Sudan University of Science and Technology

Collage of Graduate Studies

Healthcare E-Guide System using K-means Clustering Algorithm

Case Study (Healthcare Centers in Khartoum-State)

A dissertation submitted in partial fulfillment for the requirement of Master degree in

Computer Science and Information Technology

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جامعـــــة الســــــــودان للعلـــوم و التكنـــولوجيــــــا

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الآيـــــــــــــــــــــة الكريـــــــــــــــــــــة

﴿ اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ ۚ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ ۖ الْمِصْبَاحُ
فِي زُجَاجَةٍ ۖ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِنْ شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ لَا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ
لَمْ تَمْسَسْهُ نَارٌ ۚ نُورٌ عَلَىٰ نُورٍ ۗ يَهْدِي اللَّهُ لِنُورِهِ مَنْ يَشَاءُ ۚ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ ۗ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ ﴾

صدق الله العظيم

سورة النور.. الاية 35

DEDICATION

"Unity is strength .... When there is teamwork and collaboration; wonderful things can be achieved"

Mattie stepanek

To the most precious person in my life who support me in every steps that I made and provide me her time , effort and knowledge in order to be success in the life. And I exactly the mean of Unrequited tender. To the person who make me the girl who loves the science and reading ...

To those who are the secret of my happiness. To those who helped me from first day in the university until now and support me, provide me essential knowledge that I need. To those who I spend with them the most beautiful moments and shared their sorrows and delights.

My mother... My father

My sisters... My supervisor... My teachers ... My very best friends ... To all people I know and respect them

I dedicate this work ...

.... Thanks....

Ayah A.Ghaffar

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I will take this chance to thanks my soul, my breath and my heartbeats; my parents who give their life for me gave to me every things without waiting overcome…. My sisters, thanks for being my sisters… My right hand and my strength…

With a great pleasure, I would like to acknowledge my supervisor prof: Yassir Abdul Gadir Mohammed, to support me during the research and gives me his time and knowledge, he gives me the right way to learn. I learned from him the meaning of "*do not give me a fish, but teach me how to fish.*" He made me trust in myself and my abilities again. I learned from him how to learn.. how to face difficulties.. how to read between the lines.. how to understand deeply.

To Hajir sami, Mortda Aljaily, Sara mohammed, Lemia babiker, Haleema Mustafa, Ozaz bahaa and all my friends.

Thank you for being with me…

Abstract

Recently with a rapid growth of the internet and technologies, many applications and researches arises to support healthcare field and medical services.

Any person may face health problems at any moment, and search for the nearest medical center may consume a long time. Patient may need to move from medical center to another because the near hospitals may not be suitable either in terms of medical equipment, clinics or even specialist. Also the lack of information about medical services on the internet in Sudan has caused the patient to search for a long time to find a suitable medical center or move from one hospital to another to take a certain medical services.

Due to the lack of applications to serve the medical field in Sudan, there is a critical need to develop application that facilitate the search for medical services near the patient's location, in anytime and anywhere inside Sudan especially in the rare areas.

The main aim of proposed system is to design and implement secure mobile application to locate a convenient healthcare services shortly and accurately.

The system provides different search options, *GPS* to accurately locate current location of user and generate/ access *Electronic Health Record* of patients with different views based on database role and authentication. For urgent cases; the system send emergency message to the specific practitioner based on schedule, this can assist in pre-treatment or first aids and to get a good background about patient's medical history before he/she arrive the selected hospital by the system. The system implement appropriate security mechanisms without affect the system performance.

The system find out nearest healthcare services by use improved k-means clustering algorithm with improvement to in line with system requirements. This algorithm has been selected for ease, simplicity, easily editable and easy to improve.

ملخص الدراسة

في الآونة الأخيرة مع النمو السريع للإنترنت والتقنيات ، نشأت العديد من التطبيقات والأبحاث لدعم الرعاية الصحية والخدمات الطبية المقدمة.

قد يواجه أي شخص مشاكل صحية في أي لحظة ، وقد يستغرق البحث عن أقرب مركز طبي فترة طويلة. قد يحتاج المريض إلى الانتقال من المركز طبي إلى آخر لأن المراكز الطبية القريبة قد لا تكون مناسبة سواء من حيث المعدات الطبية أو العيادات أو حتى الاطباء المتخصصين. كما ان نقص المعلومات حول الخدمات الطبية على الإنترنت قد يؤدي إلى قيام المريض بالبحث لمدة طويلة عن مركز طبي مناسب أو الانتقال من مستشفى إلى آخر لتلقي خدمات طبية معينة.

بسبب عدم وجود تطبيق لخدمة المجال الطبي في السودان ، هناك حاجة ماسة لتطوير التطبيقات التي تسهل البحث عن الخدمات الطبية بالقرب من موقع المريض ، في أي وقت وفي أي مكان داخل السودان خاصة في المناطق النادرة و النائية.

الهدف الرئيسي من النظام المقترح هو تصميم وتنفيذ تطبيق الهاتف المحمول الآمن لتحديد موقع خدمات الرعاية الصحية المناسبة في وقت قصير وبصورة دقيقة.

يوفر النظام المقترح خيارات بحث مختلفة ، نظام تحديد المواقع GPS لتحديد الموقع الحالي للمستخدم بدقة, وإنشاء / وصول إلى السجل الصحي الإلكتروني للمرضى بواجهات مختلفة استنادًا إلى دور قاعدة البيانات والمصادقة. للحالات الطارئة, يقوم النظام بارسال رسالة طوارئ لطبيب محدد بناء على جدول الاطباء و ذلك يساعد في العلاج المسبق او الاسعافات الاولية و الحصول على خلفية جيدة حول التاريخ المرضي للمريض من قبل وصوله للمستشفى التي تم اختيارها من قبل النظام. يقوم النظام المقترح بتطبيق آليات الأمان المناسبة دون التأثير على أداء النظام.

يقوم النظام باكتشاف خدمات الرعاية الصحية الأقرب من خلال استخدام خوارزمية "k-means" المحسنة , و تمت اضافة بعض التحسينات لكي تتماشى الخوارزمية مع متطلبات النظام. و قد تم اختيار هذه الخوارزمية نسبة لسهولتها و بساطتها و امكانية التعديل فيها و تحسينها بسهولة.

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Chapter One

Introduction

1.1 Introduction

Recently; many Medical centers arises around the world. Many hospitals distinct from others in some services, healthcare, medical equipment or instrumentation (i.e. some instrumentation unavailable in most hospitals and available in few) or even specific practitioner.

There are a general, teaching and specialized hospitals in Sudan, and the number of hospitals is increasing. These hospitals have an emergency department, units, services, clinics and pharmacy. Some of these hospitals have a computerized system to facilitate procedures within the hospital. Some areas in Sudan (*such as remote areas*) do not have hospitals, and some areas have very few hospitals (*such as rural areas*), which leads to overcrowding of patients in these hospitals. Patients may resort to a crowded hospitals because of their distance from the big cities or because they do not know the existence of other hospitals.

Almost people may facing health problems at any time, and they may confuse to choose an appropriate nearest healthcare center or any medical services quickly. So there is a need to provide system in Sudan to search for nearest medical services quickly and provide alternatives to control overcrowding.

1.2 Problem statement

Locating healthcare centers (*hospitals, medical centers, clinic, policlinic and so on*) in short time is one of the most needed service todays. Besides requesting one of medical services at a certain time may take a considerable time, which might be unacceptable for some patients' cases.

On the other hand; some areas may have so many healthcare centers while some others have not. Patients need a guide to provide them with requested healthcare centers and services in a short time depending on their cases.

1.3 Objectives

The proposed system aimed to:

i. Design and implement a system that can locate the convenient and appropriate nearest medical centers shortly and accurately.
ii. Through providing immediate *Electronic Health Record* (EHR) gives a great supports to the practitioners and decreasing time, money and effort.

1.4 Assumptions

There is a need to know the distribution of healthcare centers, and to know the services that provided by specific centers.

i. Design the system as a MVC (*Model- View- Control*) web application will help patients to find nearest available healthcare center(s) and medical service(s).
ii. Design client side as a mobile application is more efficient and easy to use even if the patient in critical condition or not.
iii. By use appropriate and necessary security mechanisms and policies, it should provide security and "confidentiality- Integrity- Availability" in all system levels, be convenience and adequate to the patients, and no passiveness affects in the performance and accuracy of the system while using these mechanisms.
iv. By use improved k-means clustering algorithm, the system should find nearest medical services shortly and accurately.

1.5 Significance

The significance of proposed system is being in finding technical solution for healthcare problem, and the significance is:

- Locating the appropriate healthcare centers and services accurately may save lives in some cases, subsequently it needs special attention in term of researches and applications.
- There are no applications targeting the health field in Sudan.

1.5 Research Scope

The proposed system cover medical services in Khartoum-state only.

1.7 Organize of thesis

In the first chapter (Introduction) we will explain problem statement, objective, significance, assumptions and scope of research. In the second chapter (Background and Literature review) we will explain background about health information management, global positioning system, tracking algorithms, mobile application programming and literature review. In the third chapter (Methodology) we will explain appropriate lifecycle model for the system, all methods to be used in the system and then analysis this system. The fourth chapter (Design and

Implementation) includes the implementation of the methods used in the system to achieve the objectives, user interface and features. The fifth chapter (Result and Decisions) covers the results of the system and compare these results with related work. The sixth chapter (Challenges, Conclusion and future work).

Chapter Two

Background and Literature Review

2.1 Introduction

In this chapter; we'll exhibit a brief explanation about history of global positioning system, history of health information management, mobile application types and constrains, tracking algorithms and related work with verbosities.

2.2 Background

The proposed system must be based on scientific and real bases. So on this section (*2.2*) we'll refer to and explain all scientific bases on which we've based.

2.2.1 Global Positioning System history:

Global Positioning System (GPS) is a United States space-based radio navigation system that helps pinpoint accurately a three dimensional position *(for example latitude, longitude and altitude)* and provide nano-second precise time anywhere on Earth.*[1]*

GPS has its origins in the Sputnik era when scientists were able to track the satellite with moves in its radio signal known as the "*Doppler Effect*". *[1]*

In the early 1970's, the *Department of Defense (DoD)* wanted to ensure a robust, stable satellite navigation system. *DoD* launched its first Navigation System with Timing and Ranging *(NAVSTAR)* satellite in 1978. The 24 satellite system became fully operational in 1993. *[1]*

GPS is included of three different parts:

- Space Segment: A constellation of at least 24 *US* government satellites distributed in six orbital planes inclined 55° from the equator in a *Medium Earth Orbit* (*MEO*) at about 20,200 kilometers (12,550 miles) and circling the Earth every 12 hours.
- Control Segment: Stations on Earth monitoring and maintaining the *GPS* satellites.
- User Segment: Receivers that process the navigation signals from the *GPS* satellites and calculate position and time. *[2]*

GPS currently provides two levels of service: *Standard Positioning Service (SPS)* which uses the *coarse acquisition (C/A)* code on the *L1* frequency, and *Precise Positioning Service (PPS)* which uses the *P(Y)* code on both the *L1* and *L2* frequencies. But access to the *PPS* is restricted to

US Armed Forces, *US* Federal agencies, and selected allied armed forces and governments, the *SPS* is available to all users.*[1] [2]*

GPS help us to get accurate coordinates of healthcare centers' positions and to get current position of user.

2.2.2 History of health information management:

Health Information Management (HIM) is an information management applied to healthcare. *HIM* is the practice of acquiring, analyzing and protecting digital and traditional medical information vital to providing quality patient care. Traditional *(paper-based)* records are being replaced with *electronic health records (EHRs)*. *[5]*

The *Healthcare Information and Management Systems Society (HIMSS)* was organized in 1961 as the *Hospital Management Systems Society* (*HMSS*). *HMSS* is an independent, unincorporated, nonprofit, voluntary association of individuals. It was preceded by increasing amounts of management engineering activity in healthcare during the 1950s. *[4]*

The *HIM* industry can trace its roots back to the 1920s, when healthcare professionals realized that documenting patient care benefited both providers and patients. Documentation became wildly popular and was used throughout the nation after healthcare providers realized that they were better able to treat patients with complete and accurate medical history. *[5]*

The advancing technology of the '60s and '70s introduced the starts of a new system. The development of computers encouraged pioneering American universities to explore the incorporation of computers and medical records. . Early *EHR* software began to be adopted within certain departments. Healthcare software development continued to focus on these single application uses into the early 1980s. In '70s Computers were now small enough to be installed in a single department without environmental controls. Unfortunately, these transactional systems, embedded in individual departments, were typically islands unto themselves. *[4]*

In '80s hospitals began integrating applications so financial and clinical systems could talk to each other but in a limited way.

Electronic health records would allow providers to make better decisions and provide better care while reducing the incidence of medical error by improving the accuracy and clarity of medical records. In millennial; we now had enough technology and bedside clinical applications installed to make a serious run at commercial, real-time clinical decision support. *[4]*

The future of *HIM* have more changes in the works for the health information management industry even as they work toward fine-tuning the *EHR* system. As Geyfman says: *"More important than the data itself is the ability to learn actionable insights from the data" [3]*. So traditional organizations will have to realize not only how to collect data, but also to quickly and reliably process, analyze and deliver the data to those who need it, to any device.*[3]*

Despite the importance of managing health information, *HIM* procedures hasn't been implemented in Sudan yet. The medical history of patients mostly is a *paper- based*, so these information might be lost at any time. In proposed system we'll try to systematic medical information and benefits from technology in healthcare field.

2.2.3 Tracking algorithms:

Many real life application like transportation, navigation, city planning and so on need for path finding. So many algorithms uses to find shortest path, such as *Dijkstra*, *A-Star* (*A*)*, *Hierarchical A-Star* (*HAS*).

In *Dijkstra* algorithm all the nodes are linked with label of distance from the source node. In the beginning the distance is set to infinity. The node is added into the list of visited vertex node, respective distances of any nodes from the source node may change. When all the nodes are part of visited vertex set, the distances are tracked from starting of algorithm to the end. The algorithm keep track of distances to find out which distance is the minimum. It keeps the track of **all** the nodes while calculating shortest path. Then the algorithm stores this path associated with node with respect to source node. But the redundant processing increases the overhead of algorithm as well as memory and processing power required. *[6]*

A-star algorithm is an extension of *Dijkstra* algorithm. It uses heuristic function while calculating shortest path. It is compromise search method to find not just the best but good enough path in less time. *A-star* algorithm also considers the whole map while calculating the shortest path distance from start to end. So it is also affecting on memory requirements while calculate the distances. *[6]*

Hierarchical A-star algorithm divide the map into regions, any region contains a unique part of map. The input of this algorithm is source and distention node, the map is divided into regions. The higher layer of the edges points will be created. The next step is to apply *A-star* algorithm on higher layer. The algorithm gives the path from source to end containing edges and nodes of higher layer, but only those regions which may lead to the shortest path are considered for further calculations. While calculating the shortest path; the paths of region are combined together and resultant path is the shortest path for start point (source) and end point (destination). *[6]*

The advantage of using hierarchy in the map is that only part of map which leads to the shortest path is processed and other part is not. So it reduce the memory requirement. *[6]*

We have another algorithms also can find the shortest path called clustering algorithms (*e.g. k-means, DBSCAN, CLARA, PAM, chameleon*). Additionally; *bellman* algorithm and *graph growth* algorithm. *[6]*

Clustering –also called data segmentation- is a process of grouping data into clusters, the objects within a cluster have high similarity and dissimilar to objects in another cluster. A *Cluster* is a collection of data objects that are similar to one another within the same cluster and are dissimilar to the objects in other clusters. *Cluster Analysis* is how to distinguish between objects. *[19]*

Clustering is one of unsupervised learning methods. It don't rely on predefined classes and class-label training examples, it learn by observation. Clustering process is adaptable to changes.

There are several clustering methods organized into: partitioning methods, hierarchical methods, density-based methods, grid-based methods, model-based methods, frequent pattern-based methods and constraints-based clustering. *[19]*

The partitioning methods categorizes objects into k partitions where each partition represents a *cluster*. The dissimilarity is based on distance. The most well-known and commonly used partitioning methods are *k-means*, *k-medoids*, and there are much researches to enhance and improve it as well as possible. *[19]*

Traditional k-means is a widely used. It is also used to automatically organize data, compression form and finding some hidden structure. First k-means algorithm select initial cluster centroid randomly. For the rest objects; its assigned to the clusters depend on its similarity by compute the distance between object and cluster mean. In new iteration; computes the new mean for each cluster and then repeat computing the distance between cluster mean and object, so some objects moves from one cluster to another one. This process iterates until the criterion function converges. Each object must belongs to one cluster, and there is no empty cluster. *[19] [20]*

The input of an algorithm is a number of clusters and n data items or objects. The time complexity for k-means clustering algorithm is *O(nkt)* where n is a number of objects, k is a number of clusters, t is a number of iteration. *[19]*

K-means algorithm having efficient, very fast, easy to use and simplicity in implementing system, adaptability to sparse data and scalability. But it's computationally costly and the result is completely depend on initial random selection of clusters centroid in first stage, and select different centroids result different clusters, so that's affect the accuracy. *[19] [20]*

So the proposed work in *[20]* enhance k-means algorithm by minimize number of iterations and reduce time. The proposed work in *[20]* enhance k-means algorithm by the following steps: use min-max normalization method. Then sort data by use Quick Sort algorithm. Use random function to find initial centroids. Calculate the Euclidean distance between object and cluster center. Process iterates until the criterion function converges.

There are several techniques proposed to improve k-means algorithm such as parallel k-means algorithm, refinement of initial cluster centroid, implementation of cluster using map reduced, dynamic clustering … etc. there are much partitioning methods like k-modes, k-medoids, PAM, k-median, CLARANS and so on. *[19]*

2.2.4 Mobile Application Programming:

The mobile medium type is the type of application framework or mobile technology that presents content or information to the user. It is a technical approach regarding which type of medium to use.

Application frameworks are used to create any type of applications. The largest challenge of deploying applications is knowing the specific device attributes and capabilities. So many alternatives appeared, in addition to variety in mobile medium types. *[7]*

Initially the mobile applications were only developed to implement calculator, calendar, alarm and currency converter functionalities. There are three types of mobile application: native, web-based and hybrid. Many of the existing web based applications were ported to platforms on the mobile device. These web-based applications included social networking, blogging, sharing of multimedia over the web. *[7]*

Mobile applications can be classified into five major categories: Social Networking, Personal Productivity, Leisure-based, Transaction-Based, and Content Dissemination-Based. Mobile application development has received a boost with two major developments; the availability of increased network bandwidth, and mobile device requirement such as memory, processing time, screen size, battery and so on. *[8]*

2.3 Literature Review

In *[9]* the authors proposed a web application developed for fast communication between patients and doctors. There system provides list of hospitals, blood bank and medicals. To identify location of user use *GPS*. It also provides secure storage of patients' medical history and search for nearest blood bank, medicals, hospitals and search for doctors depend on their specialization.

The system *[9]* allow all authorized doctors to access and view patients' medical details and information. For security; the system use advanced security feature like validation and verification for web base application. *MD5* is an algorithm that are used to verify data integrity through the creation of 128- bit.

New user have to register according to its type of perspective (Doctor, Patient, nearest domain), for registration the user will fill the form with his personal information, then unique *OTP* (*On Time Password*) is given to the user while login for authentic access.

By using *GPS* location identification of the patient, this will provide location and path for nearest healthcare center. For searching purpose; the system uses *k-means* clustering algorithm. This algorithm search nearest domain by referring location, then it forms different clusters so it chooses nearest k cluster.

The system is developed as a web application to deals with tremendous information regarding hospitals, blood banks, medicals…etc. but we can benefit from cloud computing to safety store of those data and there is no need to thinking about infrastructures. Also in spite of mobile constraints; the mobile application is faster and comfortable than web base application. But this system doesn't cover urgent patients so they maintain its application as a web application.

Traditional *k-means* algorithm is computationally costly in terms of time complexity, and the quality of the resulting clusters is mostly depends on the way of selection of initial centroid points and this algorithm doesn't guarantee optimality of the clusters.

In *[10]*, the authors proposed a mobile system that enables *EHR* (*Electronic Health Record*) data storage, retrieve and update via cloud computing. The system is developed as an android mobile application for "Medical Emergency" to locate nearest available hospital, contacts its ambulance emergency system, accesses *EHR* of emergency patient and proposed Android Based Tracking for *EMS* (Emergency Medical System) on cloud.

The system provides various features to the user, the system finds the optimal route for the nearby hospital give them alert with the location of the patient. The system also provides detail about facilities of a specific hospital so that user has the prior knowledge of the hospital.

In client side; the user should fill its personal and medical information on cloud. The emergency condition must be selected such as accident, heart attack burn case and so on, then it will send to the server. In server side; the server accept the request, the system track out the location of patient by fetch its coordinates and type of emergency, after that the system is ready to search nearest hospital according to variables (type of emergency, availability of doctors and distance from the patient).

The EHR will be generated by pressing emergency button of the android application in case of emergency and send it to selected hospital for pre medical treatments.

According to the patient's conditions, doctor sends the prescription to the patient's phone in order to protect the user timely to get treatment. After that the life reminder alerts the user to take medicine on the time.

Server uses database to search for the nearest hospital. After searching the nearest hospital; the system suggests the list to the client. *GPS* alarm application provide the service to user by mining the shortest distance between source and destination, it will notify user if she/he arrive its destination while travelling to the destination.

The system use *A** algorithm. *A** uses heuristic approach to find nearest node within different cluster. This algorithm is one of the most popular methods for finding shortest path between two locations in a mapped area. So it's a best choice for *EMS*, but this instance limit the system so much.

For user authentication; it's done according to the role based access control. The system benefit from cloud computing in store *EHR*. The patients' information saved over cloud, this info will be used to generate *EHR*, so the EHR of the patient will be automatically generated and forwarded to the selected hospital for pre medical treatment.

The system developed as a mobile application with cloud, so we can reach more benefit from cloud technology features by using web services technologies within clouds. We can combine several services in cloud and use web services technologies to reach these services without human intervention.

In *[11]*, the authors proposed a mobile health service application based on voice interface in order to support elders by using a hybrid application to provide monitoring.

The user enters information via speech framework, apply learning function to increase recognition rate. Then the input information that sent to the healthcare server is manage, and doctor writes a note by confirm the information of the older users through the hospital's *EMR* (*Electronic Medical Record*) system. Written doctor's note can also be stored on the healthcare server, and can be checked by smartphone.

The system is ideal for the elderly or patients who have inconvenient behavior. The best feature in this system is: it can merge with most healthcare management system because it recognize the voice from patients and send it to the server, by other words; this system is as a client interface or intermediate application between client and server that can translate patient's voice and send it to the server as a text. So it can work with any existing healthcare management system easily.

But this method *"voice recognition"* may not suitable with any patient condition or even speech language, because it depend on the voice and the *SpeechRecognizer* should recognize the voice to translate it to the text correctly.

Besides the researches in healthcare field, *[12]* is an application to find nearest taxi shortly. They propose a new kind of "*KNN query – K Nearest Neighbors*" on time-dependent network, which aims at finding *k* points of interest that are closest in time to a query point.

The high amount of vehicles creates congestion in the roads, which makes travel time forecasting extremely hard. So, the assessment and consideration of traffic conditions is key for leveraging intelligent transportation systems.

With the increasing interest in intelligent transportation, more complex and advanced query types were recently proposed, such as (*kNN*) queries and route planning queries. In time-dependent networks, a *kNN* query, called TD-*kNN*, returns the *k* points of interest with minimum travel-time from the query point. The system aim to minimize the travel time from points of interest to the query point.

NN-Reverse-TD algorithm is based on the *Incremental Network Expansion* "*INE*" algorithm. The *INE* is an algorithm based on *Dijksta's* algorithm visited all the reachable vertices of query point in order of their proximity, until nearest point of interest is located. The proposed approach does the expansion using a reverse graph G^R, which allows finding and pruning candidates POIs (point of interests).

This system *[12]* search nearest taxi to the user's location by use *NN-Reverse-TD. K-Nearest Neighbors* is a regression algorithm that need dataset without class label and it will predicate the class label. The system need to store every single corner point and taxi positions to build a graph so can search for neighbors of user's location, this is huge data and record by record the search will be difficult because the algorithm makes road network and its input is query point then its reverse searching from destination to the query point. In the big cities this algorithm need to partitioning the network or filtering unneeded points to decrease network size.

The system *[13]* is an application designed to locate the nearest objects of interest in accordance with the category (*ATM, restaurant, minimarket…etc.*) and location of user.
The system is a hybrid an application developed by use *Ionic* framework which uses to develop hybrid application that feel like a native application. The application use *GPS* to locate user's current location and objects' location. This system stores location of objects in form of longitude and latitude.

The application get user's location via *GPS*, the user should choose object from category. Suppose the user need to find nearest ATM Then the application return information about nearest ATM and route between user's location and ATM. The application provides viewing comments and rating to the condition of any object in the category.

The geographical information system can assist to map a dot or even region into a longitude and latitude information, which is useful in decision making to determine the location for thermal sensor detector equipment placement. *GIS* provides algorithms and techniques to find shortest path such as Dijkstra, A*, Network analysis …etc. In this work; they store location of objects as longitude and latitude, the *GIS* can find shortest path between two points based on one of defined techniques. Also *GIS* contains several formulas to calculate distance between two points. But they didn't refer to the formula that has been used in their application.

The system *[14]* is an application which helps user to trace nearest specialist doctor, ambulance, medicals, police and the services like booking appointment with doctor, get awareness news, blood banks etc. The user could search for specialist doctors and get emergency service by calling police or ambulance. If user requires offline help for common diseases, then they can use home remedies option. This application *[14]* uses *GPS* services for getting the location of the user and by using this location application can suggest the medical services available around the user.

After logging in; the user will frequently get informed about medical campaigns, latest medical news and search for specialist doctors. If the user is offline and cannot reach to the doctor then he can use treatments given in home remedies. The application [14] is useful to the normal people who does not aware about the local area medical services.

The project *[15]* is a *MCS* research which developed an application to provides information related to the different hospitals and get the patient list of nearest of nearest hospital and available services to solve wasted time when the patient is shifted from hospital to other after admitted to the hospital and proper services are not available.

The system *[15]* using the current location of the user so the application fetches the nearest hospitals and provides the details about the hospital and their services. Once the patient click on the hospital to show the route the application is directed towards google maps and shows the nearest path with traffic.

The application has a unique feature of predicting the disease for the symptoms entered by the members and by this members can easily get to know the complete details about the diseases. They didn't refer to the method used to find nearest hospital, and if they use the same method that has been used in related work.

The work *[16]* presents an overview on shortest path analysis for an effective emergency response mechanism to minimize hazardous events. They provides web application for finding optimal routes from location of specialized response team stations to incidents site so as to maximize their ability to respond to hazard incidents.

In incidents; there is a need for fastest response to reach the incident location and both in terms of dispatching the emergency services to the location of disaster as well as evacuation of the population from that location. This requires having path analysis that would enable the routing and re-routing of vehicles from the various key locations to the event scene and from the event scene to the key locations.

Their system use *GIS* to find optimal path. *Geographic Information Systems (GIS)* was designed to support geographical inquiry and ultimately, spatial decision making. The value of *GIS* in emergency response arises directly from the benefits of integrating a technology designed to support spatial decision making into a field with a strong need to address numerous critical spatial decisions. So *GIS* holds the capability to integrate maps with detailed database information and images, and turns ordinary maps into smart maps that respond to queries and helps in complex analysis.

They use *Dijkstra's* algorithm to find optimal path. *Dijkstra's* algorithm is called the single-source shortest path. It computes length of the shortest path from the source to each of the remaining vertices in the graph. The algorithm select the optimal path among the road based on the minimum weight. But it don't consider other contributing factors such as road width, speed limit surface condition and so on.

2.4 Summary

In this chapter; we discussed the history of global positioning system which is used for navigation purposes and positioning. We present with a brief the history of health information management and development stages in each era has passed. Also we discussed mobile application types and constrains, tracking algorithms and related work with verbosity. We summarize related work in tables (2.1 to 2.8) below.

Table 2.1: paper [9] summary.

<table>
<tr><th>Paper Title</th><th>Proposed by</th><th>Published in</th><th>Techniques</th></tr>
<tr><td>Healthcare management system and domain search of nearest medical services</td><td>- Ruchi Dumbre,
- Purva Raut,
- Bhagyshree mahamuni,
- Priyanka Khose,
- Prof.Jagruti Wagh.</td><td>2016</td><td>- RESTful web service.
- OTP
- GPS: for location tracking
- K-means clustering: for searching purpose
- MD5: to provide web based security</td></tr>
<tr><th colspan="4">Results and Open issues</th></tr>
<tr><td colspan="4">The paper suggested to implement web application for faster communication between doctors and patients by use RESTful web services and deals with tremendous information regarding the hospitals, blood bank…etc.
The system provides list of hospitals, blood bank and medicals, use GPS to identify location of user and provide find path of nearest medical center by use k-means clustering algorithm.
The system use MySQL to store all data about doctors, patients and patients' history or present medical condition changes and use unique OTP given to the user to provide authentic access.
My opinion that to use cloud computing to safety store all data and there is no need to thinking about infrastructure or losing data. Also the mobile application is faster and more comfortable. The traditional k-means algorithm does not guarantee optimality of clusters.</td></tr>
</table>

Table 2.2: paper [10] summary.

<table>
<tr><th>Paper Title</th><th>Proposed by</th><th>Published in</th><th>Techniques</th></tr>
<tr><td>Domain Specific Search of Nearest Hospital and Healthcare Management System</td><td>- Nimbalkar, Rashmi A.
- R. A. Fadnavis..</td><td>2014</td><td>- Hybrid mobile Application
- Cloud computing
- GPS: for location tracking
- A* algorithm: for nearest route finding with its specialty</td></tr>
<tr><th colspan="4">Results and Open issues</th></tr>
<tr><td colspan="4">Their main aim is to develop android application for “medical emergency”.
The system locates nearest available hospital, contact its ambulance emergency system, accesses EHR of patient and proposed android based tracking for EMS (Emergency Medical System) on cloud. Authentication is done according to the role based access control.
The system suggests the list to the client. GPS alarm application provide the service to user by mining the shortest distance between source and destination, the system will notify user if he/she arrive destination while traveling to.
The system couldn’t find nearest hospital depend on different parameters such as blood module, clinic module, specific practitioner or even time of services.
We can reach more benefit from cloud technology features by using web services technology within clouds without human intervention.</td></tr>
</table>

Table 2.3: paper [11] summary.

Paper Title	**Proposed by**	**Published in**	**Techniques**
Hybrid application Access Scheme for Voice Interface in Mobile Health for Older Users	- *Choi, Jooho* - *Byung Mun Lee.*	2015	- Hybrid application, PhoneGap - Voice recognition

Results and Open issues
This paper presents how to use mobile health service based on voice interface in order to solving this problem by using hybrid application to provide monitoring. This model complements the fallen vision, perception of the older users and overcomes the heterogeneity of the mobile platform. The user enter information by speech framework, then the input information that sent to the healthcare server is manage, and doctor writes a note by confirm the information of the older users through the hospital's *EMR (Electronic Medical Record)* system. Written doctor's notes can also be stored on the healthcare server, and could be checked by smartphone. The best feature in this system is: the system can merge with most healthcare management systems because its intermediate system between client and server that can recognize patient's voice and send it to the server as text. So the system able to work with any existing healthcare management system easily. But this method *"voice recognition"* may not suitable with any patient condition, because it depend on the voice and SpeachRecognizer should recognize the voice to translate it to text.

Table 2.4: paper [12] summary.

Paper Title	**Proposed by**	**Published in**	**Techniques**
Taxi, Please! A Nearest Neighbor Query in Time-Dependent Road Networks	- Mirla Chucre - Samara Nascimento - Jose Antonio - Macedo Jose - Maria Monteiro - Marco Antonio Casanova	2016	- GPS: for location tracking - *NN-Reverse-TD* algorithm: for search nearest point of interest.
Results and Open issues			
This paper propose a new kind of "*KNN query – K Nearest Neighbors*" on time-dependent network which aims at finding *k* points of interest that are closest in time to a query point. *NN-Reverse-TD* algorithm is based on the *Incremental Network Expansion* "*INE*" algorithm. The proposed approach does the expansion using a reverse graph G^R, which allows finding and pruning candidates POIs (point of interests). The system need to store every single corner point and taxi positions to build a graph so can search for neighbors of user's location, this is huge data and record by record the search will be difficult because the algorithm makes road network and its input is query point then its reverse searching from destination to the query point. In the big cities this algorithm need to partitioning the network or filtering unneeded points to decrease network size.			

Table 2.5: paper [13] summary.

Paper Title	**Proposed by**	**Published in**	**Techniques**
Nearest Automatic Teller Machine (ATM), *Minimarket*, and Restaurants Finder Application based on GPS Technology (*Global Positioning System*)	- Andi Nugroho - Dwi Ma'ruf Alvansuri.	2017	- GIS - GPS: for location tracking - Ionic framework: to develop hybrid application
Results and Open issues			
The proposed system search for nearest ATM, minimarket, restaurant…etc. The application get user's location via *GPS,* the user should choose object from category. Suppose the user need to find nearest ATM Then the application return information about nearest ATM and route between user's location and ATM. The application provides viewing comments and rating to the condition of any object in the category. In proposed system they uses GIS techniques to determine the location for thermal sensor detector equipment placement.			

Table 2.6: paper [14] summary.

Paper Title	**Proposed by**	**Published in**	**Techniques**
Personal Health Companion – The Medical Service Finder Application	- Rohit R. Kalambate - Gaurav M. Gavankar - Tejas M. Kasare - Laxman S. Naik	2017	- GPS: for location tracking
Results and Open issues			
The proposed system is a mobile application which helps user to trace nearest specialist doctor, ambulance, medicals, police and the services like booking appointment with doctor, get awareness news, blood banks etc. If user requires offline help for common diseases, then they can use home remedies option. This application uses *GPS* services for getting the location of the user. The application is useful to the normal people who does not aware about the local area medical services.			

Table 2.7: paper [15] summary.

Paper Title	**Proposed by**	**Published in**	**Techniques**
Nearest Hospital Tracking and Disease Prediction	- Pratima Panneer Selvam	2017	- GIS - GPS: for location tracking
Results and Open issues			
This project is a MCs project which developed an application to provides information related to the different hospitals and get the patient list of nearest of nearest hospital and available services. Their system aimed to solve wasted time when the patient is shifted from hospital to other after admitted to the hospital and proper services are not available. The application has a unique feature of predicting the disease for the symptoms entered by the members and by this members can easily get to know the complete details about the diseases. This system depends on existing system in how to search for nearest hospital.			

Table 2.8: paper [16] summary.

Paper Title	**Proposed by**	**Published in**	**Techniques**
Shortest Path Analysis Based on Dijkstra's Algorithm in Emergency Response System	- Ni Kai - Zhang Yao-ting - Yue—peng	2014	- GIS - GPS: for location tracking - *Dijkstra's* algorithm: to find optimal path.
Results and Open issues			
This paper provides web application for finding optimal routes from location of specialized response team stations to incidents site so as to maximize their ability to respond to hazard incidents. Their system use *GIS* to find optimal path. So *GIS* holds the capability to integrate maps with detailed database information and images, and turns ordinary maps into smart maps that respond to queries and helps in complex analysis. They use *Dijkstra's* algorithm to find optimal path. But it don't consider other contributing factors such as road width, speed limit surface condition and so on.			

Chapter Three

Methodology

3.1 Introduction

In this chapter we'll explain system requirements, analyze the system by use appropriate software development model. Also we'll identify ideas and data description. We'll explain all methods we are going to use in this system.

3.2 Mobile Application Development Lifecycle

Software development lifecycle is critical in desktop or web application development. There are many different lifecycle models defined, and we can classify these models into two classes*: Software Development Lifecycle (SDLC)*: waterfall, spiral, prototyping, agile and so on, and *Mobile Application Development Lifecycle (MADLC)*. Desktop Software Application Development contains similar phases of any SDLC. *[8]*

All development models may vary in its activities or steps but all of them includes planning, requirement, analysis, design, test…etc. The output of each phase feeds into the next phase. In mobile application development. *[8]*

There are differences between PC and mobile application development; the life span of mobile application is less than any desktop application, Mobile application development contains various complex functionality and services -such as telephony, camera, GPS and so on- and it may require the implementation of telephony functionality. Desktop application development is much more restricted to the desktop or the laptop device. Desktop laptop have different physical interfaces such as keyboard, mouse, touch panel and other external devices but the mobile physical interfaces are strictly restricted to touch panel or the mobile keyboard. *[8]*

The Desktop application designed in one screen to support functionality to acquire desktop/laptop screen, but the mobile application requires more number of layered screens to support a similar functionality as a single large screen because of screen size differences. The idle processes running in the mobile devices would consume a significant percentage of the available battery or memory. *[8]*

3.2.1 MADLC

The *MADLC* – Mobile Application Development Lifecycle model. Its have seven phases: in *Identification phase* ideas are collected and categorized. Core functionality should be documented. The initial requirement gathering should be completed. Then the work should be documented. In *Design phase* the ideas are developed into initial design. The specific target of mobile platform is identified. The application functionality is broken down into modules and prototypes. The functional requirements are defined. The software architecture of the application is created. The work is documented. *[8]*

In *Development phase* each defined modules are coded. Development can be done in parallel, subsequently these modules can be integrated. The work should be documented. In *Prototyping phase* the functional requirement of each prototype are analyzed. Then prototypes are tested and sent to the client for feedback. When the prototype is ready it is integrated with previous prototype. The development, prototyping and testing phases are repeated until the final prototype is ready. *[8]*

In *Testing phase* the prototype types testing is performed on an emulator/ simulator followed by testing on the real device. The test cases are documented. In *Deployment phase* the application is uploaded to the appropriate application store/market for user consumption. In *Maintenance phase* Feedback is collected from users and required changes are made in the form of bug fixes or enhancements. *[8]*

3.3 The Website Planning and Analysis and design

In this section we explain how to perform a design analysis for planning process to create great web site design. To design website in deliberate manner; we should learn how to determine what elements are required for web design, how to build in differentiation and reflect system purpose. The website should focus on providing useful information. So planning and analysis process contains seven steps:

a. Phase one- Information gathering: this step is most important, we must consider what the purpose of website, what the goals should be accomplished by designing website. Also it’s important to determine specific group of people will visit the website this will help to determine best design style for website.
b. Phase two- differentiation in mind: differentiate website from related websites and must use uniqueness design and ideas.
c. Phase Three- Planning: using gathered information and putting it together to develop a site map. The site map is a list of all main topic areas of the site. This serves as a guide as

to what contents will be on the site. This phase is essential to developing a consistent, easy to understand and usefulness website.

d. Phase four- Design: determine the look and feel of your website. Target audience is one of the key factors taken into consideration. Elements, colors and contents should be determined based on target audience. Prototype designs of website should be created.
e. Phase five- Development: in this phase the designer will take all of the individual graphic elements from the prototype design and use them to create the actual and functional website. On the technical front, a successful web site requires an understanding of front-end web developing.

   Determine complexity and usability when considering adding any unusual features. Websites that include, Flash, AJAX, complex javascript or any other type of embedded code will require a lot of effort to ensure that it works with all browsers on different platforms. Before deciding on using these features, decide whether they are adding any value to the customer.
f. Phase Six: Testing and delivery: designers will test functionality of forms, scripts, navigation bar and son on, also they will test website in different browsers to ensuring that the website is optimized to be viewed properly in the most recent browser versions.
g. Phase Seven: Maintenance: to bring visitors to website we should offer new contents. In this phase information should be up to date, fix bugs and offer maintain packages. *[17][18]*

3.4 System Methods

3.4.1 Improved k-means algorithm

In chapter two, we talk about location tracking algorithms uses to find shortest path and we explained *k-means clustering* algorithm in details. In proposed system we'll improve k-means algorithm to in line with system requirement.

Mainly *Clustering algorithm* used to find hidden knowledge in collected data. In [9] the authors used k-means clustering algorithm to find shortest path. As we discussed in chapter two; k-means algorithm grouping objects into clusters depend on similarity, so the algorithm could find shortest path by referring location, grouping objects into clusters and then choose nearest k cluster. In proposed system we benefited from [9] and how they uses clustering algorithm to find nearest healthcare center. We'll improve k-means clustering algorithm as below:

i. **Input:** *F_D = {d1, d2, …, dn}* // *F_D* contains filtered data objects based on user chosen, user's current location *P(lat, lon)* // *P* is a point, *lat* is a latitude, *lon* is a longitude.

ii. **Output:** Set of nearest data objects to the centroid.

iii. **Steps:**

1. Filter data objects based on user chosen.
2. Generate *Lists* to store data objects as a points of coordinates, *L1* and *L2*. // *L1* and *L2* contains latitudes and longitudes.
3. Generate one cluster center (*C*) and assign a value to the center (*C=P (lat, lon)*). /* the selection of the number of cluster center (centroid) is based on area to be searched, and the selection of the centroid and its value isn't randomly. */
4. Calculate distance between *C, L1* and *L2* by use *Haversine formula* instead of *Euclidean distance formula*. // *L1* and *L2* contains latitudes and longitudes.
5. Generate *hashmap* to store distance, (*H= (i, d)*) // *H* is a hashmap, *i*= index, *d* is a distance between objects and *C*.
6. Sort *H* ascending.
7. Select first three entry in *H*.
8. Generate resultant list.
9. End

3.4.2 Security mechanisms

Nowadays security aspect being critical and important to any system. So we going to apply security mechanisms into every system level to guarantee integrity and confidentiality. Security mechanisms and methods discussed as follow:

There is need to protect data integrity and accessibility. The protection of data should be provided in each system levels. *Profile* defines database users' behavior and restriction on database resources to prevent wasting resources, each profile define restriction on resources and implementation of password policies. *[21]*

To make passwords unable to crack or expectation; *password policies* can keep it save as well as possible, it's enhance the password robustness and deals with complexity of password, aging or password age, usage and storage. Some of these policies is: (Enforce password history, Maximum password age, Maximum password length, complexity, store password encrypted, Maximum password reuse …etc.) *[21]*

Each user should granted minimum *privileges* to do assigned tasks. Only administrator granted system privileges. She/he able to add and delete users, grant and revoke privileges. *Role* used to organize and administrate privileges. Role could create as we want to create user, assign privileges to the role, and then assign users to the role. *[21]*

Limiting access to hardware, database resources, and files. *Identification* and *authentication* methods should be applied. Restricting access to the database by using *access control* techniques, either *Discretionary access control or Mandatory access control.* Discretionary access control techniques of granting and revoking privileges on relations has traditionally been the main security mechanism for relational database system. Mandatory access control includes discretionary access control techniques, its classifies data users based on security classes (TS,S,C,U). *[21]*

Ensure data integrity by restricting access to the data, applying encryption, validation and constraints on the data. Also *VPD* or Virtual Private Database; controls data access at the row or column level. *[21]*

3.5 System Analysis

System analysis is very important to build the system. In *MADLC*; Identification phase is parallelizes system analysis in system requirement phase and analysis phase in *SDLC*.

3.5.1 System requirements (Identification phase)

The main objective of this phase is to come out with a new ideas or improvements to the existing application. There are several applications (web based and mobile) developed to find shortest path. In this project, we going to modify mobile application by use different tracking algorithm, security mechanisms and mobile development lifecycle.

The whole system depends on a collected ideas and requirements. System requirements categorized into two main categories: *Functional Requirement* and *Non-Functional Requirement*. So we have to define ideas with its core functionality, gathering initial requirements and the time required to develop the application.

The basic data we need in this project is practitioners' information and its specialties, information about healthcare centers and its locations, information about medical services and clinics schedules. The basic ideas is to find shortest path, exchange *electronic health records* and find medics and medical services. Also we try to improve performance by use different method called enhanced *k-means* clustering algorithm. Additionally we need standardize health information for patients to generate *electronic health records*.

3.5.1.1 Functional Requirements

Functional requirement defines the core functionality of the system and essential. Functional requirements are described as follow:

Security is essential to ensure an authorized users can access patients' data and only authenticated users should use the system. User interface is essential to provides interaction between server and client. Find shortest path between current location (user's location) and nearest healthcare center is main objective of this project. Database is essential to store data about patients, practitioners, health records, healthcare centers and its location. Provide information about healthcare centers and practitioners schedule. Provide medical history records based on database-role.

3.5.1.2 Non-Functional Requirements

Non-functional requirement is to improve the functionalities and to achieve the quality of the system. Non-functional requirements are described as follow:

Performance is essential for the system to be fast and convenience, especially the major system function is to find shortest path shortly. Scalability required in the system to extend it easily, because of use web services technology; the system will be able to expend. User interface should be easy to use, simple and suitable for elders.

3.5.2 System use case

Use case view us haw the user interact with the system. There are three actor; administrator, practitioner and patients. Each actors has certain level of access to the system and responsibility. Also there are several security levels and any user belongs to certain level.

Administrator: Administrator is responsible to maintain the system, check security and application logs, server issues, handles errors in the system, add/ edit healthcare services, edit patient/practitioner information. See figure (3.1).

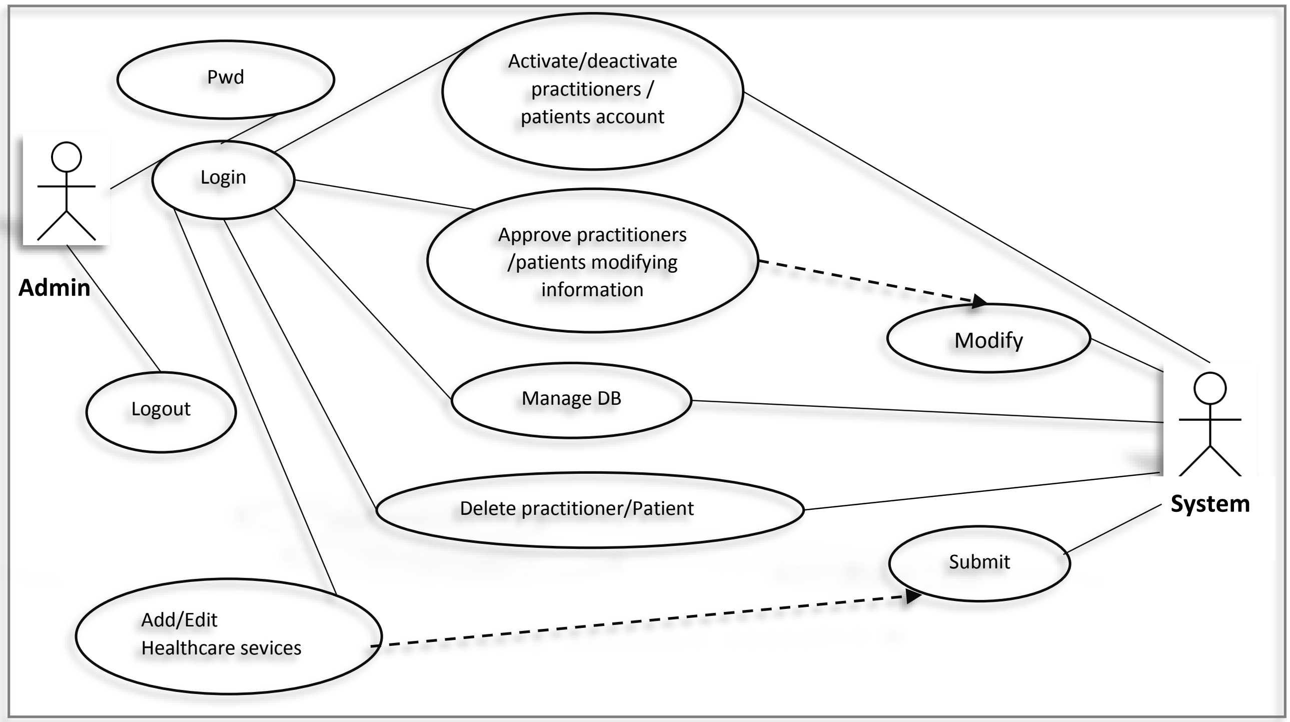


Figure 3.1: Use case diagram of Administrator

Practitioner: Practitioner is responsible to view its basic information, maintain the patients' *EHR* and exchanges it with other Practitioner. Practitioner able to search for nearest healthcare services. See figure (3.2).

Patients: Patient is responsible to view its basic information, and request admin to edit his information because patient unable to edit his information directly. The patient can search for nearest healthcare services. See figure (3.3).

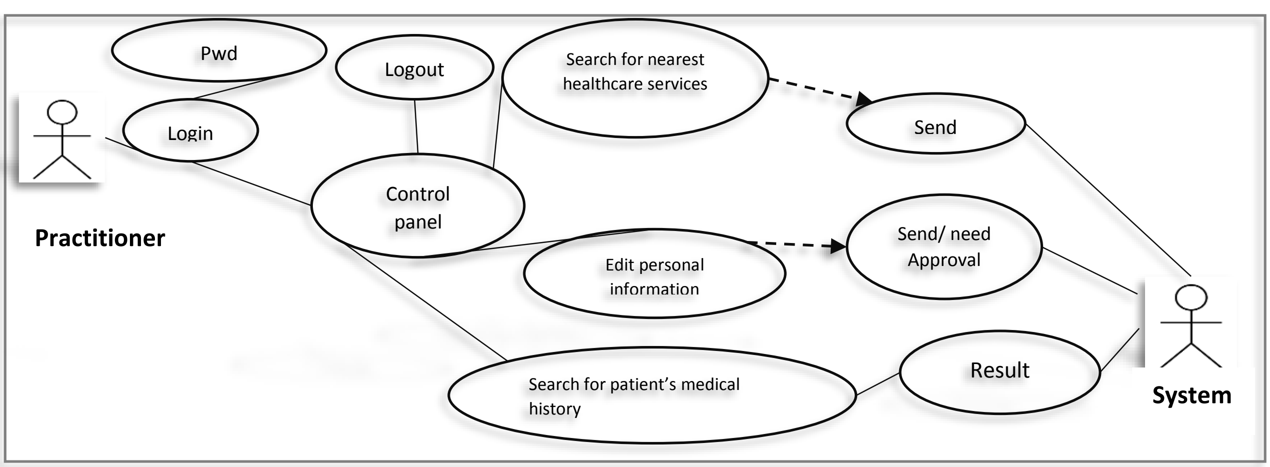


Figure 3.2: Use case diagram of Practitioner

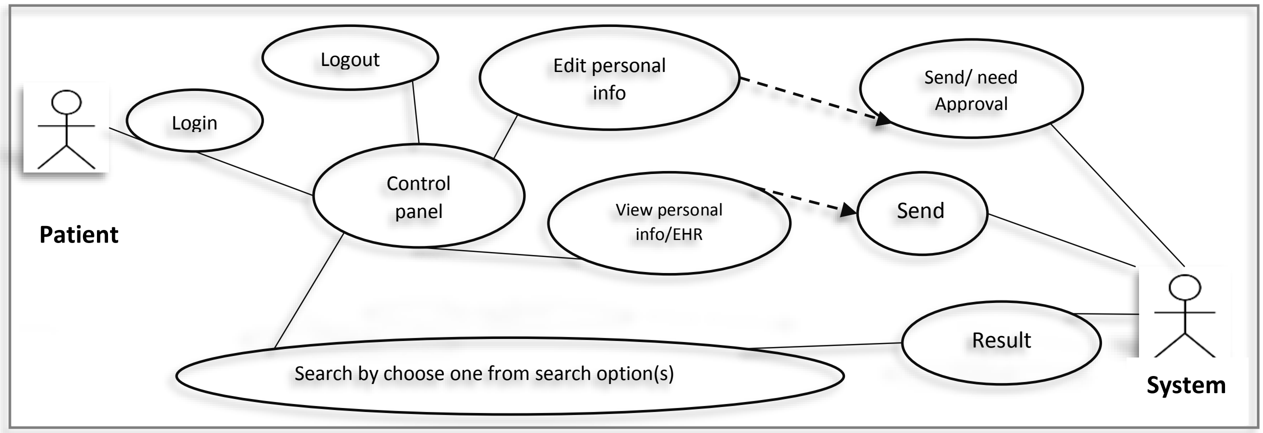


Figure 3.3: Use case diagram of Patient

3.5.2.1 Use case scenario of Login

An authorized actor want to enter to the system. The actor must enter its username and password, the system should verify if the actor authenticate to enter the system or not. If the username and password is valid; the actor is able to enter the system, otherwise the actor must try to enter parameters correctly, or it's unregistered at all. See figure (3.4).

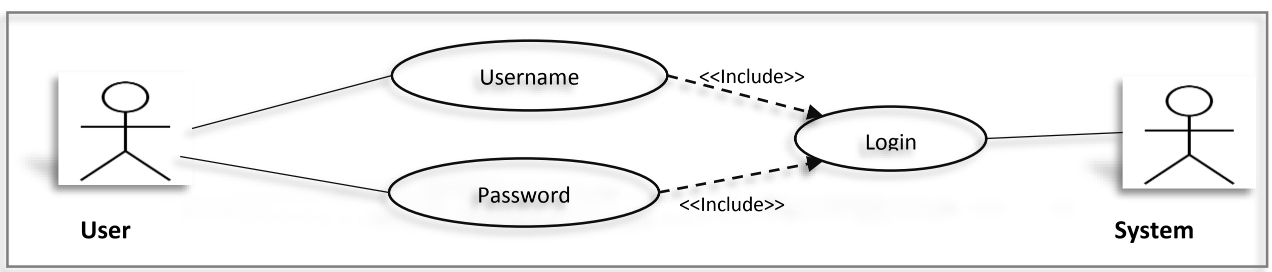


Figure 3.4: Use case diagram of Login process

3.5.2.2 Use case scenario of Registration

Actor should be registered to be an authenticated. The registration form is so important, because the system depends on information of healthcare, patients and medics. In case of edition; only administrator can edit and add those information. The system will check the registration form entry is valid or not.

The patient actor information must include username, password, full name, age, blood group, location, tel no, medical history if exist and so on. Medic actor information must include full name, certificates, specialize or general, work location and so on. Healthcare information must include exact location, type, sector, policlinic and so on. See figure (3.5).

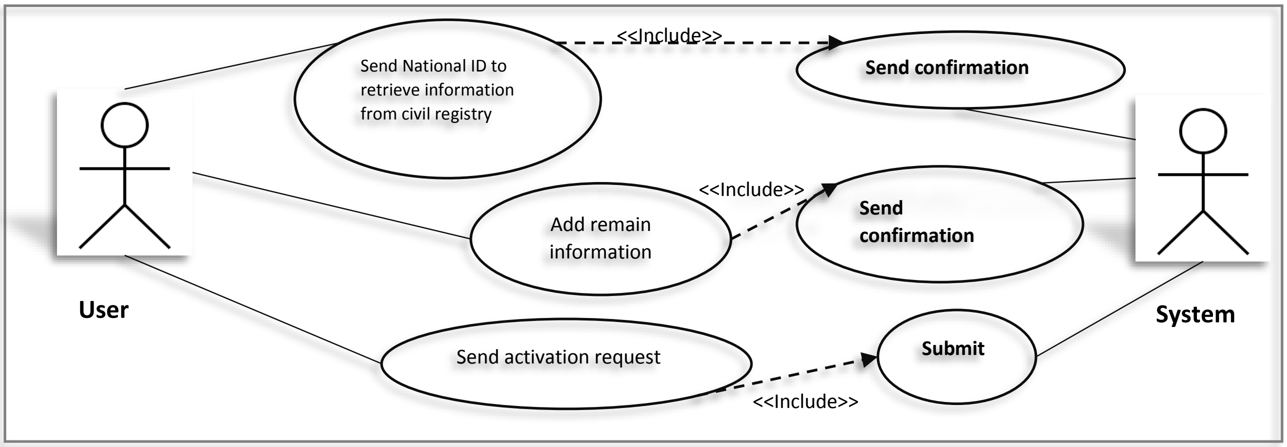


Figure 3.5: Use case diagram of Registration process

3.5.2.3 Use case scenario of Activate/De-activate user account and modifying user' info

Administrator able to activate and de-activate account. After registration step; username and password will send to the admin, the admin activate user account and assign user to specific database role, either practitioners role or patients role. For modifying info the user send request to the admin, the admin must check request and modify user information. See figure (3.6).

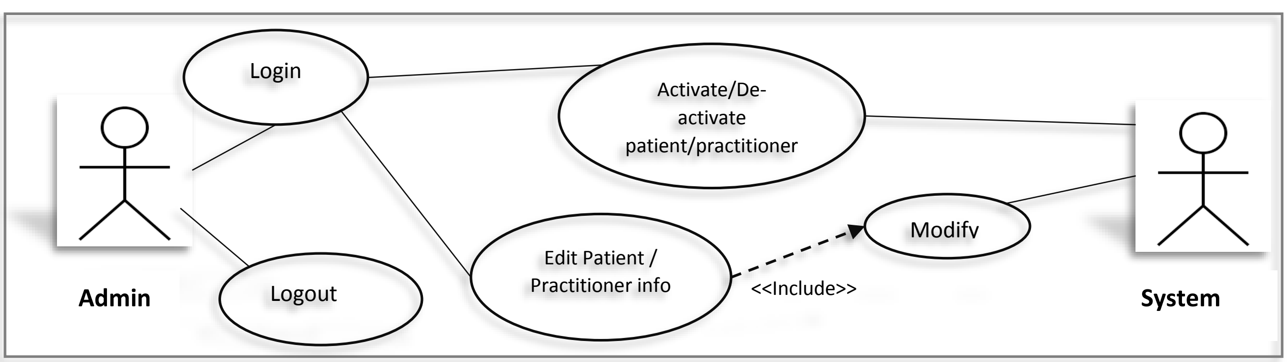


Figure 3.6: Use case diagram of Activate/De-activate user account and modifying information process

3.5.2.3 Use case scenario of Add and Edit healthcare info

Administrator able to add and edit healthcare information. In addition to healthcare centers, the system could track blood bank location, pharmacies and laboratories, so the administrator must add and modify all important information about healthcare centers. See Figure (3.7).

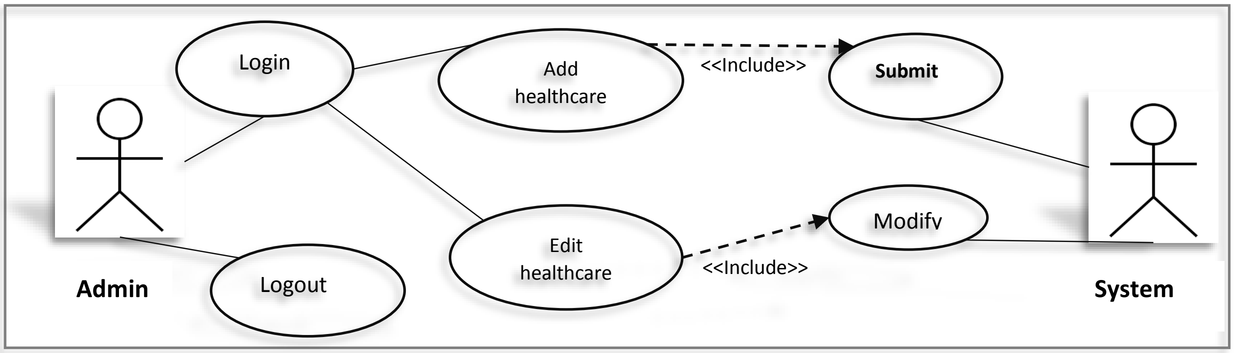


Figure 3.7: Use case diagram of Add and Edit healthcare centers info process

3.5.2.4 Use case scenario of search nearest medical center

The client must enter its username and password, after verification the system display search with its option and history, the client must choose option(s) to search. The server will receive request from client, depend on these parameters the system will return shortest path to the client, track algorithm will take these parameter and search for nearest path.

The system will return result to the user as soon as possible. The basic input is type of emergency, user location, there are additional search options like type of healthcare center, local of healthcare center, patient health case, specialty of healthcare center, specific practitioner, or even medical services. See figure (3.8).

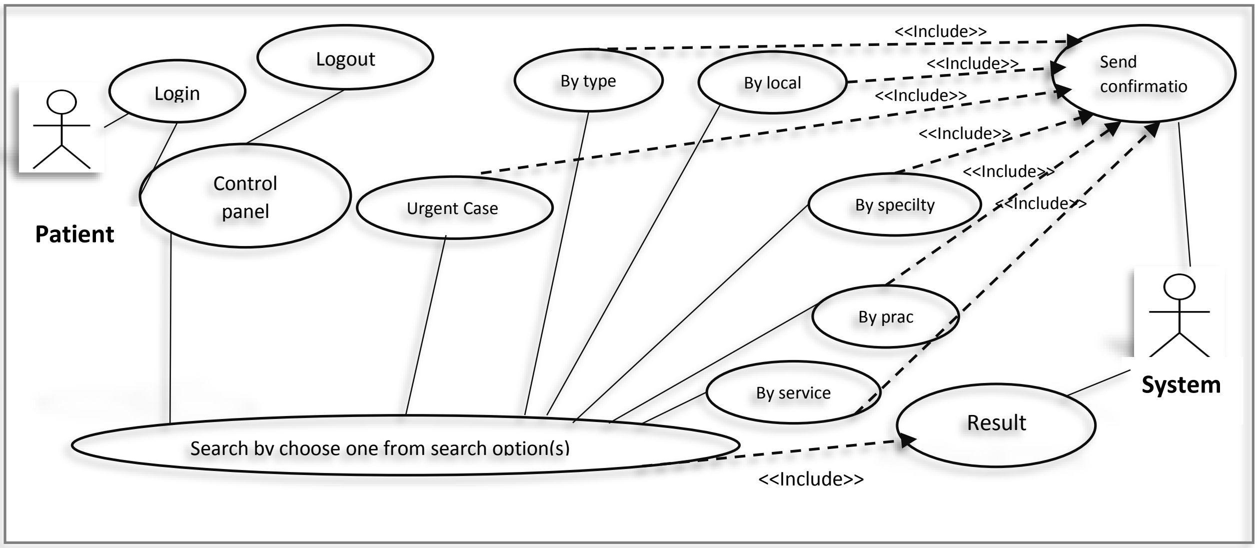


Figure 3.8: Use case diagram of search nearest healthcare service.

3.5.3 System Sequence Diagram

The Sequence Diagram models the collaboration of objects based on a time sequence. It shows how the objects interact with others in a particular scenario of a use case. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario.

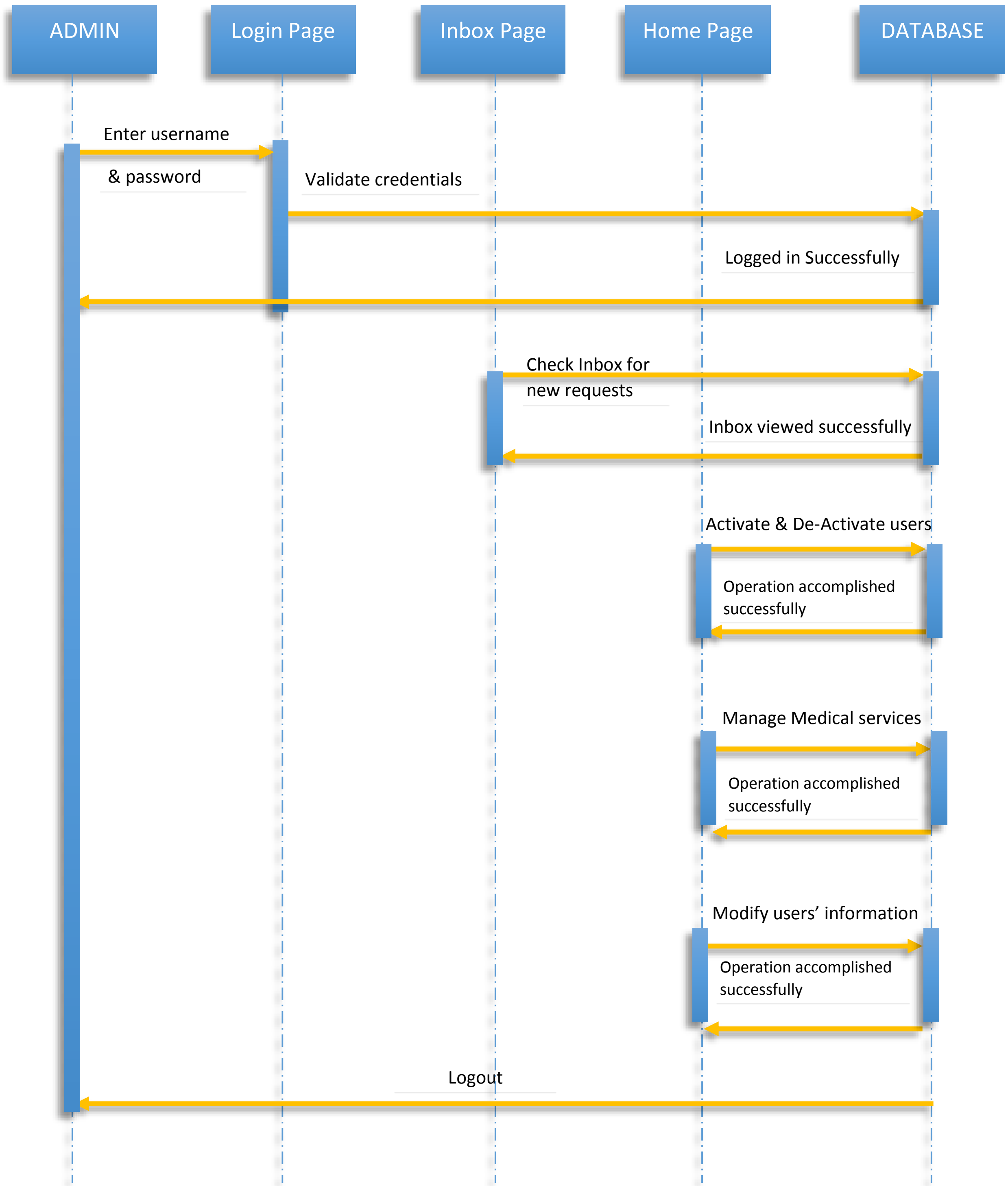


Figure 3.9: Sequence diagram on Admin.

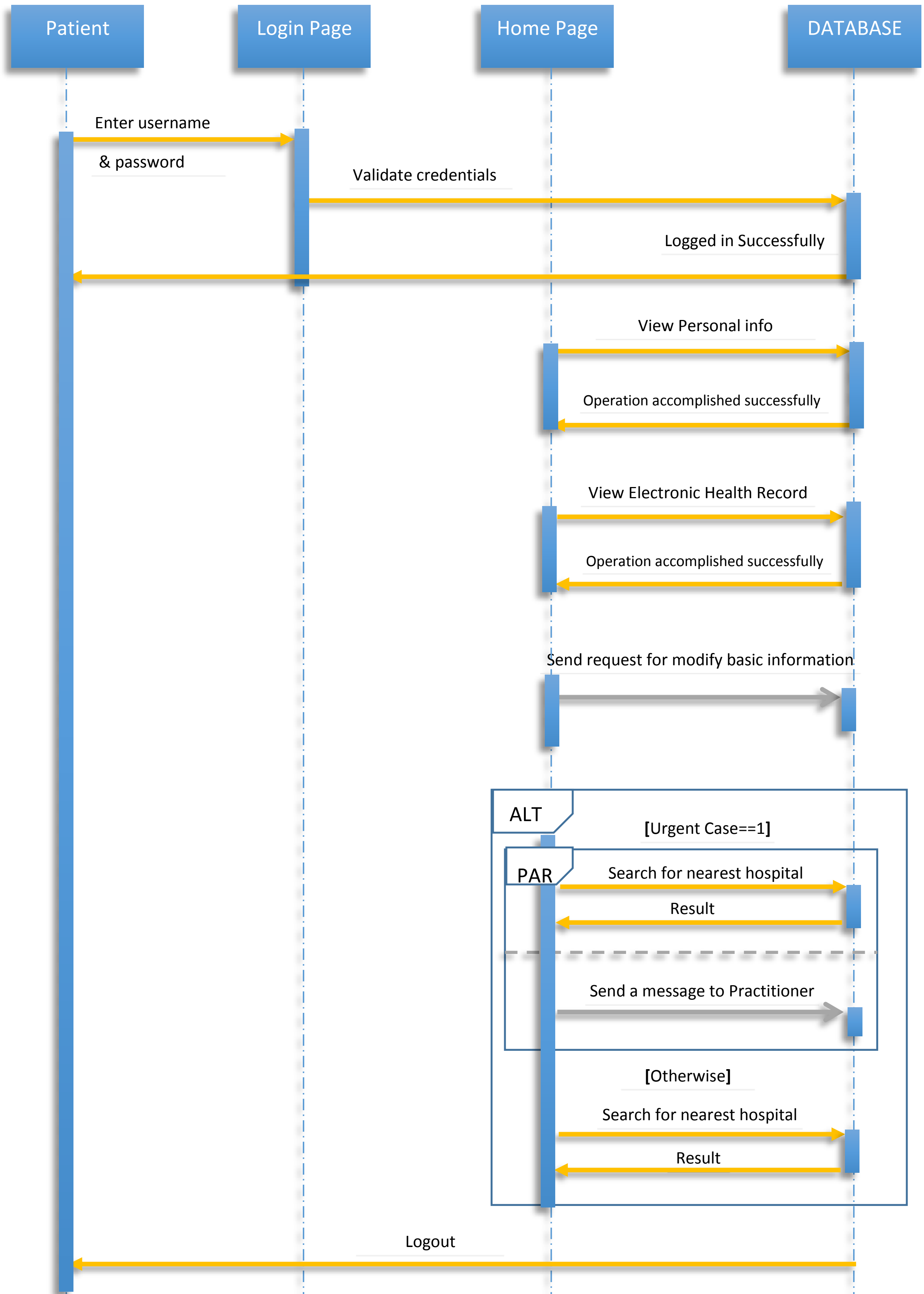


Figure 3.10: Sequence diagram of Patient.

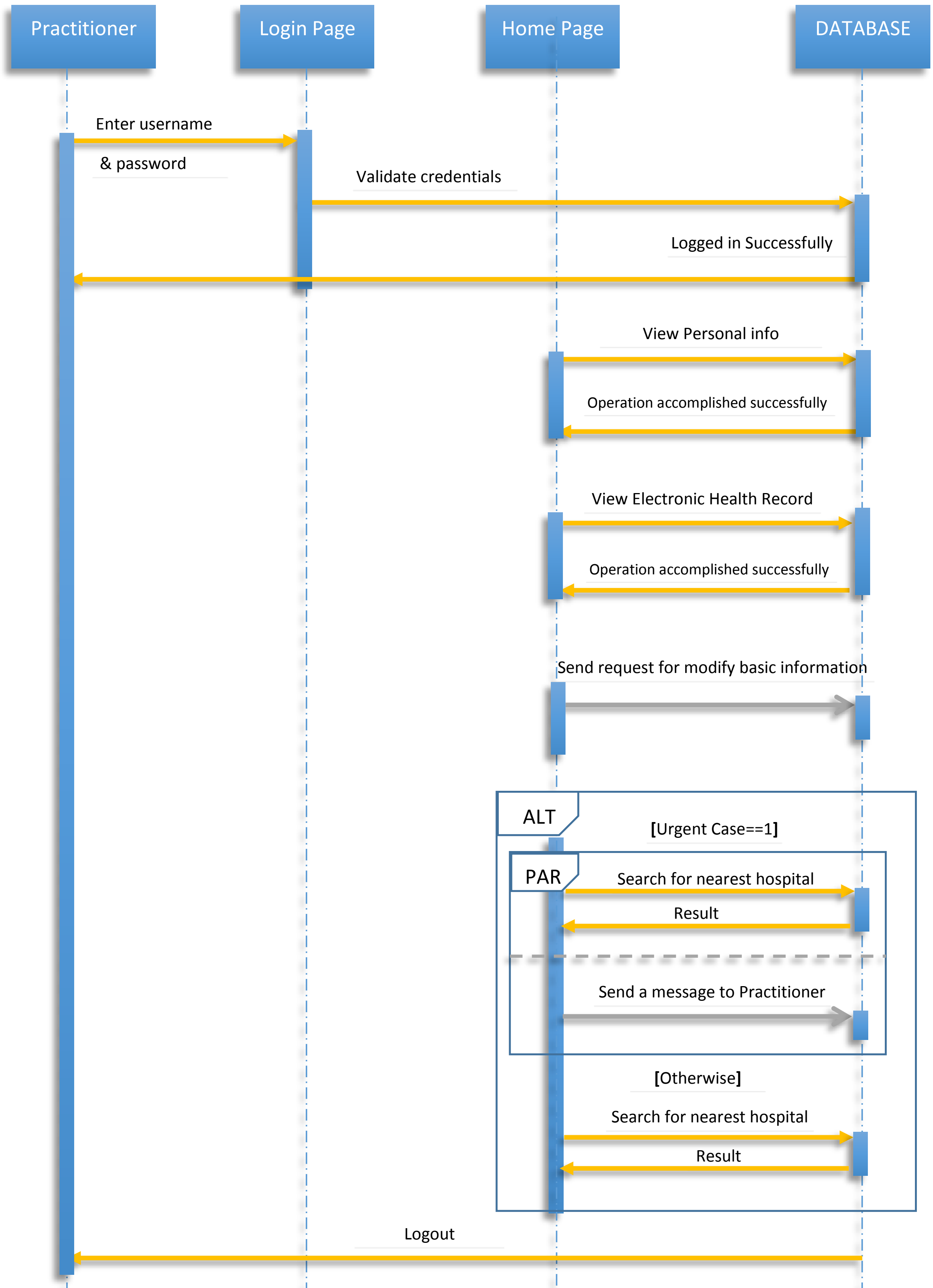


Figure 3.11: Sequence diagram of Practitioner.

3.5.4 The web Site Design and Development Process

There are numerous steps in the web site design and development process. In this section we will explain how to design.

3.5.4.1 Phase one: Information gathering

In this phase we will determine the information we needed to design website. The main objective of website is to find nearest healthcare center. The website must provide view *EHR*, edit information. Security mechanisms are needed especially to protect users' information and *EHR*.

3.5.4.2 Phase two: Differentiation in mind

There are similar products that provide find nearest healthcare centers. So we must differentiate website from similar. Website provides extra search options such as search by type, local, specialty and so on.

3.5.4.3 Phase three: Planning

There are main topics in website; guidance content in a main page that provides full information about website objectives and how to browse website. After logging in the user will redirect to specific page based on database role, the patient have different role from practitioner. Patient need to view its profile, search nearest healthcare center and view its *EHR* so the website will provide these information to the patient. When we provides viewing these important information we need to support security features to prevent attackers from accessing or tamper sensitive information.

3.6 Summary

In this chapter we explained system requirements, how to analyze the system by use Mobile Application Development Lifecycle model and differences between *SDLC* and *MADLC*. We explained differences between PC and mobile application development. Also we identified ideas and data description for proposed system. We explained all methods we going to use in followed chapter and to be implemented in proposed system. Finally we explained website analysis to design and develop useful website to achieve proposed system objectives in deliberate manner.

Chapter Four

Experimental Study

4.1 Introduction

In this chapter we'll explain system implementation, design the system by use appropriate techniques and frameworks. Also all functional requirements to be coded. We'll explain all methods we are going to use in this system and how we design our system to reach system target.

4.2 SQL Server Management System 17:

According to the *National Institute of Standards and Technology* (*NIST*) public security board, SQL Server has the lowest number of security vulnerabilities across major database vendors. In addition, the *Information Technology Industry Council* (*ITIC*) has deemed SQL Server "*the most secure database*." *[24]*

SQL Server is designed to be secure by reducing potential security risks, allowing administrators to selectivity choose connectivity and remote features based on their organizations' needs. The latest features in SQL Server 2016 significantly raise the bar of data security, providing new and enhanced features to protect data from various threats. SQL Server 2016 security features can be organized into three areas of focus: Access Control, Data Encryption and Proactive Monitoring. *[24]*

4.3 MVC Architecture

Model View Controller is a design pattern for computer software. *MVC* architecture helps to split applications into logical units and can be considered an approach to distinguish between the data model, processing control and the user interface. It separates business logic from interface logic. This architecture makes applications more effective and provides a framework which enforces better and more accurate design. *[22]*

"*And, just as the views know their model but models doesn't know its views, the controllers knows their views but the view doesn't know its controller*". I quote this sentence as it is from *[23]*, this sentence explain how view-model-controller are separated from each other, this separation makes application maintainable and easy to track errors and faults.

4.4 System Implementation

4.4.1 System Architecture (Design phase & Development phase)

A very important part of the design phase is to create the storyboard for the user interface interaction: this storyboard describes the flow of the application.

A. Capabilities

i. Client will use *GUI* to interact with system.
ii. Client need to register and fill its personal information.
iii. Client need to login in to access its personal page (search page).
iv. Patient able to edit its personal information (but indirectly) and unable to edit its medical information.
v. Practitioner able to edit its personal information (but indirectly) and to edit patients' medical information was created by him.
vi. The system provides search options to search for nearest healthcare center, and these options are:
   - Urgent cases.
   - Type of healthcare center: either hospital or medical center.
   - Specialization of healthcare center: such as general or pediatrics.
   - Local of healthcare center: such as Khartoum, Khartoum north or Omdurman.
   - Specific Specialist practitioner –practitioner name with specialty.
   - Specific services: such as CT Brain.
vii. The result will display as information about healthcare center and display its position in Google Map. These information support additional information in case inability to load map.
viii. Practitioner can search for patient health records by its ID.
ix. Practitioner can view all *EHR*, but patient can view only its *EHR*.

B. Processes

i. Client fill registration form and send request to server.
ii. Server get these information and store it in SQL Server database.
iii. Username and password sent to an admin mail, the admin will check if its match with other, otherwise the admin will activate login account and then send email to client.

iv. Now the client able to access system by enter its username and password.

v. Server get login credential and try to connect to the *SSMS* by use received connection string. If login successfully the client redirect to search page.

vi. The client should choose one from search options.

vii. Server accept request from client and get selected search option.

viii. It tracks patient location accurately.

ix. And then find out nearest healthcare center based on patient's current location and selected search option. Then send results to the client.

x. Client could view its information and show its medical history records.

xi. Admin task- add/edit healthcare centers and services information that stored in database and update it regularly, activate/de-activate accounts and edit client information.

xii. When practitioner insert new medical information about patient, the *EHR* of patient to be generated.

xiii. By use *RLS*; server side filter views for clients and no need to write code in servlet or model to filtering data. For example: to show *EHR*; same query will be used, but different behavior will be happened, select query without any where clause, but because of *RLS* data will be filtered before retrieved to client, patient will see its medical records only, practitioner will see all records.

4.4.2 Security features in SQL Server 17:

As we discussed above; SQL Server 17 provides security features like Always Encrypted, Security Policies, Roles, Audit, Row-Level-Security, Password Policies, Access Control Techniques and so on.

In proposed system we applied security features discussed below:

I. Disable "*sa*" account to prevent unauthorized access. See *figure (4.1)*.

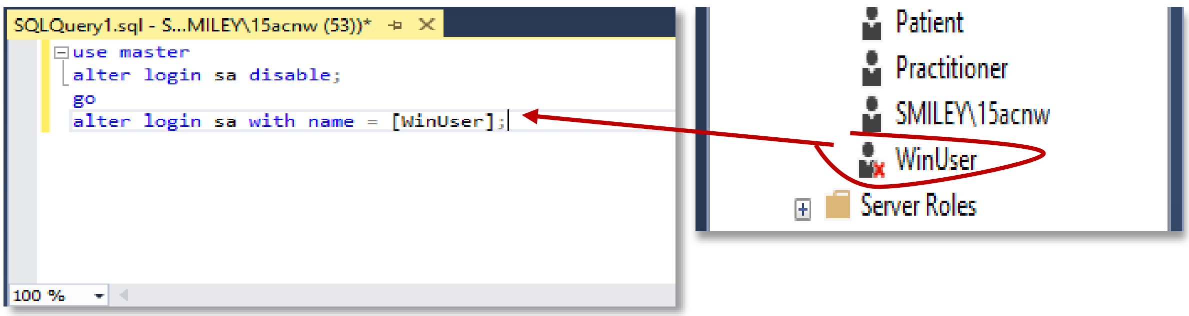


Figure 4.2: Disable "sa" account.

II. Any user have a login account to access database. See *figure (4.2)*.

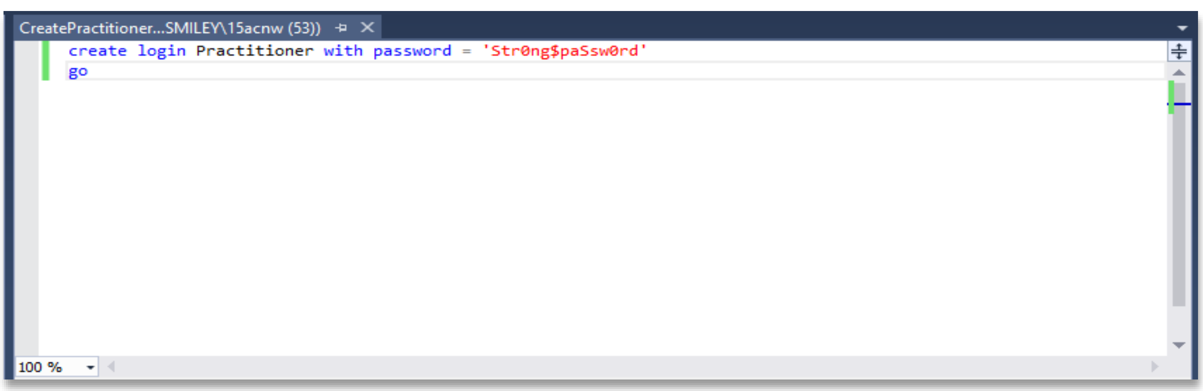


Figure 4.3: Create Login account.

III. *Role-based* security allow you to assign permissions to a role instead of to individual users. Then any user added as a member to created role, will get those permissions was assigned to the role.

In our system; two roles was created and assigned appropriate privileges, no more privileges- no less privileges - *Discretionary access control techniques* -. Then users assigned to these roles. See *figure (4.3)*.

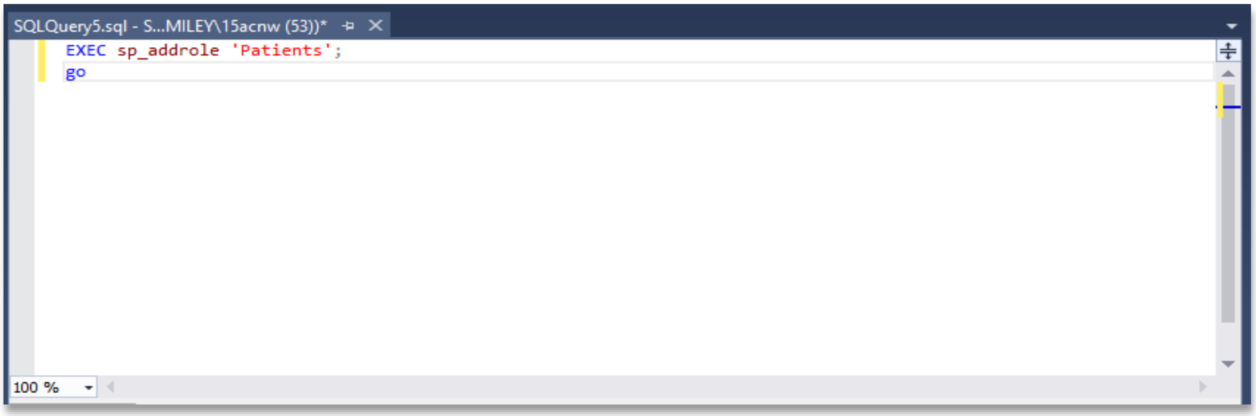


Figure 4.3(A): Create Role.

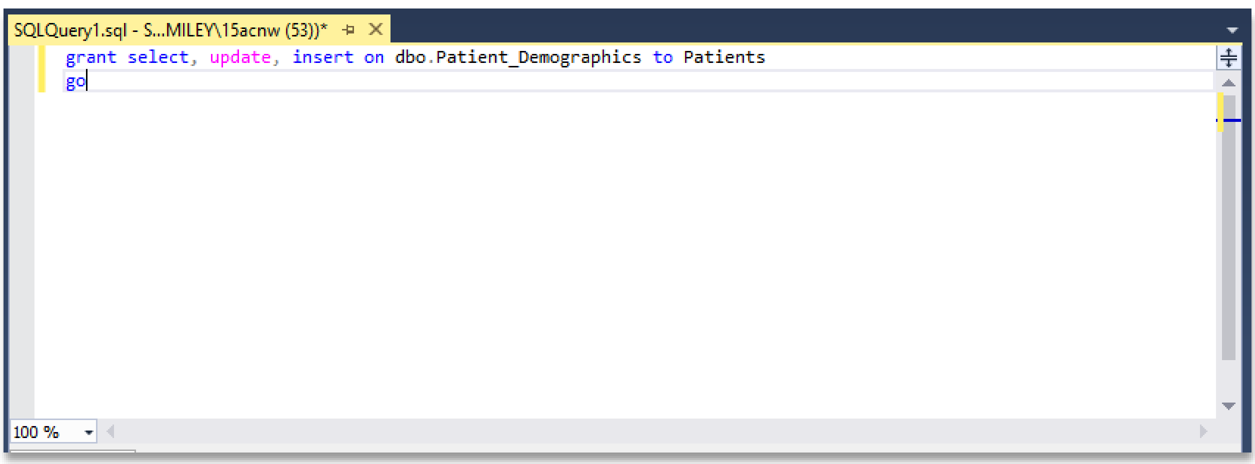


Figure 4.3(B): Grant Privileges to Role.

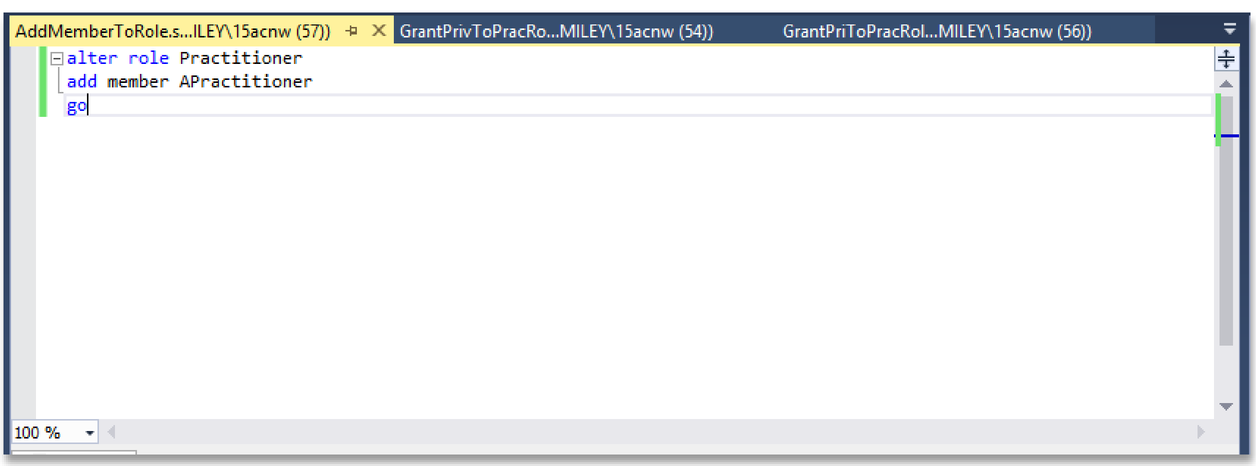


Figure 4.3(C) : Add members to Role.

Figure 4.3: Illustrate Role Implementation in SSMS v17.2.

IV. *Row-Level Security* (*RLS*) is a SQL Server feature that simplifies and centralizes access logic in a security policy at a per-row level. *RLS* uses filter and block predicates to determine which records are visible for a particular transaction, protecting data from unauthorized reads or writes (update/delete). Since predicates are evaluated at the Database Engine, no additional logic is required in the client application. It's enforced by a security policy, which invokes an inline table-valued function as a security predicate.

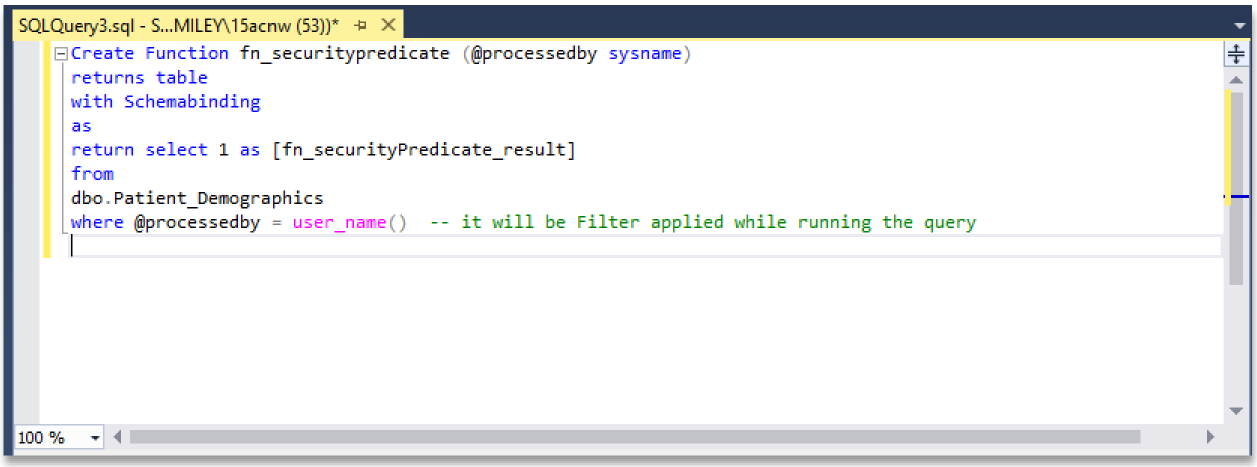


Figure 4.4(A): Create Function to filter rows by usename.

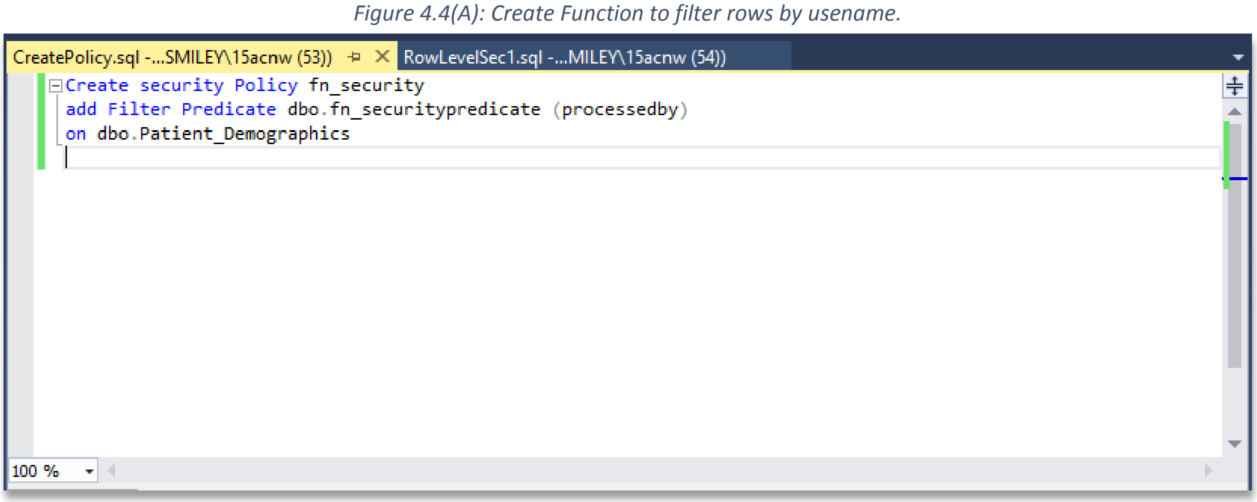


Figure 4.4(B): Create Security Policy to add filter predicate.

Figure 4.4: Illustrate Row Level Security implementation in SSMS v17.2.

With filter predicates, filtered rows are excluded silently Here *RLS* was applied. First we create function to predicate user by compare username in table and current user and filter rows based on username. Then create policy to execute created function [24]. See *figure (4.4)*.

V. Password should be strong to grantee the possibility of breaking password. *SSMS* support enforce password policies and enforce password expiration.

VI. *Always Encrypted* is a feature designed to protect sensitive data. It allows clients to encrypt sensitive data inside client applications and never reveal the encryption keys to the Database Engine. Always Encrypted was applied encryption function to encrypt *EHR* data. In *SSMS* provides two type of encryption: Randomized and Deterministic. Randomized encryption uses a method that encrypts data in a less predictable manner, so it's more secure than Deterministic encryption but prevent searching, indexing, grouping and joining on encrypted columns. *[25]*

Deterministic encryption always generate the same encrypted value for any given plain text value. Its allow equality join, grouping and indexing on encrypted columns, but unauthorized users able to guess information about encrypted values *[25]*. See figure (4.5).

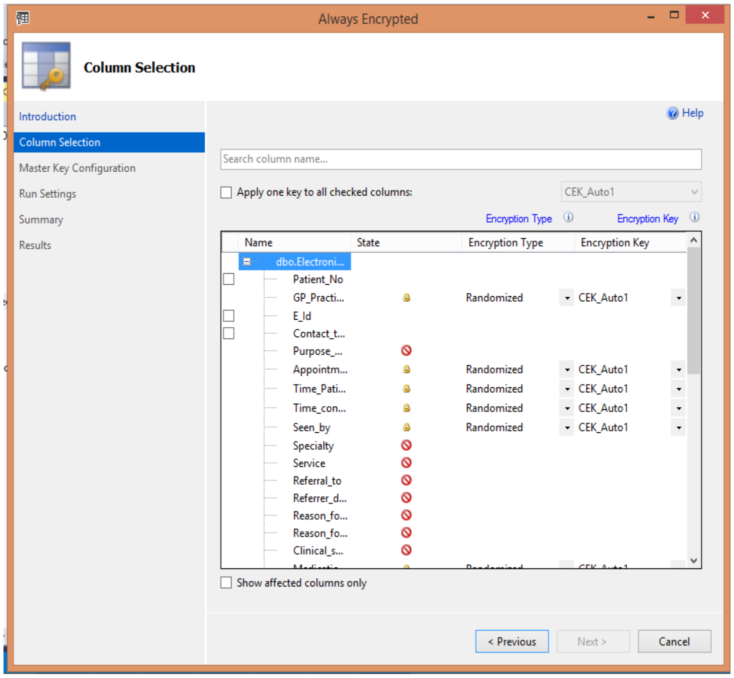


Figure 4.5(A): Choose Columns to be encrypted.

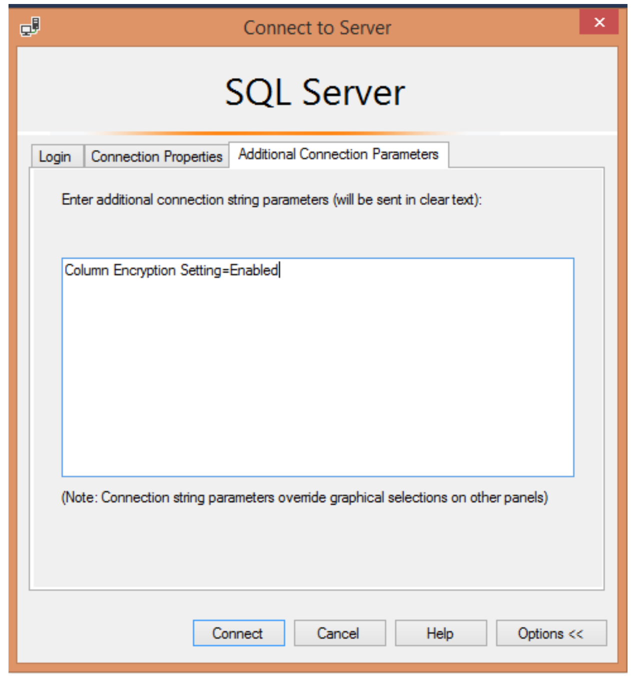


Figure 4.5(B): Enable encryption in connection String.

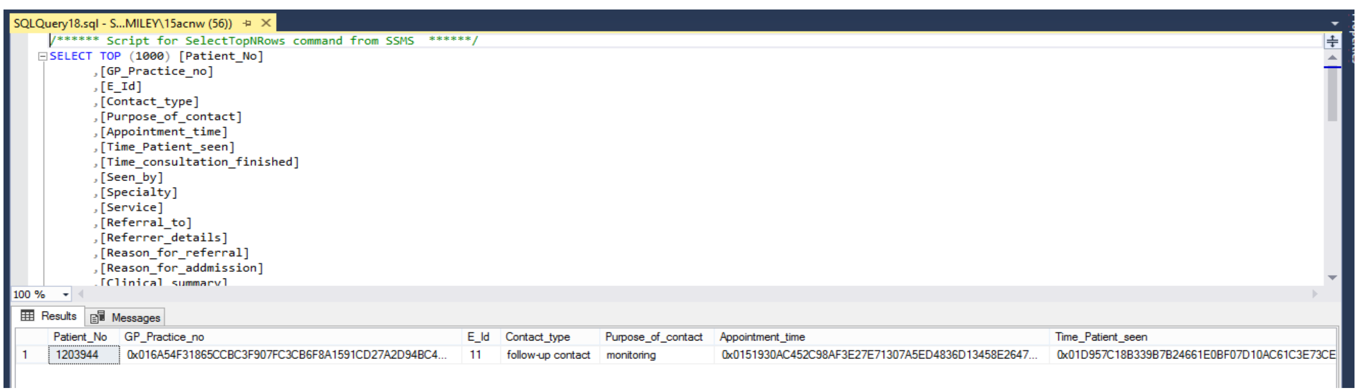


Figure 4.5(C) : When select from encrypted table; we can view all enctypted data.

Figure 4.5: Illustrate Always Encrypted Feature in SSMS v17.2.

4.4.3 SQL Server Database

We create Database by use *SSMS v17.2*. "*HealthCare_Management_DB*" contains seven tables to store healthcare centers information, *EHR*, practitioner information, patient information, services and practitioners schedules. Relationship between tables illustrated in *figure (4.6).*

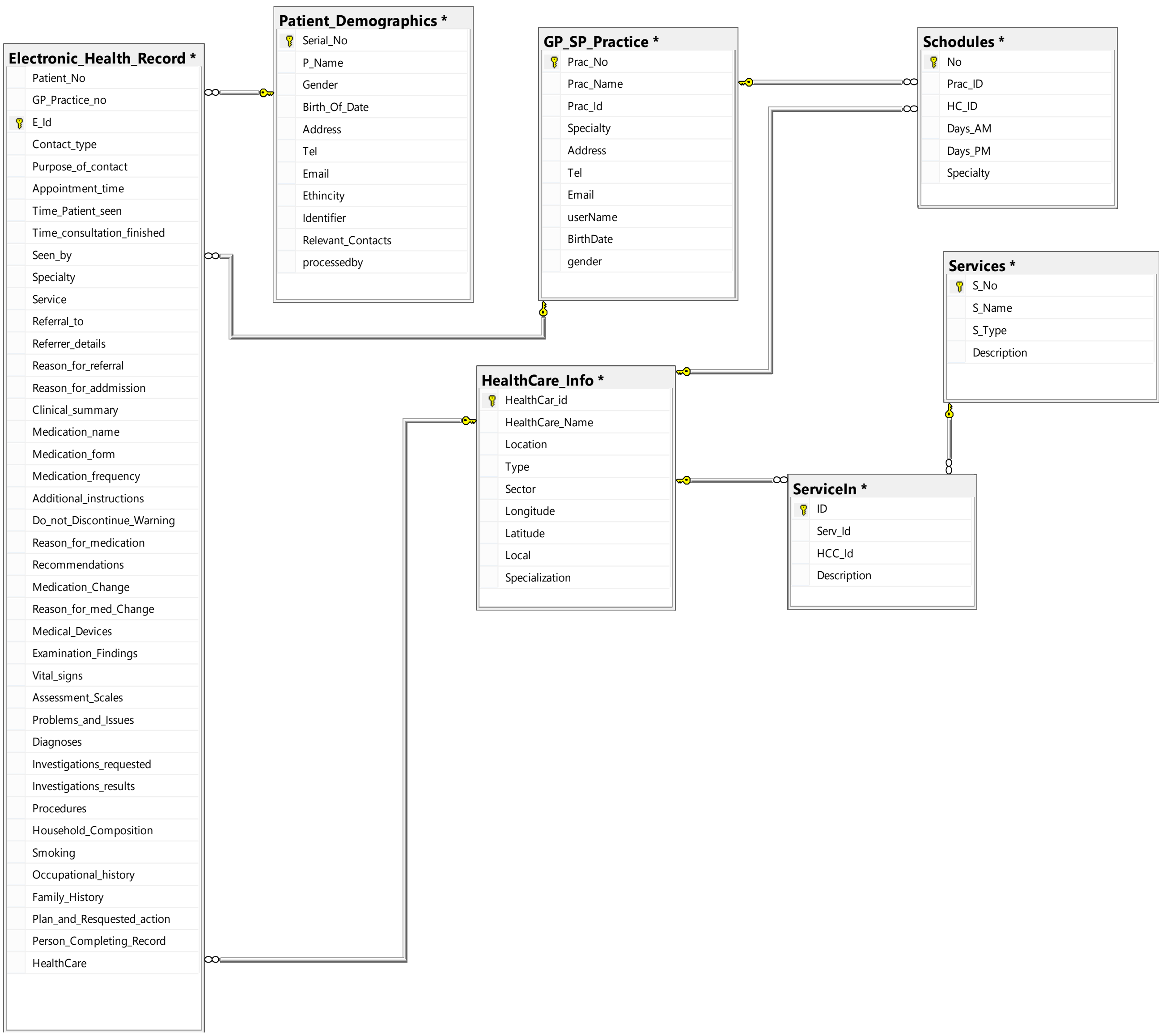


Figure 4.6 : Database Diagram.

4.4.4 MVC Implementation

There are different technologies support *MVC* implementation such as Microsoft technology and oracle. There many platforms to implement *MVC* like *PHP, Visual Studio .NET, TodoMVC*, *NetBeans* and so on. *ASP.Net* and J2EE are more popular than other techniques, any techniques has advantages and disadvantages.

In proposed system, we use NetBeans to implement *MVC*. It based on java programming languages. View built as jsp pages to display input/output and interact with end user. Practitioner view was separated from patient view.

Model built as java classes, and java beans to carrying data. Controller built as servlet.

4.4.5 Electronic Health Record implementation

EHR is very important in any healthcare management system. All medical history to be stored in database. Practitioners and hospitals able to exchange these information, ambulance can view patient's medical history and critically assist in pre-hospital treatments.

In Sudan; *EHR* not yet implemented. We design proposed system as if it implemented in Sudan. To design *EHR* correctly; we have benefited from *[26]*. The standard provides efficient and transparent means of recording, transmitting and accessing reliable clinical information in order to manage and deliver high quality care to patients.

4.4.6 System User Interface Design

The system work in all smartphone devices. The screen contents was organized to be comfortable on mobile screen (mobile friendly website design).

The pages was designed to contain necessary elements and minimize "*scroll down*" as much as possible, and prevent "*horizontal scroll*". We choose appropriate font family and size. Background of pages are light to make page's contents easy to read. All components have convenient color. Because the website will be accessed via mobile browser and smartphones have different screen resolution; we took note of this difference, all elements was determined its dimensions as percentages to take space in mobile screen convenience with screen size.

In proposed system each type of actors has its view; for example: patient has its view, practitioner has its view, no unnecessary or unneeded element. For example: in navigation bar of Login page we don't need view medical history link. The main view in proposed system is patient's personal page when patient can search nearest medical services. All remains pages are complementary, but in the same time these pages are important for any healthcare management system especially medical history. System *UI* explained below:

- Home page: an interface and frontal of system. It contain a brief explanation about website target and its purpose. See figure (4.7).
- Registration page: an interface help users to register and store basic information. There are two registration page: one for patient and another page for practitioner.

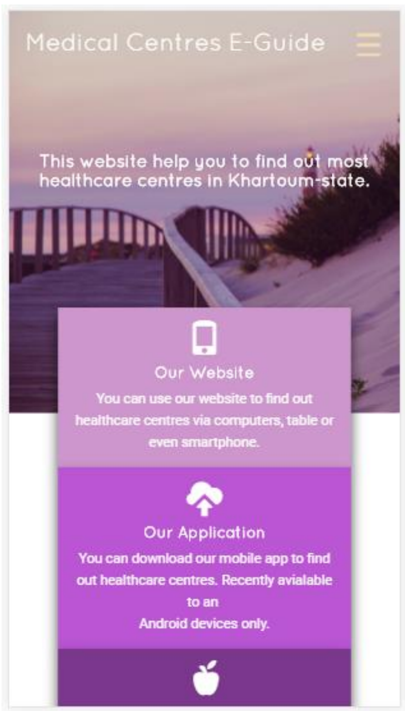


Figure 4.7: Home page.

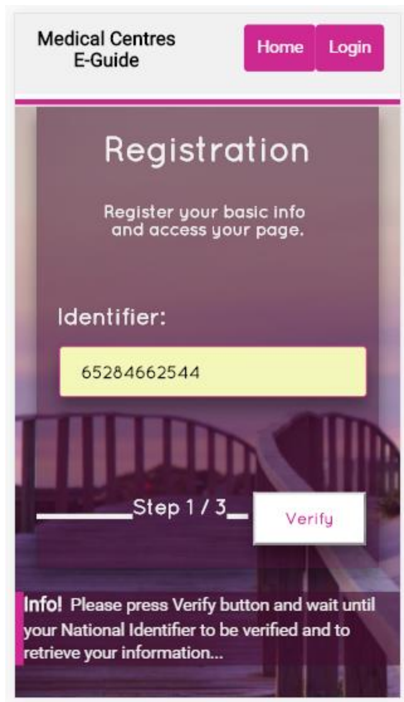


Figure 4.8: Registration page- Step one.

- The registration process splits into three steps, each step has a page separated from the rest of the steps; first page is to verify user identity, patient must enter national identifier and request will sent to civil registry database to retrieve copy of data – see figure (4.8), if the identifier is exist the data (*read only*) will display to patient for confirmation. Practitioner must enter medical number and request will send to database to retrieve copy of data, if the identifier is exist the data (*read only*) will display to practitioner for confirmation. See figure (4.9).

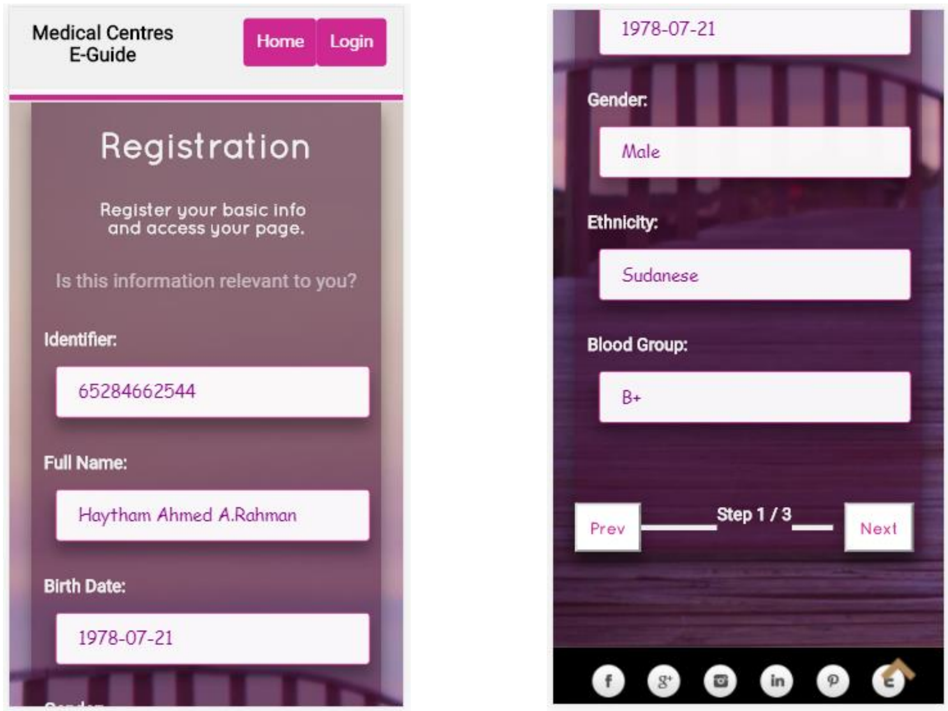


Figure 4.9: Regestration page- retrieve information from civil regisrty.

- In second step the user must enter remain information, and –full name, birthdate, identifier- to be copied from civil registry database and then the mail message will be sent to admin to activate account. See figure (4.10). In third step; when all previous steps complete successfully the system display message to user to check its email for activation, if user receive activation email from admin then user able to login. See figure (4.11).

Figure 4-10: Registration page step two.

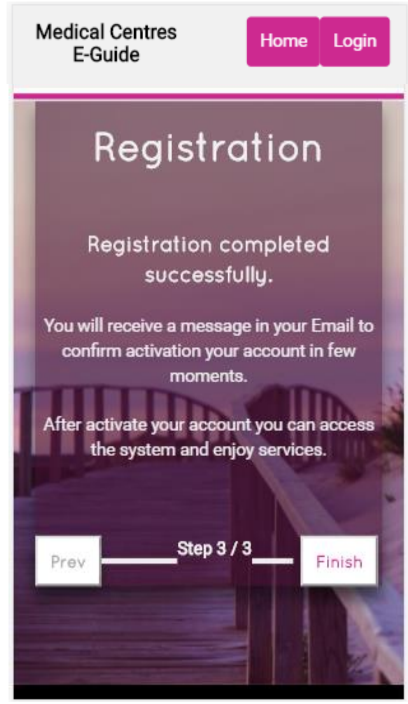


Figure 4-11: Registration page- last step.

- Login page: an interface use to access system after enter right username (login) and password. The user will be redirected to the personal page based on username (login), so the system will try to connect to the server by *sql authentication*. The user will have less privileges based on database role, the patient have specific view in the system, and practitioner have too.
- Personal page (search page): an interface provides search for nearest medical services. See figure (4.12).

The user must choose one of search options, in background system track user position. See figure (4.13).

- The system provides search options: search by type of medical center/ by local/ by service/ by practitioner/ by specialty, so the user couldn't choose more than one option at the same time.

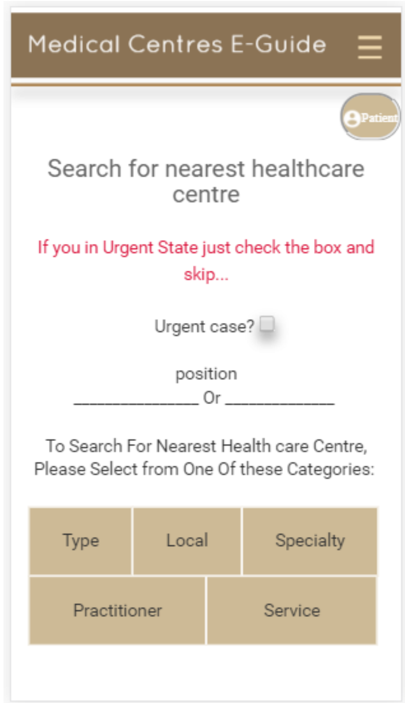


Figure 4.12: Search page.

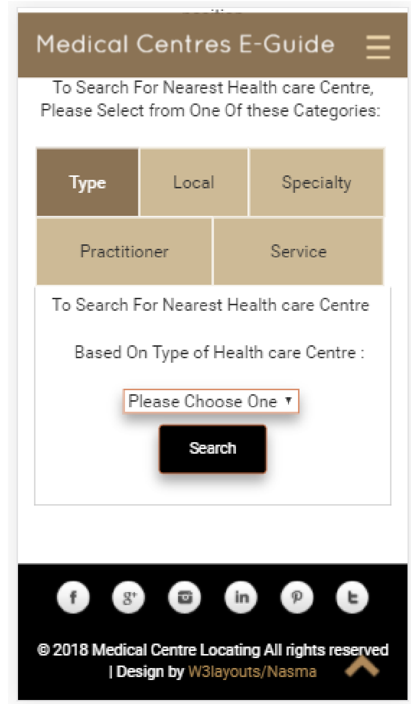


Figure 4.13: search based on type.

- For the urgent cases; we added a check box to minimize time and steps as much as possible. When the user check this check box, the system will search for the nearest hospital immediately and will send an emergency message containing the patient's number to the specific practitioner based on schedule of the general practitioners. This step (sending emergency message) is hidden.
- Results page: an interface display searching result on two way: details and show in map with directions. See figure (4.14).
  Details contain full information about medical center such as: name, specialization, location, type, tel and so on. If user's device couldn't load map or direction, these information help user to find the medical center.
- This page also contains healthcare centers button to show healthcare center on google map, and another button to get direction between current location and healthcare center.

- In bottom of this page, we also display directions as a text in case if the user device has a problem in load map.

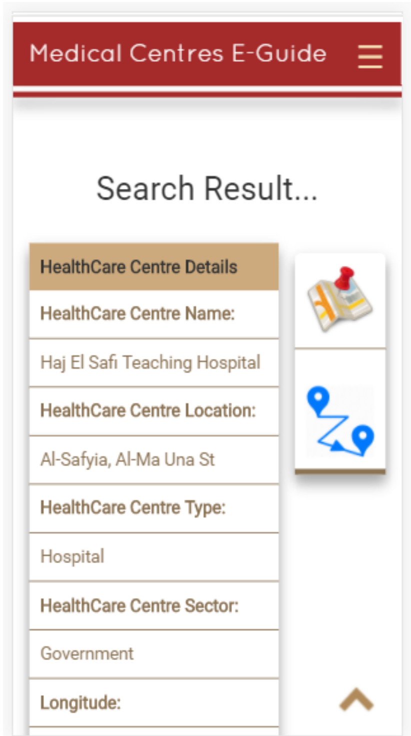


Figure 4.14(A): Result page-with details.

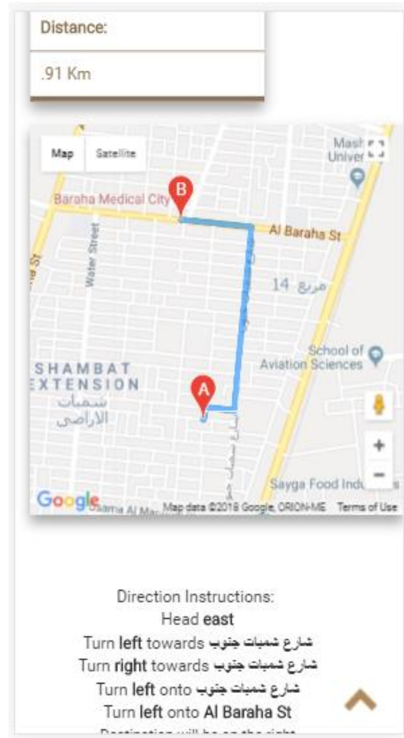
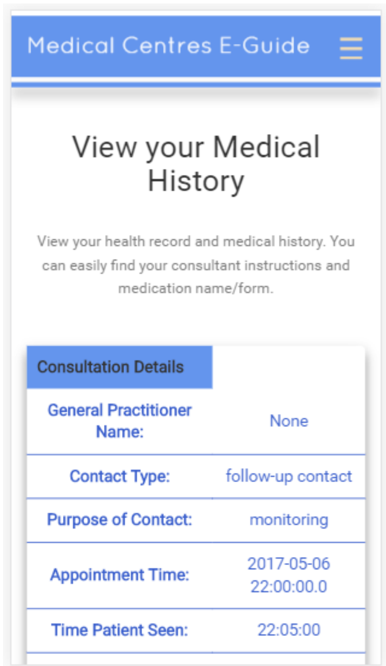


Figure 4.14(B): Result page- direction between hospital and current location.

Figure 4.14: Results page.

- In urgent case the system returns nearest healthcare center (one result), otherwise the system returns nearest three healthcare centers.
- Patient able to view its medical history only. Practitioner able to view any medical history records. Because the practitioner need to view patient's medical history to get a good background about the patient's condition See figure (4.15).



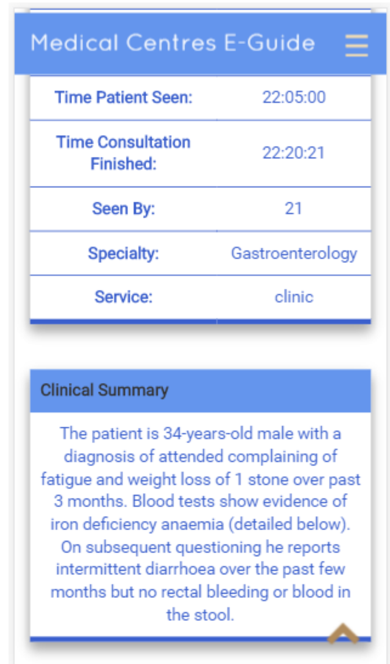


Figure 4.15: Medical history page (sample).

- The medical history displayed in a read only form to prevent modification, whether intentionally or not.

  The system uses standard of *EHR*, but not all standard fields. So in this page; the patient could see full information about consultation details such as contact type, appointment time, seen by and so on, clinical summary, investigations, examination findings, medication information, problems and issues and so on.
- User able to view its profile, but unable to edit information directly. See figure (4.16).

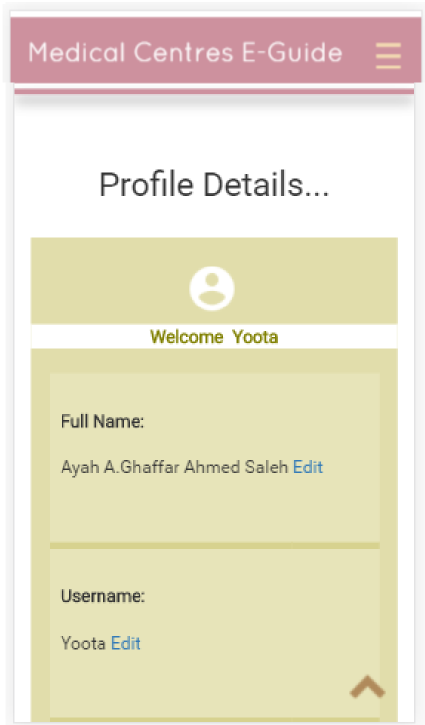


Figure 4-16(A): Profile page- Read only.

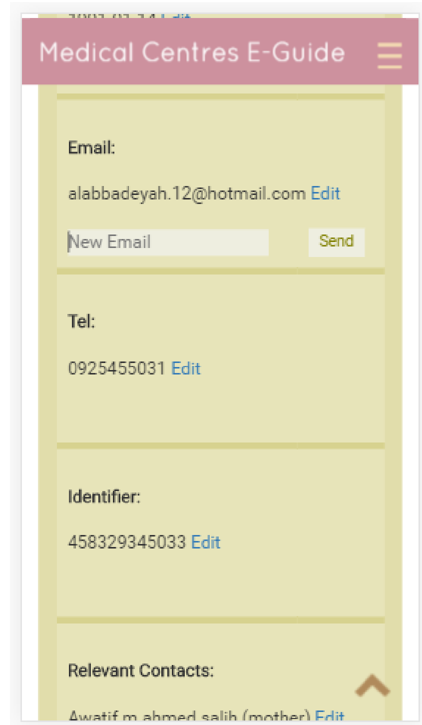


Figure 4-16(B): profile page- Edit email address

Figure 4.16: Profile page.

- User send modifying request to the admin mail and wait for approval, if modification process have been completed, the user to be notified via email.
- We implemented modification process by this way to prevent unnecessary modification for user information and to maintain data integrity.
- Admin could access and control system. After logging in; the admin can review the requests such as activate user account, de-activate account, modify user information and son on. See figures(4.17 and 4.18)

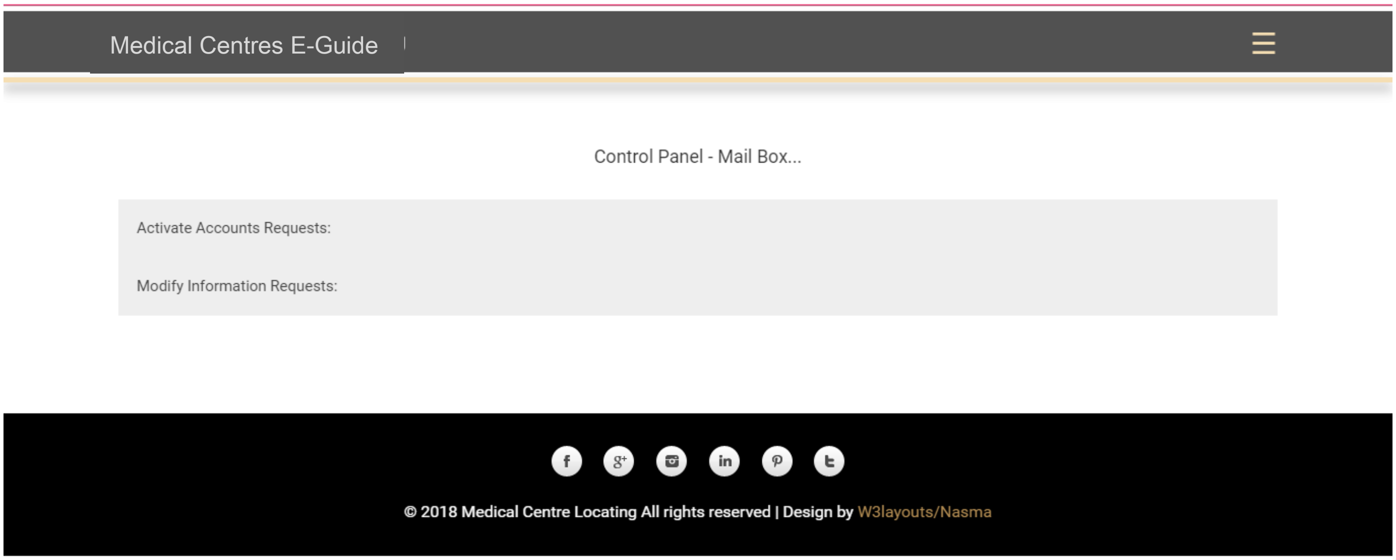


Figure 4.17: administrate mail page. here admin can see all requests.

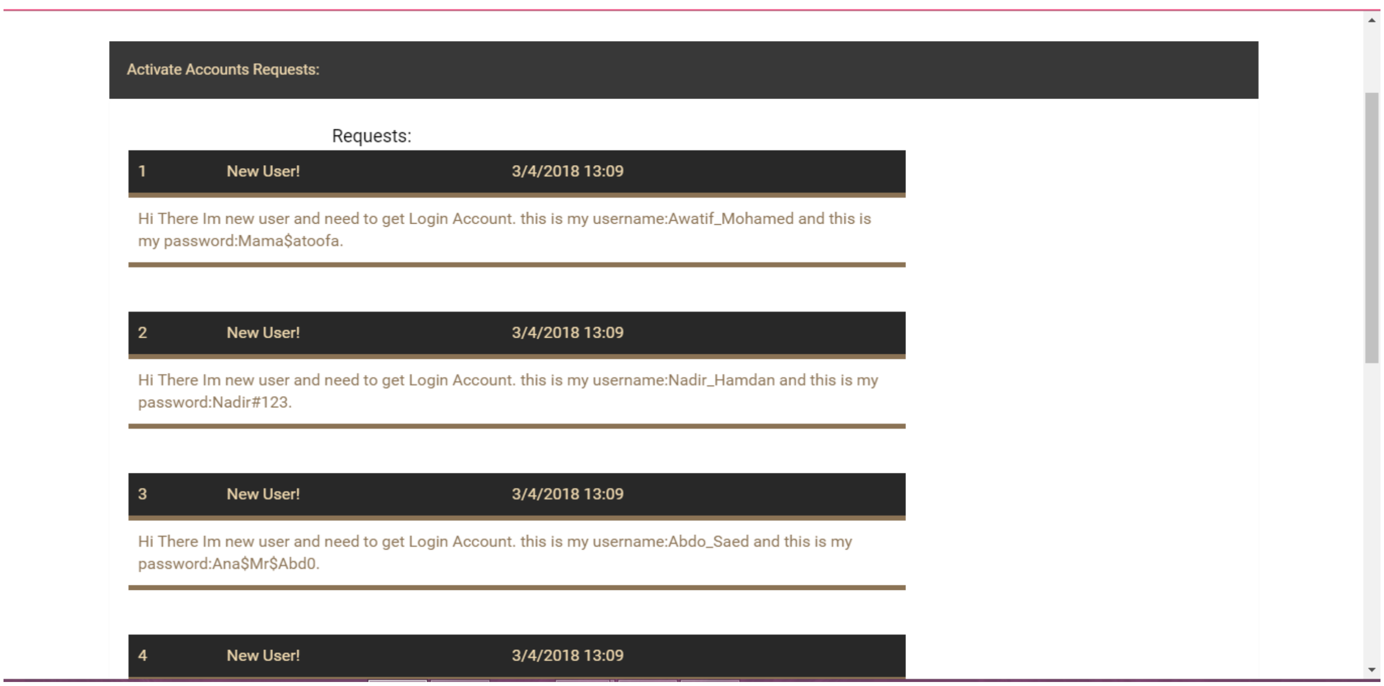


Figure 4.18: Administrate mail page- Activate account requests.

- The admin can add/modify services and medical center, activate/ edit user information. See figures (4.19, 4.20 and 4.21).

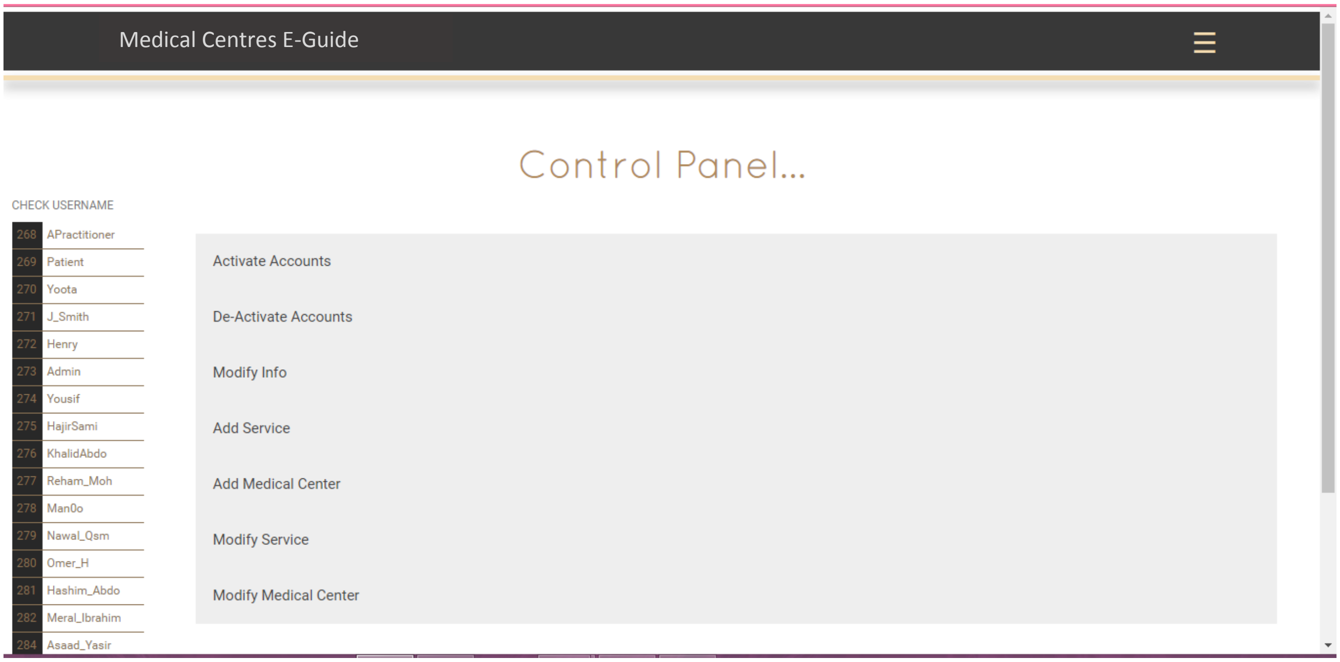


Figure 4.19: Control panel. The table in the left display logins in the system. Tabs in the center are operations.

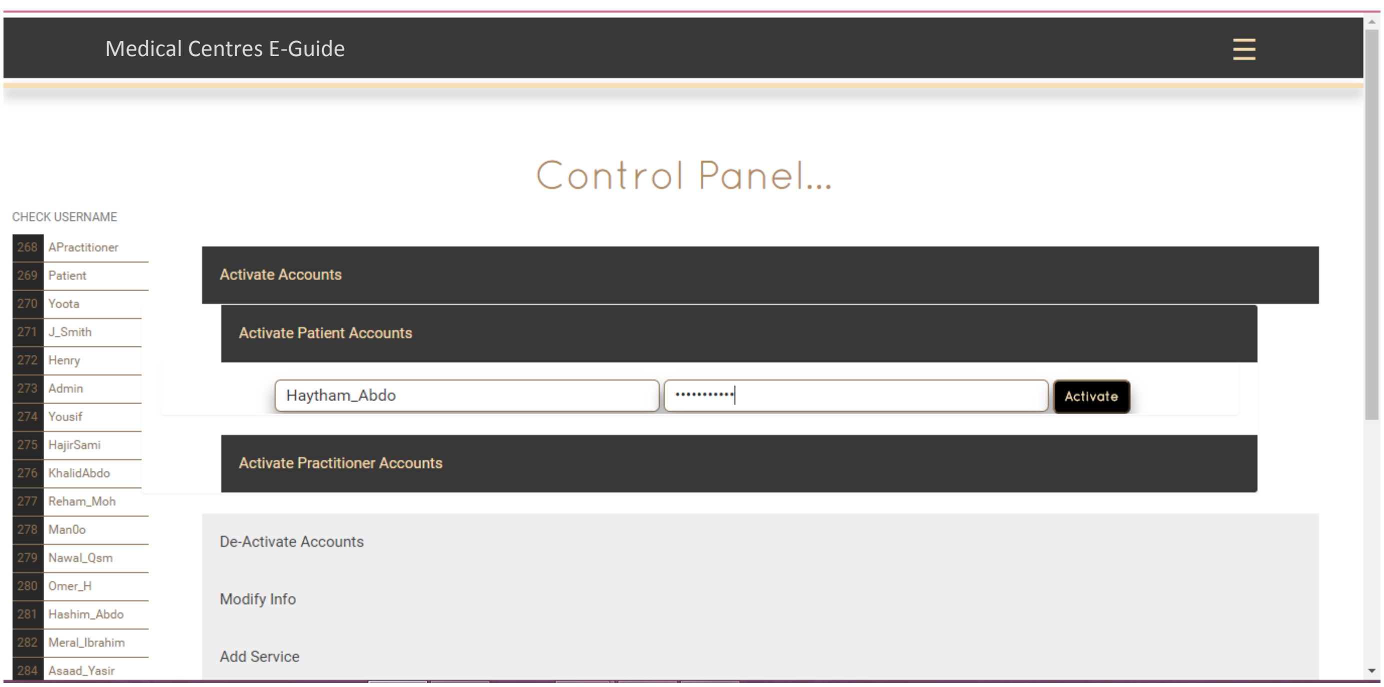


Figure 4.20: Activate account.

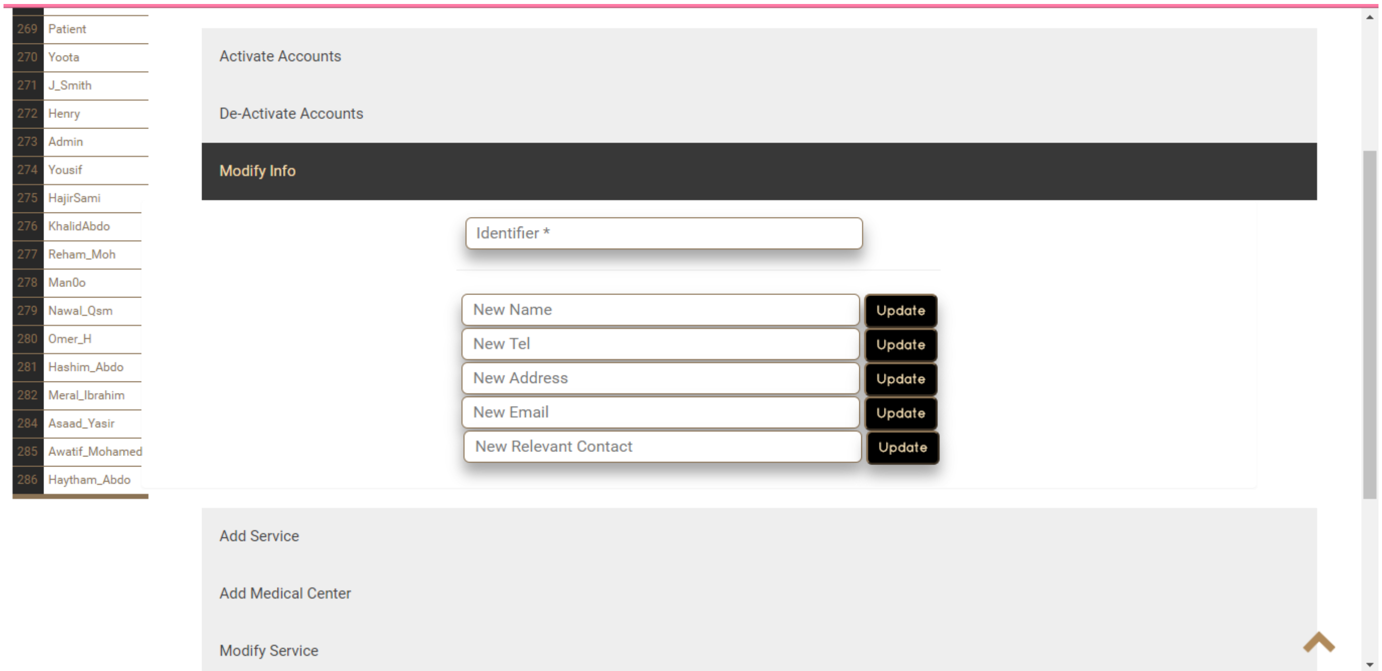


Figure 4.21: Control panel- modify user's information.

- The third actor in proposed system is the *Practitioner*. After logging in; the practitioner able to view its medical history, personal information search for nearest medical services, search for medical records of patient (see figure 4.22) and check its inbox for new emergency messages (see figure 4.23).
- The practitioner able to add new medical record and view any medical record but without modification these records.

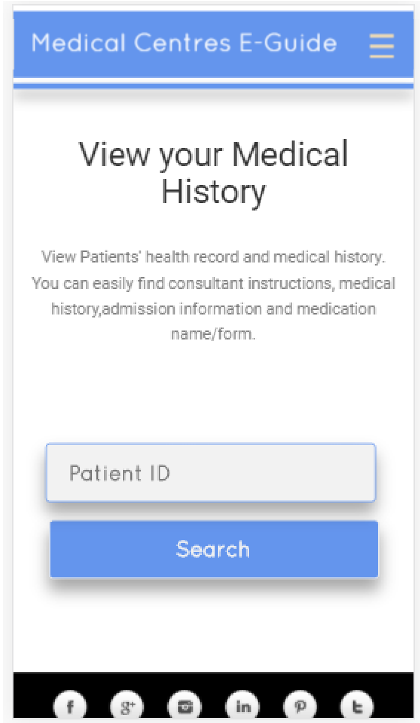


Figure 4.22: Search for patient's medical records by entering patient ID.

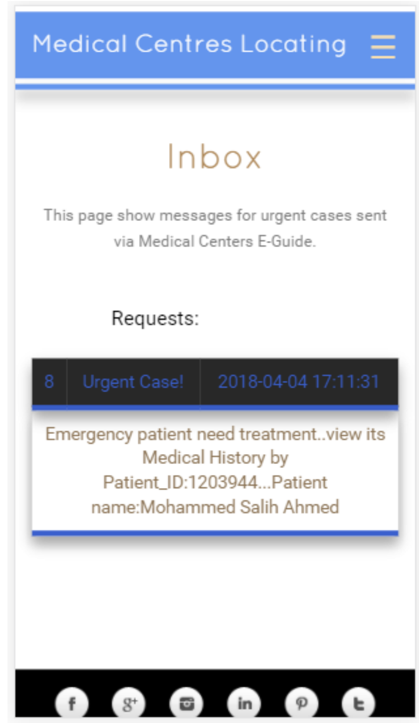


Figure 4.23: view emergency messages.

4.5 Summary

In this chapter explained system implementation. We designed the system by use appropriate techniques such as *MVC* technique and *google API*. Also all functional requirements was coded and we review requirement and how we achieve system targets. We was explained all methods used in proposed system and how we designed proposed system to reach system target. We discussed security features and we implement features that needed in this system with no problems caused by implementing security features.

Chapter Five

Results and Discussion

5.1 Introduction

In this chapter we will discuss results of proposed system and compare proposed system with related systems.

5.2 Proposed system results

The proposed system *"design and implementation of healthcare centers e-guide system"* is a secure mobile web application that provides search for nearest medical services shortly and accurately. We discussed results as follow:

I. First assumption was "Design the system as a *MVC* web application will help patients to find nearest available healthcare center(s) and medical service", we design system by use *MVC* technology. *MVC* architecture is characterized by separating of control, model and view. It's easy to maintain and track errors and failures. No high response time. The time needed for implementation considered timeless.

II. Second assumption was "Design client side as a mobile web application is more efficient and easy to use by patients whether they are in critical condition or not", we developed mobile application because most people around the world have mobile phone. It's reachable and more efficient when the system is targeting healthcare field.

III. Third assumption was "By using appropriate and necessary security mechanisms and policies, it should provide "*confidentiality-integrity-availability*" in all system levels, be convenience and adequate to the patients and no passiveness affects in the performance and accuracy of the system while using these mechanisms", *SQL Server 2017* provide security features to support security in application level, network level, database level and data level.

   So we used some of these features, these features didn't hinder the performance of the whole system. Patient couldn't do anything beyond its privileges. Practitioner couldn't overstep its privileges.

IV. Fourth assumption was "By using improved k-means clustering algorithm, it should provide locating nearest medical services shortly and accurately", we improved *k-means* algorithm to in line with project requirements. *K-means* clustering algorithm is simple and efficient, but it's computationally costly and the result is completely depend on initial random selection of clusters centroid in first stage, and select different centroids result different clusters, so that's affect the accuracy.

V. The proposed system provide several choices to search for nearest medical services in Khartoum-state. The patient able to search by type healthcare center, by specialization of healthcare center, by specific practitioner, by local of healthcare center, or even by type of medical service.

VI. Urgent cases able to use the system, it just need to check the urgent checkbox. When the user check the checkbox; the system will search for nearest hospital and send a message to the available practitioner in that hospital. This message contains patient ID with full name, by entering this ID the practitioner could view patient's medical history and to have a background about patient's condition and what to do before the patient reaches the hospital.

VII. The proposed system use *Google Map API* for highly accurate user's position tracking.

VIII. The google Map can search for nearest healthcare center but with limited features. In proposed system we use *google map API* to view the position of selected healthcare centers in map to easily tracking it.

IX. Also the proposed system provides get direction between patient's position and nearest healthcare center.

X. Because the internet speed is undefined, we display results also with details such as healthcare center name, local, distance (*kilo-meter*), coordinates and sector. In case that the user unable to load map, these information could help user to know its destination.

XI. *EHR* was play important rule in our system. Any Practitioner can search by patient's ID and get its medical history.

XII. We apply proposed system in different location have been taken randomly from Khartoum-sate (Khartoum north, Omdurman and Khartoum) to ensure the accuracy, the results are shown in table (5.1).

Table 5.1: system results

No	Patient location	System Results	Correct Results
1	15.664841, 32.545675	15.673213, 32.544234	15.673213, 32.544234
2	15.651175, 32.536748	15.651078, 32.531562	15.651078, 32.531562
3	15.627449, 32.552991	15.628147, 32.552348	15.628147, 32.552348
4	15.649785, 32.487904	15.645738, 32.490050	15.645738, 32.490050
5	15.681704, 32.483670	15.682830, 32.499720	15.682830, 32.499720
6	15.765418, 32.575379	15.739023, 32.565629	15.739023, 32.565629
7	15.619849, 32.656534	15.617673, 32.632076	15.617673, 32.632076
8	15.609161, 32.541996	15.611363, 32.551857	15.602911, 32.536306
9	15.607189, 32.558722	15.611299, 32.559747	15.611299, 32.559747
10	15.602838, 32.519764	15.601846, 32.530385	15.601846, 32.530385
11	15.566145, 32.539063	15.577166, 32.543301	15.577166, 32.543301
12	15.503229, 32.641450	15.507408, 32.624280	15.507408, 32.624280
13	15.896635, 32.596422	15.892154, 32.578706	15.892154, 32.578706
14	16.028842, 32.574993	14.543853, 32.924034	16.010460, 32.577924
15	15.852950, 32.323634	15.804973, 32.390655	15.804973, 32.390655
16	15.639815, 32.524519	15.641319, 32.526337	15.641319, 32.526337
17	15.414341, 32.580428	15.444190, 32.540522	15.444190, 32.540522
18	15.393461, 32.878057	15.405465, 32.860853	15.405465, 32.860853
19	15.408427, 32.505225	15.400901, 32.510858	15.400901, 32.510858
20	15.314557, 32.464040	15.299700, 32.462978	15.299700, 32.462978

Accuracy= TP + TN / TP + FP + FN + TN => Accuracy= 0.9 => **90%**

Precision= TP / TP + FP => Precision= 0.8888888889 **≈ 0.89**

Recall= TP / TP + FN => Recall= **1**

F1= 2 * (Precision * Recall) / Precision + Recall => F1= 0.9411764706 **≈ 0.94**

XIII. We took a group of sites randomly. The group contains twenty sites from the Khartoum state. Then results has been validated to determine the accuracy and efficiency of the proposed system.

XIV. The proposed system accuracy is 90%, the incorrect results are very close to the right result by a few meters, but the importance of time for emergencies and the few difference may endanger the patient's life, so the accuracy should be higher than 90%.

5.3 Comparative study

We explained when use traditional *k-means* algorithm and compare the results with proposed system below:

a. Traditional *k-means* need to iterate over whole data to calculate distance between centroid and objects, the iteration finished when no change in clusters' objects.

   In proposed system the algorithm also need to iterate over data, but we filtering data before calculating distance and exclude unnecessary data to reduce search process time.

b. Traditional *k-means* use *Euclidean distance* formula to calculate distance between centroid and objects.

   In proposed system we use *Haversine* formula to calculate distance between centroid and objects. This formula able to work with earth shapes and latitude/longitude *[27]*.

c. Traditional *k-means* have essential steps, if any step ignored or reduced then the result will be incorrect. Determine *"K"*, initialize centroids randomly, calculate distance between centroids and all objects, calculate new means, and then repeat calculating the distance between new means and all objects. This process iterates until the criterion function converges.

   In proposed system if we work with several centroid we need to extra step to search for "*patient's position*" in whole objects and find out its neighbors. Also may this point is closest to the boundary of clusters, and its neighbors in other cluster so we need to use another algorithm to find out neighbors.

   So no need to more than one centroid. The centroid is "*patient's position*", we need to iterate over all filtered data to calculate the distance between centroid and objects. No need to extra algorithm of function to find out neighbors.

d. When we use *Euclidean distance* formula to calculate distance between user's position and whole data, almost that's give wrong result. The *Euclidean* formula is unable to work with earth shapes.

For example: suppose the user currently in "shambat" in Khartoum-North and this is coordinates of user location (15.644521, 32.637595), the nearest hospitals are: "*Haj El-Safi Teaching Hospital*" and "*Baraha Medical City*", but when we use *Euclidean* formula it's return "*Saudi Hospital*" in Omdurman and "*Baraha Medical City*". See figure (5-1). This formula calculate the distance linearly and regardless of earth shapes or even water surfaces. Same above example reused to calculate distance but by use Haversine formula, its return right results "*Haj El-Safi Teaching Hospital*" and "*Baraha Medical City*", see figure (5.2).

```
Sorted Map:{41=0.008167989441289792, 17=0.008286443370490396, 15=0.0136
First index:41
41---0
17---1
Saudi Hospital
Baraha Medical City
437403
```

Figure 5.1: Calculate distance between current position and medical centers by use Euclidean distance formula.

```
Sorted Map:{41=0.916656299254312, 20=2.0350329753503225, 25=3.192
First index:41
41---0
20---1
Haj El Safi Teaching Hospital
Baraha Medical City
```

Figure 5.2: Calculate distance between current position and medical centers by use Haversine formula.

As we discussed in related work section in chapter two; there are different methods to find nearest service or find optimal path, below we compare our results with related work results regardless of research scope:

A. The *[10]* is an application for emergencies. When the patient press the button, the EHR will be generated and send to the selected hospital, *GPS* alarm application will notify user if she/he arrive its destination while travelling to the destination. The system use A* to find nearest node in mapped area.

The proposed system isn't to the critical conditions, but it also help urgent cases to find nearest hospital by check an urgent checkbox, the system then fetch patient's position and calculate distance by use Haversine formula, return full information about this hospital and then send patient's ID to the practitioner in the selected hospital to view medical history of this patient.

B. The *[11]* is an application for emergencies. When the patient speak, the system recognize the voice, convert to text and then send the text to the doctor, also the doctor can writes a note to the patient and patient can check the note by smartphone easily.

   The proposed system isn't work with voice recognizing or providing communication between patients and doctors.

C. The *[12]* is an application find nearest point of interest to the query point with minimum travel time by use *NN Reverse-TD* algorithm. This algorithm needs to store every single corner points of streets and taxi positions to build a graph and reverse search process from destination to the query point.

   The proposed system we filtering data based on search option has been selected, and we uses improved k-means clustering algorithm to find nearest medical services.

D. The *[15]* doesn't work with method to find shortest path and how to improve search for nearest hospital process, they adding new features to the system such as predicating disease and department. The system provide search for nearest hospital with route and details, availability of services and predicate diseases.

   The proposed system could find nearest medical services with search options such as search by type, local, specialty, service, urgent case or even specific practitioner. The result should return to user with details and route between medical center and user's position. But proposed system couldn't predicate disease or department.

E. *[13], [14], [16]* uses GIS to find shortest path. GIS get coordinates as input and then it calculates distance by one of defined algorithms such as Dijkstra, A*. The programmer either just choose the algorithm or modify the chosen algorithm.

F. For emergency systems, the highly important issue is how urgent case should deal and interact with the system and then how to find shortest path-A* and Dijkstra is commonly used in this area. So in *[11]* the system use voice recognizer to interact with a patient, in *[10]* the system use press button and *GPS* alarm. For the system provides search for nearest services such as nearest hospital, ATM, restaurant and so on; thinking in how to search for nearest services and provides more options because the user is not in critical situation. Also in *[14]* the system provide offline home remedies and latest medical news…etc. in *[15]* the system provide predicating disease and departments if patient unaware about appropriate department based on symptoms.

5.4 Summary

In this chapter we have discussed results of proposed system and compared these result with traditional k-means algorithm. We also review assumptions again and check whether the system is with or against. We compared our result with existing systems in the same track regardless of research scope or targets.

Chapter Six

Challenges, Conclusion and Future work

6.1 Introduction

In this chapter we discussed all challenges that the proposed system faced. Conclusion and future work.

6.2 The Challenges of the System

In proposed system, the major goal is to find nearest healthcare center from user's position. So there are some issues may affect the performance and accuracy discussed below:

1- Internet connection: the application needs internet connection to make session between client and server.

2- Uploaded Healthcare Centers' Information: there is need to collect and update information manually.

The challenges we faced on this research discussed below:

1. The Sudanese government doesn't have a network to connect all medical centers with ministry of health and with each other.
2. Most of medical centers don't have a computerized system and still use papers system.
3. Scarce information about medical centers in internet, so we need to collect those information manually as we did.
4. Few medical centers upload the schedule of clinics on its website.
5. All medical centers throughout Sudan have not used and applied the concepts of electronic health records and there is no cooperation and exchange of information among them.

6.3 Conclusion

The proposed system "*design and implementation of healthcare centers e-guide system*" .The major goal we have achieved is to provide search for nearest healthcare center shortly and accurately. The system provide several search options to help patients to find what they need.

6.4 Recommendations

We recommends the following:

- Deploy the system in a real life and support it to help people to find out medical services.
- Provides full and up to date information about medical centers and computerize all medical centers' system to link it with a server (network).
- Improve the system and connect it with other healthcare management system such as e-reservation or even e-payment.

6.5 Future Work

The system can be further enhanced by:

- Use web services technique and cloud computing.
- Enhance system to provide other services such as medications or blood bank.
- Enhance system to check availability of medical center and how much bed in certain hospital.

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