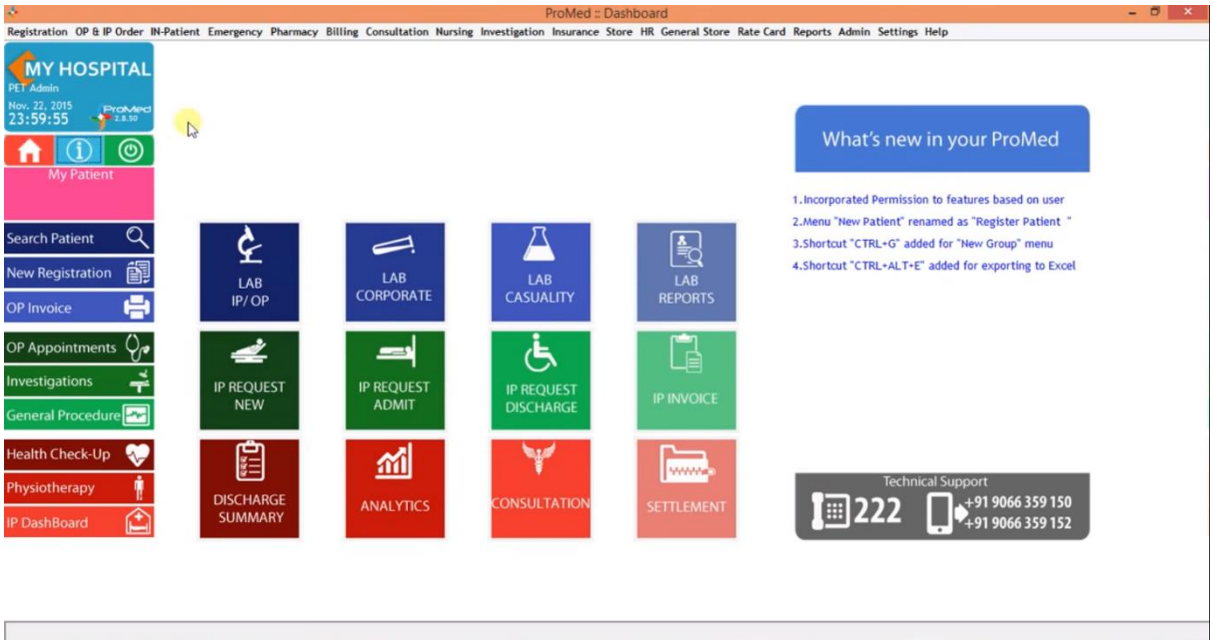

Figure 1. 3: ProMed dashboard

1.12.1 Advantages:

- ProMed is easy to customize and flexible to incorporate.
- Ease of handling accounts.
- Fully automated insurance workflow.
- The appointment management system reduces staff workload.
- Eliminate manual record keeping.
- The ProMed Lab interface enables the automation of all machines in the department.
- ProMed is simple, easy to use and manage, and can manage medical records with one click.
- The reports provided as part of ProMed are accurate and detailed, this is due to the validation of multi-level reports.
- Customer support is very good.
- ProMed contains new additions such as the integrated nurse call system.
- User-friendly and comprehensive software for health care data management.
- Reduces technicians' tasks and improves productivity.

1.12.2 Disadvantages :

- There are some problems with using the pharmacy module.
- Customization provided by ProMed is un-matching.
- The mobile application fills the gap.

Conclusion:

In this chapter, we have introduced Healthcare Management Systems, their role, and their influence on patients' records management. It facilitates the functions of many actors such as clinics, doctors, receptionists, lab workers, and technical directors. Also, we have presented some of the most known HMS in the world, and the one known in Algeria. Taking into account all the mentioned details, we can conclude that the hospital management system has become imperative for the continuation of the modern medical institution. In the next chapter, we will talk about the Case Study of the clinic that we choose as a sample which was the clinic of Alkaala M'sila.

CHAPTER 2: CASE STUDY: AL KALAA CLINIC OF M'SILA

1. Introduction:

Despite the attention which is given to health as an important subject in Algeria, the medical field is still perceived to be the hardest and suffers from several challenges. During our experience that has been held In the Kalaa clinic, and through studying the workflow, we noticed that there is no real digital system. The latter made it difficult to improve the clinic management system because many clinics show some sort of weaknesses in various areas.

This chapter tries to present an overview of the existing management system, which is not yet digitalized, and discuss its various concepts, organization chart, and its hierarchy. Moreover, we attempt to mention the documents investigated during this study.

2. Al kalaa Clinic of M'sila:

2.1. Presentation of the clinic:

Al kalaa Clinic is located in the center of M'sila, right next to the Seville ishbilia Road. Exactly in the Al-Mokrani cooperative.

The clinic of al kalaa has four different floors, each one of them contains the following:

1- The ground floor has a pharmacy, laboratory, examination hall, radiology services, administrative services, and Mortuary.
2- The first floor has an operations room, resuscitation hall, and Specialized examination hall.
3- The Second Floor has a hospitalization ward.
4- Third Floor has an obstetrics department, maternity department, and hospitalization ward. fourth
5- The fourth Floor has The Kitchen and the Cleaning room. There is also a special medical emergency ward open 24 hours a day.

It also provides other services such as general radiology, medical care, Bandages changes, ultrasound, and a resuscitation hall

2.2. The organization chart of the Al kalaa clinic:

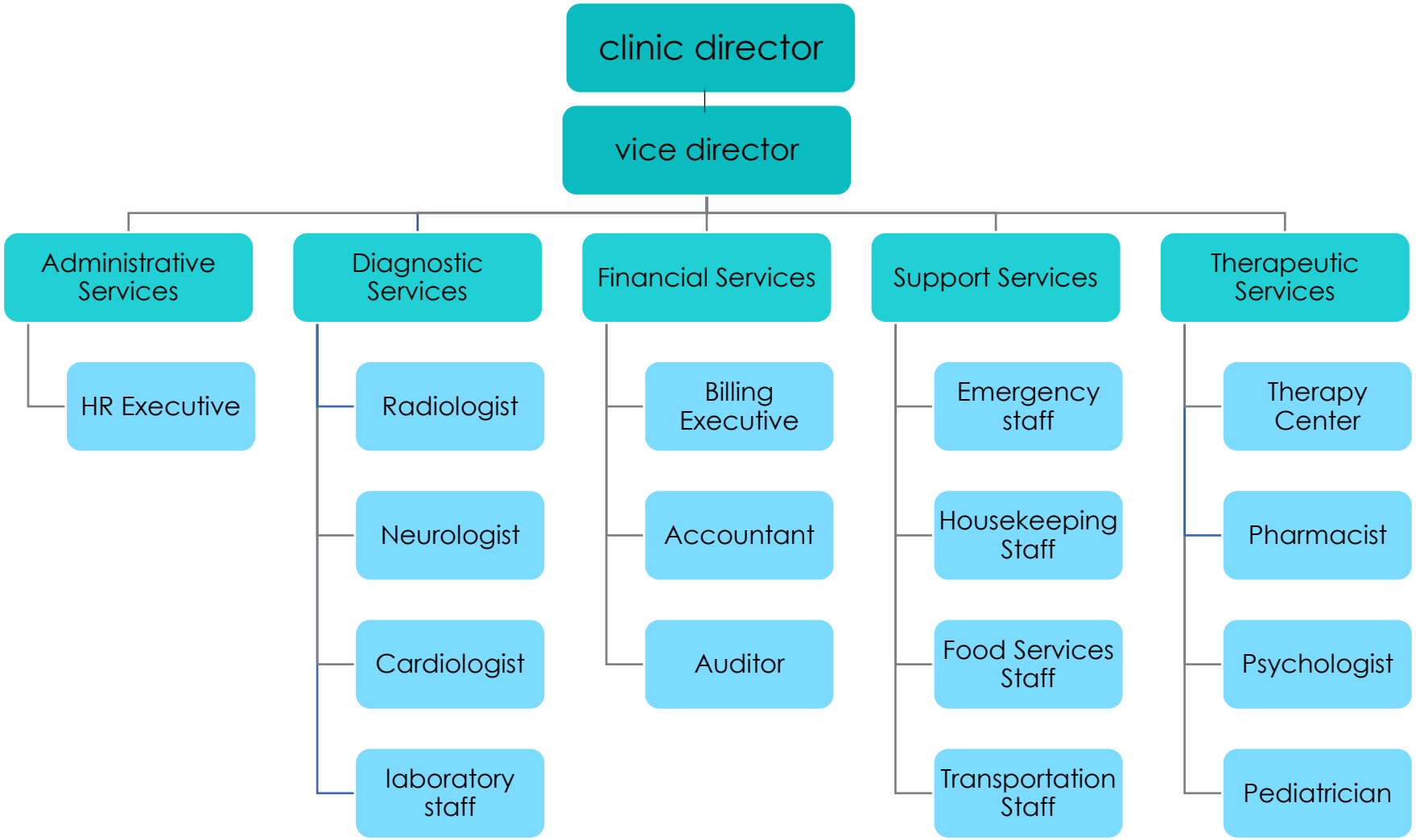

Figure 2. 1: Al kalaa organization chart

2.3. Presentation of Medical services:

Medical services in the clinic include the following medical specialties:

2.3.1. Surgery services:

This specialty of surgery service includes therapeutic and exploratory surgeries and follow-up of patients after surgery.

1- General Surgery.
2- Cardiothoracic Surgery.
3- Orthopedic Surgery.
4- Kidney surgery.
5- Urology Surgery.

2.3.2. Radiology services:

The clinic has multiple services for radiology with modern medical technology and devices that support the work of doctors and enable 24 hours of diagnostic procedures

2.3.3. Obstetrics and Gynaecology:

It provides the diagnosis and treatment of gynecological diseases and the necessary surgical procedures.

2.3.4. Laboratory's services:

The clinic's medical laboratory's services are available to all patients (clinic patients or other patients) and internal departments of the clinic.

2.3.5. Emergency services:

The clinic has a 24-hour emergency department, that ensures emergency care for all ages and medical specialty cases.

2.3.6. Intensive Care services:

are superior and focused medical services for acute conditions, these services differ from other medical services in the quality of the service provided to the patient and the accuracy of his follow-up so that every patient needs a nurse to follow around the clock.

2.4. Existing System:

Based on the interviews we had in al kalaa clinic with general practitioners in the field, medical managers, and nursing heads we discovered that the management system is still paper-based, a fact confirmed by the documents we have, and we, therefore, observed also that patients still need to be present during all the procedures as follows:

1- people are still making appointments manually so the patient has to physically go to the clinic to make an appointment. However, the clinic provides the opportunity to make appointments by placing a phone call. But in this case, people are often left unattended.

2- still using the traditional waiting list and the patients still have to wait for the doctor's arrival.
3- the patients have to wait their turn and need to confirm their presence again when its time.
4- Information about Patients is done by just writing the Patients name, age, and gender. Whenever the Patient comes up his information is stored freshly.

All this work is done manually by the receptionist and other operational staff and a lot of papers are needed to be handled, also the medical staff performs many functions through the use of papers and programs such as Office software like word and excel. So the clinic currently using a manual system for the management and maintenance of critical information. The current system requires numerous paper forms. Often information is incomplete or does not follow management standards. Forms are often lost in transit between departments requiring a comprehensive auditing process to ensure that no vital information is lost. Multiple copies of the same information exist in the hospital and may lead to inconsistencies in data in various data stores.

3. Study of documents:

Each clinic has documents and laws that ensure the management and conduct of all internal operations for excellence in the provision of medical services, we will display some of these documents.

3.1 Certificate of hospital care:

This document contains the following information:

N°	Information	Description
1	First name	Guardian's first name.
2	Last name	Guardian's last name.
3	Birthdate	Guardian's birthdate.
4	Birthplace	Guardian's Place of birth.
5	N.I.C.N. / D.L.N.	National identification card number or Driver's license number.
6	Issued date	Date of issue for National identification card number or Driver's license number.

7	Place of issue	Place of an issue for National identification card number or Driver's license number.
8	First name	The patient's first name.
9	Last name	The patient's last name.
10	Birthdate	The patient's birthdate.
11	Date	Issued date of Certificate of hospital care
12	Concerned	Guardian's signature.

Table 2. 1: Information used in Certificate of hospital care

The document also contains the following items:

01- I am licensed for the medical staff to perform the surgery and bear all the consequences of each emergency or complication swelled during and after the operation.

02- I am committed to paying all expenses resulting from surgical hospitalization or services provided, note that the amounts are written and proposed are calculated outside the tax fees.

03- I am also refrained from claiming the contractor doctor's dues bill of 40% percent of the total amount of the operation.

3.2 Medical report:

This document contains the following information:

N°	**Information**	**Description**
1	Date	Issued date of Medical report.
2	First name	The patient's first name.
3	Last name	The patient's last name.
4	Age	The patient's age.
5	Diagnosis	Diagnose the patient situation.
6	Entry date	The patient's admission date to the Clinic for hospitalization.
7	Operator	The name of the doctor who operated for the patient.

8	Anesthesiologist	The name of the anesthesiologist numbed the patient.
9	The report	The place designated for writing the medical report.

Table 2. 2: Information used in Medical report

3.3 Certificate of stay:

this certificate is issued at the request of the person concerned to serve and be valid as of right

N°	**Information**	**Description**
1	N	Certificate of stay number.
2	First name	The patient's first name.
3	Last name	The patient's last name.
4	Age	The patient's age.
5	From	The patient's admission date to the Clinic for hospitalization.
6	To	The patient's leaving date from the Clinic.
7	Date	Issued date of the certificate of stay.
8	The technical director	Sign and seal the technical director.

Table 2. 3: Information used in Certificate of stay

3.4 Treatment sheet:

This document contains the following information:

N°	**Information**	**Description**
1	First name	The patient's first name.
2	Last name	The patient's last name.
3	Age	The patient's age.
4	Doctor	The name of the doctor who follow-up the patient.
5	Intervention on	The date of the doctor's intervention
6	Doctor-only	The place is designated for the doctor.

7	Date	The date of treatment
8	Treatment	Type of treatment
9	Observations	The patient's condition

Table 2. 4: Information used in Treatment sheet

3.5 Monitoring sheet:

This document contains the following information:

N°	Information	Description
1	Bed number	Patient's bed number.
2	First name	The patient's first name.
3	Last name	The patient's last name.
4	Age	The patient's age.
5	Date	Issued date of monitoring sheet.
6	Entry date	The patient's admission date to the Clinic for hospitalization.
7	Operated on	The date of the operation for the patient.
8	Intervention	The date of the intervention
9	Hours	Time of examination
10	BP	BLOOD PRESSURE
11	Pulse	Heartbeat
12	Te	Temperature
13	Diuresis	The amount of urine in 24 hours
14	Asp, Gastri	Fluid removed from the stomach
15	Lame	The amount of liquid in the gallbladder

Table 2. 5: Information used in Monitoring sheet

3.6 Room Ticket:

This document must be edited every time there is an examination, it consists of five parts and each part have specific information:

Part 1: contain the patient information		
N°	**Information**	**Description**
1	CNAS registration number	The serial number of the National Social Insurance Fund.
2	Patient code	Patient identification number in the clinic
3	Room	Patient's room number
4	Hospitalization period	The patient's entry and exit date
5	First name	The patient's first name.
6	Last name	The patient's last name.
7	Date and Birthplace	The patient's birth date and place of birth.
8	Age	The patient's age.
9	Son of	The patient's parents.
10	Municipal	Patient residence municipal
11	Daïra	Patient residence daïra
12	Province	Patient residence province
13	Social status	Patient social status
14	Contract marriage of	Patient contract marriage
15	Nationality	The patient's nationality
16	Profession	The patient's profession
Part 2: contains the patient's address and accompanying information		
17	Patient's address	Momentary and usual address

18	name, kinship, address of the person to be notified in case of need	The name and kinship and address of accompanying if exist (accompanying address is the same patient address)
19	Minor accompanied by	The kinship of accompanying if the patient is minor
20	Established in the name of	
Part 3: contain the conditions of admission		
21	patient admitted urgently-certificate issued by	The doctor who wrote the certificate
22	patient evacuated from	Accident type (social accident, work accident, common law accident)
23	family identification book	The family book number
24	Municipal of	The name of the municipal
25	Issued on	The date of issue
26	Category	The category of the family book
27	Date, hour, location, circumstances	Date, time, location and circumstances of the accident
28	Name and address of the insurance company	Name and address the patient insurance company
29	Name and address of the perpetrator	Name and address the perpetrator on the patient
30	Name and address of the civilly responsible	Name and address of the civilly liable
31	investigating authority	The authority responsible for the investigation
32	transported by	Who get the patient to the clinic
Part 4: contain the exit information		
33	Room	The number of room

34	Bed	The number of bed
35	The patient left on	The date and time the patient left
36	Date	Document release date
37	The proposed for admission	All evacuation rooms where the patient was including debs and dates
Part 5: reserved for medical service		
38	Exits diagnostic	Diagnostic of the patient before his discharge
39	Outgoing from	The name of the chief doctor

Table 2. 6: Information used in Room Ticket

3.7 Analysis results sheet:

This document consists of 6 parts:

Part 1: contains patient information		
N°	**Information**	**Description**
1	First name	The patient's first name.
2	Last name	The patient's last name.
3	Sex	The patient's Sex.
4	Age	The patient's age.
5	Sampling date	Patient's sampling date.
6	Blood	Type of blood group.
Part 2: contains Biochimie results		
7	Blood sugar	The amount of sugar in 1 liter of blood
8	Urea	The amount of urea in the blood
9	Creatinine	The amount of creatinine in the blood
Part 3: contains hemostasis results		

10	Prothrombin	Prothrombin ratio
11	APTT (TCK)	activated partial thromboplastin time
Part 4: contains serology results		
12	HIV	Negative or positive for HIV
13	HCV	Negative or positive for hepatitis C virus
14	HBS	Negative or positive for hepatitis B surface antigen
Part 5: contains the complete blood count (CBC) results		
15	WBCs	The number of white blood cells in 1 liter of blood
16	RBCs	The number of red blood cells in 1 liter of blood
17	HB	The amount of hemoglobin in 1 dl of blood
18	HT	The percentage of hematocrit in the blood
19	MCV (VGM)	Mean corpuscular volume
20	MCH (TCMH)	Mean corpuscular hemoglobin
21	MCHC (CCMH)	Mean corpuscular hemoglobin concentration
22	PLT	The amount of platelet in 1 liter of blood
Part 6: contains urine chemistry results		
23	Bilirubin	Urinary bilirubin levels
24	Urobilinogen	The amount of urobilinogen in a urine sample
25	Ketone	The level of ketone in the urine
26	Glucose	The amount of sugar (glucose) in a urine sample.
27	Protein	The amount of protein present in the urine
28	Nitrite	The presence of nitrites or not
29	Leukocytes	Positive or negative for leukocytes in urine

30	PH	The ph in urine
31	Density	The level of urine density

Table 2. 7: Information used in the Analysis results sheet

4. Conclusion:

Though all these operations and a large number of patients, and Though the computers and laptops that clinic have which use just to print documents and use some Office software, we did not find any information system for managing all the aspects related to the clinic operations or at least met the needs of the clinic workers and patients. Therefore, given all the problems that we have described before, we concluded that delivering a paperless system for health clinics is highly required.

CHAPTER 3: ANALYSIS AND DESIGN

1. Introduction:

This chapter presents the practical part of this project, the analysis and design phase that will be done through diagrams.

To lead to a design and analysis we have chosen the UML, which allows us to model clearly and precisely the structure and behavior of a system independently of any method or programming language.

2. Proposed System (web application as services):

2.1 Applications As a Service:

Applications as a service refers to the delivery of computer software applications as a service via the Internet. This type of software is also referred to as SaaS (Software as a Service), software on demand and on-demand software.

On-demand software has been gaining an increasing share of the software market, due to the cost savings and efficiency gains it can offer to organizations, regardless of their size.

Applications as a service can also provide software to enterprise users more efficiently, because it can be distributed and maintained for all users at a single point – in the public cloud (Internet).

Software on demand is a new paradigm for the industry that provides the primary benefit of lowered operational and capital expenses for enterprise information technology services.

When an organization decides to implement software on-demand as a solution for their enterprise software needs, internal information technology services can become more efficient. IT personnel are no longer required to focus on the installation, maintenance, and support of enterprise software and the hardware that supports such software.

The efficiency gained through the software on demand frees up IT personnel for the more important tasks of managing IT resources as a strategic tool to optimize their business operations. [6]

Characteristics:

There are several key characteristics SaaS model of software delivery. These characteristics and how they differ from the traditional software model (on-premise) are as follows:

Centralized Hosting / Delivery – this characteristic of SaaS differs from the traditional model of software delivery that requires the added operational overhead of providing software to users through different distribution channels. [6]

Uniform Platform for Delivery – this characteristic of SaaS differs from the traditional model which requires different software packages for different operating systems. With SaaS, all solutions run on a single platform with a uniform type of client interface (browser). [6]

Open Collaboration / Sharing – this characteristic of SaaS differs from the traditional model of software delivery which requires IT administrator management of user permission profiles for shared access to computing resources. With SaaS, platform tools such as automated user provisioning provide SaaS consumers with the necessary tools to control how and when they share tasks, data, and information with other users.[6]

2.2 Multi-Tenancy System With Separate Databases:

2.2.1 Tenant definition:

"A tenant is a group of users sharing the same view on an application they use. This view includes the data they access, the configuration, the user management, particular functionality, and related nonfunctional properties".[7]

2.2.2 Multi-tenancy definition:

"Multi-tenancy is an approach to share an application instance between multiple tenants by providing every tenant a dedicated "share" of the instance, which is isolated from other shares with regard to performance and data privacy".[7]

2.2.3 Multi-tenancy advantage:

There is a lot of advantages of multi-tenancy architecture we will site some of theme

- Easier single-client restores.
- Easier data exports.
- Easier multi-server scalability.
- Easier security management.
- Easier maintenance windows.

2.2.4 The architecture of A Multi-Database System:

Multiple Databases: a separate database can be used to store each customer's data. Access to the database can then be restricted by using SQL login credentials.

In a multi-database multi-tenancy system, each user's data is stored in its database. A separate database is therefore required to hold login details and provide details of where the user's data is stored. This could point to a database on the same server or a remote data location.

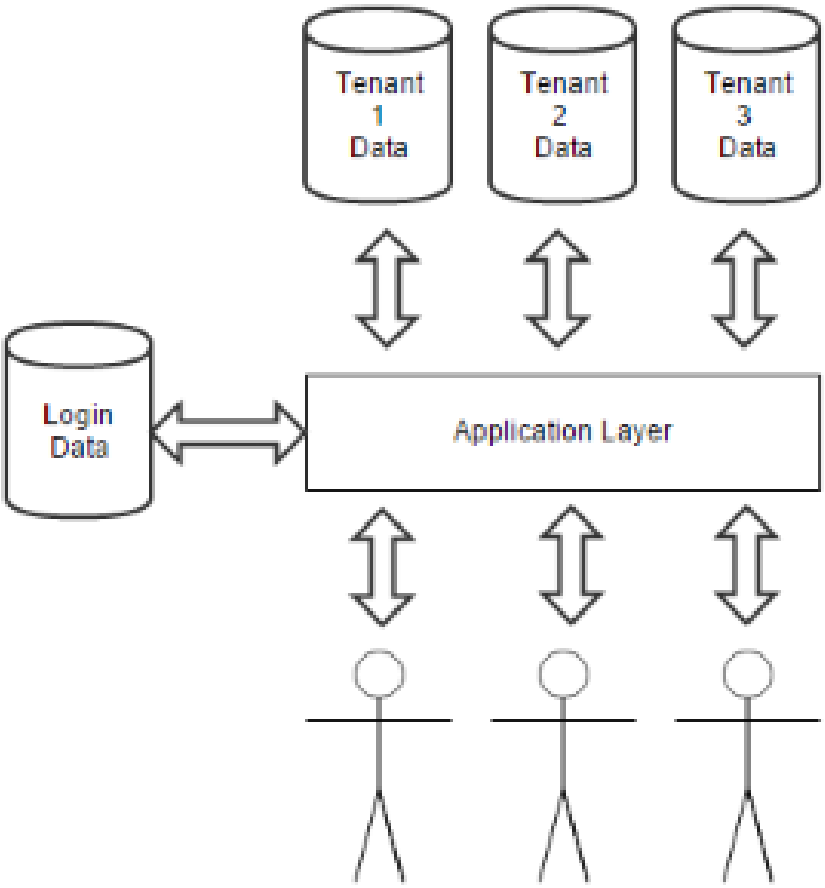

Figure 3. 1: Multi-Tenancy System With Separate Databases architecture

3. Application's Analysis and Design:

Based on our study and analysis of the case study design, we provide the following UML models to describe formally our proposed architecture.

3.1 Analysis by use case diagram:

The global use case diagram represents the different functions of our application and the needs and requirements of the various actors who will interact within the system.

3.1.1 General use case diagram:

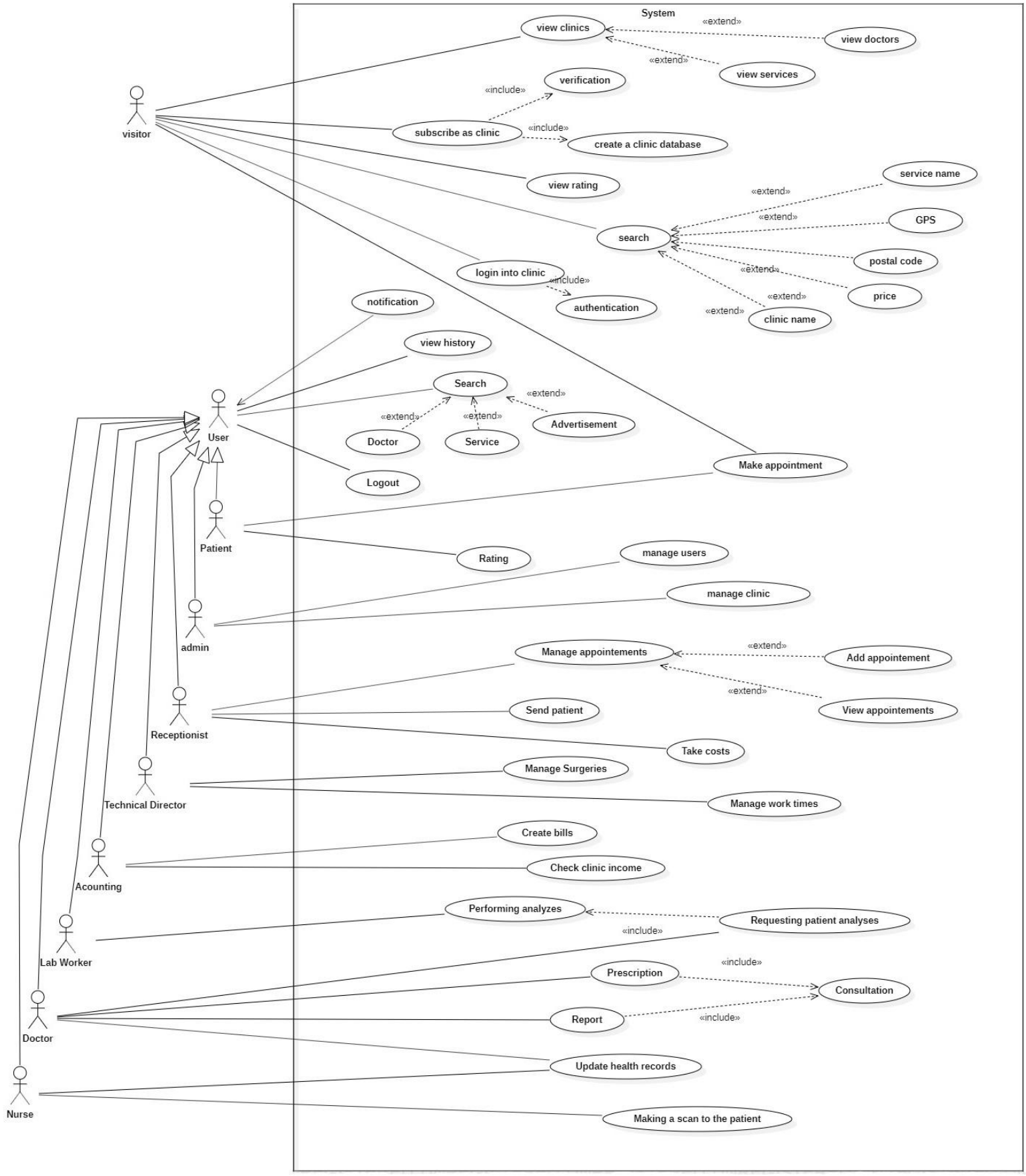

Figure 3. 2: General use case

Next, we will detail in the above use case.

3.1.2 Visitor use case diagram:

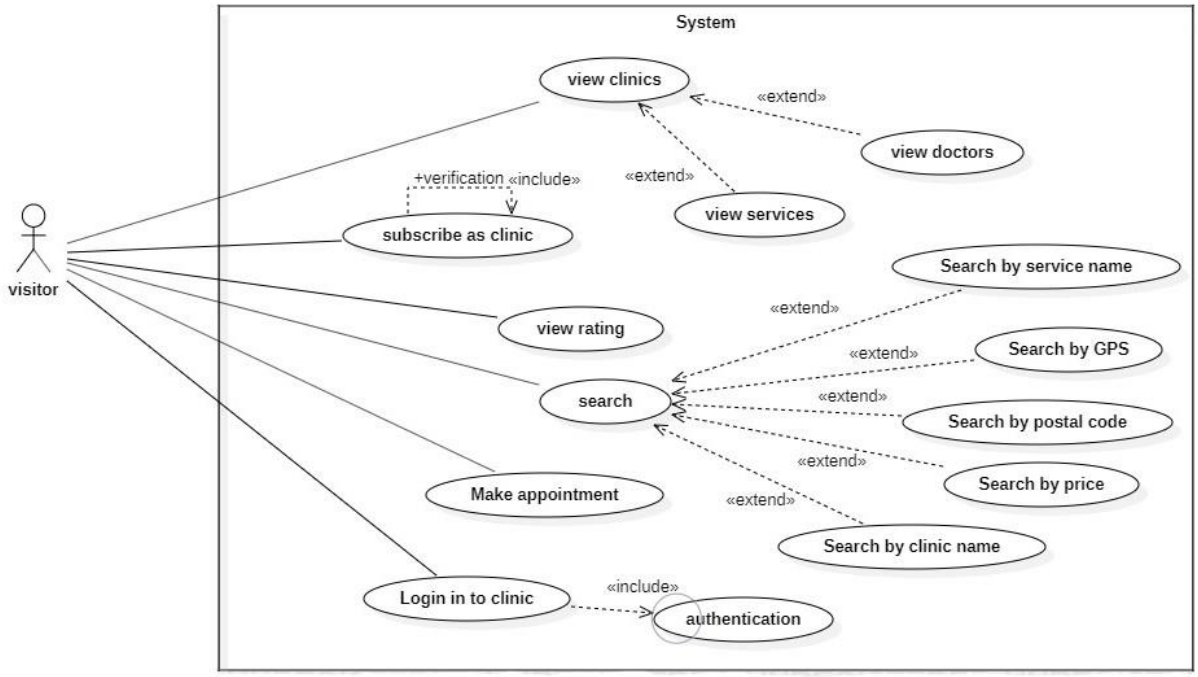

Figure 3. 3: Visitor use case

- **The actors:**
  - **The visitor:** an unregistered user that can consult the clinic profile and make an appointment or either register as a clinic
- **Use cases:**
  - **View clinics:** Browse clinics profiles and see doctors or services for each clinic
  - **Subscribe as a clinic:** request of subscription for a new clinic by providing client personal information and Property documents
  - **View rating:** Review the rating provided by the patients of each clinic
  - **Search:** Search for a clinic by clinic name, service name, service price, postal code or GPS
  - **Make appointment:** set an appointment by providing personal information and email address
  - **Login into clinic:** login into the clinic using email and password.

3.1.3 User use case diagram:

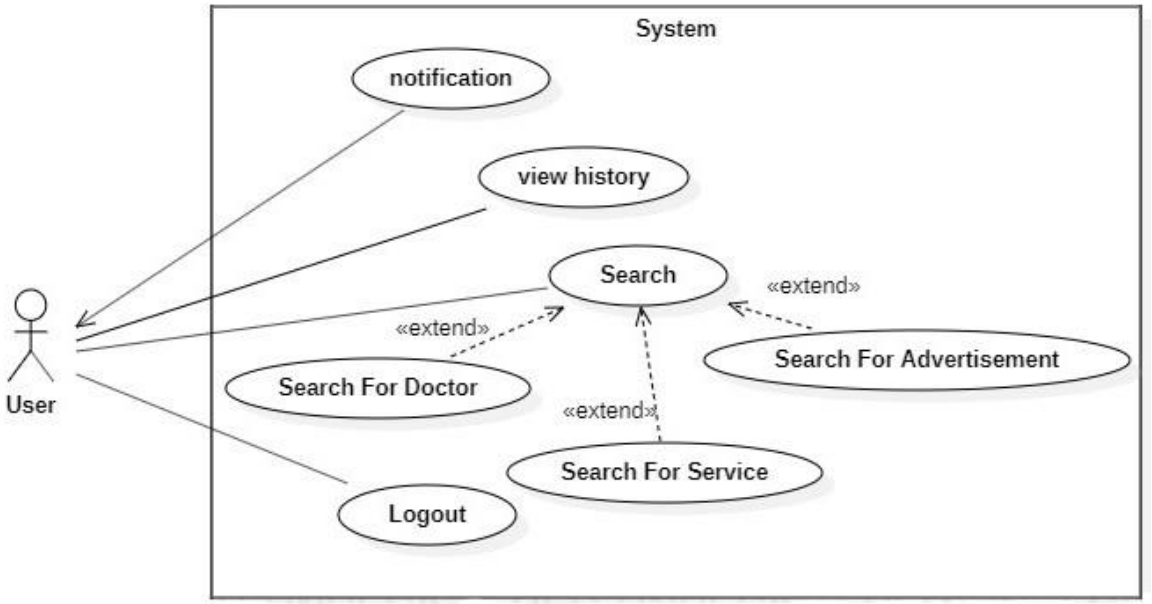

Figure 3. 4: User use case

- **The actors:**
  - **User:** any connected account called user on general, also any user can receive a notification, review his history, search in the clinic about Doctors or Services or advertisements and also can logout
- **Use cases:**
  - **Notification:** notifications are sent by the application of specific information.
  - **View history:** review personal history.
  - **Search:** Search in-clinic profile about the doctors or services or advertisements.
  - **Logout:** Logout from the clinic.

3.1.4 Patient use case diagram:

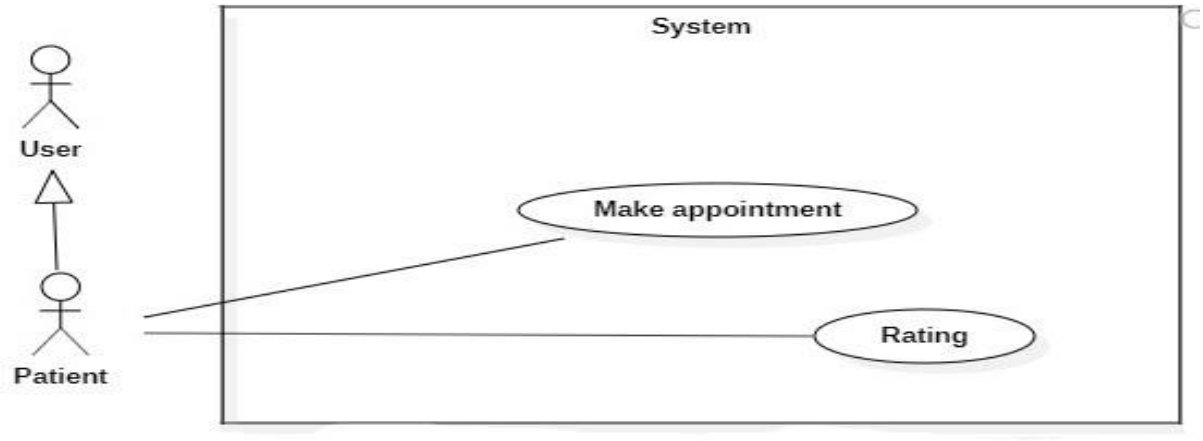

Figure 3. 5: Patient use case

- **The actors:**
  - **User:** a registered user that has an account in a clinic.
  - **Patient:** a user with type patient can consult its profile, view its history, and make appointments with its registered information
- **Use cases:**
  - **Make appointment:** set an appointment by select the date and the doctor (the personal information is registered before)
  - **Rating:** give the clinic a rating from 5 stars

3.1.5 Admin use case diagram:

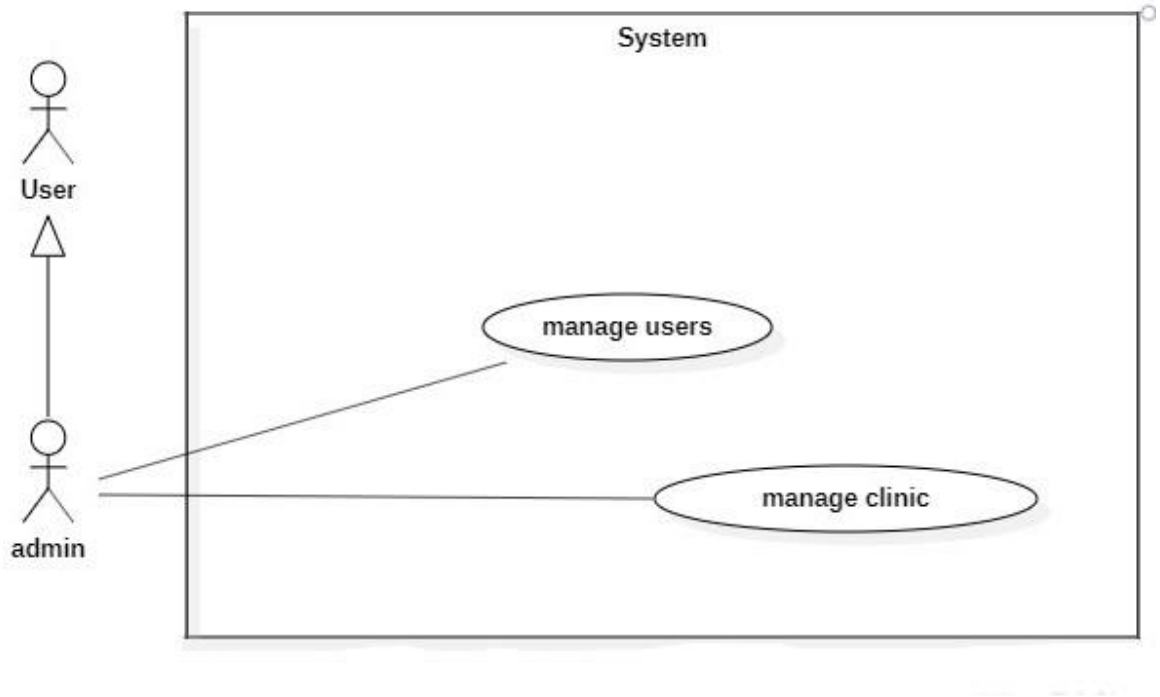

Figure 3. 6: Admin use case

- **The actors:**
  - **User:** a registered user that has an account in a clinic.
  - **Admin:** Can do whatever a general user does, also, can manage the users (create, delete, review, enable or disable users) and manage the clinic (manage clinic profile, services, advertisements …)
- **Use cases:**
  - **Manage users:** create, review, update, delete and enable or disable users accounts
  - **Manage clinic:** edit clinic profile, manage the services and advertisements

3.1.6 Receptionist use case diagram:

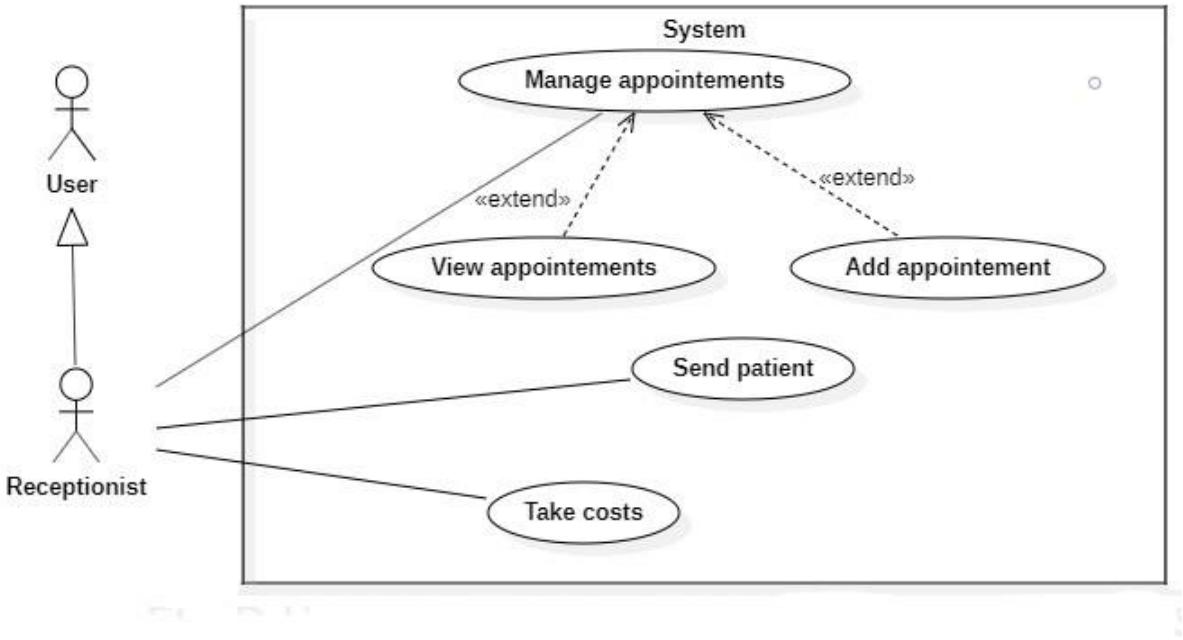

Figure 3. 7: Receptionist use case

- **The actors:**
  - **User:** a registered user that has an account in a clinic.
  - **Receptionist:** can manage appointments and pass the patients and catch the costs
- **Use cases:**
  - **Manage appointment:** review today appointments and add new appointment (on the same day)
  - **Send patient:** pass the patient to consultation or analysis
  - **Take costs:** catch the costs of each patient when he finishes its progress

3.1.7 Technical Director use case diagram:

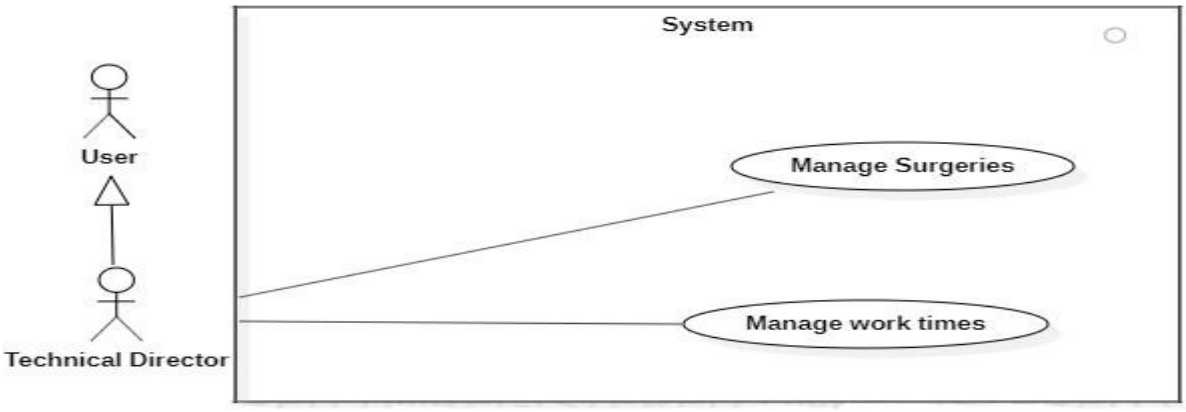

Figure 3. 8: Technical director use case

- **the actors**:
  - **User:** a registered user that has an account in a clinic.
  - **Technical director:** Responsible for preparing work hours and surgery date.
- **Use cases:**
  - **Manage surgeries:** set the date of the surgeries and the stuff of the surgery
  - **Manage work times:** Scheduling work times of each user employee

3.1.8 Accounting use case diagram:

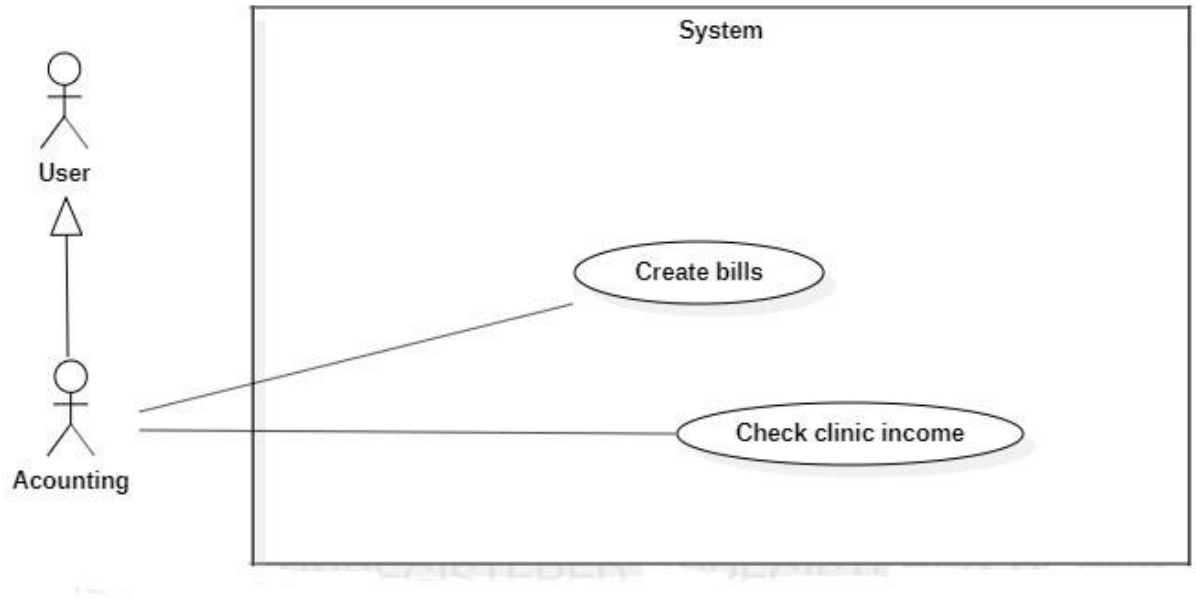

Figure 3. 9: Accounting use case

- **the actors**:
  - **User:** a registered user that has an account in a clinic.
  - **Accounting:** Responsible for clinic income accounts.

- **Use cases:**
  - **Create bills:**
  - **Check clinic income:** check the incomes of the clinic that come from the services (consultation, analysis …)

3.1.9 Lab Worker use case diagram:

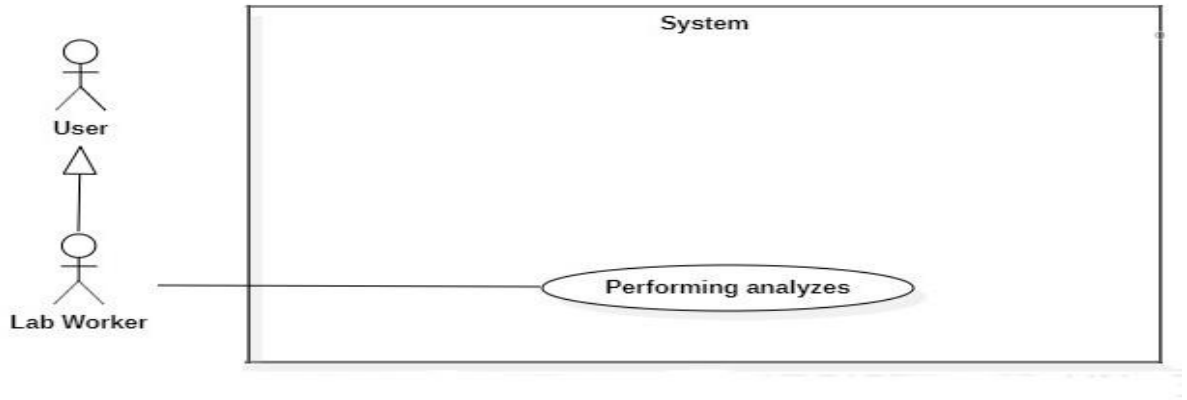

Figure 3. 10: Lab worker use case

- **the actors**:
  - **User:** a registered user that has an account in a clinic.
  - **Lab worker:** its role is to analyze the patients and create an electronic analysis for each patient.
- **Use cases:**
  - **Performing analysis:** perform analysis to the incoming patient, whether at the request of the doctor or coming directly from the appointment

3.1.10 Doctor use case diagram:

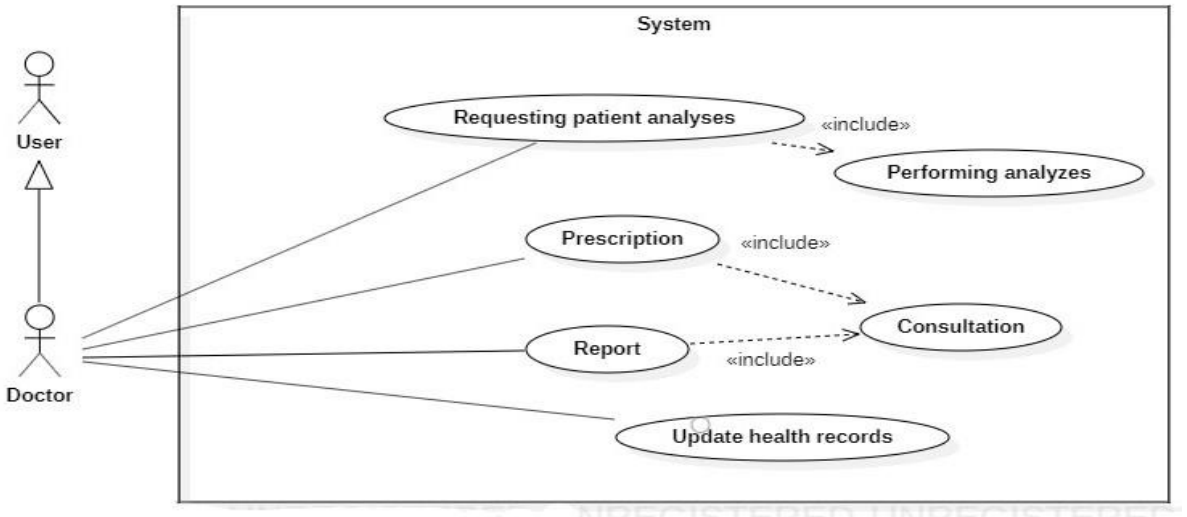

Figure 3. 11: Doctor use case

- **the actors**:
  - **User:** a registered user that has an account in a clinic.
  - **Doctor:** his responsibility is about consulting the patients, request patient analysis if needed, set electronic reports, and prescriptions to patients.
- **Use cases:**
  - **Requesting patient analysis:** request specific analysis to the patient if needed during the consultation
  - **Prescription:** create an electronic prescription and print it during the consultation
  - **Report:** create an electronic report during the consultation
  - **Update healthcare record:** by adding new consultation to the patient record

3.1.11 Nurse use case diagram:

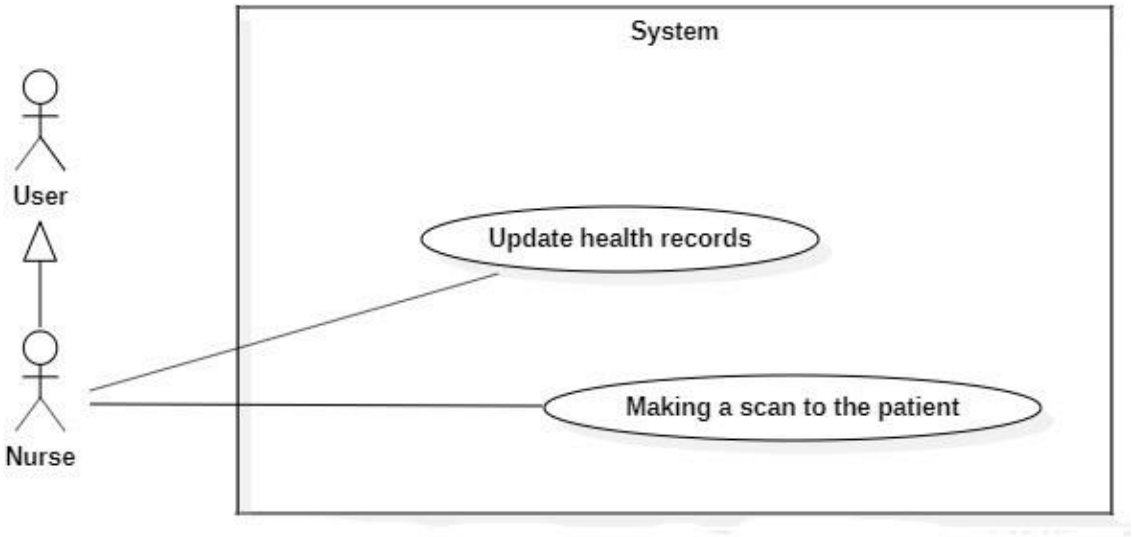

Figure 3. 12: Nurse use case

- **the actors**:
  - **User:** a registered user that has an account in a clinic.
  - **Nurse:** the role of the nurse is to checkup the patient and update the patient's health record.
- **Use cases:**
  - **Making a scan to the patient:** by chack the patient status in a specific duration(blood pressure, the sugar level in blood …)
  - **Update health record:** by registering the patient biological status every time

3.2 Applicatin's Design by static diagram:

The class diagram represents the main structure of our application system at the level of classes, shows their relationships, associations, generalizations, and dependencies.

3.2.1 Users class diagram:

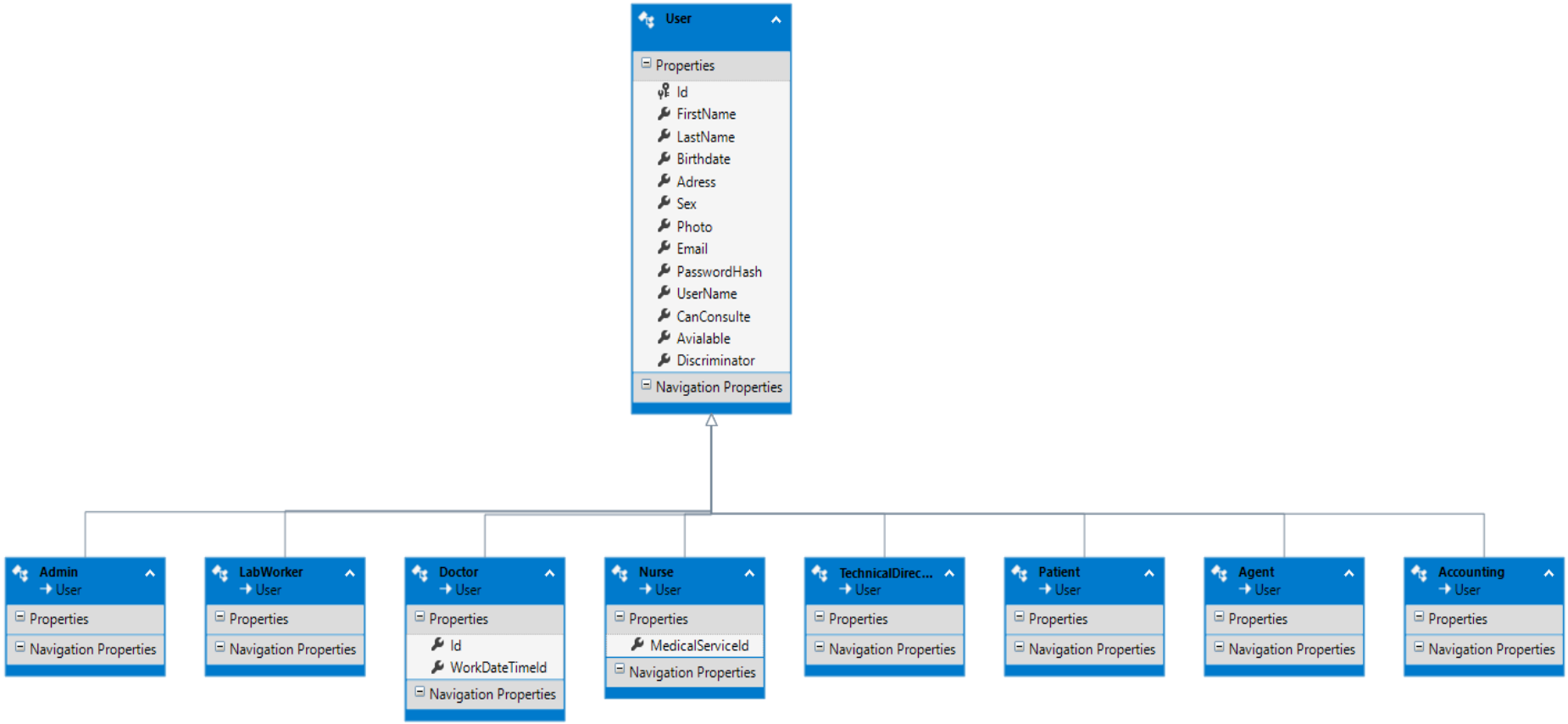

Figure 3. 13: User class diagram

3.2.2 Patient class diagram:

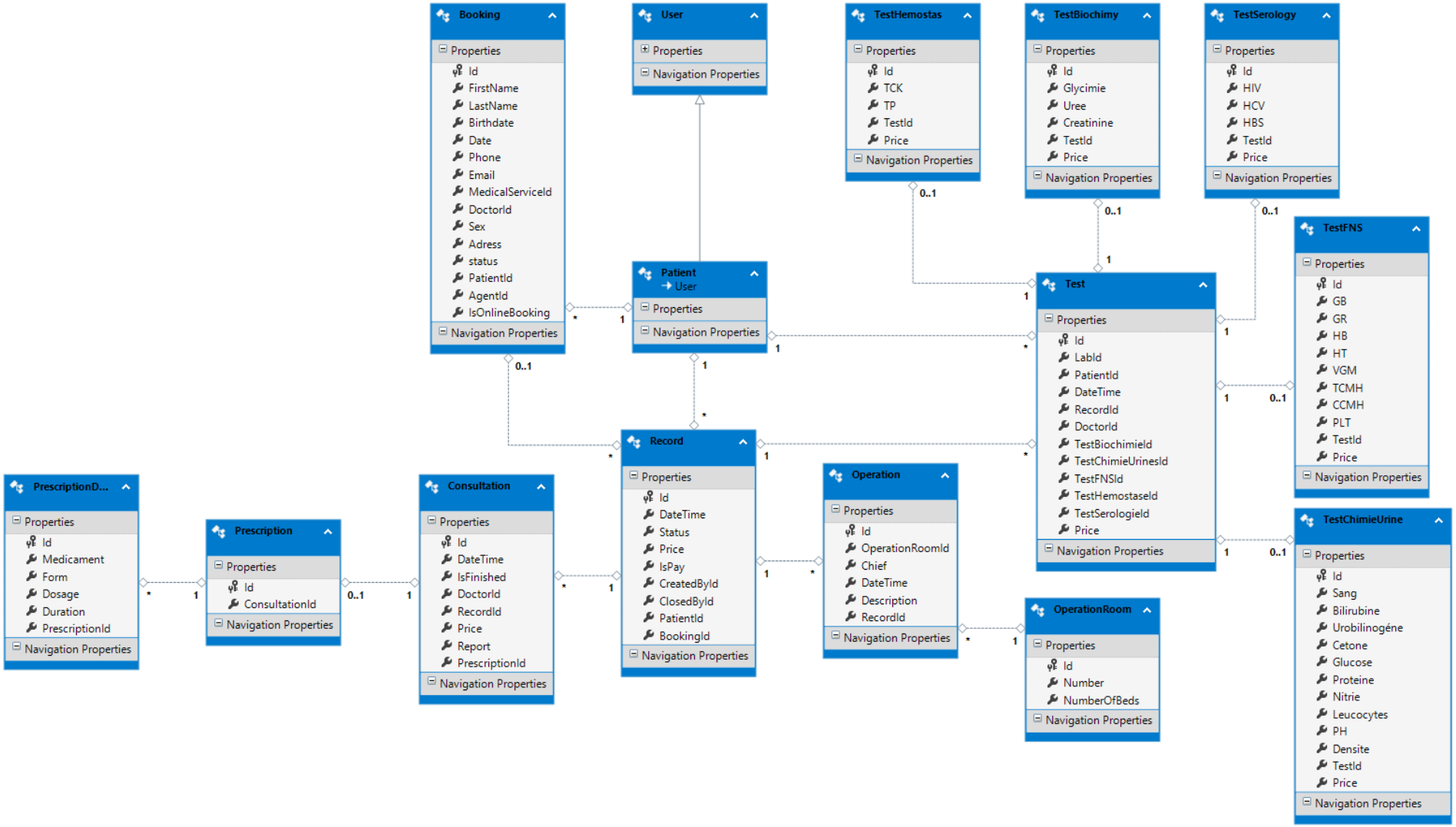

Figure 3. 14: Patient class diagram

3.2.3 Doctor class diagram:

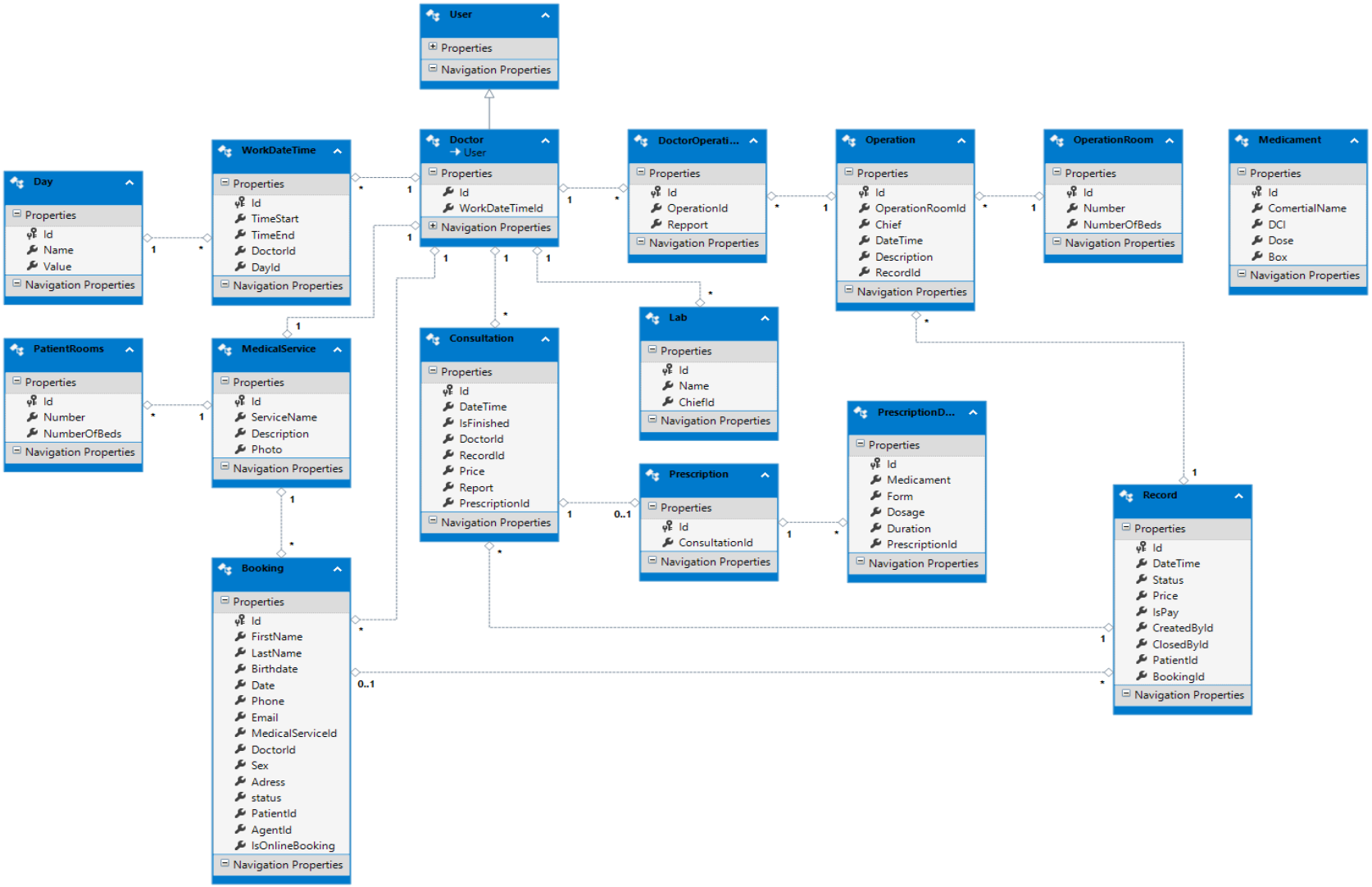

Figure 3. 15: Doctor class diagram

3.2.4 Nurse class diagram:

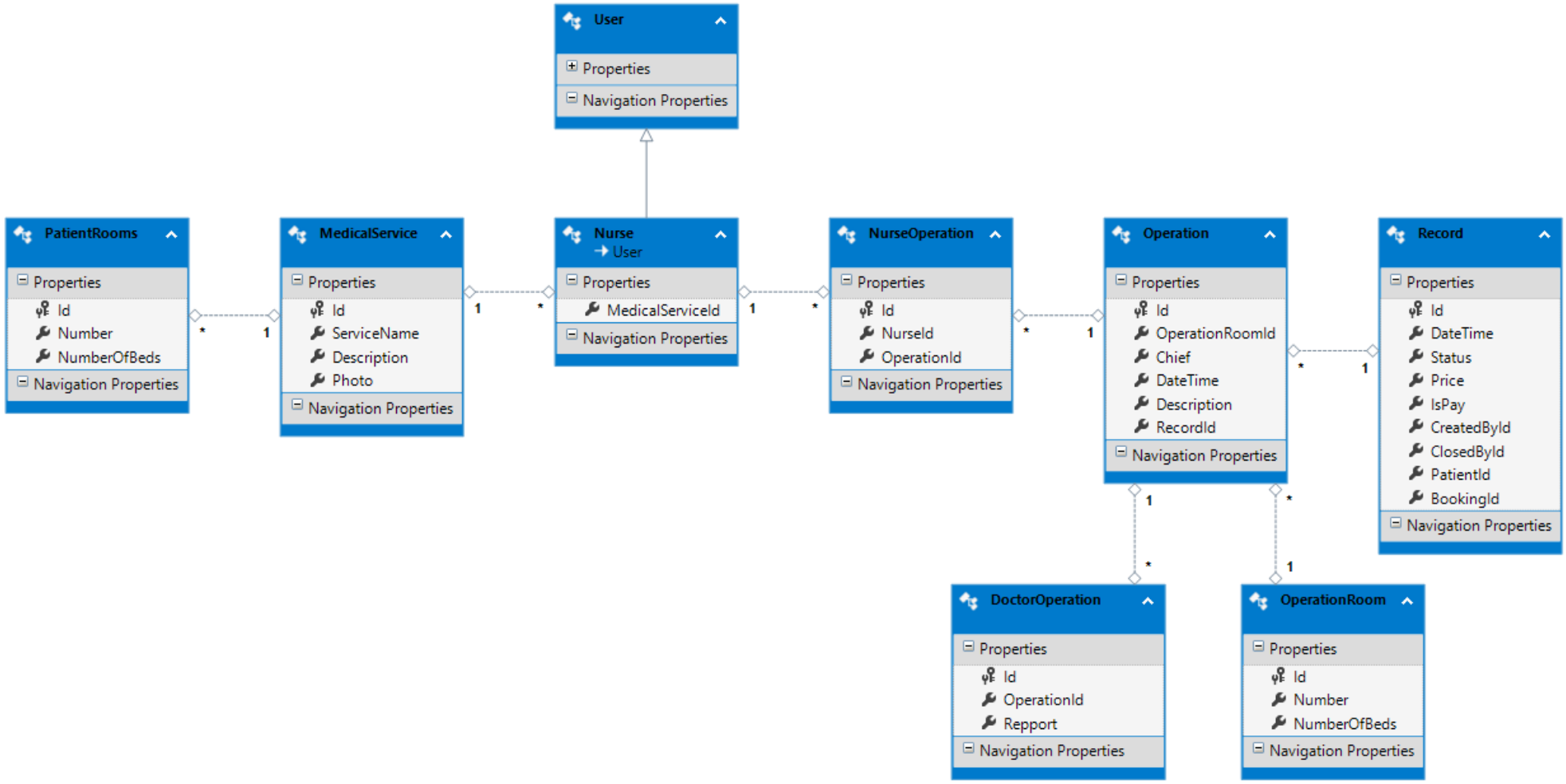

Figure 3. 16: Nurse class diagram

3.2.5 Lab Worker class diagram:

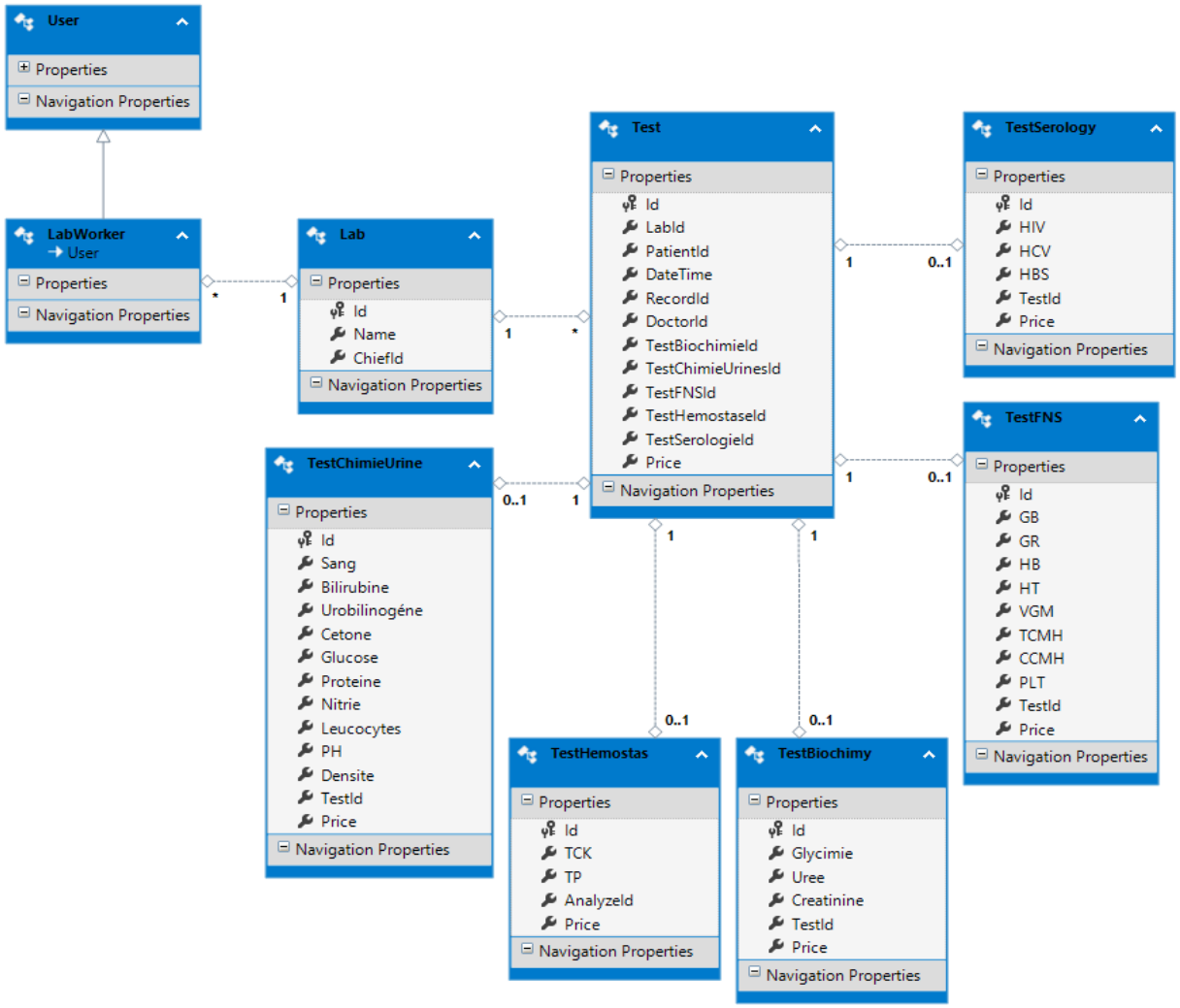

Figure 3. 17: Lab worker class diagram

3.2.6 Technical Director class diagram:

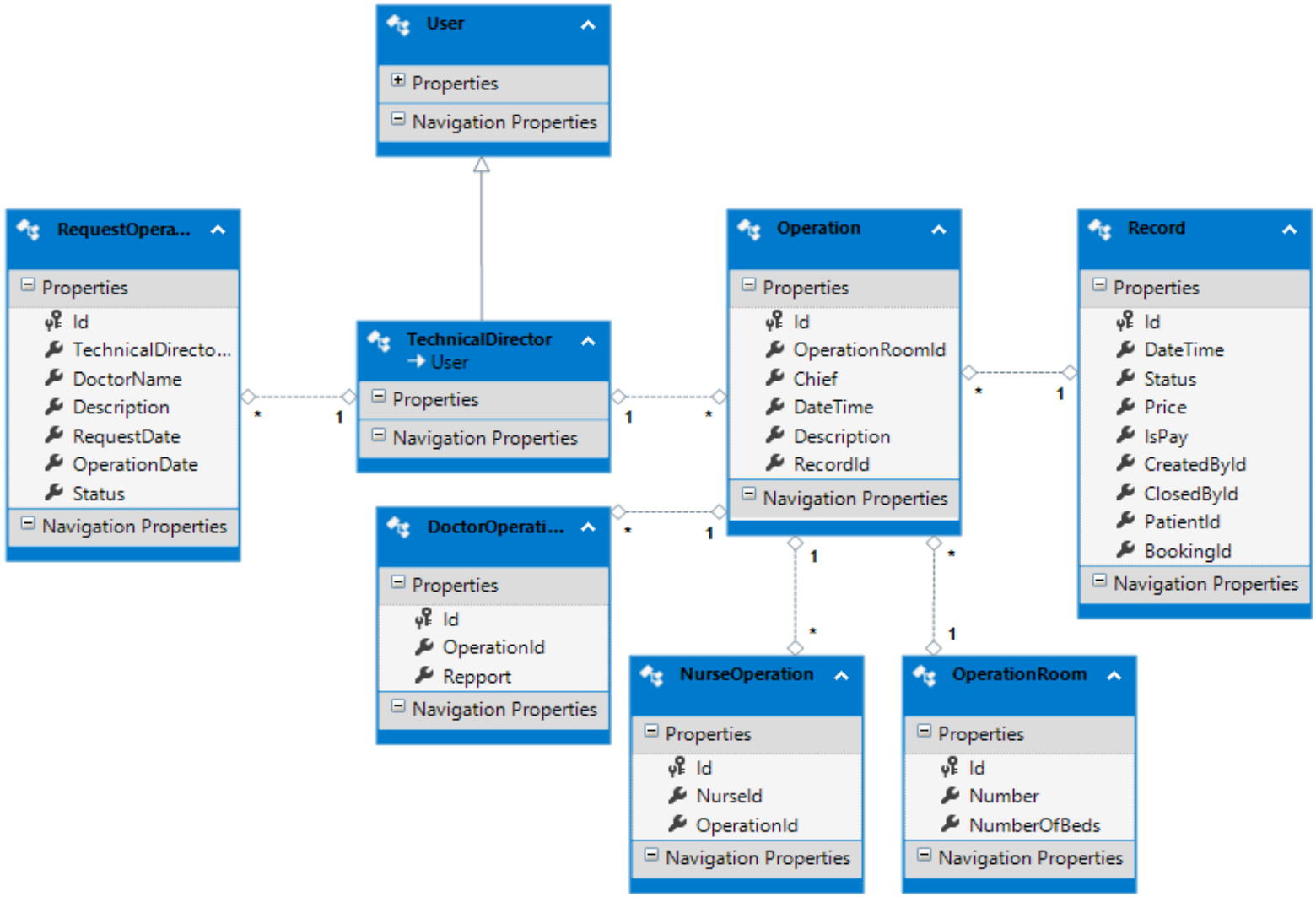

Figure 3. 18: Technical director class diagram

3.2.7 Accounting class diagram:

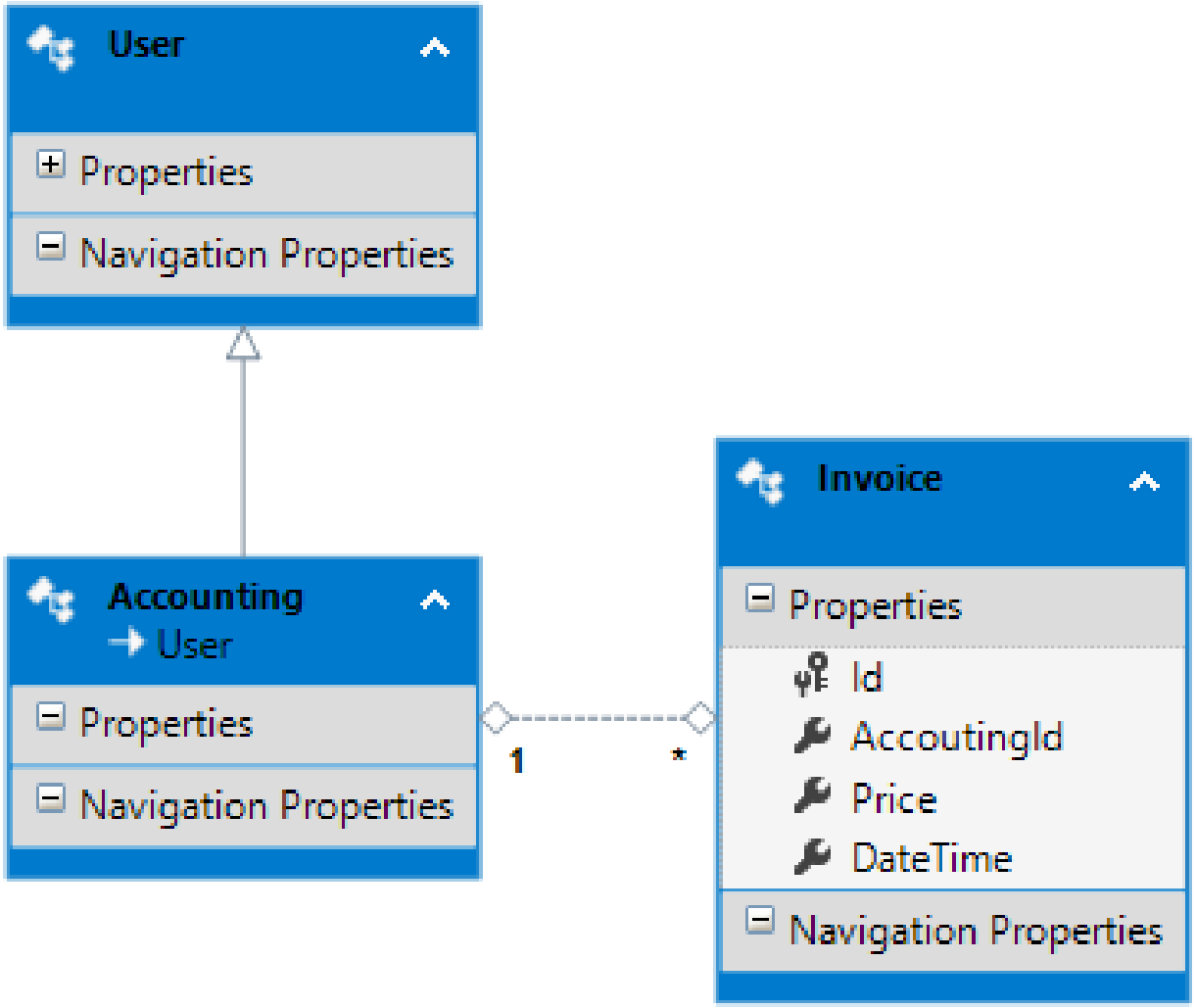

Figure 3. 19: Accounting class diagram

3.2.8 Admin class diagram:

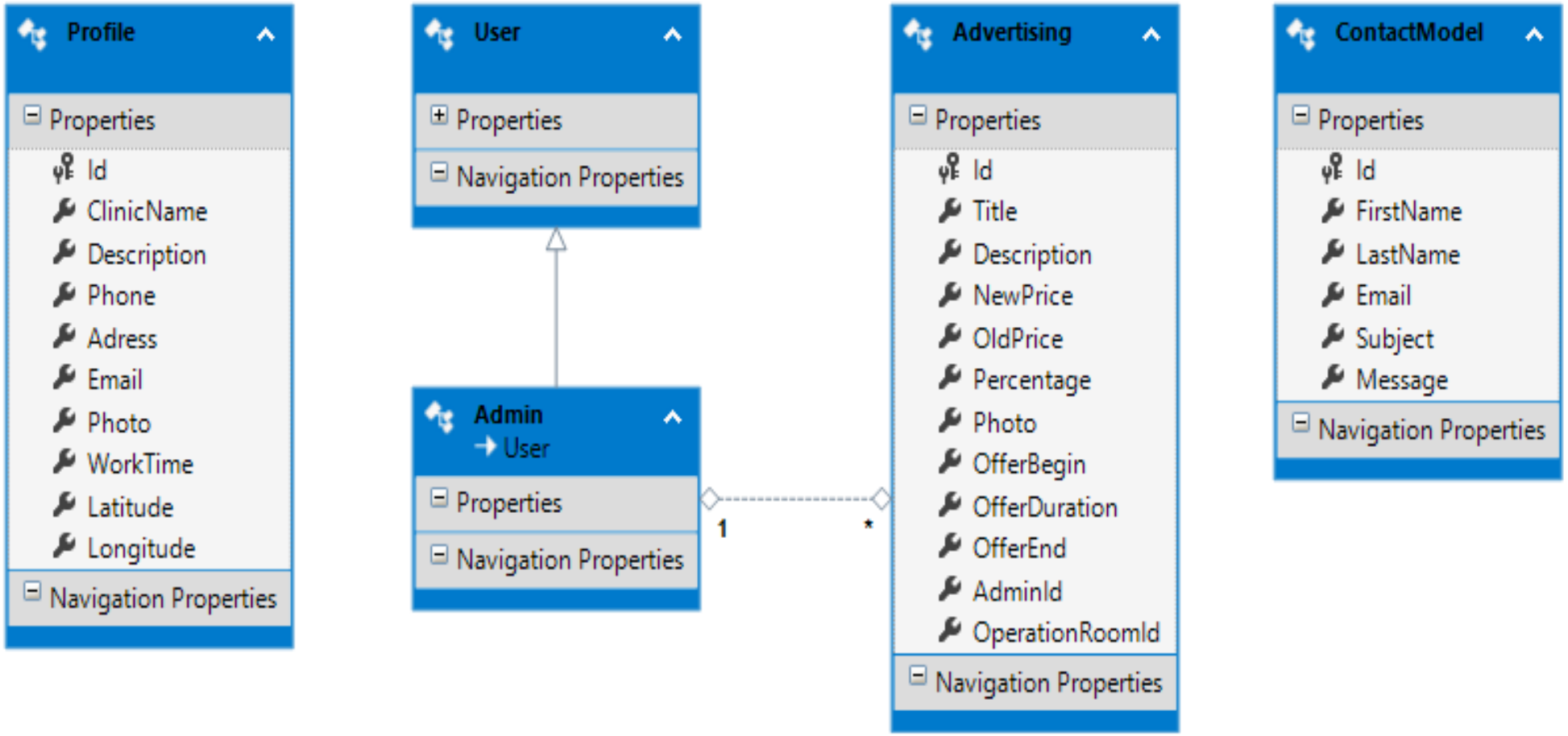

Figure 3. 20: Admin class diagram

3.2.9 Receptionist class diagram:

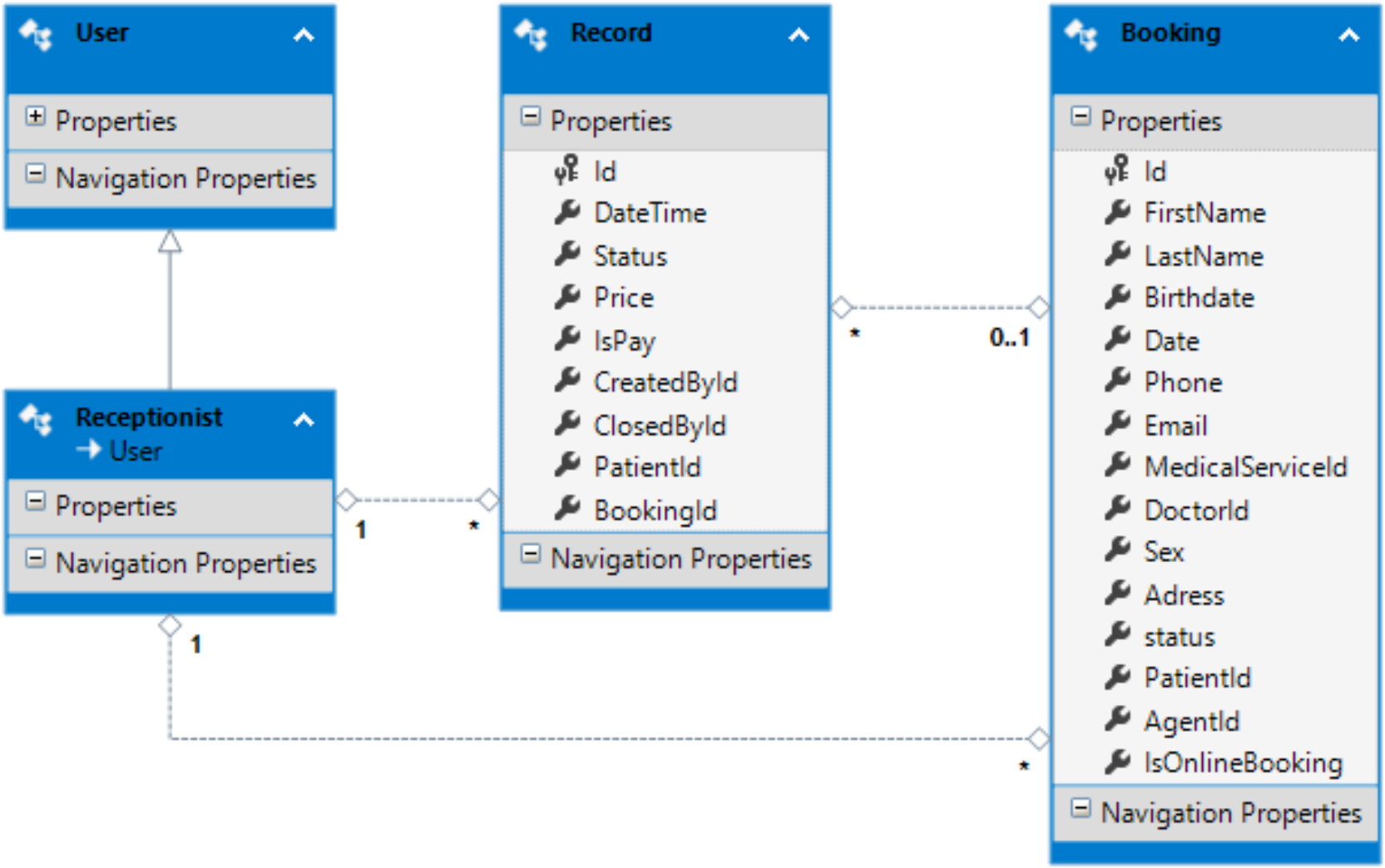

Figure 3. 21: Receptionist class diagram

3.2.10 General class diagram:

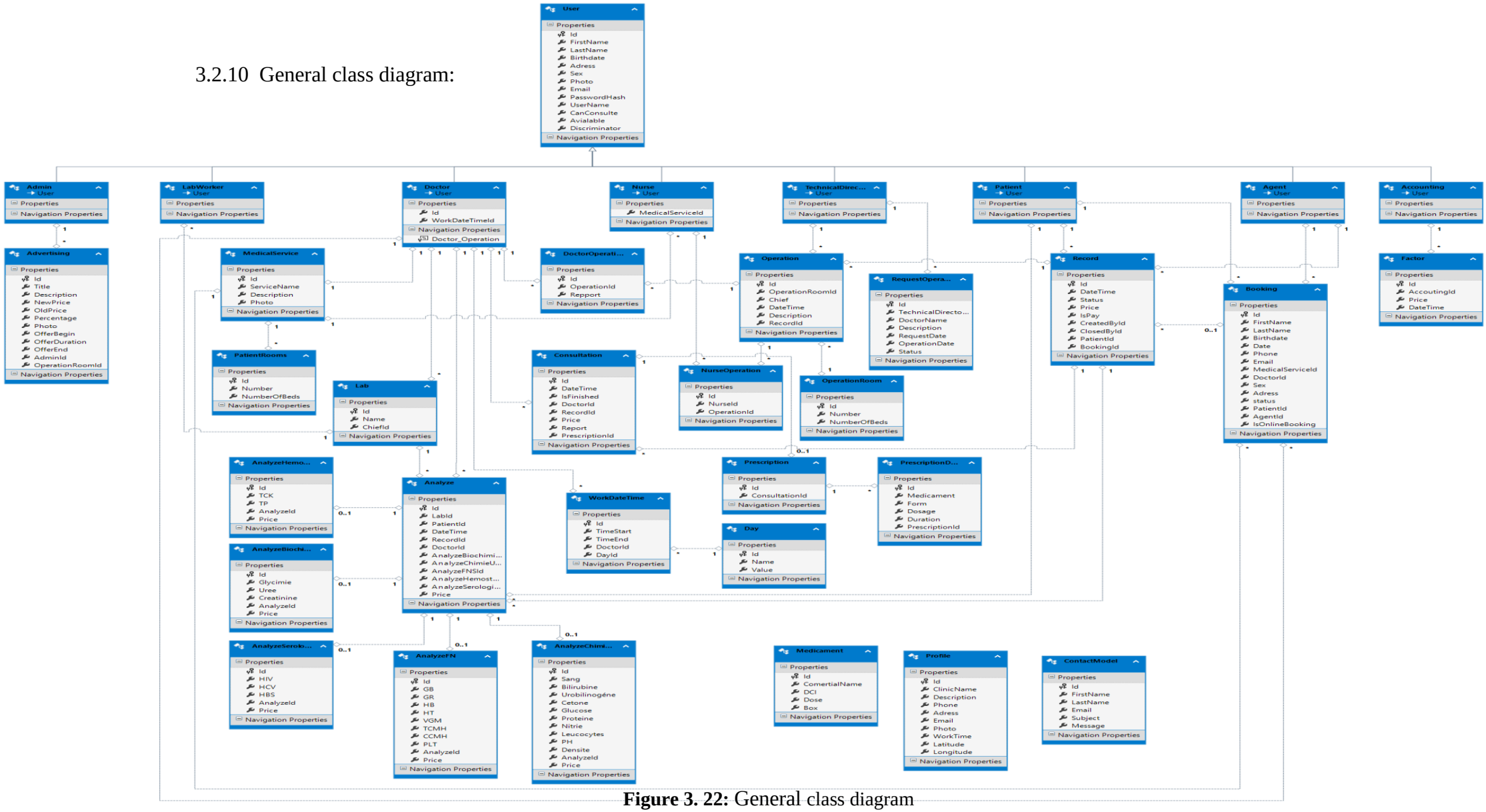

Figure 3. 22: General class diagram

3.3 Application's Design by Sequence diagrams:

3.3.1 Sequence diagram for Registering:

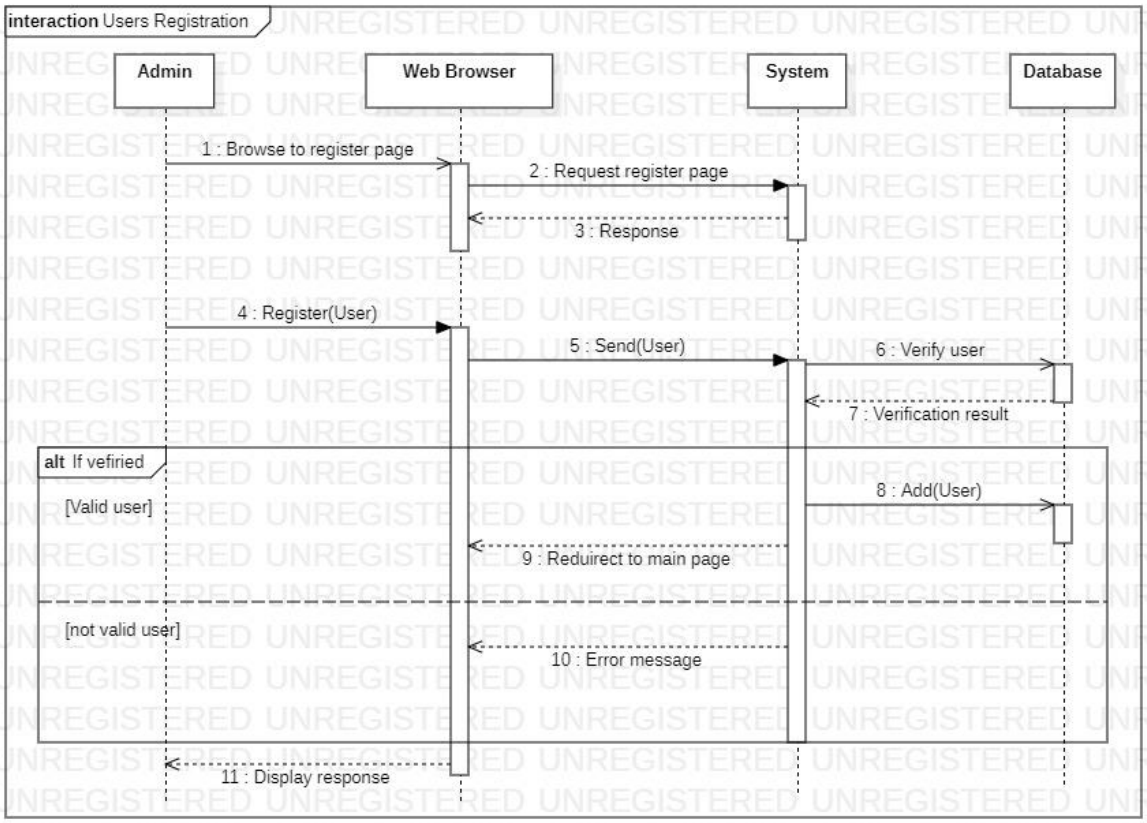

Figure 3. 23: Sequence diagram of registering

Name: Registering

Objective: Users register by an admin account.

Actors: Admin

Pre-condition:

- Admin must be authenticated (Log in).

Nominal scenario:

1. Admin enters to the register page.
2. The system displays the register page.
3. Admin fills the registration form and sends it to the system.
4. The system checks the information sent from the Admin, create a new user (account), and redirect to the Employees page.

Post-condition:

- Successful: the creation of a User (account), updating the database.
- Failure: return to the registration page.

Extensions:

- Required fields not filled: the system asks to fill the empty fields.
- Invalid input, an error message displays.

3.3.2 Sequence diagram for Appointment:

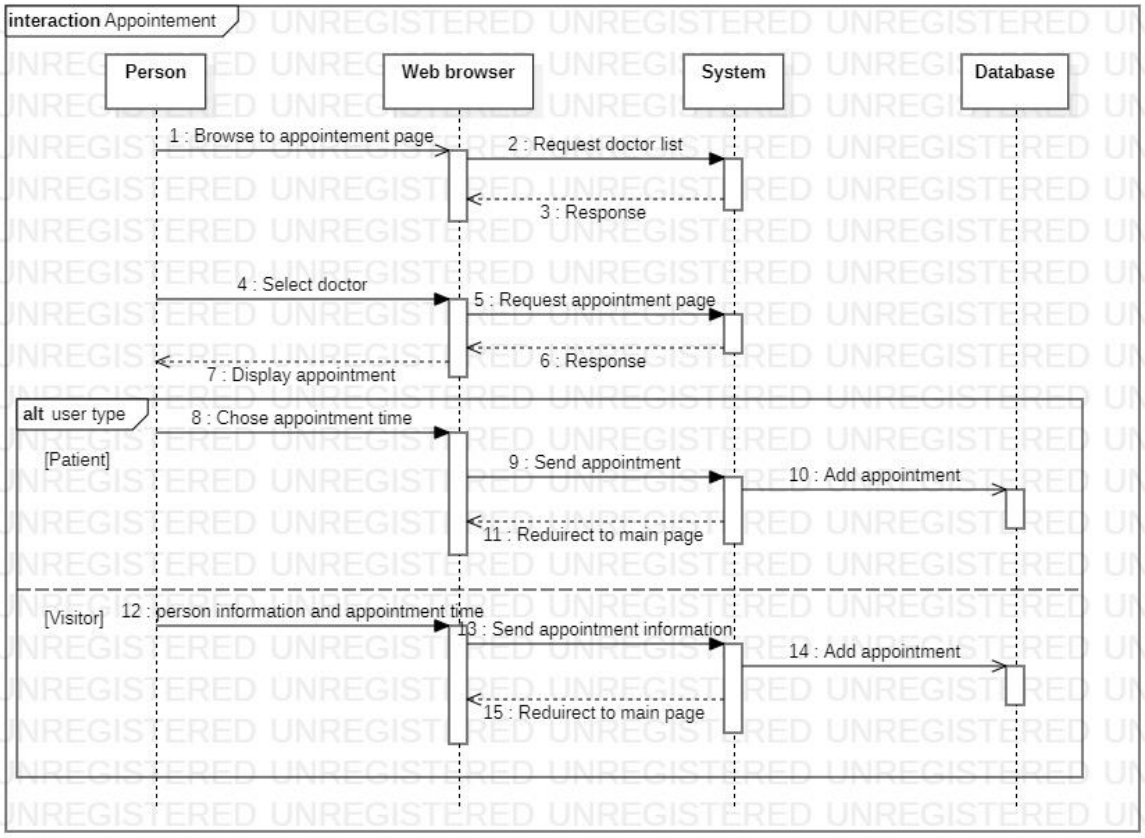

Figure 3. 24: Sequence diagram of appointment

Name: Appointment

Objective: The person makes an appointment to a specific doctor.

Actors: Person (Visitor, Patient)

Pre-condition:

- User must be in the target clinic

Nominal scenario:

1. User browses to the appointment page
2. The system displays the list of available doctors
3. The user selects the doctor
4. If the user logged in as a patient, he must enter the appointment date only elsewhere he has to enter its personal information too and send it

5. If the information is valid the system redirects to the appointment page

Post-condition:

- Successful: the creation of an Appointment, updating the database.
- Failure: return to the Appointment page.

Extensions:

- Required fields not filled: the system asks to fill the empty fields.
- Invalid input, an error message displays.

3.3.3 Sequence diagram for send patient progress:

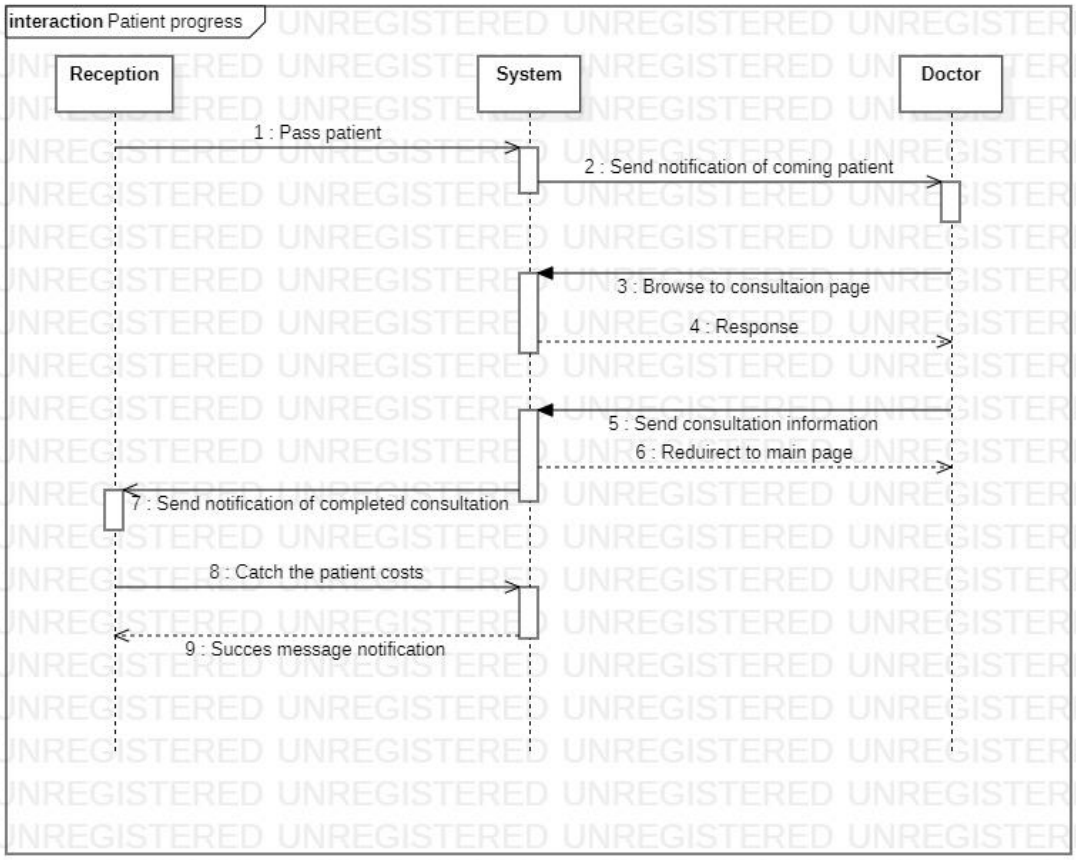

Figure 3. 25: Sequence diagram of patient progress

Name: patient progress.

Objective: Send the patient form Receptionist to the doctor.

Actors: Receptionist, Doctor.

Pre-condition:

- The receptionist must be authenticated (Log in).
- The doctor must be authenticated (Log in).
- The patient must have a booking.

Nominal scenario:

1. Receptionist pass patient from the list of booking
2. The system sends a notification to the target doctor telling that a new patient has come
3. Doctor browse to consultation page to consult the patient
4. After the doctor is done the system sends a notification to the receptionist contain a message of a patient completes its consultation and contain the costs
5. The receptionist catches to costs of the coming patient

Post-condition:

- Successful: Send the patient, updating the database.
- Failure: return to the Dashboard page.

3.4 Application's behavior by Activity diagrams:

3.4.1 Signup of clinic Activity diagram:

To sign up as a clinic, in the application, the client must enter his true personal information and the proper documents of the clinic, then if the application administrator accepts the request, the clinic profile will be created and an acceptance email will be sent to the client.

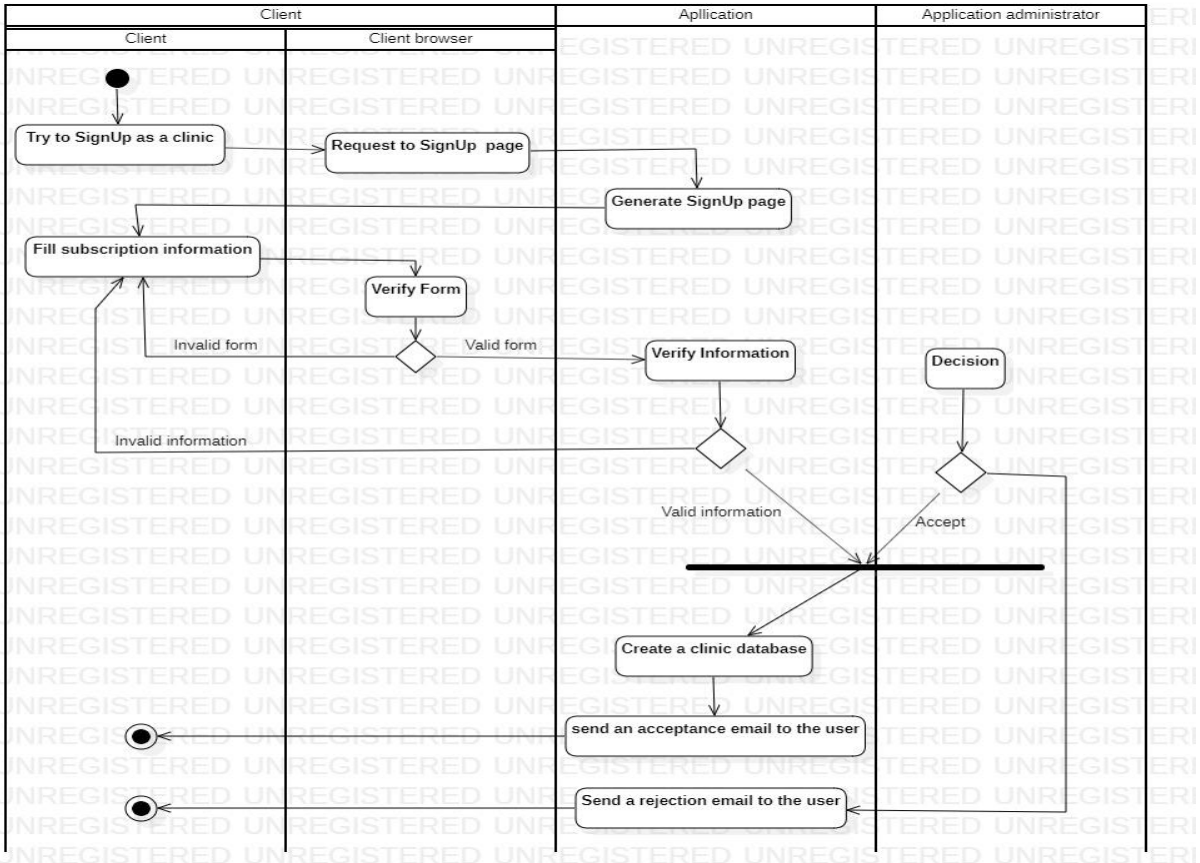

Figure 3. 26: Activity diagram of clinic subscription

3.4.2 Consultation Activity diagram:

After notification comes to the doctor, he goes to the consultation page and examines the patient and creates an electronic prescription or sends him to make an analysis before. After that, the doctor save the consultation and the application notifies the receptionist

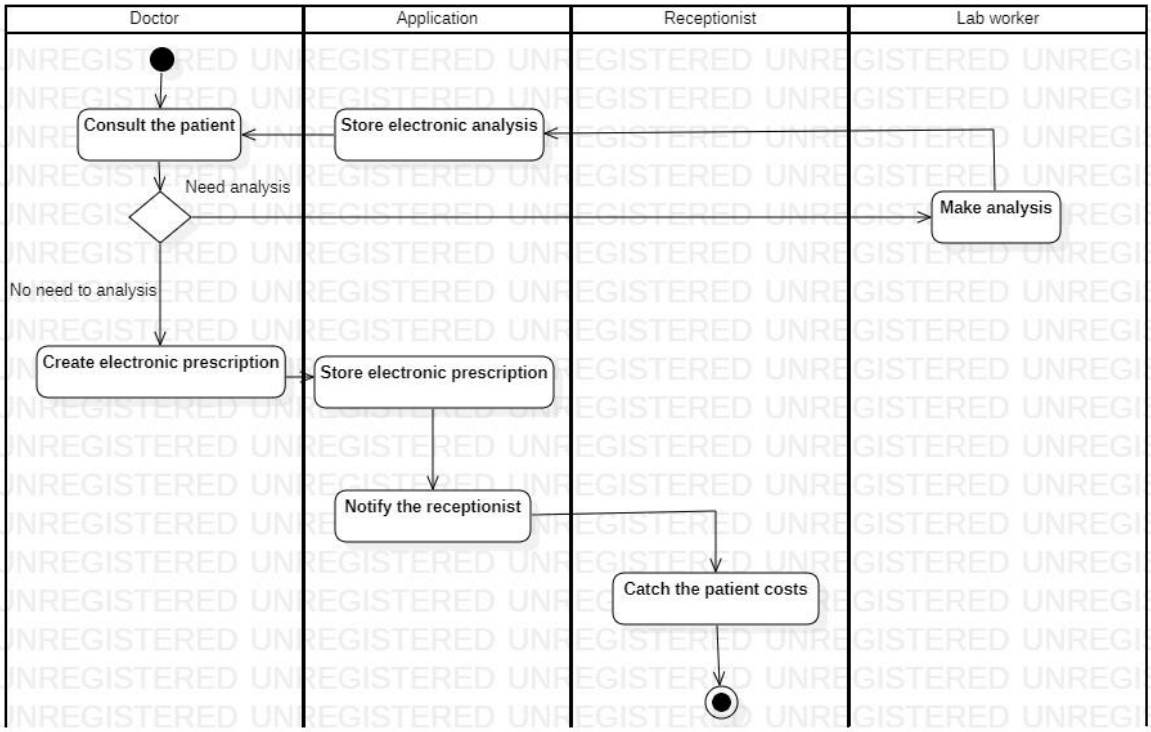

Figure 3. 27: Activity diagram of consultation

3.4.3 Analysis process Activity diagram:

The receptionist passes the patient to make an analysis, and the application will notify the lab worker. The lab worker creates an electronic analysis and prints it, the application then notifies the receptionist again.

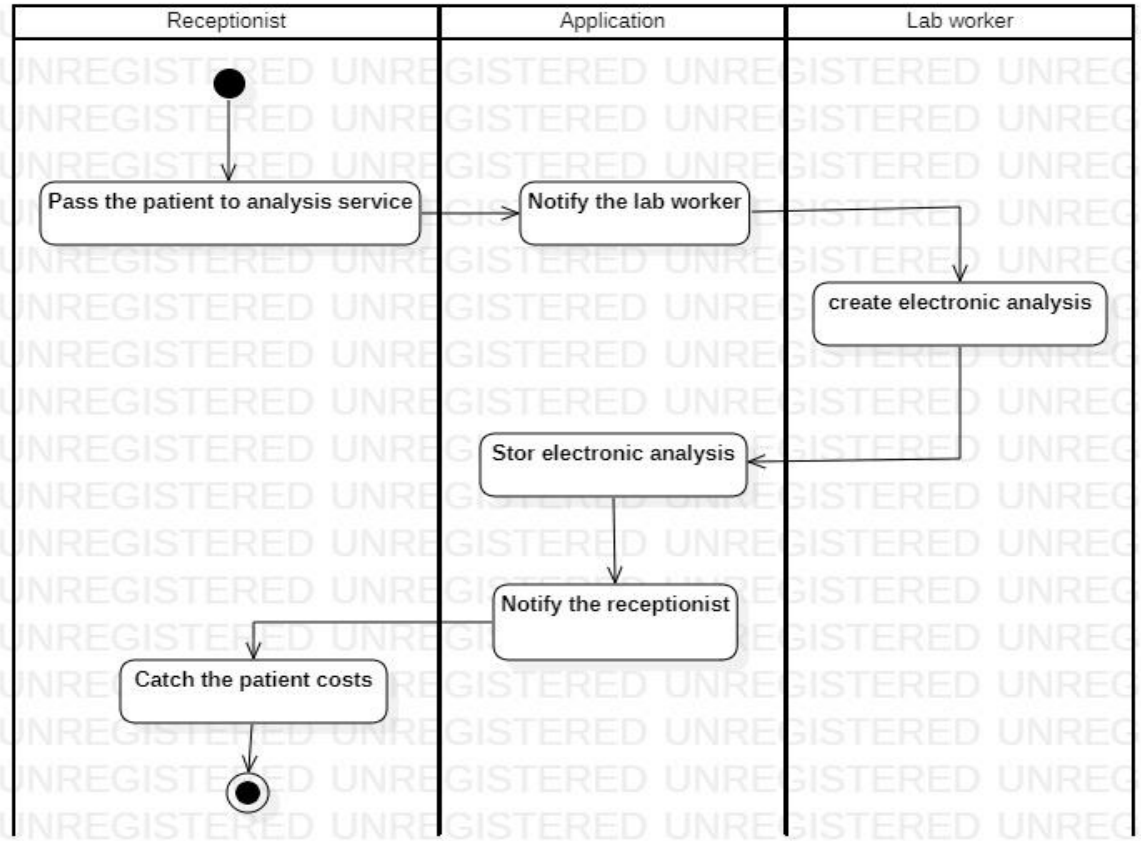

Figure 3. 28: Activity diagram of the analysis process

3.5 Deployment diagrams:

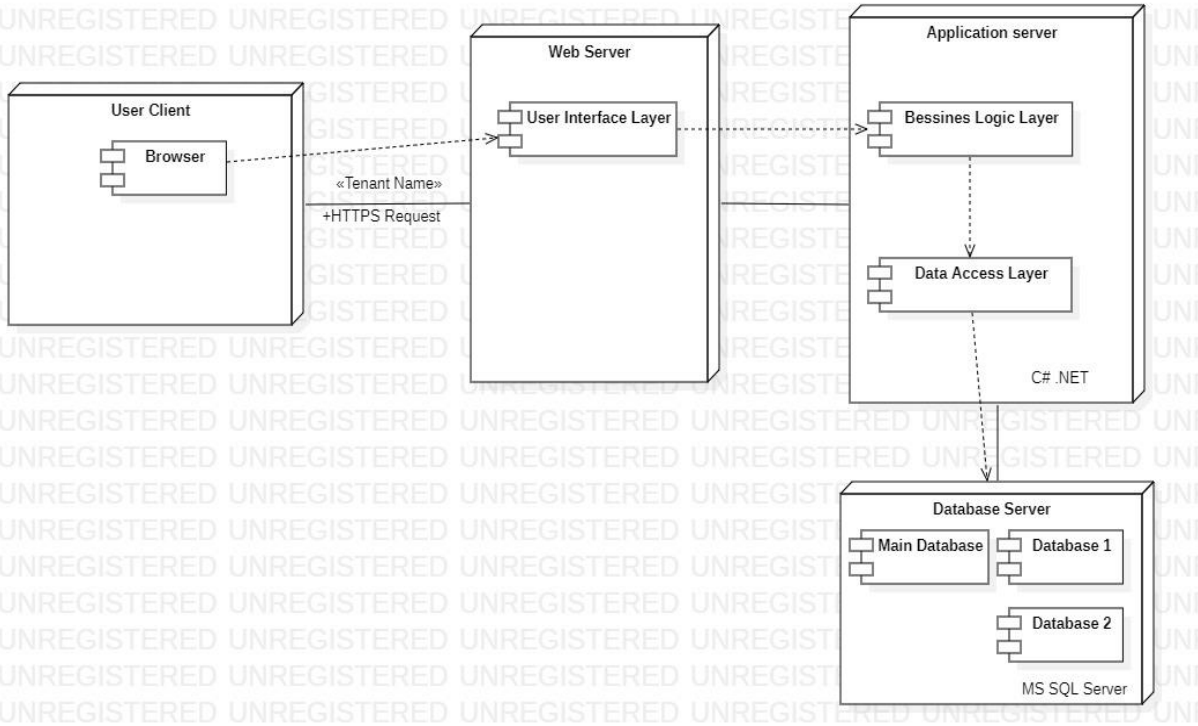

Figure 3. 29: Deployment diagram

- User client: the resource requester by web browser either by a computer operating system or by the mobile operating system.
- A web server accepts and fulfills requests from clients for static content (i.e., HTML pages, files, images, and videos) from a website. Web servers handle HTTP requests and responses only.
- An application server exposes business logic to the clients, which generates dynamic content
- Database server used to provide database services like storing, processing and securing data

4. Conclusion:

In this chapter, we followed a modeling process to develop our application, based on the UML language, we chose the main structural and dynamic diagrams such as use case diagram, class diagram, sequence diagram, activity diagram, and ending with a deployment diagram.

CHAPTER 4: IMPLEMENTATION AND REALIZATION

1. Introduction:

This chapter is the last part of this thesis, it deals with the description of the environment, the programming languages, the development tools used for its realization, and an overview of the work done in terms of screenshots.

2. Presentation of the development tools:

2.1. Visual Studio 2019 :

"The Visual Studio integrated development environment is a creative launching pad that you can use to edit, debug, and build code, and then publish an app. An integrated development environment (IDE) is a feature-rich program that can be used for many aspects of software development. Over and above the standard editor and debugger that most IDEs provide, Visual Studio includes compilers, code completion tools, graphical designers, and many more features to ease the software development process".[8]

2.2. C# language:

"C# (pronounced "See Sharp") is a simple, modern, object-oriented, and type-safe programming language. C# has its roots in the C family of languages and will be immediately familiar to C, C++, and Java programmers. C# is standardized by ECMA International as the **ECMA-334** standard and by ISO/IEC as the **ISO/IEC 23270** standard".[9]

2.3. Entity Framework:

"Entity Framework is a modern object-database mapper for .NET. It supports LINQ queries, change tracking, updates, and schema migrations. EF works with many databases, including SQL Database (on-premises and Azure), SQLite, MySQL, PostgreSQL, and Azure Cosmos DB".[10]

"Entity Framework introduced the Code-First approach with Entity Framework 4.1. Code-First is mainly useful in Domain-Driven Design. In the Code-First approach, you focus on the domain of your application and start creating classes for your domain entity rather than design your database first and then create the classes which match your database design. The following figure illustrates the code-first approach".[11]

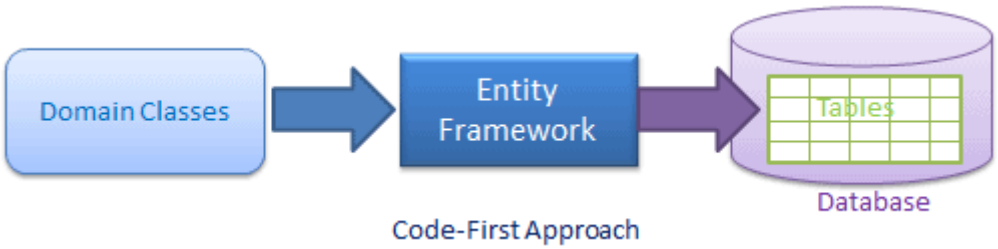

Figure 4. 1: Code-First approach with Entity Framework

2.4. SQL Server:

"SQL Server is a relational database management system, or RDBMS, developed and marketed by Microsoft.

Similar to other RDBMS software, SQL Server is built on top of SQL, a standard programming language for interacting with the relational databases. SQL Server is tied to Transact-SQL, or T-SQL, the Microsoft's implementation of SQL that adds a set of proprietary programming constructs.

SQL Server works exclusively on Windows environment for more than 20 years. In 2016, Microsoft made it available on Linux. SQL Server 2017 became generally available in October 2016 that ran on both Windows and Linux".[12]

1.13 ASP.net

".NET is a developer platform made up of tools, programming languages, and libraries for building many different types of applications. ASP.NET extends the .NET developer platform with tools and libraries specifically for building web apps".[13]

2.5. IIS:

"Internet Information Services (IIS) for Windows® Server is a flexible, secure and manageable Web server for hosting anything on the Web. From media streaming to web applications, IIS's scalable and open architecture is ready to handle the most demanding tasks".[14]

2.6. MVC (Model-view-controller):

"MVC is a design pattern used to decouple user-interface (view), data (model), and application logic (controller). This pattern helps to achieve separation of concerns.

Using the MVC pattern for websites, requests are routed to a Controller that is responsible for working with the Model to perform actions and/or retrieve data. The Controller chooses the View to display, and provides it with the Model. The View renders the final page, based on the data in the Model".[15]

2.7. SignalR:

"ASP.NET SignalR is a library for ASP.NET developers that simplifies the process of adding real-time web functionality to applications. Real-time web functionality is the ability to have server code push content to connected clients instantly as it becomes available, rather than having the server wait for a client to request new data".[16]

2.8. HTML:

"HTML (Hypertext Markup Language) is a text-based approach to describing how content contained within an HTML file is structured. This markup tells a web browser how to display text, images and other forms of multimedia on a webpage".[17]

2.9. CSS:

"Cascading Style Sheets, most of the time abbreviated as **CSS**, is a stylesheet language used to describe the presentation of a document written in HTML or XML (including various XML languages like SVG or XHTML). CSS describbes how the structured element must be rendered on screen, on paper, in speech, or on other media".[18]

2.10. Bootstrap:

"the world's most popular front-end open source toolkit, featuring Sass variables and mixins, responsive grid system, extensive prebuilt components, and powerful JavaScript plugins".[19]

2.11. JavaScript:

"JavaScript (JS) is a lightweight, interpreted, object-oriented language with first-class functions, and is best known as the scripting language for Web pages, but it's used in many non-browser environments as well. It is a prototype-based, multi-paradigm scripting language that is dynamic, and supports object-oriented, imperative, and functional programming styles. JavaScript runs on the client side of the web, which can be used to design / program how the web pages behave on the occurrence of an event. JavaScript is an easy to learn and also powerful scripting language, widely used for controlling web page behavior".[20]

2.12. jQuery;

"jQuery is a fast, small, and feature-rich JavaScript library. It makes things like HTML document traversal and manipulation, event handling, animation, and Ajax much simpler with an easy-to-use API that works across a multitude of browsers. With a combination of versatility and extensibility, jQuery has changed the way that millions of people write JavaScript".[21]

2.13. AJAX:

"Ajax (Asynchronous JavaScript and XML) is a method of building interactive applications for the Web that process user requests immediately. Ajax combines several programming tools including JavaScript, dynamic HTML (DHTML), Extensible Markup Language (XML), cascading style sheets (CSS), the Document Object Model (DOM), and the Microsoft object, XMLHttpRequest".[22]

2.14. JSON:

"JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language Standard ECMA-262 3rd Edition - December 1999. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language".[23]

2.15. Bitbucket:

"Bitbucket is Git repository management solution designed for professional teams. It gives a central place to manage git repositories, collaborate on your source code and guide you through the development flow. It provides awesome features that include:

- **Acces control** to restrict access to your source code.
- **Workflow control** to enforce a project or team workflow.
- **Pull requests** with in-line commenting for collaboration on code review.
- **Jira integration** for full development traceability.
- **Full Rest API** to build features custom to your workflow if they are not already available from our **Marketplace**".[24]

2.16. Sourcetree:

"Sourcetree simplifies how you interact with your Git repositories so you can focus on coding. Visualize and manage your repositories through Sourcetree's simple Git GUI".[25]

2.17. Syncfusion:

"Syncfusion is a software development company based in Morrisville, North Carolina that creates software components and tools for the Microsoft .NET platform, including user interfaces and reporting tools for developers on desktop, mobile, and web platforms".[26]

2.18. StarUML:

"StarUML is modeling software that runs on Windows with an open source license and supports the Unified Modeling Language (UML) modeling notation. Based on UML version 1.4, StarUML allows using eleven different types of diagram, accepting UML 2.0 notation. It supports actively the Model Driven Architecture (MDA) approach implementing the UML profile concept and allowing to generate code for Java, C# or C++".[27]

3. Security:

Web application security is the process of securing confidential data stored online from unauthorized access and modification. This is accomplished by enforcing stringent policy measures.

bellow some used technics in our application.

3.1. Authentication:

Authentication is the process of obtaining identification credentials such as username and password from a user and validating those credentials against some authority. If the credentials are valid, the entity that submitted the credentials is considered an authenticated identity. Once a user has authenticated, a system can decide if the user is authorized to continue. Without knowing who a user is, authorization cannot take place.

```
[Authorize]
public class ProfileEmployeeController : ApplicationController
{
        ...
}
```

3.2. Authorization:

Authorization determines whether an identity should be granted access to a specific resource.

Here is an example :

```
[Authorize(Role = "Patient, Admin")]
public class PatientController : ApplicationController
{
        ...
}
```

3.3. Anti XSS (Cross Site Scripting)

In ASP.NET MVC the users are not allowed to post scripts and HTML code by default.

3.4. CSRF (Cross Site Request Forgery)

In Asp.net mvc the developer can prevent this attack by Puting a user-specific token as a hidden field in submit forms, and check that the right value was submitted. The user requests an HTML page that contains a submit form,the developer include two tokens in the response. One token is sent as a cookie, the other is placed in a hidden form field. The tokens are

generated randomly so that an adversary cannot guess the values. When the user submits the form, it must send both tokens back to the server (The browser automatically does this when the user submits the form.). If a request does not include both tokens, the server disallows the request.

In MVC we use the AntiForgeryToken to achieve this mission:

```
@using (Html.BeginForm("Login", "Account", FormMethod.Post, new { @class = "form-h
orizontal", role = “form”}))
{
  @Html.AntiForgeryToken()
   ...}
```

```
▼<form action="/Account/Login/loginLink" class="form-horizontal" id="form0"
method="post" role="form">
    <input name="__RequestVerificationToken" type="hidden" value=
    "0Fo8hEjzigjLplUCCdxYHGjVeUMXq83-
    w1lUlEsK4JqTdeuH_3fIIdrxq3YTZrTNkGjfETF_29OhSlc1Yd-
    mIYh4zGTloy7yyqq90cOBlu41"> == $0
```

Figure 4. 2: The generated Anti Forgery Token

3.5. Cookie Stealing:

To prevent cookie stealing you must apply the SSL certificate that only allows HTTPS requests.

```
1   using System.Web;
2   using System.Web.Mvc;
3
4   namespace ClinicManagementSystem
5   {
        1 reference
6       public class FilterConfig
7       {
            1 reference
8           public static void RegisterGlobalFilters(GlobalFilterCollection filters)
9           {
10              filters.Add(new HandleErrorAttribute());
11
12              filters.Add(new RequireHttpsAttribute());
13          }
14      }
15  }
16
```

Figure 4. 3: Configure HTTPS protocol

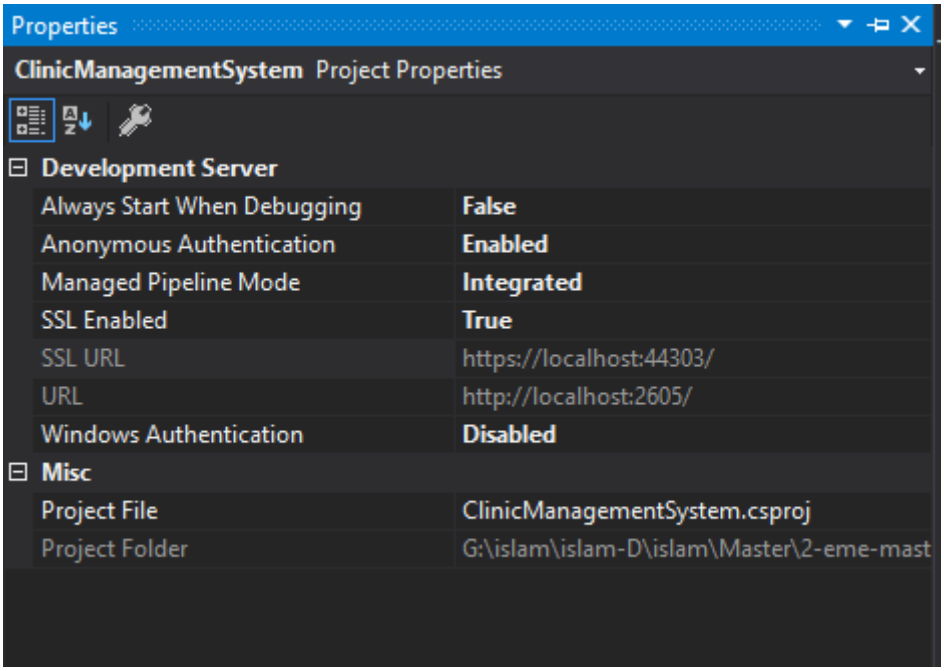

Figure 4. 4: Enable SSL certificate

3.6. Preventing Open Redirection Attacks:

We can take advantage of the changes in ASP.NET MVC 4 & 5, a new method was added to validate before redirecting the URL, the method is called "RedirectToLocal". Whenever we redirect the user to any URL in the MVC application, we must check that Url is local or not. If not, we must raise an exception that an open redirection attack was attempted.

In MVC5, the AccountController Login method has:

```
return RedirectToLocal(returnUrl);
```

3.7. Blocking Brute Force Attacks:

A brute-force attack is an attempt to discover a password by systematically trying every possible combination of letters, numbers, and symbols until you discover the one correct combination that works.

To prevent this type of attack the user account locked after a specific number of login attempts which are 5 attempts.

```
63          // Configure user lockout defaults
64          manager.UserLockoutEnabledByDefault = true;
65          manager.DefaultAccountLockoutTimeSpan = TimeSpan.FromMinutes(5);
66          manager.MaxFailedAccessAttemptsBeforeLockout = 5;
```

Figure 4. 5: The method followed to prevent Brute Force attack

3.8. File Upload Protection:

To prevent the attackers from uploading malicious files, you need to implement the following steps:

- The file to be uploaded should be validated against white-list extensions.
- Restrict the maximum file size.
- Disallow uploading executable files.

```
341             string fileName = null;
342             if (PhotoFile != null)
343             {
344                 if (PhotoFile.ContentLength > 0 && PhotoFile.ContentLength < 10485760)
345                 {
346                     string extension = Path.GetExtension(PhotoFile.FileName);
347                     if (extension == ".jpg" || extension == ".png" || extension == ".gif" || extension == ".jpeg")
348                     {
349                         fileName = Path.GetFileNameWithoutExtension(PhotoFile.FileName);
350                         fileName = fileName + DateTime.Now.ToString("yymmssfff") + extension;
351                         string path = Path.Combine(Server.MapPath("~/Image/EmployeePhoto/"), fileName);
352                         PhotoFile.SaveAs(path);
353                     }
354                 }
355             }
```

Figure 4. 6: The method followed to prevent File Upload attack

4. Presentation of the system (Presentation of the application):

The home page contains two option of sign up as new clinic or sign in as a user, and present all the registered clinics, each one shown with a description and button that redirect to clinic's profile.

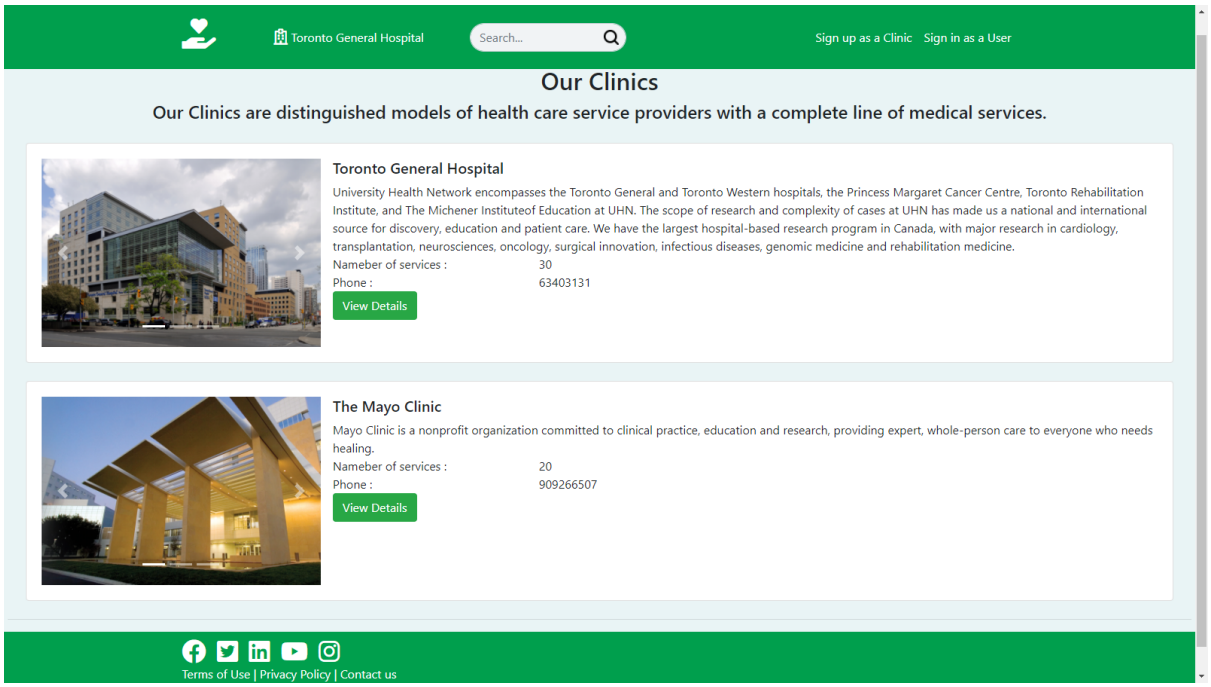

Figure 4. 7: Home page.

On the registration page, the user must provide his personal information and the name of his clinic attached to clinic ownership documents and identity documents.

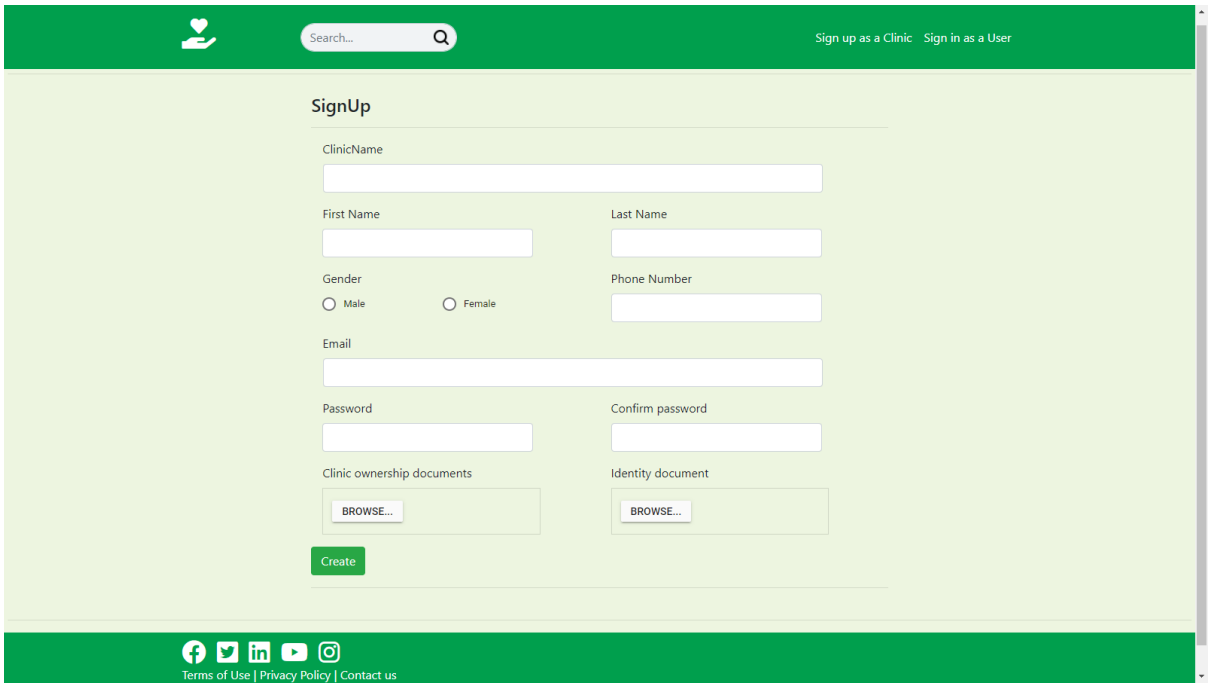

Figure 4. 8: Sign Up for the clinic.

The page contains three input fields for the clinic name, username, and password with the option to remember the user, as well as showing all the clinics that the user has logged into before.

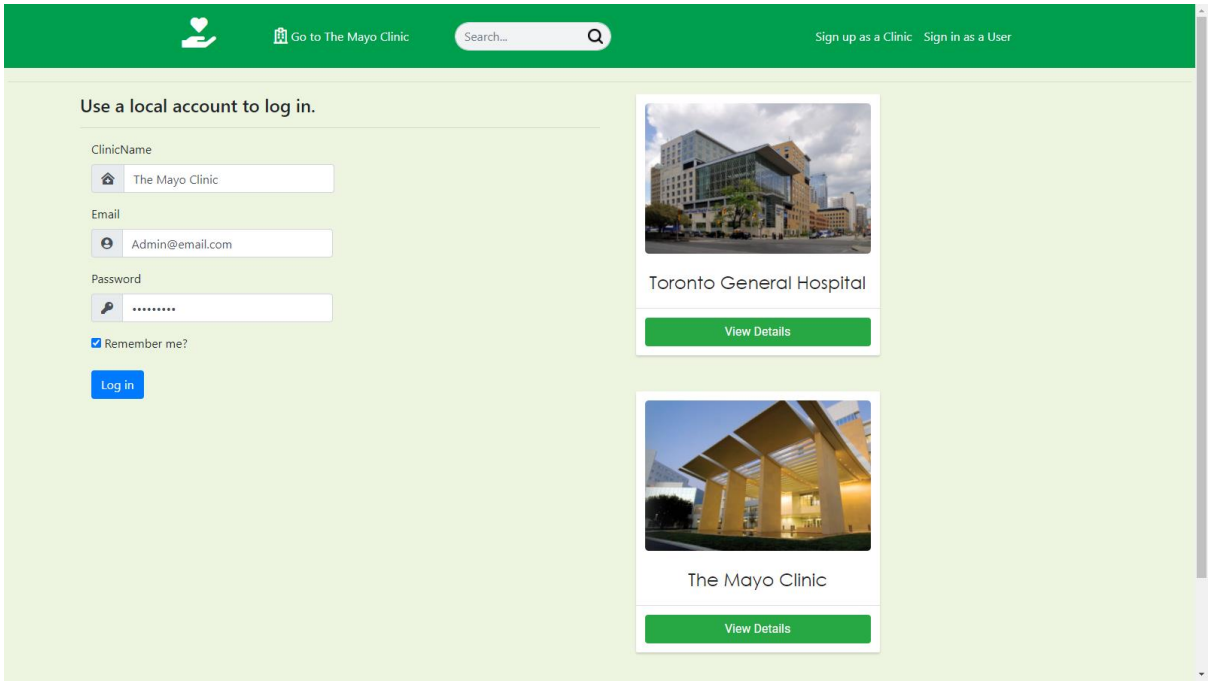

Figure 4. 9: Login page.

The user can reach this page after visiting a clinic profile, in this page the user enters his username and password only to logging into the currently visited clinic.

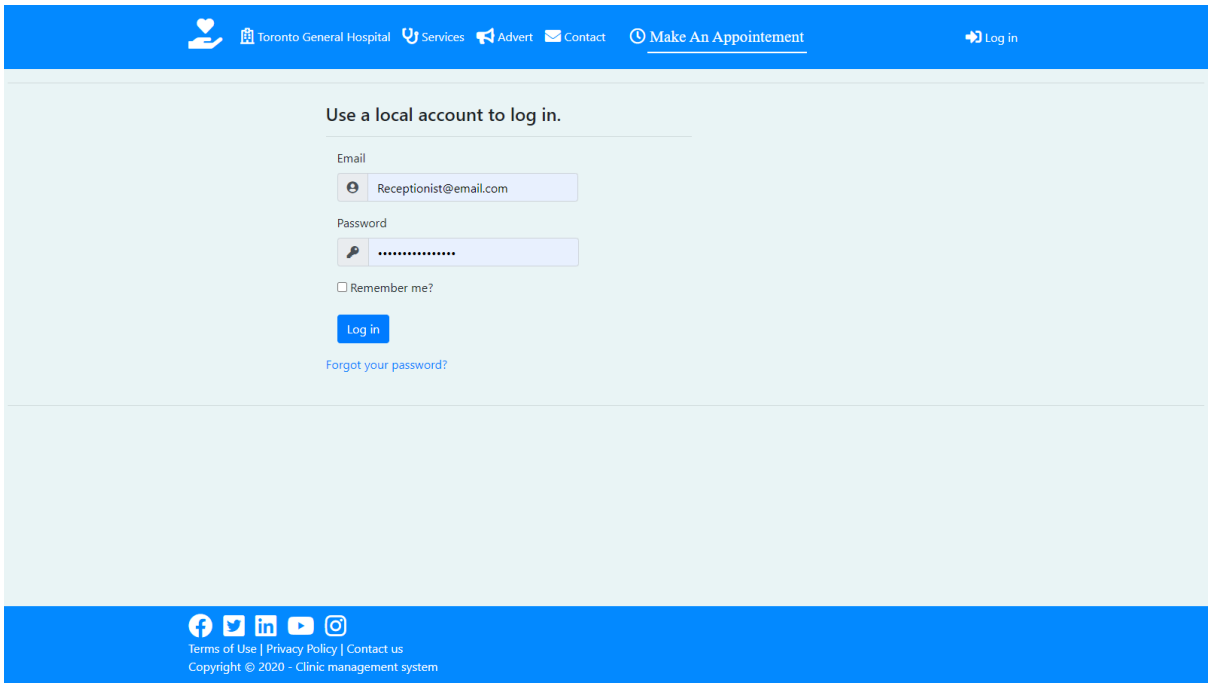

Figure 4. 10: Login page after the user visit the clinic profile.

The clinic profile is the first shown page when a user visits the clinic contains the clinic photos, description, existing services, doctors, advertising, and the location on the map. also, there is a navigation bar fixed in the top contain the name of the visited clinic, services, advert, contact, make an appointment, and log in.

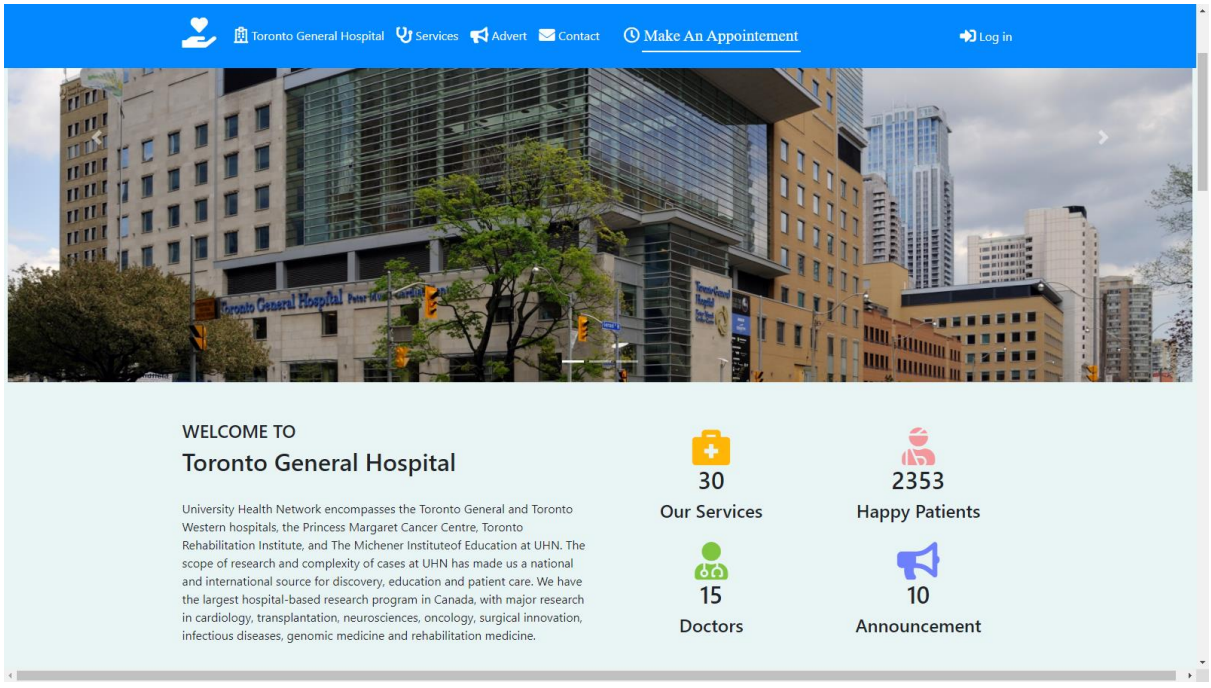

Figure 4. 11: Clinic profile – description.

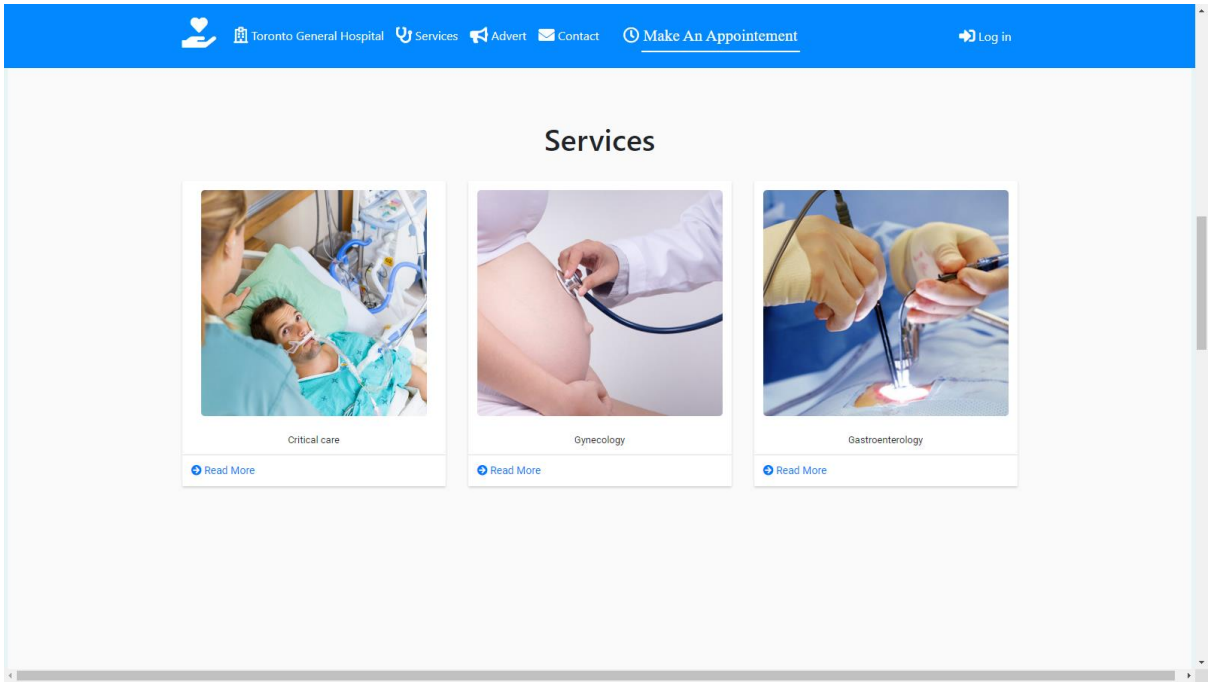

Figure 4. 12: Clinic profile – services.

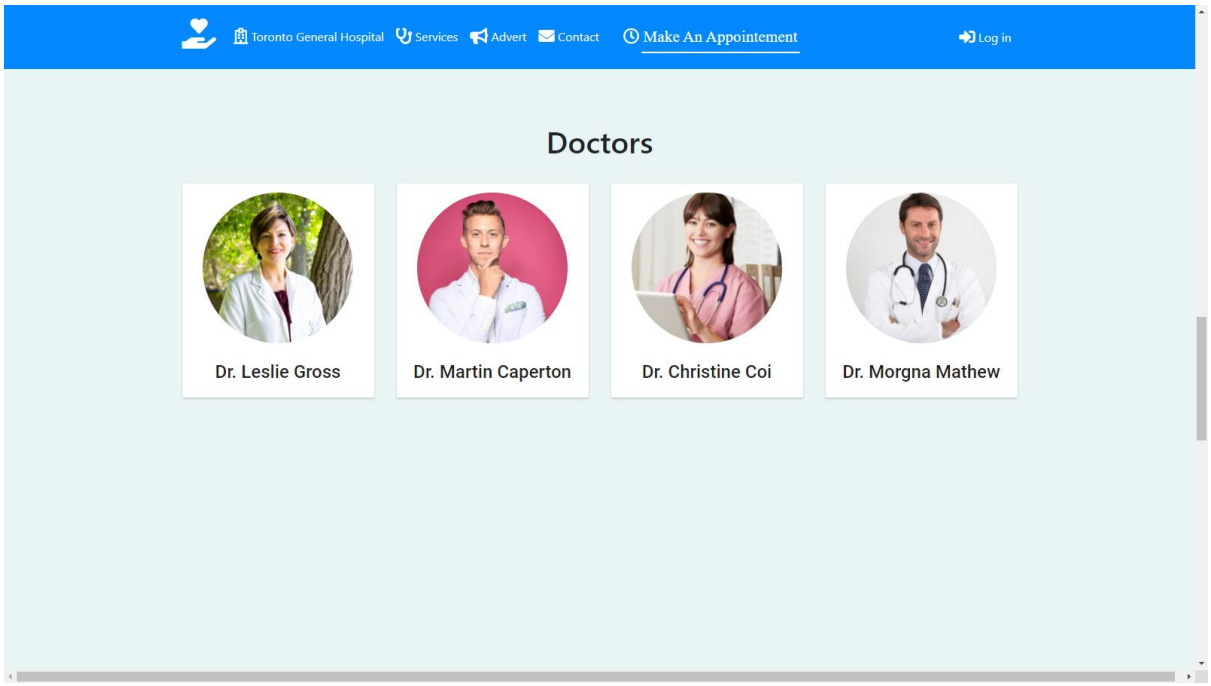

Figure 4. 13: Clinic profile – doctors.

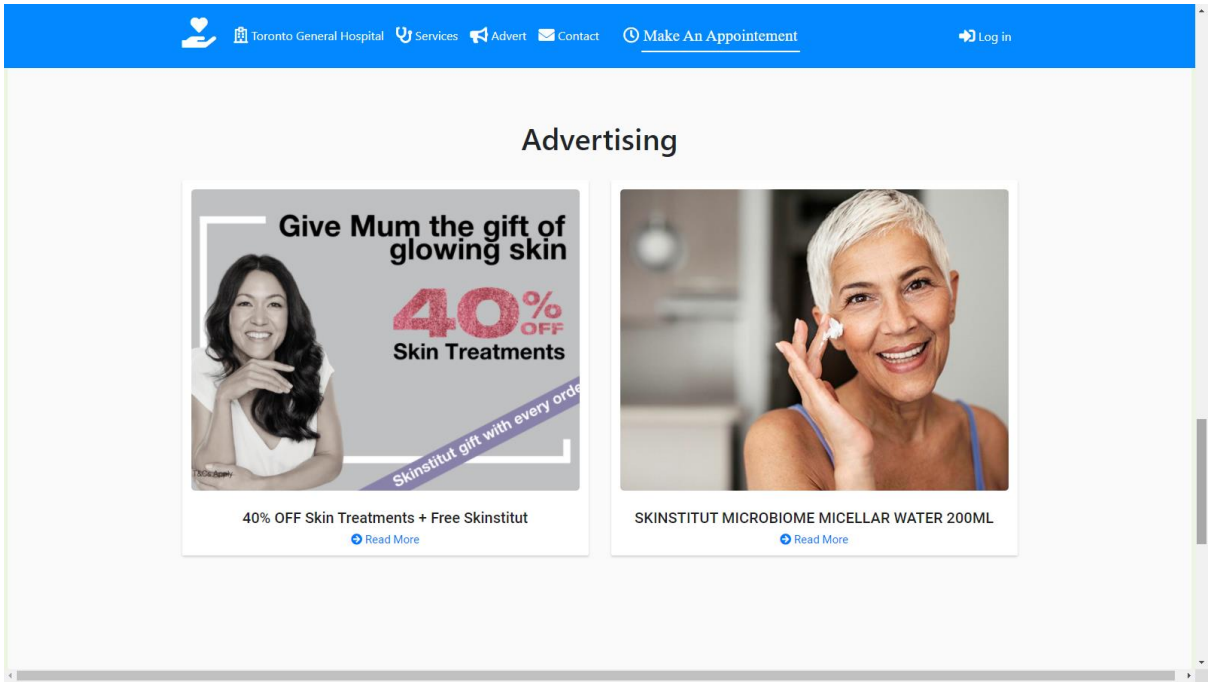

Figure 4. 14: Clinic profile – Advertising.

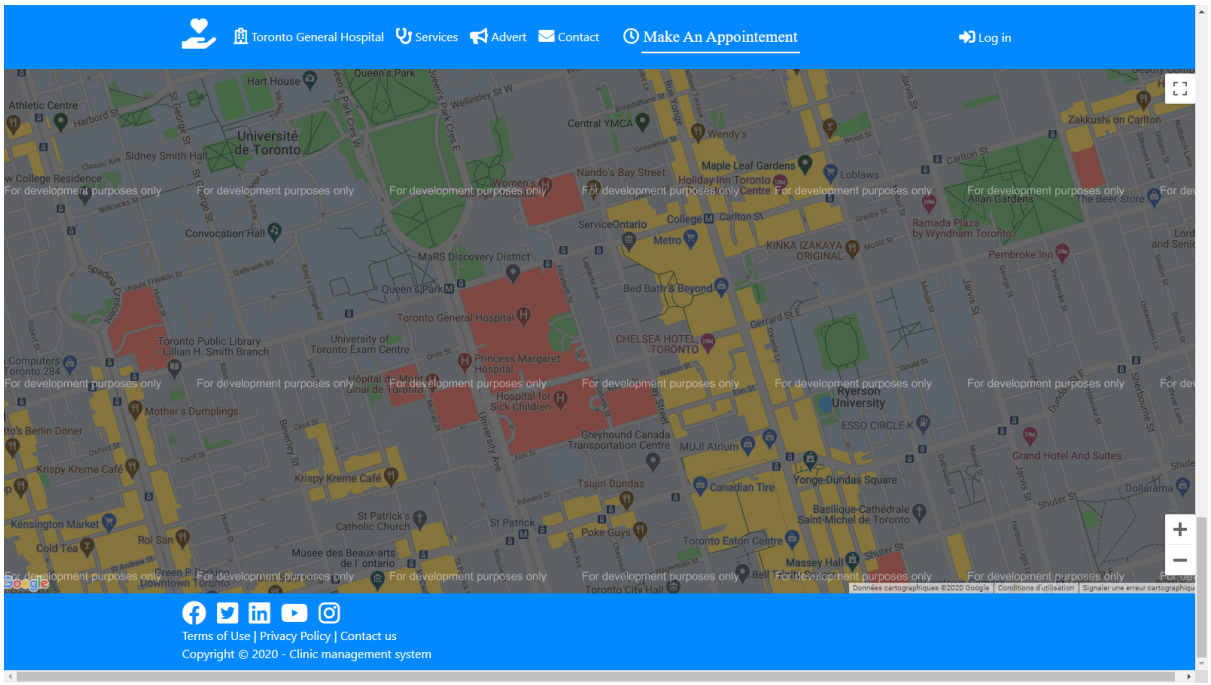

Figure 4. 15: Clinic profile – map.

The dashboard is the page that shown after the admin logged in, present the statistic of the services number, patients number, doctors number, the number of the advertising, and also present a chart of the number of patients treated in the year.

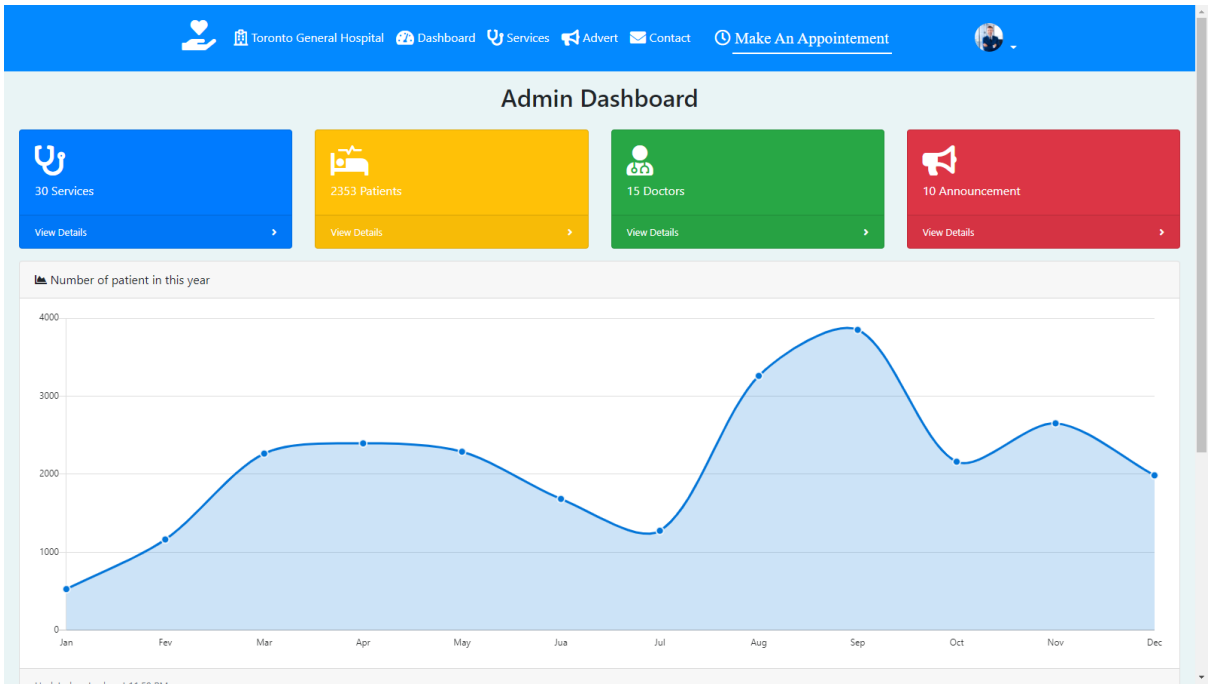

Figure 4. 16: Admin dashboard.

The user profile page shows all the necessary information of the user in a simple and easy design with an edit option.

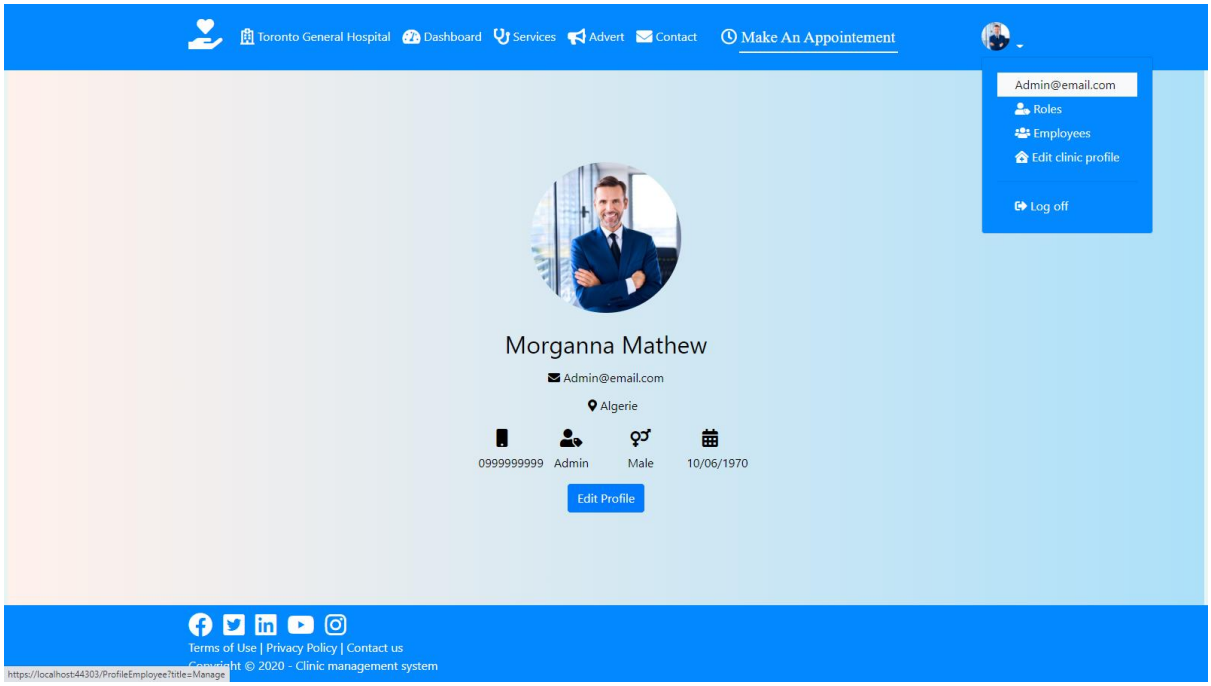

Figure 4. 17: User profile.

On this page, the user can edit any information including personal information, password, profile picture beside to confirm the email after change it.

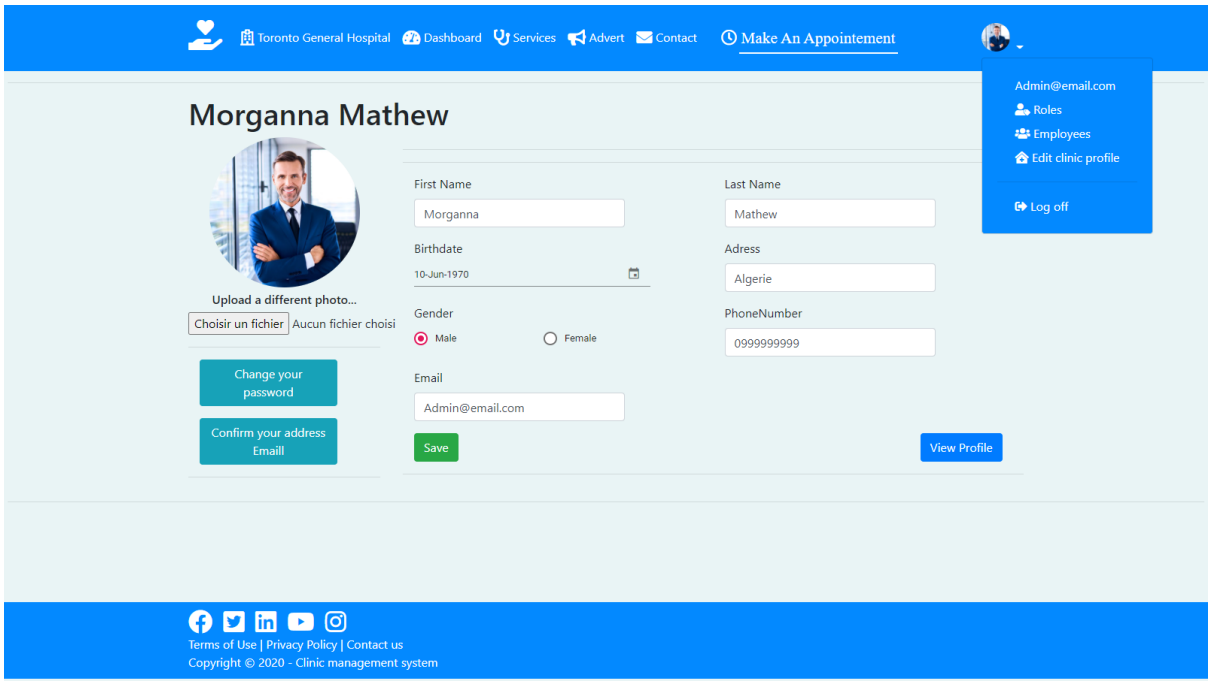

Figure 4. 18: Edit user profile.

This page lets the user edit the clinic profile such as description, email, phone, location coordinates, and name.

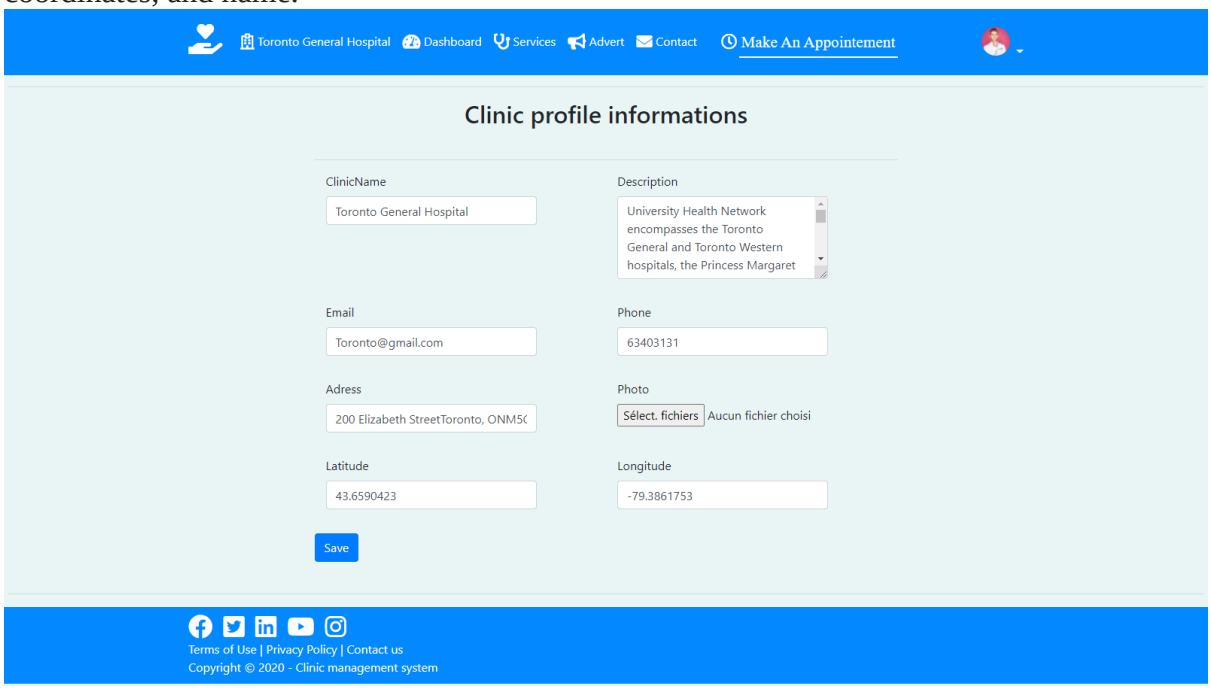

Figure 4. 19: Edit clinic profile

This page shows all the existing services in the clinic with edit, deletes, and create options by the admin.

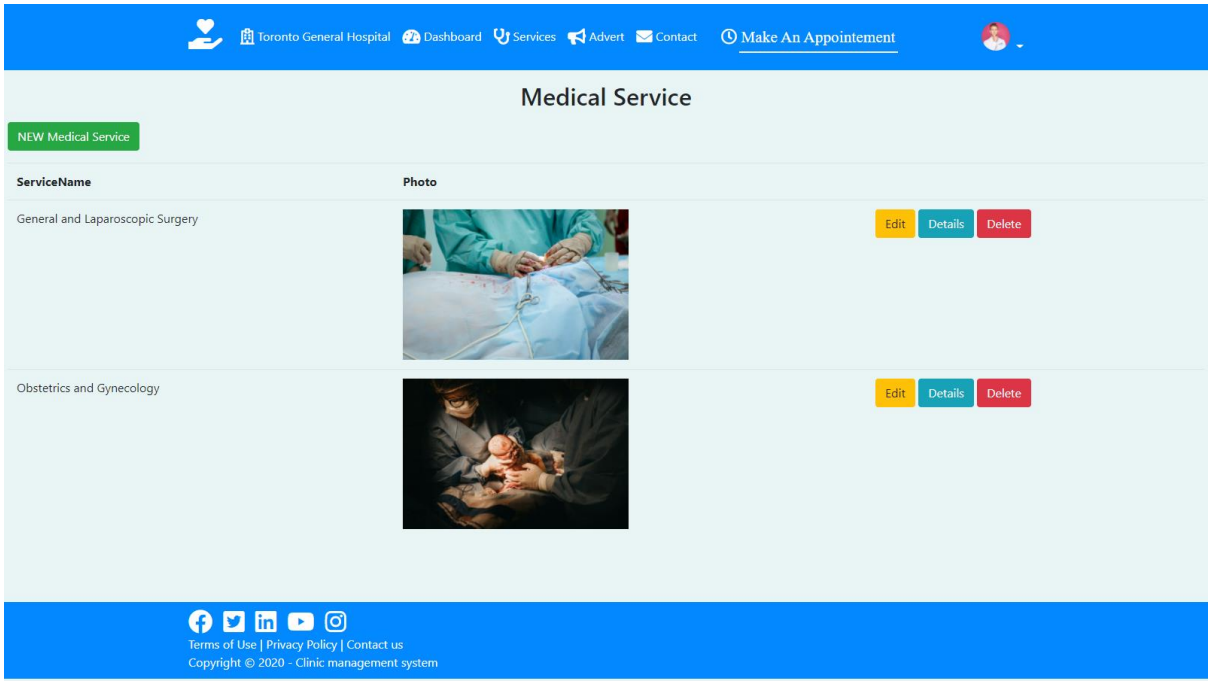

Figure 4. 20: Medical Service Index.

The admin can create a new medical service by entering the medical service name, the description, and photos.

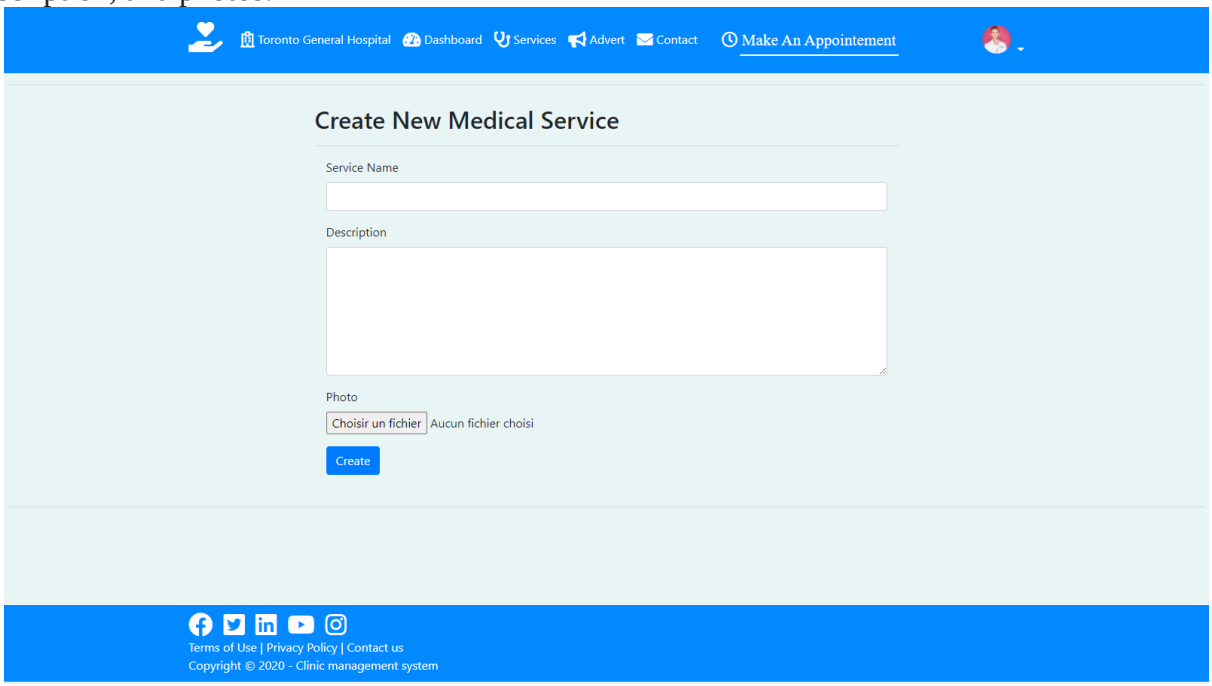

Figure 4. 21: Create a new medical service.

This page shows all the existing advertising in the clinic with edit, delete, and create options by the admin.

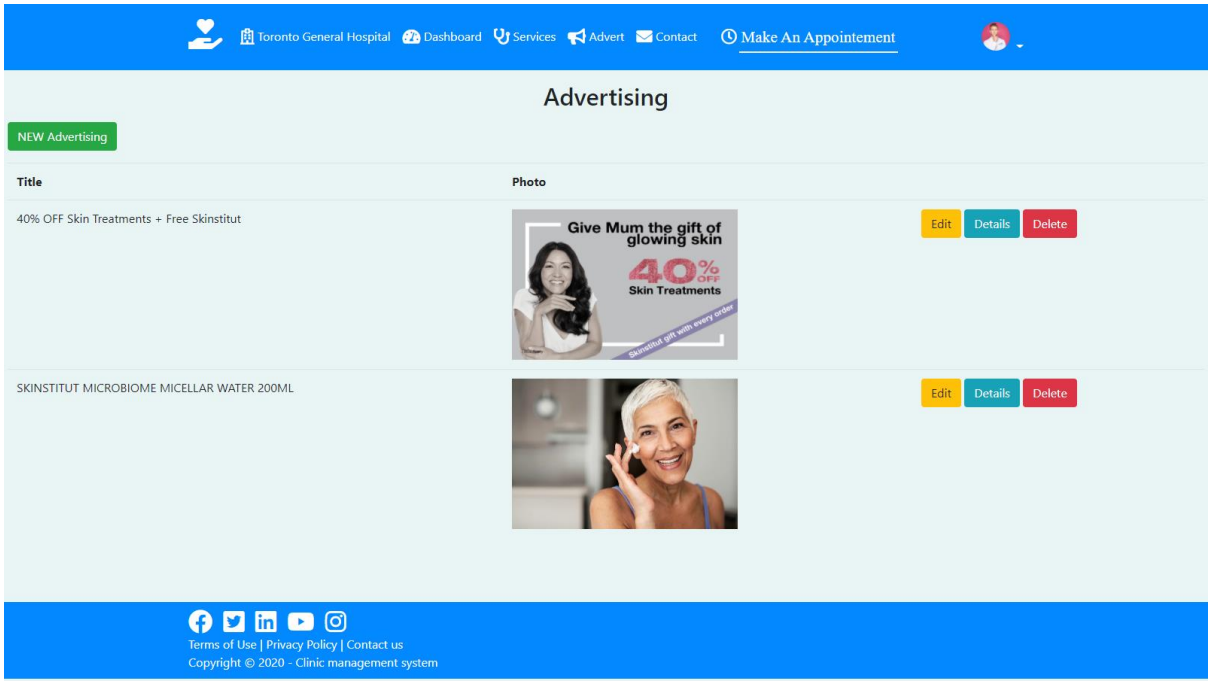

Figure 4. 22: Advertising index.

In addition to the information that exists in the advertising index, advertising details also show the description of the advertising.

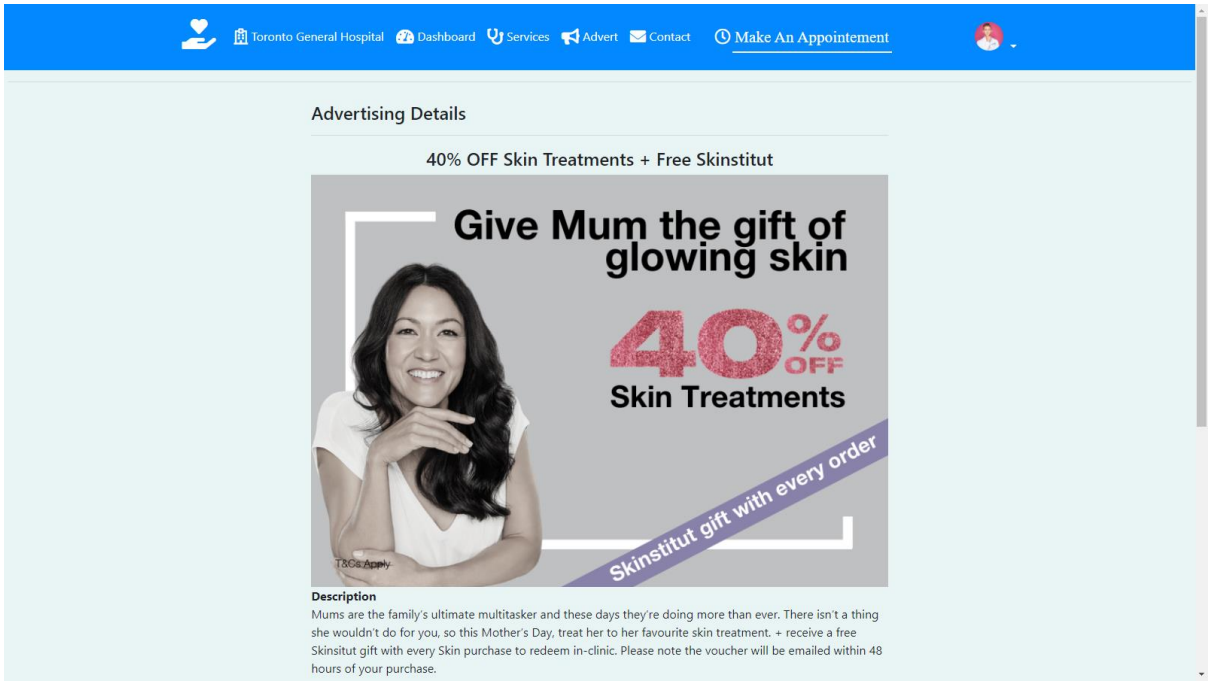

Figure 4. 23: Advertising details.

In this page the admin can view all the employees of the clinic including their information, the admin also can add, edit, delete, and search for users.

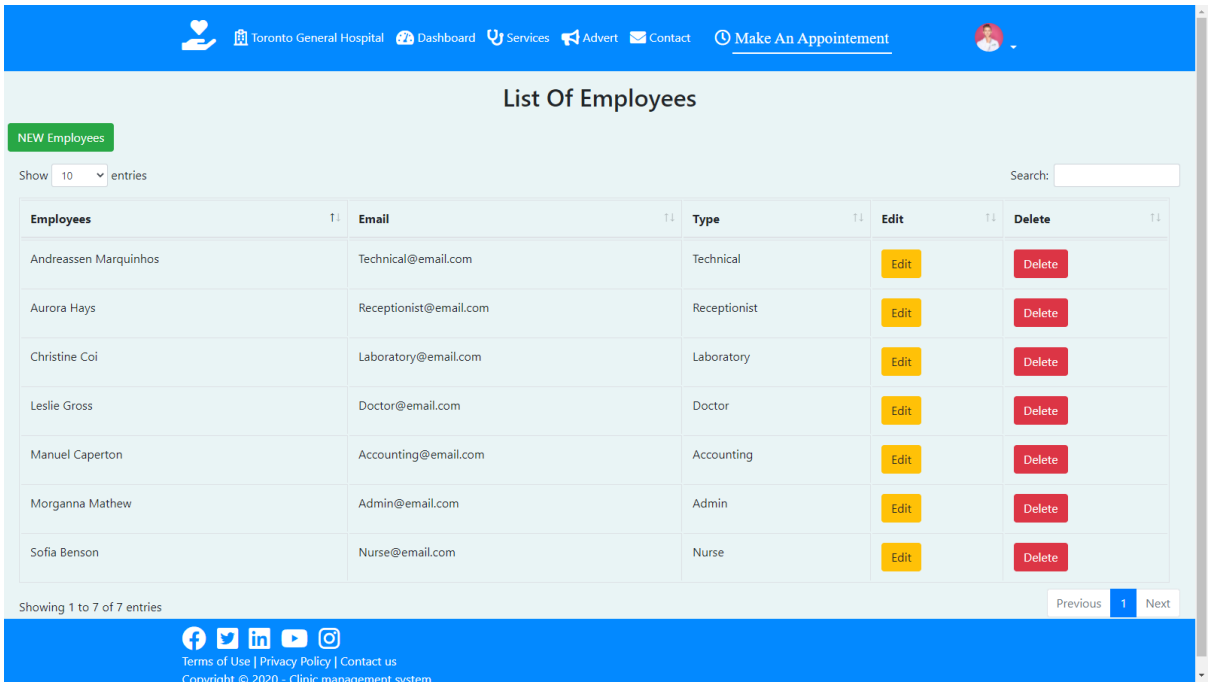

Figure 4. 24: Employee index.

This page is where the admin can create a new user with a specific type.

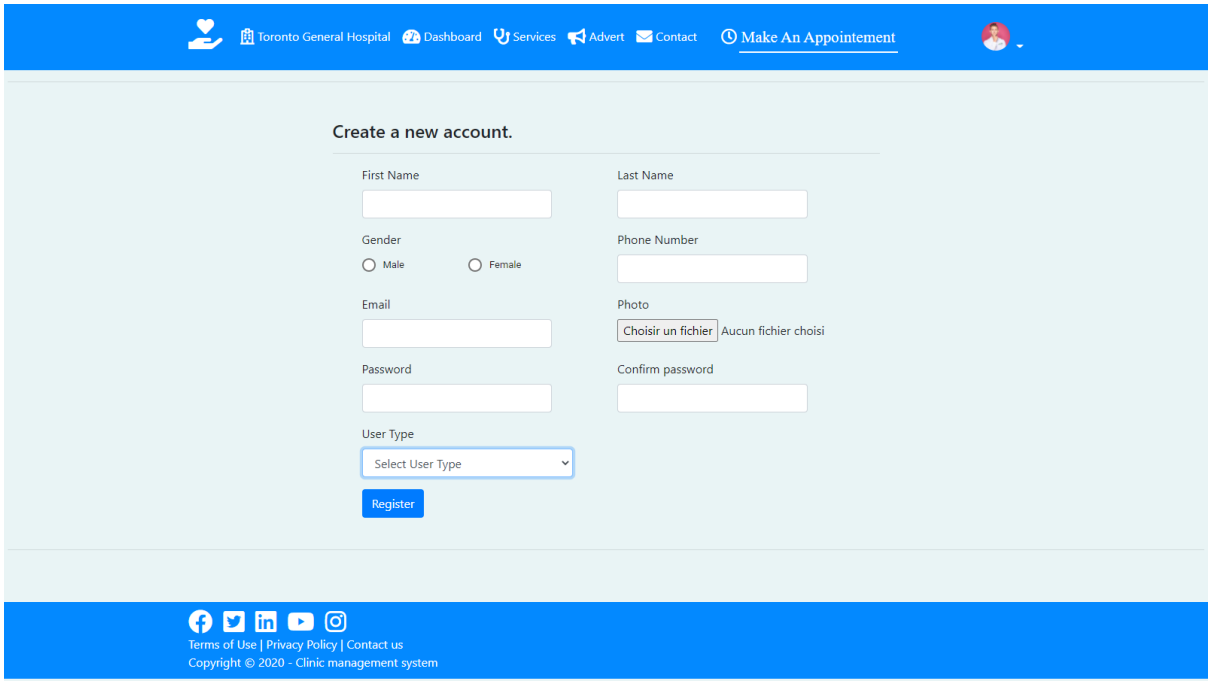

Figure 4. 25: Create a new account.

On this page the admin can view all the doctors of the clinic including their information, the admin also can edit the medical service and work time for each doctor.

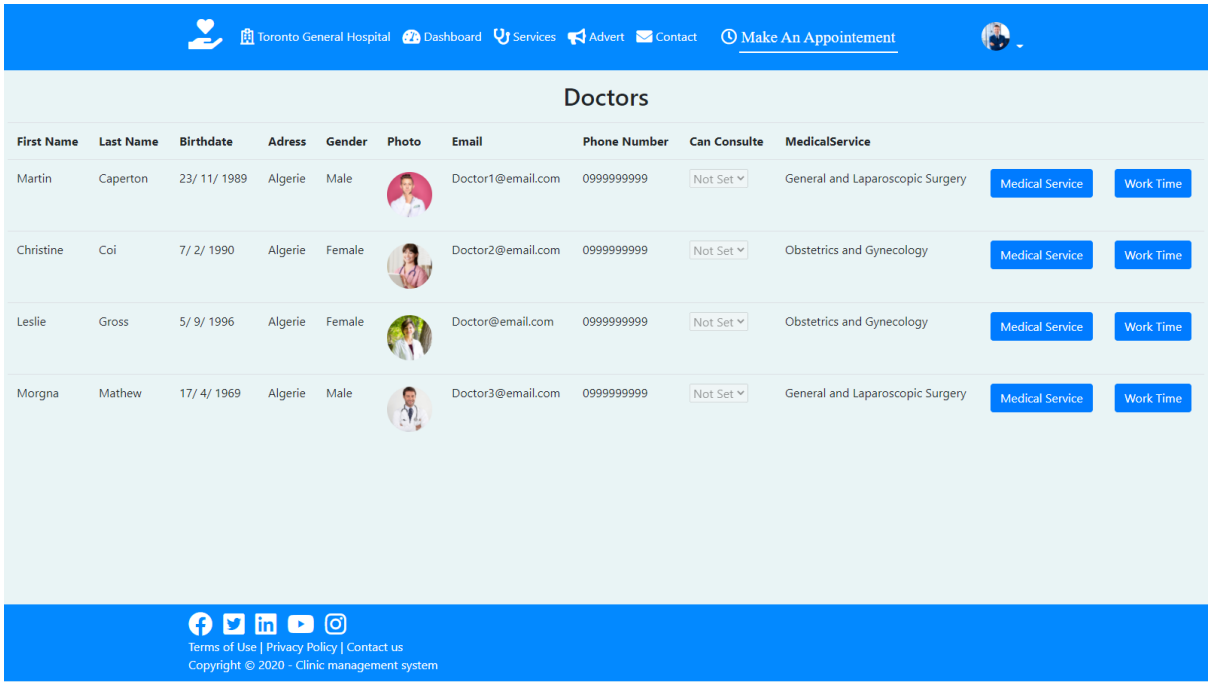

Figure 4. 26: Doctor settings.

This page displays the working days of all doctors that the patient or visitor can schedule an appointment. by clicking on the make appointment button the application redirects to another appointment page to select a date and fill personal information.

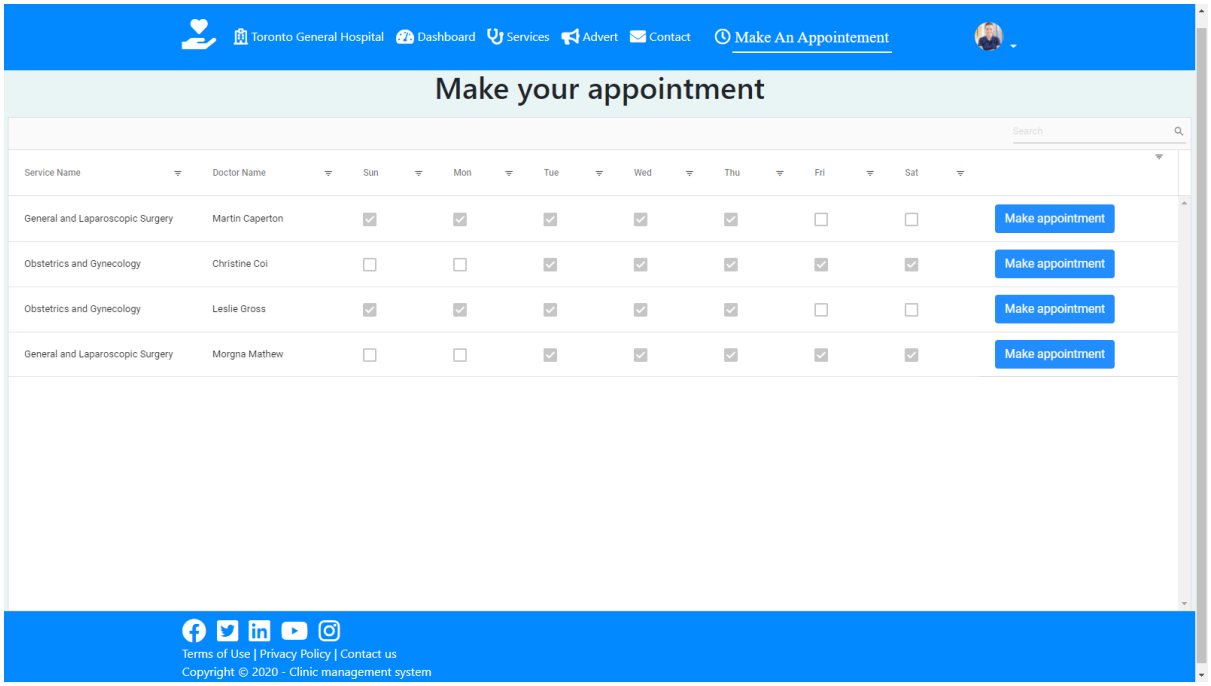

Figure 4. 27: appointment index.

This is the page where the patient fills his personal information and selects a date of appointment.

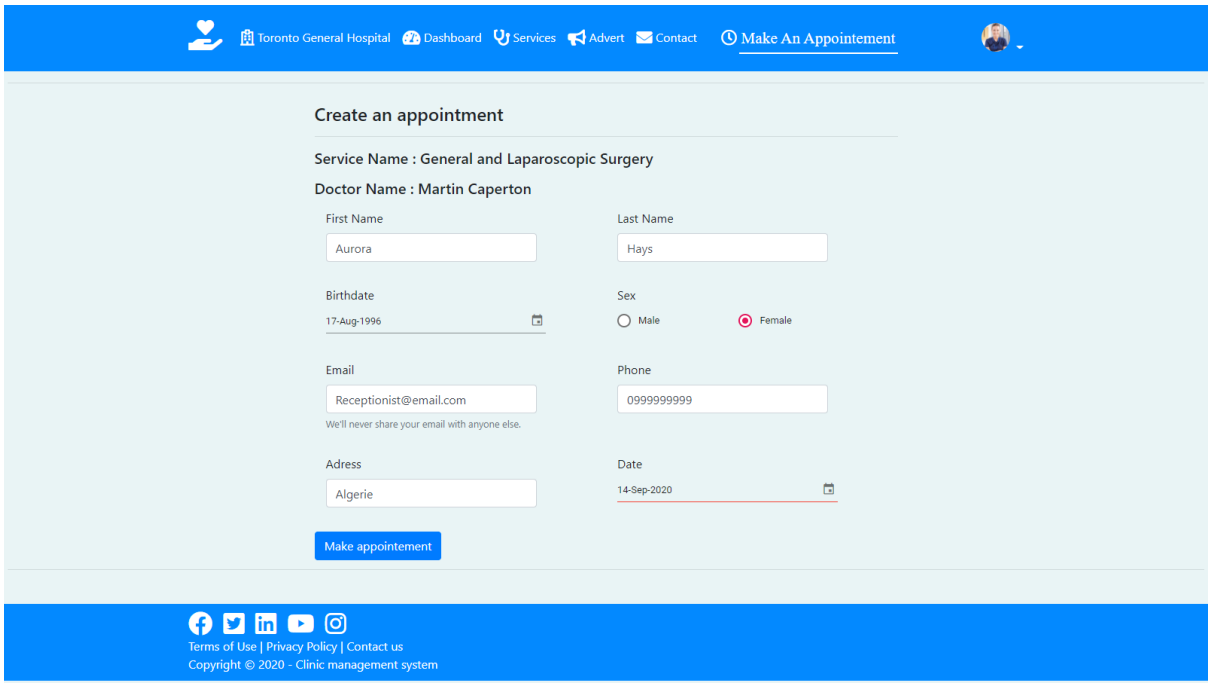

Figure 4. 28: Appointment form.

The doctor dashboard presents all today's bookings for a doctor.
This page also presents the medical report button and prescription button to take action without booking. consult patient button to consult the incoming patient, the doctor can know that there is an upcoming patient through the notification shown in the top right of the page.

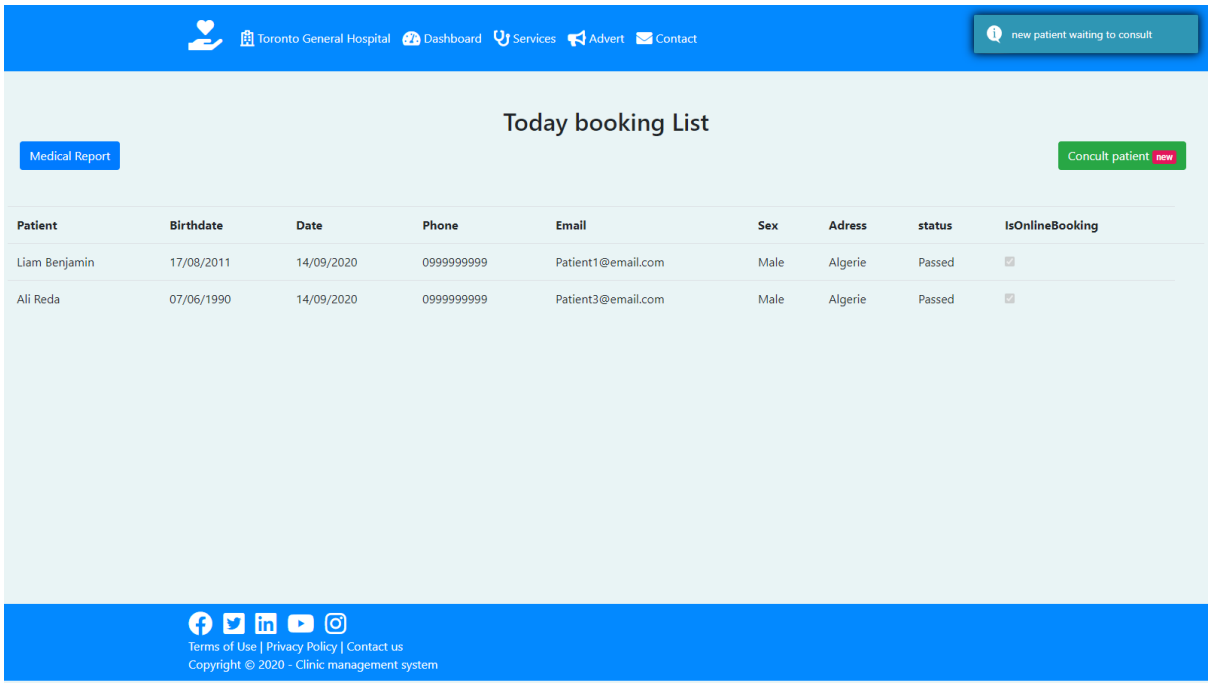

Figure 4. 29: Doctor dashboard.

Here, where the doctor can make a prescription for the patient, he can also write a report if necessary and determine the price of the consultation with the option to print prescriptions.

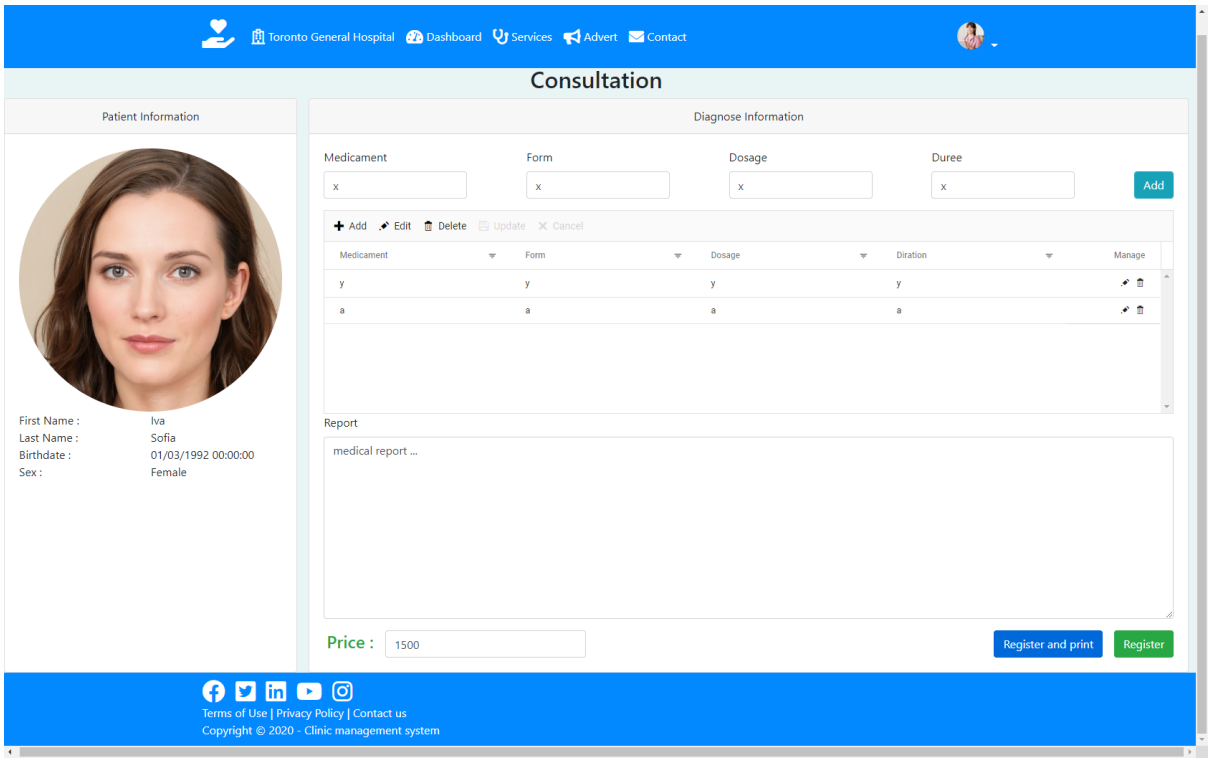

Figure 4. 30: Consultation page**.**

All bookings shown on one page including waiting patients, patients in progress, and finished patients, the receptionist can know that there is a finished patient through the notification shown in the top right of the page.

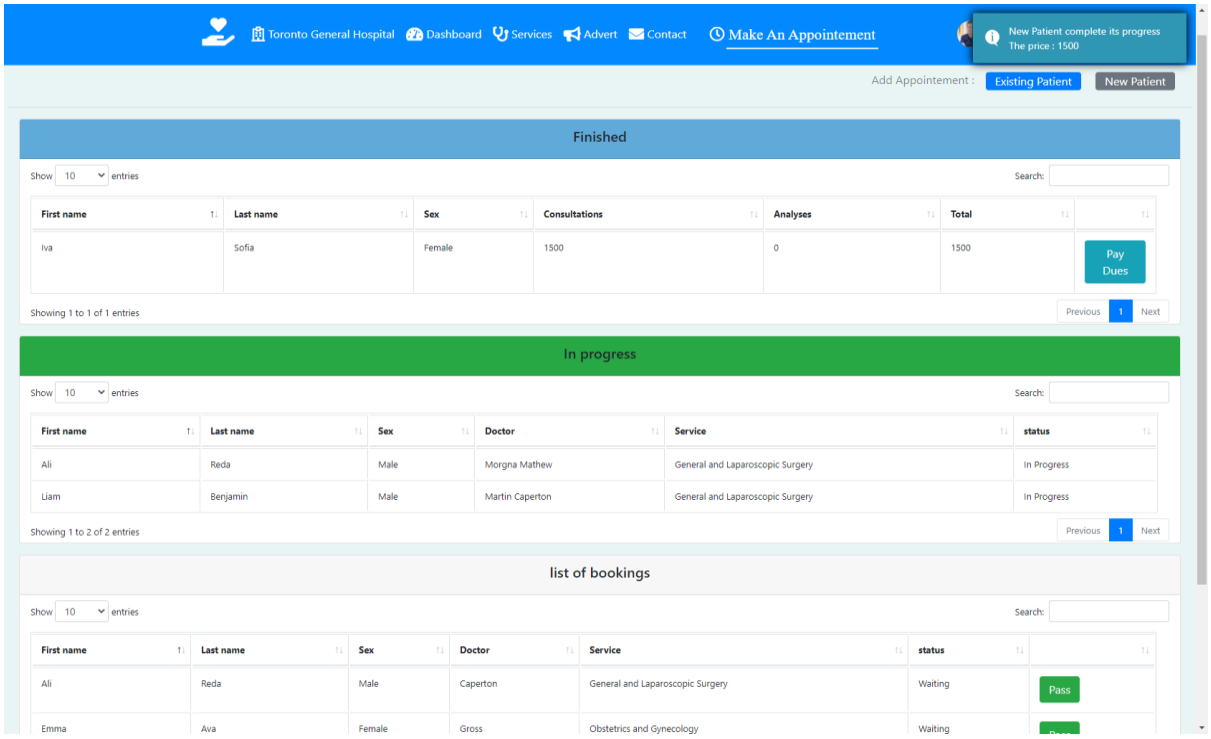

Figure 4. 31: Receptionist dashboard.

The patient is redirected to this page after logging in, this page contains all the history of the consultation and analysis with the option to view the details of each one of them.

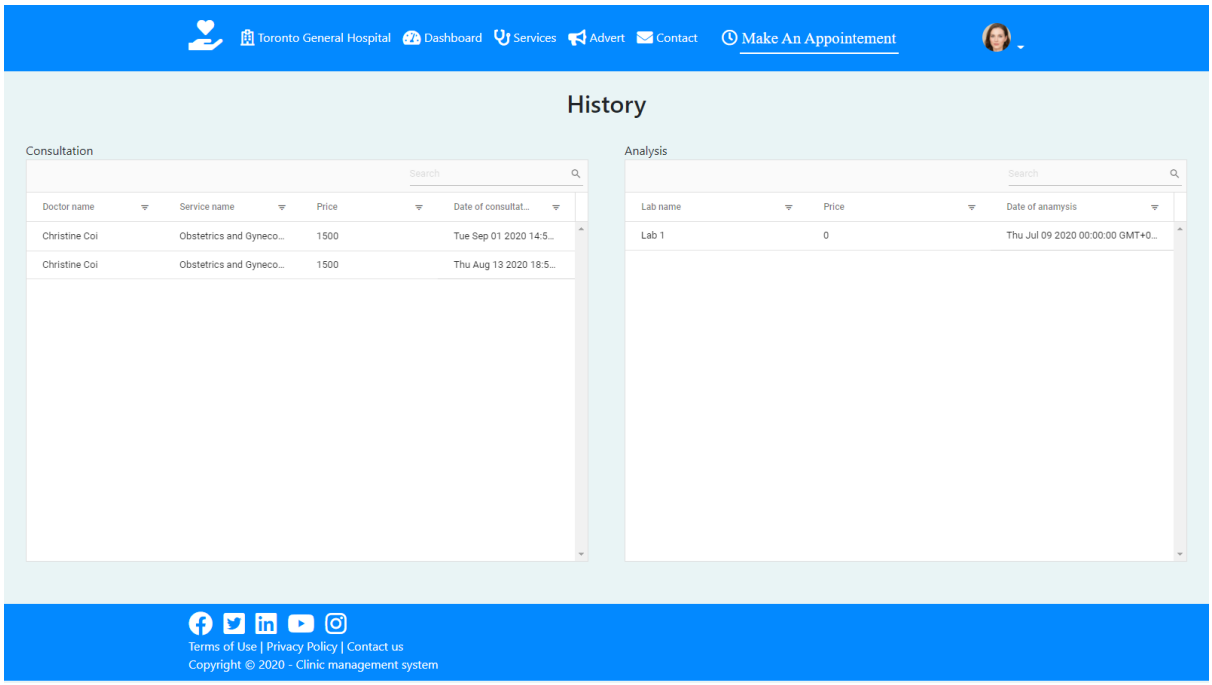

Figure 4. 32: Patient dashboard.

Any visitor can access this page and send a message to the clinic administration by providing their full name and email.

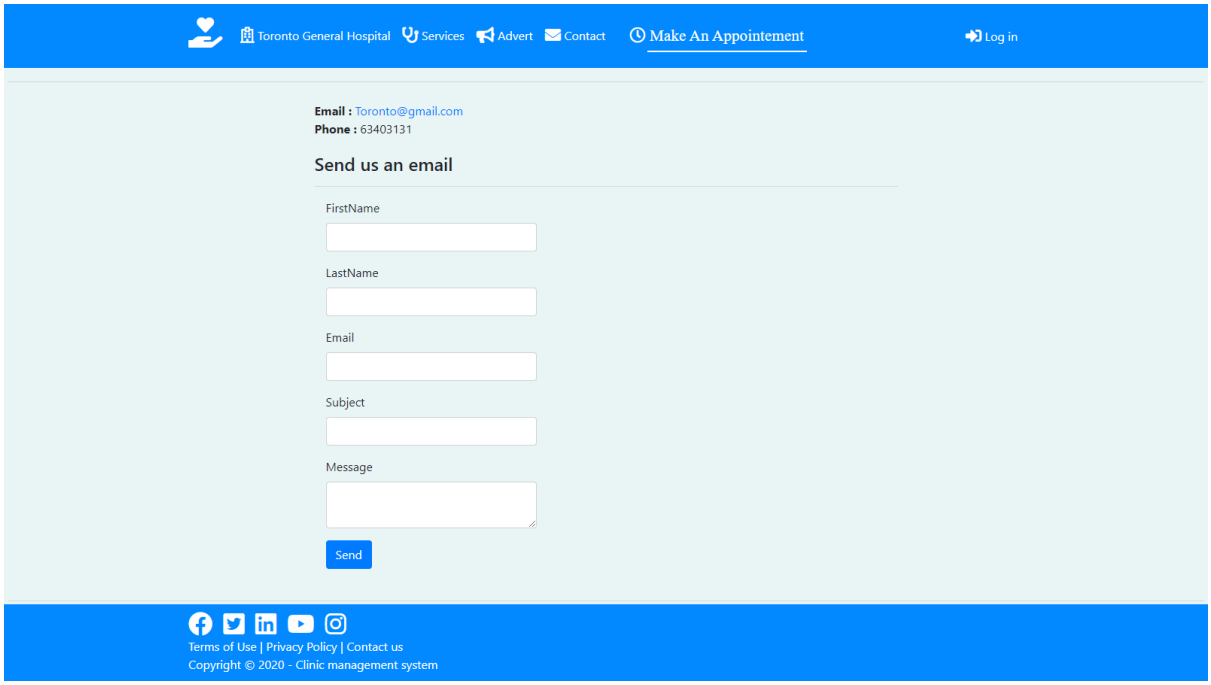

Figure 4. 33: Contact page.

5. Conclusion:

In this chapter we have highlighted all the techniques necessary for the realization of our web application. We have indicated to the development environment and the useful and necessary tools for the creation of the web application and we have given real examples of our realized web pages.

CONCLUSION

Web-based software contributed to improving management systems. The CMSs integrated the clinics during the last decades, with the increasing need for healthcare providers to accurate and efficient systems, cloud computing technology have been more and more needed in the medical field.

Our experience has revealed and corrected all the ambiguity of the unorganized processes existing before, with great precision in an incredible time, the daily operation required a big human intervention and lasts a long time to be ready with plenty of mistakes, It becomes to be done in a moment with a single click.

The ordered list of waiting patients and finished patients with their costs in front of the receptionist. The patient record was ready in front of the doctor by a single click. Simple and easy input interface to all users and many other features that work efficiently, all these tasks are coordinated by real-time notification.

By the use of recent technologies such as: SQL SERVER and LINQ ENTITY FRAMEWORK code first which gave an observable DBMS speed compared to the number of tables used in the database of our application which exceeds 35 tables

We achieved finally our goal of building this cloud-based software of the clinic management system and provided it as a web application as a service (SaaS) for different clients (clinic) by using multi-tenancy architecture, this architecture allows making customization to every client.

We hope that we have finally helped to improve the quality of the health system in general and healthcare providers in particular, we look forward that this study does not stop here and be improved in the coming years with other design and development capibilities.

BIBLIOGRAPHICAL REFERENCES

[1] B. Hamilton, *Electronic health records*, 2nd ed. New York, NY: McGraw-Hill, 2011.

[2] "What is an electronic health record (EHR)? | HealthIT.gov." https://www.healthit.gov/faq/what-electronic-health-record-ehr (accessed Mar. 15, 2020).

[3] "Santymed : Logiciel de gestion de clinique et cabinet médical." https://santymed.com/ (accessed Apr. 02, 2020).

[4] "eHospital - Hospital Management System | EHR Software." https://www.adroitinfosystems.com/products/ehospital-systems (accessed Apr. 05, 2020).

[5] "ProEmTech Infosystems Private Limited :: ProMed." https://www.proemtech.com/promed.php (accessed Apr. 04, 2020).

[6] "SaaS Overview," *Apprenda*. https://apprenda.com/library/software-on-demand/ (accessed Jun. 07, 2020).

[7] "ARCHITECTURAL CONCERNS IN MULTI-TENANT SaaS APPLICATIONS:," in *Proceedings of the 2nd International Conference on Cloud Computing and Services Science*, Porto, Portugal, 2012, pp. 426–431, doi: 10.5220/0003957604260431.

[8] TerryGLee, "Overview of Visual Studio." https://docs.microsoft.com/en-us/visualstudio/get-started/visual-studio-ide (accessed Aug. 10, 2020).

[9] dotnet-bot, "Introduction - C# language specification." https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/language-specification/introduction (accessed Aug. 10, 2020).

[10] wadepickett, "Entity Framework documentation." https://docs.microsoft.com/en-us/ef/ (accessed Aug. 10, 2020).

[11] "What is Code-First?" https://www.entityframeworktutorial.net/code-first/what-is-code-first.aspx? (accessed Aug. 10, 2020).

[12] "What is SQL Server," *SQL Server Tutorial*. https://www.sqlservertutorial.net/getting-started/what-is-sql-server/ (accessed Aug. 10, 2020).

[13] "ASP.NET | Open-source web framework for .NET," *Microsoft*. https://dotnet.microsoft.com/apps/aspnet (accessed Aug. 10, 2020).

[14] "Home : The Official Microsoft IIS Site." https://www.iis.net/ (accessed Aug. 10, 2020).

[15] "ASP.NET MVC Pattern | .NET," *Microsoft*. https://dotnet.microsoft.com/apps/aspnet/mvc (accessed Aug. 10, 2020).

[16] bradygaster, "Introduction to SignalR." https://docs.microsoft.com/en-us/aspnet/signalr/overview/getting-started/introduction-to-signalr (accessed Aug. 10, 2020).

[17] "What is HTML and How Does Hypertext Markup Language Work?" https://www.theserverside.com/definition/HTML-Hypertext-Markup-Language?fbclid=IwAR3sqhDz9NJEOVaStv38pzNiuyFazJWlsAbwmfTkb9cMhqHge9EDDDb-3SU (accessed Aug. 10, 2020).

[18] "CSS | MDN," Sep. 29, 2015. https://web.archive.org/web/20150929020648/https:/developer.mozilla.org/en-US/docs/Web/CSS (accessed Aug. 10, 2020).

[19] M. O. contributors Jacob Thornton, and Bootstrap, "Bootstrap." https://getbootstrap.com/ (accessed Aug. 10, 2020).

[20] "About JavaScript," *MDN Web Docs*. https://developer.mozilla.org/en-US/docs/Web/JavaScript/About_JavaScript (accessed Aug. 10, 2020).

[21] J. F.- js.foundation, "jQuery." https://jquery.com/ (accessed Aug. 10, 2020).

[22] “What is Ajax (Asynchronous JavaScript and XML)? - Definition from WhatIs.com,” *SearchWinDevelopment*. https://searchwindevelopment.techtarget.com/definition/Ajax (accessed Aug. 10, 2020).
[23] “JSON.” https://www.json.org/json-en.html (accessed Aug. 10, 2020).
[24] “Bitbucket: What is Bitbucket? - Atlassian Documentation.” https://confluence.atlassian.com/confeval/development-tools-evaluator-resources/bitbucket/bitbucket-what-is-bitbucket (accessed Aug. 10, 2020).
[25] “Sourcetree | Free Git GUI for Mac and Windows.” https://www.sourcetreeapp.com/ (accessed Aug. 10, 2020).
[26] “Syncfusion - EverybodyWiki Bios & Wiki.” https://en.everybodywiki.com/Syncfusion (accessed Aug. 10, 2020).
[27] “StarUML.” http://www.umlzone.com/articles/staruml/ (accessed Aug. 10, 2020).

ABSTRACT

The purpose of this study is to develop and deliver a web application as a service for different clients. The application is designed to be used by healthcare providers. The study was able to produce the application that would provide space to every client to manage the clinic, this solution includes human resource management. The software provides also the possibility of online appointment to patients and facilitate the work of the clinic employees and make easy coordination between employees, doctors and patients accurately. This allows the employees to focus entirely on their jobs, which will benefit the patient as well. With a secure information exchange through a robust web platform, it would not be possible to access unpermitted data to meet the privacy of the medical fields.

ملخص

الغرض من هذه الدراسة هو تطوير وتقديم تطبيق ويب كخدمة لعملاء مختلفين. تم تصميم التطبيق ليتم استخدامه من قبل مقدمي الرعاية الصحية. تمكنت الدراسة من إنتاج التطبيق الذي من شأنه توفير مساحة لكل عميل لإدارة العيادة، ويشمل هذا الحل تسجيل الموظفين وتخزين بياناتهم في النظام، ويوفر البرنامج خيار تحديد موعد عبر الإنترنت للمرضى وتسهيل عمل موظفي العيادة والتنسيق بينهم بدقة وفي لحظة مما يتيح للعمال صب كامل تركيزهم على وظائفهم، الامر الذي يعود بفائدة أكبر للمريض. من خلال التبادل الآمن للمعلومات لا يمكن الوصول إلى البيانات غير المسموح بها وهذا يتوافق أيضًا مع خصوصية المجالات الطبية.

RESUME

Le but de cette étude est de développer et de fournir une application Web en tant que service pour différents clients. L'application est conçue pour être utilisée par les prestataires de soins de santé. L'étude a été en mesure de produire l'application qui fournirait un espace à chaque client pour gérer la clinique, cette solution comprend l'enregistrement des employés et le stockage de leurs coordonnées dans le système. Le logiciel fournit une option de prise de rendez-vous en ligne aux patients et facilite le travail des employés de la clinique et simplifie la coordination entre eux avec précision et rapidité, cela permet aux employés de se concentrer entièrement sur leur travail, ce qui profitera davantage au patient. Avec un échange d'informations sécurisé, il n'est pas possible d'accéder à des données non autorisées et ceci respecte également la confidentialité des domaines médicaux.