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Location Based Patient Assistant Mobile Application

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List of Acronyms

AA	Addis Ababa
API	Application Program Interfaces
DBMS	Database Management System
GIS	Geographic Information System
GPS	Global Positioning System
HIS	Health Information System
IDE	Integrated Development Environment
ISP	Internet Service Provider
JSF	Java Server Faces
LBS	Location Based Service
LBPAMA	Location Based Patient Assistant Mobile Application
RDBMS	Relational Database Management System

Abstract

Location Based Services (LBS) include applications that provide relevant location related information of peoples and materials. It is accessible with mobile devices through the mobile network and it is important to reduce our efforts during various tasks such as: assisting patients, finding particular address of some place, routing, getting and knowing different service offers on the different products.

There are different works presented related to patient assistant system by different peoples. But the proposed works could not allow patients or users to get the nearest health facility information depends on their health facility service choice and their current location; could not provide a service to show optimal route between patient current location and health facility location and could not allow to provide important information about hospitals, health centers, pharmacies and blood banks in a single system.

The aim of this Location Based Patient Assistant Mobile Application is to provide accurate and relevant information to patients or users based on their current location and choice of health facility service type without wasting their time, cost and life. This PAMA has mobile application side and desktop web application side. The mobile application side focuses on: accessing important information about the nearest health facility depends on the user or patient current location and their choice of health facility service type, showing the nearest health facility location and showing optimal route on a map. The web application part of the system helps authorized persons to manage health facilities' service type, number of beds and other important health facilities related information.

While developing the prototype of the application implemented different location based tools and development environments applied. During the development of the location based patient assistant application built in mobile GPS and Google map API uses to find the current location of the patient or user and MapBox Application Program Interfaces (API) used to show the route and the nearest health facility location freely without incurring additional cost on a Map. The application evaluated using functionality testing and usability testing. The testing result shows this application is important to assist patients or users to get current location related information of health facilities without wasting their time and cost.

KEYWORDS: Location Based Service, GIS, GPS, Patient Assistant System

CHAPTER ONE

INTRODUCTION

This section states background of the research work, the motivation scenario, problem statement, various methods which used to implement the proposed application, significance, scope and limitations and different application areas of the proposed work.

1.1 Background

Geolocation refers to the geographical (latitudinal and longitudinal) location of an internet connected device. The Geolocation technology has played a significant role in the growth of many startups, and it led to the development of mobile apps that are based on Geolocation. Geolocation technology changed the whole situation altogether in the market. Now, the mobile apps that come on the market are based on Geolocation technology, and this has changed the way the businesses served their clients. Today, lots of applications are based on this technology, and it has given rise to location-based services in the market [1].

Location Based Service can be defined as computer applications (especially mobile computing applications) that deliver information tailored to the location and context of the device and the user. Location Based system is important to reduce our efforts during various tasks like shopping, finding particular address of some place, route selection, getting and knowing different service offers on the different products.

Addis Ababa city has the highest concentration of healthcare facilities and trained healthcare practitioners in the country. The city is almost at the geographic center of the nation, covering an area of 530.14 square kilometers [2]. In Addis Ababa, almost all public and private health center and hospitals facilities and equipment for administering emergency care are inadequate. Even hospitals that have dedicated space and staff for receiving acute care patients lack basic equipment and medications [2]. Getting exact and real information of human and material resources of the health facilities is really important to get effective treatments on time and to prevent mortality rate. If we get an emergency quickly, being a short distance from the hospital we have the advantage of being able to arrive in the emergency room in a short minute and we have a chance to get efficient treatment before our life is endanger. Provide timely information to users or patients who need health care

services is very important to minimizing cost, time and mortality rate of peoples from the lack of accurate and exact information on time.

However, there is no efficient mechanism to access relevant information related to the health facilities in AA city. Understanding of the Addis Ababa (AA) current situation and evaluating different LBS provides lesson to develop a Patient Assistant Mobile Application using LBS. This application helps patients to indicate where to get an adequate facility based on their current location and their choice of health facility service. And also, it helps patients to get adequate information of optimal route to rich to the preferred health facility location.

In this work, the nearest position of health facilities will be calculated with a built-in feature of Global Positioning System (GPS) in Smartphones and using better performance algorithm. The route from their current location will be displayed by MapBox Application Program Interfaces (API).

1.2 Motivation of the Study

The motivation of this work is complete, accurate and timely health facilities information is important to provide quality of service to users or patients. With an increasing number of mobile devices featuring built-in Global Positioning System (GPS) technology, LBS have experienced a rapid growth in mobile technology. Location Based service is important to reduce our efforts during various tasks like finding particular address of some place, providing the route to be navigated by the user on receiving their destiny, finding nearest place and accessing relevant information that related to a particular place.

People around the city are in need of moving from place to place both for health care services and other reasons. In that case peoples may not be aware of the route for their destiny location. And the demand for healthcare services has increased over the years due to the growing population.

There are a lot of healthcare centers are found in the city but accessing accurate information of the nearest health facility resources is a tough task, giving accurate information on time is basis of saving human life. In order to provide a solution to these problems, it motivates to develop Patient Assistant Mobile Application using Location Based Services to provide accurate and exact information on time to patients or users to the nearest heath facility.

1.3 Statement of the Problem

Location-aware technologies play a great role to the health care industry to manage resources and personnel, to determining where and when to improve the quality of care, to increase accessibility of service, to track the location of people and to reduce costs and increase efficiency [3].

Location based mobile applications are critical importance peoples to access exact information about the health facilities incase an accident happens on their move from place to place. Provide timely information to users or patients who need health care services is very important to minimizing cost, time and mortality rate of peoples from the lack of accurate and exact information on time. Thus, anyone might need the information of nearest healthcare facility (e.g., hospitals, health centers, and diagnostic centers) if they need on their move from place to place. Lack of information about nearby hospitals, health centers, and diagnostic centers may cause death to victims of the accidents. To face this type of medical emergency, people might have to know information about the health facilities e.g., hospitals, health centers, and diagnostic centers around the place where the accidents occur.

In Ethiopia most of the health facilities are found in Addis Ababa City, in the city various private and public health facilities are found. However, because of lack of adequate medical infrastructures, most of the health facilities do not provide adequate service to patients [4].

Access to basic essential health facility information and infrastructure in Addis Ababa has been limited and most of the time patients cannot get exact information about health facility information. But it is necessary patients or users to get important information about the health facility location, route, health center service type, doctor and other information. In the city it is difficult to get shortest route to travel to the nearest health institution and there is no mechanism to access the information about available service type of the nearest hospital or health center, the doctor and other important information based on their current location and selection. Many times, these situations caused ineffective treatments or patients may not get efficient treatment on time so, their life will be endangering. In addition to these patients or users waste their time and cost without getting adequate service.

However, in the current situation of the country do not have a system which provides combination of basic functions such as: providing detail information of the nearest health

facility depends on patient/user choice of health facility service type, locating the nearest health facility to the patient and determination of optimal route to guide patient/user.

Various studies have been done in the area of location-based patent assistant system and the following researches have been mentioned.

Nimbalkar and Fadnavis [5] proposed system which allows to register and manage user`s personal and medical information and the system uses A* algorithm for nearest route finding. But the selected algorithm for nearest route finding it searches all existing nodes and then continues to compare the results obtained between each node. As presented in [6] the number of unnecessarily examined nodes reduce the speed of the search process of the A* algorithm. So, longer search process leads to waste patient or user time, cost and life.

As described in [7,8] the proposed works allows to managing available information for the healthcare centers (hospitals, clinics, and diagnostic centers) and allows locating an appropriate medical facility. However, the proposed work doesn't provide information to patients or users about the optimal route to reach to their destination.

As described in Akarsh and et.al [9] the proposed system helps to manage related to blood bank information such as registration of blood bank and blood banks can update stock details like quantity of blood, blood type etc. However, the system does not have facilities to locate the nearest other health facilities and does not allow to manage other health facility information such as hospitals, pharmacies and clinics.

The earlier proposed location-based patient assistant systems have limitations to provide accurate and relevant information of health facility to patients depends on choice of patients' health facility service without wasting their time, cost and life. Therefore, this project is aimed to address the above problems by developing LBS based mobile application and a desktop web application. The desktop web application helps to allow authorized users to manage health facilities information, health facilities service and other relevant information. The mobile application assists patient or user to get relevant information about the nearest health facility, assist patient to get nearest location and optimal route between current location and nearest health facility location on a map depends on his/her choice of health facility service type.

1.4 Objectives

General Objective

The general objective of this work is to develop Location Based Mobile Application to assist patients to get optimal route map and relevant information of the nearest health facility depending on their current location and their choice of health facility service.

Specific Objective

The specific objectives of the project are to:

- Study and select suitable nearest location searching, routing and web mapping techniques
- Design and develop a web site to allow authorized persons to manage information about the health facility service and other relevant information.
- Design and develop a mobile application to allow user or patient to access relevant information depends on their choice of health facility service and to allow patients to view the optimal route and the location of the health center on a map.
- Test and evaluate the developed system.

1.5 Methods

To achieve the general and specific objective of this project, the following methodologies are going to be used:

Literature review

In the course of this study, various location-based services, mobile application development technologies, nearest location searching techniques, web mapping techniques and any other relevant literatures and related works will be reviewed and will be adopted if necessary.

Data collection

The relevant data for this study will be gathered by using both primary and secondary source of data. The geographical user's current location data will be collected from built in mobile GPS using Google Map API and the geographical location of the health care facility and route data will be collected from MapBox. Other data will be collected by conducting questionnaires, relevant document and internet sources.

Prototyping

The effectiveness and the performance of the developed application will be tested and evaluated.

Testing and evaluation

The proposed solution will be evaluated in terms of its objectives and user evaluation will be used to evaluate the application.

1.6 Scope and Limitations

The scope of this work only focuses on accessing important information about the nearest health facility (only hospitals, health centers, pharmacies and blood banks) depends on the user or patient current location and their choice of health facility service, displaying the nearest health facility location and the optimal route on a map and managing the health facilities information.

The proposed work only shows the optimal route between the user location and his/her destination without considering real-time traffic conditions.

1.7 Significance

Aim of this work is to provide accurate and relevant information to patients or users to the selected healthcare center service without wasting their time, cost and life. The proposed work will provide combination of the following basic functions:

- allow the admin to manage the health facilities information about the doctor, number of beds, health facility service type and other relevant information
- users or patient can search health facility service and can access available information about the selected health facility service type
- users or patients can access nearest health facility based on their current location and their selection of health facility service on a map
- allow to show the shortest route from the patient or user current location to the preferred health facility location on a map

1.8 Application of Results

LBS application widely used in different areas, some of them are government and private health care centers, road constructions and transportation organizations, private users or patients can be used it. The distribution of health facilities is importance to governments and the community at large to provide high and equitable levels of health care for people. So, the government and community can be used the proposed system to distribute and allocate necessary health facilities such as: allocating medical equipment in appropriate place, managing available health facility resources and personnel in appropriate place. And private sector health care companies can be using the proposed system to provide appropriate decision like: establishing new business, improving the existing business etc. and the road and transportation service sectors can be used the system to allocate available route and to provide available transportation service to users. Finding the available health facility information like finding the nearest health facility, optimal rout and health facility resource information is very difficult to users especially for patients. So, the proposed application contributes many benefits for users or patients to access health care related information like location, route and details of nearest health facility on their move. As such, this work applied on different government and private application areas to provide important information related to health facilities.

1.9 Organization of the Document

The rest of the report is organized as follows: Chapter Two presents reviewed literatures on main concepts of different Location Based Services (LBS) and assess: different LBS technologies, location and route-finding algorithms and the use of location-based technologies to health care areas. Chapter Three incorporates review of related works done on patient assistant systems or applications. Chapter Four presents system requirement analysis. While Chapter Five presents System Architecture and Design. Chapter Six presents the prototype of the application; application testing and it presents various tools that are used to design and implement the proposed system. The last chapter presents conclusion and future works.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

Through this will be assessed existing works on different Location Based Services (LBS) and assess different LBS technologies, location and route finder algorithms. In addition, the application of Geographical Information System (GIS) in different areas and the use of location-based technologies to health care areas will be described.

2.2 Location Based Service (LBS)

A Location Based Service (LBS) is an information and entertainment service, accessible with mobile devices through the mobile network and uses GPS to locate user's current location and user can select the new destination of their interest or they can choose the predetermined destination location which is closer to the current location. Through Query processing the user can retrieve the current location [10]. Location Based system is important to reduce our efforts during various tasks like shopping, finding particular address of some place, getting and knowing some good offers on the different product [11].

The basic components of LBS are service provider's software application, a mobile network to transmit data and requests for service, a content provider to supply the end user with geo-specific information, a positioning component (GPS), and the end user's mobile device. Location Based Service provides the users information services which originate from the geographic location of the end user mobile device. Using these services, it is possible for the users to find current location and locate other persons, vehicle, resources. It also used to provide location-sensitive services, in addition to tracking their own location. [11].

2.3 Location Information Acquisition Methods

According to [12] the authors presented an implementation of a location-based service developed for smartphone devices and also in the paper reviewed different methods of location acquisition and contemporary technologies for development of software systems based on the location-based services.

The Global Positioning System (GPS) is a satellite-based navigation system that provides location and time information. According to [10] GPS uses 27 satellites to enable a user to pin-point his or her current location. GPS provides users with accurate information about their position and velocity, as well as the time, anywhere in the world and in all weather conditions. It is a good solution for outdoor positioning with high accuracy. We adopted it as the positioning tool for mobile devices with GPS module. The accurate location information can be extracted through parsing GPS data. But GPS works well for outdoors only and because of the radio signals are blocked by buildings, it is not preferable for indoor environments [13].

According to [14] the standard method for location acquisition is the use of a GPS receiver however; there are at least four alternative methods for location determination, which can be used in combination. These methods are: Cell phone towers: When the GPS satellite signal cannot penetrate the surrounding area and reach the receiver, the device may acquire location information from a cell phone base-station. This happens in closed spaces, surrounded by concrete walls. This method is less accurate than GPS positioning; Wi-Fi access point: this method is accurate, but required an active Wi-Fi hotspot; IP address geolocation: the accuracy of this method depends on the Internet Service Provider (ISP); User defined location: when a user registers for a service, he or she may enter the address of residence, which can be used to determine the geolocation.

2.4 Location Based System Technologies

There are different technologies existed which related to the development of location based application for smart phone.

2.4.1 Geographical Information System (GIS)

Geographic Information system (GIS) is an operational system that collects, analyzes, stores and disseminates geographic information. Using GIS software, you can put maps and other geographic data into the computer. After you have the data in the computer, you can store, retrieve, and edit that data. You can analyze it (for example, find geographic features, measure distances, or compare patterns) and produce output from it (create new maps from what you find). GIS applies in different areas, some of them are: local government applies GIS for public works/infrastructure management (roads, water and sewer); transportation

industry it uses for airline route planning, transportation planning/modeling; real estate and marketing areas it uses for retail site selection and site evaluation; public safety, crime analysis, fire prevention, emergency management, health care and military or defense [15].

2.4.1.1 Components of GIS

A geographic information system (GIS) includes different components such as: hardware, software, data, people, and methods for capturing, managing, analyzing, and displaying the information related to the surface of the earth. Hardware: is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations. Software: GIS software provides the functions and tools needed to store, analyze, and display geographic information. Data: Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data. People: GIS technology is of limited value without the people who manage the system and develop plans for applying it to real world problems. GIS users include who design and maintain the system to those who use it to help them perform their everyday work. Methods: A successful GIS operates according to a well-designed plan and business rules [16].

2.4.1.2 Data Models for GIS

In order to visualize natural phenomena, one must first determine how to best represent geographic space. Data models are a set of rules and/or constructs used to describe and represent aspects of the real world in a computer. There are raster and vector data models are existed in GIS [17].

Raster Data Models

Raster data (also known as grid data), in a GIS, raster data is a cell-based representation of map features. Satellite images, aerial photography and scanned images are all stored in raster format. The raster data model consists of rows and columns of equally sized pixels interconnected to form a planar surface. These pixels are used as building blocks for creating points, lines, areas, networks, and surfaces [17].

Vector Data Models

Vector data is classified into three types: point, line (arc), and polygon data. Vector data is entered into a GIS by digitizing these features from a base map. All vector data is stored as an x,y coordinate or a series of x,y coordinates [17].

2.4.2 Databases and Operating system

There are different relational databases technologies existed to develop LBS, a relational database stores data in a structured format, using rows and columns. Most well-known relational database management system (RDBMS) includes Oracle Database, MySQL, Microsoft SQL Server, PostgreSQL and IBM DB2 [12].

Operating system is the most important component for all mobile devices and there are wide ranges of operating systems available in markets from different corporations like Apple (IOS), Google (Android), Microsoft (Windows), Blackberry (Java ME), Nokia (Symbian), etc. Applications for these operating systems are developed using different programming languages like Objective c (IOS), java (Android) and C# (Windows phone) [18].

The Android operating system is the most widely used cellphone operating system in the World. It occupies 71.1% of the global Smartphone operating system market share. This shows that the Android operating system occupies a very important position in smartphone operating system. People can download a variety of Android mobile application in android stores, and there are many android applications that provide the smart mobility service such as Google maps. Android operating system has four main levels from the bottom up which are Linux kernel layers, library, application software architecture and application. The application includes four components which are activities, broadcast receiver, service and content providers [18,19].

2.4.3 Web Mapping

Web mapping is the process of designing, generating and publishing maps on the internet. Web mapping offers real time maps, frequent update of maps and sharing of geographical information; web maps are used in showing the route map. In the Internet, there are various web mapping services available including Bing maps, Yahoo and Google Maps. Web maps were to give as much information to a user including information that was viewable on a route map [19].

2.4.3.1 Google Maps API

Google maps API is the most widely used web mapping service across the globe. It utilizes advanced geocoding capabilities and delivers secure map content over the browser. Google Maps can be used free of charge for non-commercial purposes. Google Maps facilitates many services such as the Google Maps website, Google Ride Finder, Google Transit, and maps embedded on third-party websites via the Google Maps API. It also provides the capability of viewing local business information including business locations, contact information and driving directions depending on the location of a particular recipient. Google maps web mapping service has flexibility in use, map quality and better customization features [19].

2.4.3.2 Mapbox

Mapbox is one of the most advanced mapping services and one of the best alternatives to Google Maps. It provides set of tools for creating custom dynamic and static maps for both mobile applications and websites. Mapbox provides different API including Directions API that provides users functionalities such kinds of calculating optimal routes for driving, cycling, or walking, taking traffic and incident information into consideration, choosing desired arrival and departure times, creating routes and others. Map box is preferable by well-known different companies like DHL, DPDgroup, Grubhub, Instacart, Facebook, Shopify, The New York Times, etc. The majority of data Mapbox uses is openly available, and Mapbox supports a community of volunteer mappers. They often provide the freshest updates, including fast-changing location data. Mapbox data sources include OpenStreetMap (OSM), USGS, Landsat, Natural Earth, and OpenAddresses[19,20].

2.5 Algorithms for LBS

To determine the closest facility for a user and the shortest path to travel from one point to another it requires algorithms. The Closest Facility algorithm helps the user to find the nearest facility when there is more than one facility offered [21]. And a shortest path algorithm is important to location-based system to find the shortest and fastest path or route from a starting point to an ending point. There are different shortest path algorithms are proposed by different authors; the most common shortest-path algorithms are Dijkstra's, A* and Bidirectional A*. They provide reasonable solutions to the shortest path problem.

These algorithms are widely utilized by different web mapping service providers. For example, MapBox web mapping service uses a bidirectional A* search algorithm and also it uses the Traveling salesman problem (TSP) algorithm to optimize their route. And Google maps use Dijkstra's pathfinding algorithm to find the most optimal routes [22].

2.5.1 Dijkstra Algorithm

The Dijkstra's Algorithm is often used in routing and this algorithm finds the shortest path between two nodes on a network. This algorithm can be applying on a graph which is directed and got the edges with non-negative weights. Dijkstra's algorithm is the fastest well known for directed graph sin shortest path algorithm. This algorithm is one of the most popular algorithms used to solve the shortest path problem, but the algorithm can only be used on graphs with no negative edge values. The Dijkstra algorithm is mainly aimed at the graph with non-negative weight nodes; it can only be used in single-source shortest path problem [23,24].

2.5.2 A* Algorithm

A* algorithm combine the advantages of the Dijkstra algorithm and the first search algorithm [25]. A* algorithm takes a long time because this algorithm for performing searches calculates all existing node values and stores them and then compares them to existing data. But A* algorithm is more effective and efficient to determine the shortest path than the Dijkstra algorithm when using one directional or Bidirectional methods [23].

2.5.3 Bidirectional A*

The benefits of a bidirectional A* compared to an ordinary A* search is time efficiency. The normal A* search starts from the origin and uses a heuristic to find the shortest single path from origin to destination. The bidirectional search is faster than the normal A*, because it runs two simultaneous searches: one forward from the initial state, and one backward from the goal, stopping when the two meets. The reason for this approach is that in many cases it is faster than the normal A* [22].

2.5.4 Haversine Formula

This formula was first discovered by Jamez Andrew in 1805, and it was first used by Josef de Mendoza y Ríos in 1801. The term of haversine itself was created in 1835 by Prof. James Inman. The Haversine formula is an equation important in navigation, giving great-circle

distances between two points on a sphere from their longitudes and latitudes [26]. This formula is used to calculate the distance between two points on the Earth's surface specified in longitude and latitude.

$$d = 2r\sin^{-1}\left(\sqrt{\sin^2\left(\frac{\phi_2-\phi_1}{2}\right)+\cos(\phi_1)\cos(\phi_2)\sin^2\left(\frac{\psi_2-\psi_1}{2}\right)}\right)$$

d is the distance between two points with longitude and latitude (ψ,ϕ) and *r* is the radius of the Earth [26].

2.6 Location-Based Services in Healthcare

Geographic Information System (GIS) is one of LBS technology and it has helped the health care industry manage resources and personnel, it has helped other consumer service enterprises and also it plays a critical role in determining where and when to intervene, improving the quality of care, increasing accessibility of service, finding more cost-effective delivery modes [27]. Location-aware technologies can help hospital staff and administrators to manage resources effectively. The ability to track the location of people and assets gives hospital staff the ability to manage assets effectively, tackling safety problems, reducing costs and increasing efficiency [3].

CHAPTER THREE

RELATED WORK

Various works were reviewed from related to this work written by different researchers at different periods for healthcare issues, like finding a shortest path, locating the nearest health facilities, searches an adequate facility for the user based on the user's location etc. Some works are presented as follows:

3.1 Location Based Health Care Systems

Semantic web-based healthcare recommendation system for diagnosis and treatment of diabetic patients

In Ethiopia, there are many patients with chronic diseases like diabetes and the number of people who need constant assistance is increasing. This results to the long patient and operation waiting lists, shortages of hospital beds, inadequate medical facilities and professionals to provide patients with health care in emergency units and other healthcare departments. Taye [28] developed semantic web based healthcare recommendation system for diagnosis and treatment of diabetic patients. The system supports physicians in the diagnosis and also it supports the diabetes patients to improve the quality of daily life and they can get the basic instructions and treatments regarding their health status. This system gives possible treatments only for diabetic patients and it is not implemented for mobile based applications.

A Design of Mobile Health for Android Applications

Rao and Krishna [29], Android based mobile health application designed to recommend exercise for each individual who has different age and physical characteristics (e.g., sex, weight and height). In addition to this the application presented special exercise advice for patients with health issues and generates food tips and recommendations for different categories of people who are underweight, overweight or obese due to a computation of their body mass indices. However, this application is not designed to provide location based information to the users or customers.

Domain Specific Search of Nearest Hospital and Healthcare Management System

Nimbalkar and Fadnavis [5] proposed Domain Specific Search of Nearest Hospital and Healthcare Management System, which is Android Based Tracking for EMS (Emergency Medical System) on cloud. The system can be used to provide quick emergency service to the patient in a case of emergency at independent of his/her location on a click of a button as well as it also provides health related information including medicinal prescription related with the person to the hospital. The proposed system locates nearest available hospital, contacts its ambulance emergency system, accesses Electronic Health Record of emergency patient that can critically assist in pre hospital treatments.

Additional features of the proposed system in [5] which gives to user of the system and the hospital is in case of emergency, the system finds the optimal route for the nearby hospital give them alert with the location of the patient. And according to the user's conditions, doctor sends the prescription to the user's phone in order to protect the user timely to get treatment. After the prescription is sent to the user's mobile phone, the life reminder alerts the user to take medicine on the time. However, the proposed system is not interactive to user because the system could not allow to display the nearest available hospital using map. In addition, the system does not allow patients to get nearest health facility depends their choice of available health facility service.

Location-based mobile health care facility search system

A location-based mobile health care facility search system for senior citizens proposed by[8], this study allows senior citizens to locate an appropriate medical facility by using smartphone’s GPS-based location information together with a mobile push system. However, the proposed system does not allow getting detail information of the nearest health facility from the user location depends on patient choice of available health facility service.

Blood Locator System

To overcome the problem of arranging blood immediately whenever needed in case of an accident or for any particular treatment Akarsh and et.al [9] proposed Blood Locator System. The proposed system is android based location tracking application which notifies

users to donate blood after 3 months completion of blood donation, shows blood bank stock details and in which users can find blood banks and donors when they required blood. The authors they used Google map to locate blood banks and donor on the Google Map and they used Haversine formula to find nearest blood bank and donor. The system reduces time and cost and ensures correct location tracking of blood banks and donor nearby. However, the system did not cover other health facilities such as hospitals, pharmacies and clinics, which only provide facility to find and donate blood in less time. In addition, the system does not show the route to rich to the nearest blood bank.

HealthCare Information Management System Using Android OS

Chauhan et al. [30] proposed Healthcare Information Management System Using Android OS, the major objective of this application was to determine to user's location to his/her family member in the case of emergency along with the nearest hospital. The second major objective was to determine the disease by using the method of Touch Sensing. The proposed application checks symptoms of many diseases along with their treatment and location of the doctor which is specialized for that particular disease. In addition, it provides the diet which is best suited to recover from that particular illness and the proposed application incorporated a facility which alerts the nearest hospital facility along with the hospital's location when the user pressed emergency button. To accomplish the location of the hospital as well as the user's location information both geocoding and reverse geocoding were used along with location API's. To accomplish the proposed work they adopted Eclipse(4.2.0) IDE, Android Version 4.0 or above mobile device or above, Google Location Services APIs and Touch Sensing method to pinpoint the exact location/area of the symptom.

As presented in Chauhan et al. [30], the proposed application provides symptoms of many diseases along with their treatment and location of the doctor which is specialized for that particular disease. In addition, the proposed application will send the location and emergency message to any five selected people if user is in any trouble if and only if the injured person has a smart phone with internet facility when the time of accident occurs. However, the proposed system is that it does not allow to get the nearest heath center information depends on the choice of users and current location.

Implementation of Health Information System Using Location Based Services

Poornima et al. [31] proposed Implementation of Health Information System Using Location Based Services (HIS). The HIS provides a solution for Locating the nearest hospitals as per the user's preferences using the Network Analysis, Finding the shortest route from an origin to a single destination and finding the closest facility from an origin to multiple destinations. To determine the closeness and the shortest path to the healthcare facilities using the ArcGIS software, they proposed Bidirectional shortest path algorithm. The proposed application is used to create desktop applications through which a user can get information regarding their location. However, it is not implemented for mobile based application in order to locate the nearest healthcare facility for a user.

3.2 Summary

There are different patient assistant systems or applications developed in different countries. In the reviewed paper section 3.1, some the proposed systems could not allow patients/users to get the nearest heath center information depends on their health facility service choice and their current location. The others could not cover other health facilities like hospitals, pharmacies and health centers, which only provide facility to find and donate blood in less time. In addition, others are not implemented for mobile based applications and others could not allow to display the nearest available health facility and optimal route using interactive map.

The aim of this work is thus to develop location-based patient assistant mobile application to show the current location of the patient and the routes between the patient and the preferred health facility location depends on patient's health facility service choice using interactive map. The presented work in section 3.1, Google Map API can utilize to show the route between current location and the destination. The Google Map Directions API enables users to get directions for different modes of transportation, such as transit, driving, walking, and cycling. But the proposed application implemented using Mapbox open-source API, which shows the route and the nearest location of health facility on a map. One of the key reasons why Mapbox API is more preferable to develop the proposed application than Google API, Mapbox API shows a route without any charging and it is a flexible open-source platform that has become incredibly popular among developers because, it allows creating custom

mobile and online maps. But Google API starting to charge for a previously free feature; it has disabled the use of Directions service route API for free and introduced the mandatory enabling a billing to use direction service. The following Table 3.1 shows the comparison of mapping APIs

	Type of API	Price	Waypoints	Routing	Routing Algorithm
MapBox API	Map	Free	Yes	Yes	Bidirectional A*, TSP
Google API	Map	5$ <	Yes	Yes	Dijkstra's
Google API	Map	Free	No	No	Static map

Table 3.1 Categorization of Map APIs (Source: diva-portal.org)

CHAPTER FOUR

SYSTEM REQUIREMENT ANALYSIS

The objective of the project is to develop mobile and web-based application that provide route and map-based health facility information to patient. In order to achieve the envisaged objective, map box routing and mapping application programming interface, web and mobile application development framework are employed for developing the solution.

4.1 Existing System

Currently, the Ethiopian ministry of health does not have a system which provides easy information access of health facility such as: service category, contact address, ownership and other information related to health facility. But, Ethio Health Directory developed Health Directory system, the directory system included contact address of Government offices, public, private and NGO actors in the health sector, health facility service category and other stake holder categories. The purpose of the directory system is to facilitate business to business networking, flow of information and easy information access to users. However, this directory system is underway for the next edition and they intended to include GPS Location for the facilities and to start mobile application in the next version of the directory system.

4.2 Functional Requirement

Functional requirement is an area of functionality that Location Based Patient Assistant Mobile Application system must support.

The major functions of this system are:

- Allow the administrator to register health facility information
- Allow the administrator to manage health facility information
- Allow the administrator to view health facilities detail information
- Allow the users or patients to search health facilities information
- Allow the users or patients to view the nearest health facilities detail information
- Allow the users or patients to view the nearest health facility location on a map

- Allow the users or patients to view the shortest route from current location to the preferred health facility location on a map

4.3 System Model

4.3.1 Use case and Actor

Use cases are used during requirements elicitation and analysis to represent the functionality of the proposed system. Use cases focus on the behavior of the system from an external point of view. A use case is used to describe a function provided by the system that yields a visible result for an actor. An actor describes any entity that interacts with the system, such as a user, another system and the system's physical environment. The identification of actors and use cases resulted in the definition of the boundary of the system that is, in differentiating the tasks accomplished by the system and tasks accomplished by its environment. The actors are outside the boundary of the system, whereas the use cases are inside the boundary of the system. The following Use Case and Actors are identified for the proposed system call Patient Assistant Mobile Application using LBS. Use case diagram of this application is shown in Figure 4.1.

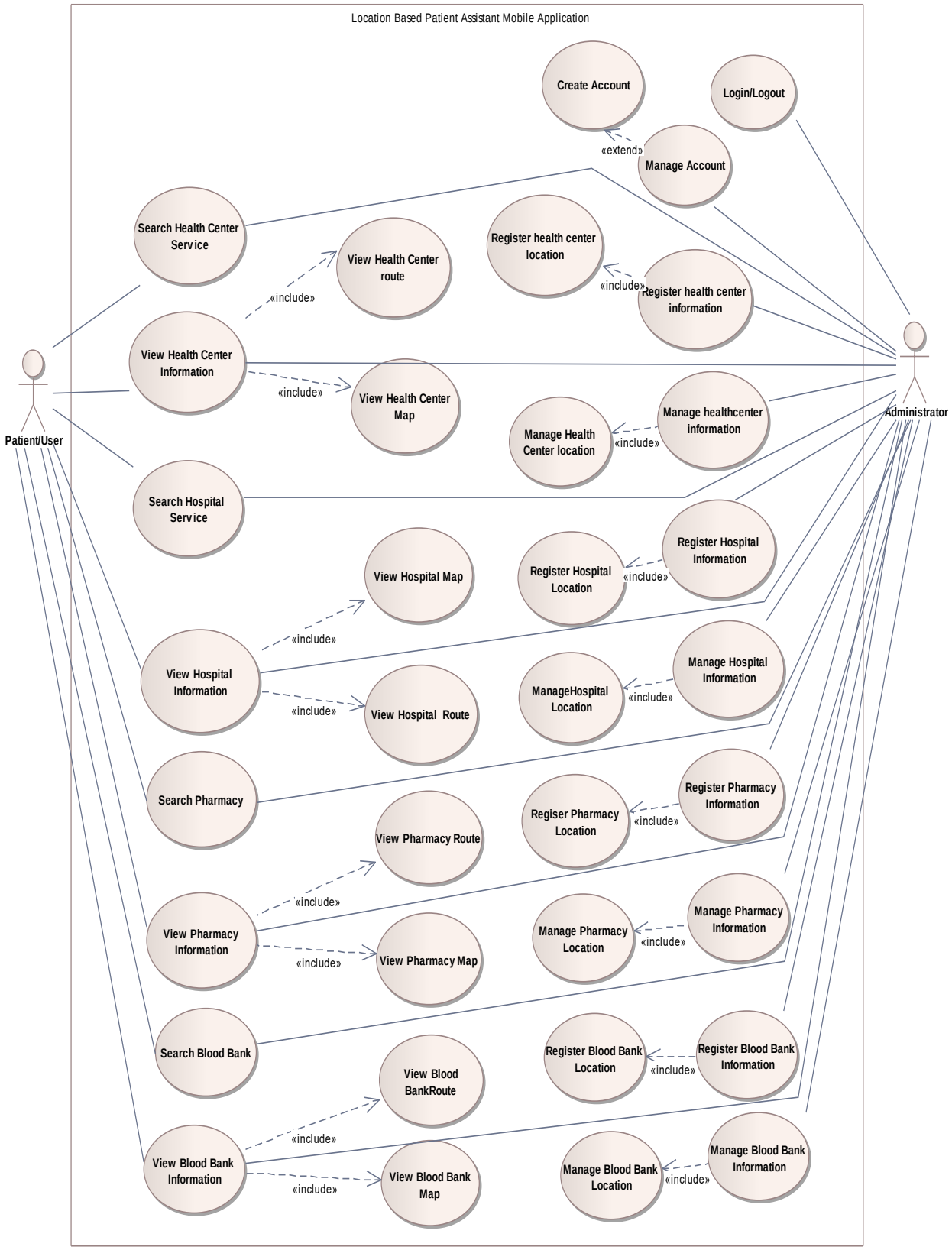


Figure 4.1: Use Case Diagram for PAMA

4.3.1.1 Descriptions of Actors

Administrator: a person who is responsible for managing all activities of the system such as register health facility information, create account, modify account (change password or Id), Update/modify health facility information and can view health facility information. **Patient or User**: a person who accesses the system and uses Patient Assistant Mobile Application.

4.3.1.2 Use case descriptions

The following tables show the description for the above use case. Each use case has unique identifier UC (use case) number. The description details how each actor interacts with the system in order to use the services implemented.

Use Case Name	**Create Account**
Identifier	UC01
Actor	Administrator
Purpose	This use case allows the Administrator to create account
Pre-condition	The administrator must be launching the system
Flow of Events	
1. The Administrator wants to create account 2. The Administrator chooses health facility link 3. The system displays user management link 4. The Administrator clicks on user management link and fill necessary information and click on save button 5. The system checks the username entered by the Administrator [Alternative 5] 6. “User created successfully” message displayed to the administrator.	

Alternative Flow of Events	
Alternative Flow 5: [the Administrator enters existing name or blank the required field.] 5.1. The username exists or fill in the required fields Message will be display. 5.2. The system resumes at step 4	
Post condition	The administrator will have privileges to modify/update the system

Table 4.1: Create Account description

Use Case Name	**Login**
Identifier	UC02
Actor	Administrator
Purpose	The administrator login to the application using username and password
Pre-condition	The administrator must be registered to access the system
Flow of Events	
1. The administrator wants to login the system 2. The administrator opens the system 3. The system displays login page 4. The administrator inserts his/her own user's name, password and clicks on Login button 5. The system verifies [Alternative Flow 5] 6. The system displays home page	
Alternative Flow of Events	
Alternative Flow 5: If the administrator user name or password incorrect 5.1. The system display, "Incorrect Login", Error	

Message 5.2. The system resumes at step 4	
Post condition	The administrator successfully logged in to the system

Table 4.2: Login description

Use Case Name	Manage health center information
Identifier	UC03
Actor	Administrator
Purpose	This use case allows the Administrator to update/delete health facility information
Pre-condition	The Administrator launches the system and logged in successfully
Flow of Events	
1. The administrator wants to modify /update system 2. The system displays health center 3. The administrator selects health center link 4. The system displays management link 5. The administrator selects management link 6. The system display search page 7. The administrator fills the search field and click on find button 8. The system displays the search result 9. The administrator chooses which one of the systems want to update 10. The system displays update page 11. The administrator fills necessary information and click update/delete button	

12. The information will be validated [Alternative Flow 12] 13. The system searches the updated/deleted filled [Alternative Flow 13] 14. Updated/deleted the selected field component 15. "Updated/deleted successfully" message display to the administrator	
Alternative Flow of Events	
Alternative Flow 12: If the administrator misses required field 12.1 The system displays error message 12.2 Use case resumes at step 11 Alternative Flow 13: If the information already registered 13.1 The system displays error message 13.2 Use case resumes at step 11	
Post condition	The health center information updated/deleted

Table 4.3: Manage health center information description

Use Case Name	Register health center information
Identifier	UC04
Actor	Administrator
Purpose	Allows the administrator to register health facility information
Pre-condition	The administrator opens the system and select health center link
Flow of Events	
1. The administrator wants to register health center information.	

2. Administrator clicks on health center link 3. The system displays health center information registration page 4. The administrator should register health center information 5. The administrator clicks on save button 6. The information will be validated [Alternative Flow 6] 7. The system creates health center information [Alternative Flow 7] 8. The administrator gets confirmation 9. End use case	
Alternative Flow of Events	
Alternative Flow 6: If the administrator misses required field 6.1 The system displays error message 6.2 Use case resumes at step 4 Alternative Flow 7: If the health center already registered 7.1 The system displays error message 7.2 Use case resumes at step 4	
Post condition	The health center information created

Table 4.4: Register health center information description

Use Case Name	Search health center service
Identifier	UC05
Actor	Patient/User
Purpose	Allows the patient/user to search health center available information

Pre-condition	The patient/user opens application on a mobile phone Select the health center information and click search button.
Flow of Events	
1. The patient/user launches the system 2. Display the home page and the patient/user select the preferred health center link 3. Select available health center services from combo box 4. Click on search button [Alternative Flow 4] 5. Display the health center information	
Alternative Flow of Events	
Alternative Flow 4: If no search result found 4.1 Use case resumes at step 2	
Post condition	The health center information displayed

Table 4.5: Search health center information description

Use Case Name	View health center information
Identifier	UC06
Actor	Patient /user
Purpose	Allows the patient/user to view health center detail information, map and route
Pre-condition	The patient/user opens application on a mobile phone Select the health center services
Flow of Events	
1. The patient/user launches the system	

2. The patient/user selects detail information [Alternative 2] 3. The patient/user selects map of the health center [Alternative 3] 4. The patient/user selects route of the health center [Alternative 4] 5. Display the health facility information	
Alternative Flow of Events	
Alternative Flow 2: If the patient/user selects detail information 2.1 The system displays health center detail information Alternative Flow 3: If the patient/user select map 3.1 The system displays location of health center on a map Alternative Flow 4: If the patient/user select route 4.1 The system displays route from current location to the nearest health center on a map	
Post condition	The patient/user gets information about health center, gets the route to reach the destination from current location based on map and he/she gets the location of the health center on a map.

Table 4.6: View health center information description

4.3.2 Class Diagram

Class model shows the classes of the system, their interrelationships, the operation and attributes of the class. A class is a representation of an object. To describe a class, we define its attributes and methods. Attributes are the information stored about an object while methods are what the object or the class does.

Figure 4.2: Hospital Class Diagram

4.3.3 4.2.3 Sequence Diagram

The sequence diagram is useful to shows the interaction logic between the objects in the system in the time order that the interactions take place. Sequence Diagrams shows how objects communicate with each other in terms of a sequence of messages. They emphasize the sequence of the messages among the different objects. Sequence Diagrams also indicates the life spans of objects relative to those messages. They are good at showing collaborations among the objects. We use sequence diagrams to look at the behavior of several objects within a single use case.

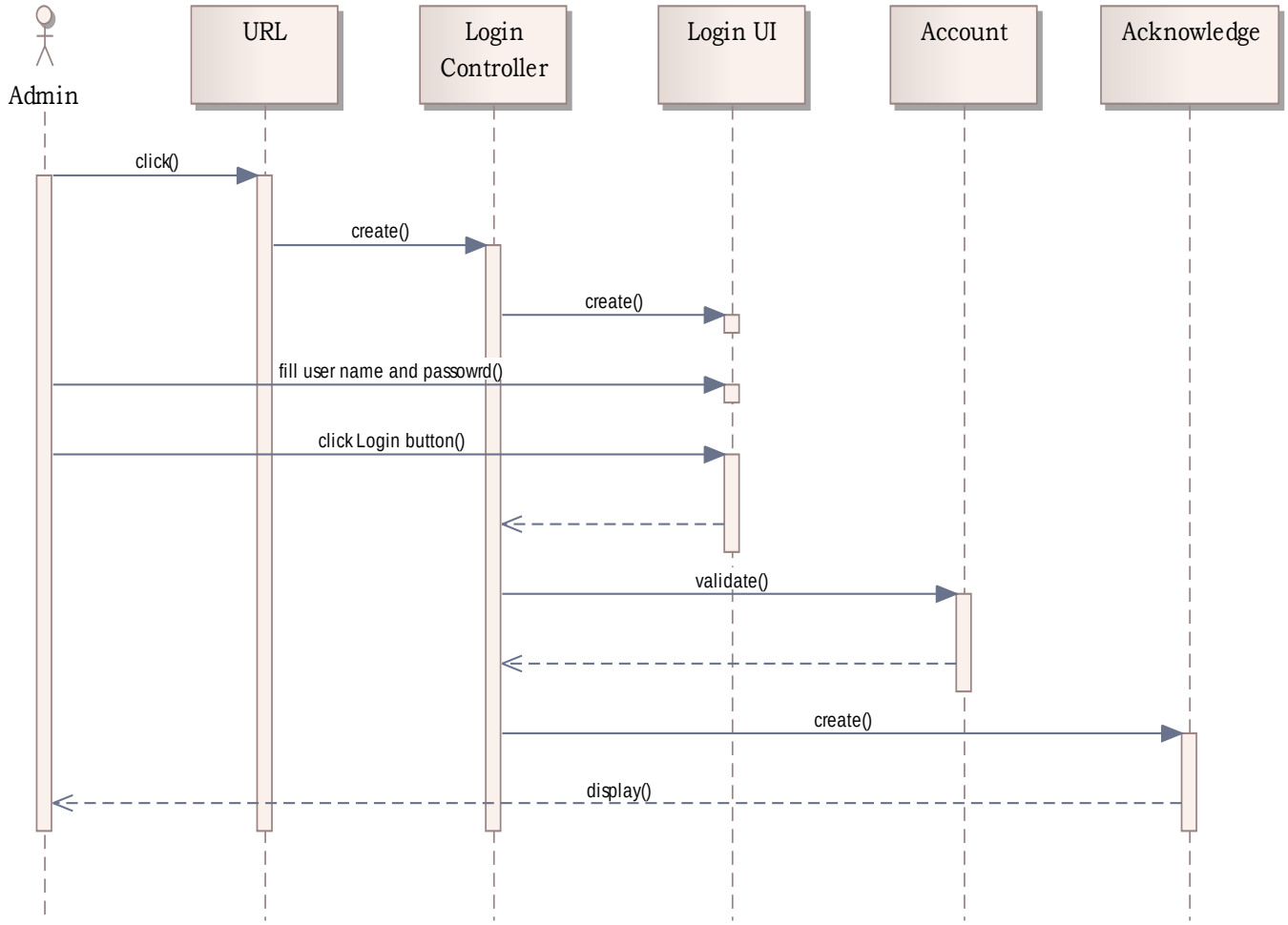


Figure 4.3: Login Sequence Diagram

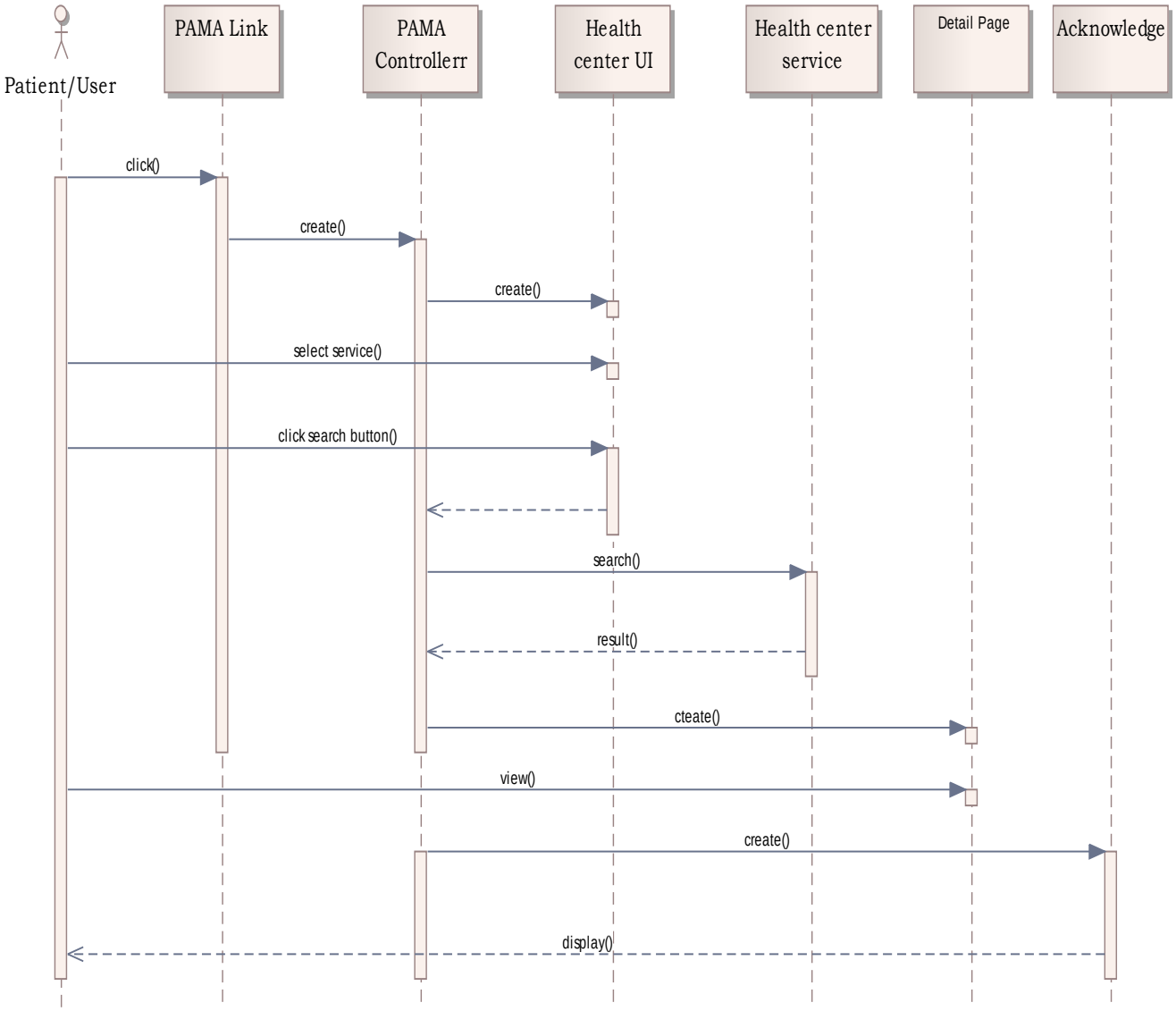


Figure 4.4: Search Health Center Service Sequence Diagram

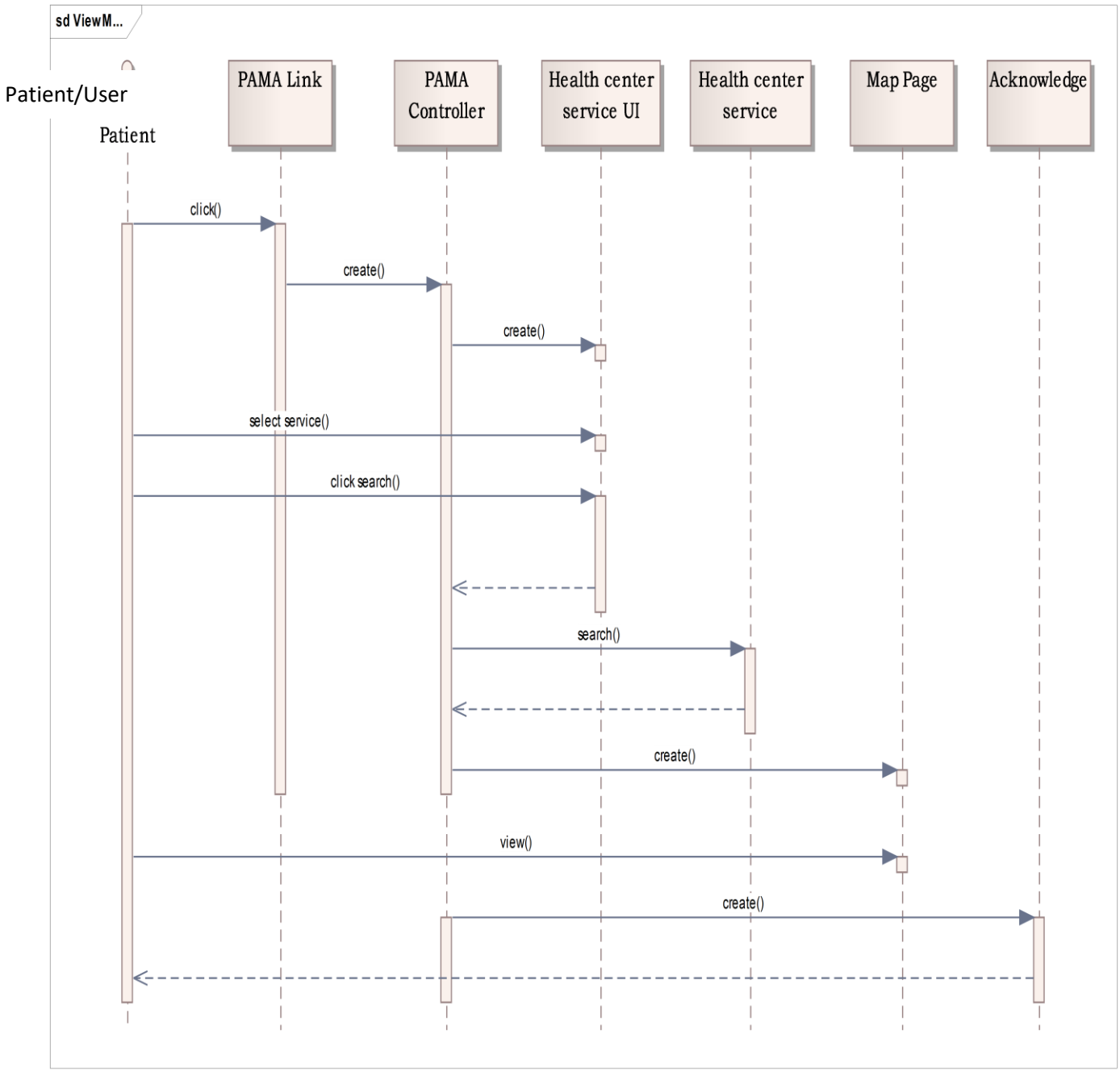


Figure 4.5: View Health Center Map Sequence Diagram

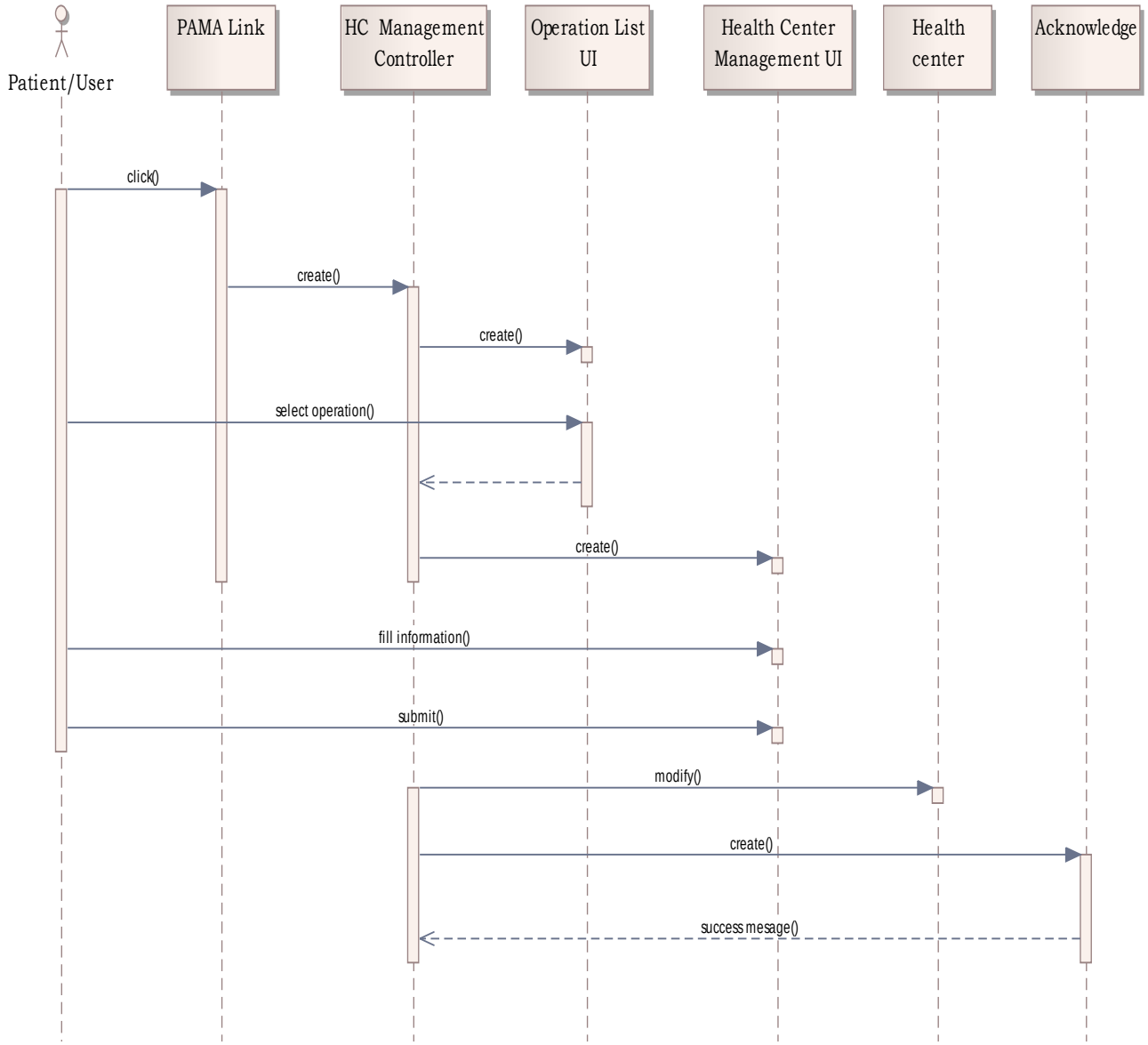


Figure 4.6: Manage Health Center Information Sequence Diagram

4.4 Nonfunctional Requirements

Nonfunctional requirement describes how well the system supports the functional requirement. It identifies aspects that are visible to the user but not directly related to the functionality of the system. These include the following aspects of the system:

Performance Requirements

The system should have reliable performance and fast response time. In order to minimize the time and to increase the performance, powerful application server is used and fast

location acquisition techniques and better performance algorithms should be used to accomplish the functionalities of the system and the system should be accessed by number of users at a time. So, to increase access speed it should be used multiple copies of data and server.

Security

The system should be secured from external intruders and internal misuse. It should be modified and managed only by authorized administrator. Patients can access the system to view and search health facility information using mobile without any authentication but the system managed and modified only by authenticated administrator.

Error Handling

The system should be able to validate user inputs to their assigned value and it should display error message.

Reliability

The system should be reliable and gives accurate result to all users by using most accurate location acquisition methods and by using most accurate algorithms to calculate the shortest route and nearest health facility location.

Usability

The system should be understandable by authorized administrator of Ethiopian Ministry of Health and patients that will need health facility services and location information. The interface should be easy to use and it should have graphical user interface so that users can easily be familiar with the system. User manual should be prepared to make the system easy to learn, operate and usable for accomplishing tasks.

Documentation Requirements

The overall development process should be documented including the Requirement Analysis, System Design, and Implementation details for easily maintainable and understandable.

CHAPTER FIVE

SYSTEM ARCHITECTURE AND DESIGN

System Design Document (SDD) is a foundation for the system functional components, code development, system testing and deployment. The description of these functions will assist the implementation strategy to ensure that the system meets the defined requirements.

The proposed LBPAMA is designed based on the functional and non-functional requirements and analysis models defined in the preceding chapter. This chapter describes the design goals expected from the system, decomposition of the system into smaller subsystems, architecture of the system, hardware/software mapping, persistent data management and access control.

5.1 Design Goal

Design goals identify the qualities that Location Based Patient Mobile Application will focus on and they are derived from the nonfunctional requirements in the application domain. The qualities of the design goals are selected from the following design criteria's which are grouped in to: Dependability, Performance, maintenance and user criteria.

Dependability Criteria

Reliability: The output of the system should be reliable by using the most accurate location acquisition methods of GPS and Wi-Fi access point and by using Haversine formula to calculate accurately the nearest health facility location.

Security: the system does not allow non-authorized users using a form-based authentication.

Robustness: the system validates invalid user input, updating and deletion of user data by providing some information about the error.

Performance Criteria

Responsive time: The system should provide as fast response as possible. In order to minimize the time powerful server should be used. Because, server components provide

services to multiple client components so on the server should be use faster processor, multiple processors, multiple memories and fast internet access. In addition, to give fast response to user it should be use GPS fastest location acquisition techniques to outdoor service and should be use better performance algorithm to find route and to calculate the nearest health facility location. So, the system uses Haversine formula and MapboxAPI to fast the searching time of shortest path and the nearest location. Because Mapbox API uses bidirectional A* algorithm, this is fastest shortest route searching algorithm. Replica is one of important techniques to increase the performance of the system. Hence, the system should be use data and hardware replication to store data in more than one place and device.

Throughput: The system should be able to support a number of users at a time using the available bandwidth of the system. The MS-SQL DBMS used in the system development supports a number of users' concurrent access of the database without consistency problem.

Maintenance Criteria

Modifiability: The system should have to be easily modifiable to support changes or upgrading without causing problem to other systems functionality. To insure this, the system applies object-oriented principles and it designed using the layered architecture. Layered architecture provides modules of the system to be implemented and maintained independently and enables different Location Based Patient Assistant Mobile Application components can be changed without affecting the other components.

User Criteria

Usability: To make the system clear and interactive to users, the system should have uniform background and graphical user interface. In addition, buttons and links of the interface should be comfortable to use and user manual should be prepared to allow users to use the system easily and to understand the system operations clearly within short time.

Availability: the system should be available for users as long as the server machine is available, and the WAN internet exists. And the system should be available for outdoor and indoor service by using both wi-fi and GPS location acquisition method. Wi-fi should

be used for indoor service and GPS should be used for outdoor service. The system should protect random failures of hardware by adding multiple copies of identical components and the system should have a high cohesion by keeping together things that are related to each other.

Utility: all the functional requirements identified in Chapter Four have been implemented in the system to address the possible functional requirement of the system users.

5.2 Architecture of the system

The architecture used for the system is client server application, such architecture is one of the most commonly used type of architecture to provide greater application scalability, high flexibility, high efficiency, lower maintenance, and better reusability of components. As described in Figure 5.1 the architecture of the system includes five layers namely, Interface Layer, Business Layer, Service Layer, API Layer and Data Storage Layer. The top layer of the system architecture is “Interface Layer”, on this layer the user interface codes are implemented to enable information access to mobile users.

The second layer is the Business Logic layer; this layer contains the main subsystem of the application and responsible for handling all the core functionalities of the system without the user interface.

The third layer is the Service Layer; this layer interacts with API Layer to provide Route identification service, Patient Location Identification Service, Mapping service and Health Facility Location Identification service. Patient Location identification service allows identifying the current location of the patient using Google Map Service. The mapping service allows adding map into mobile application using Map box API key and route identification service allows showing the route from current location to the user preferred health facility service using Map box route API key. And Health Facility Location Identification service uses to identify the exact location of the health facility.

The fourth layer is the API Layer; this layer includes Google Map API key to identify the current location of the user from users mobile GPS and Map box API key to show map and route of the health facility.

The fifth layer is Data Storage Layer; this layer is the back-end for Location Based Patient Assistant Mobile Application. And it uses to manage, retrieve, update and store health center data, hospital data, pharmacy data and blood bank data.

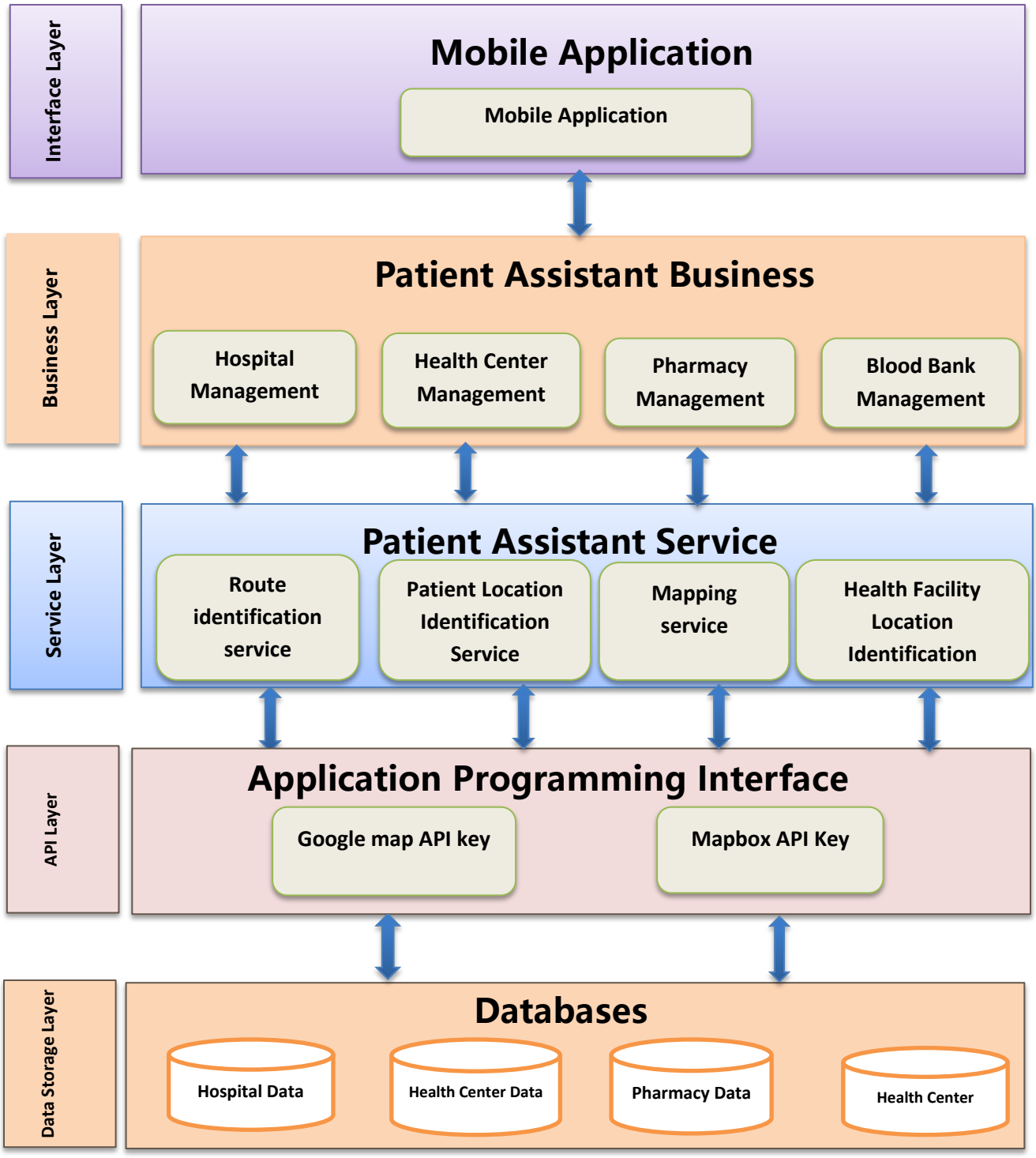


Figure 5.1: Architecture of Location Based Patient Assistant Mobile Application (LBPAMA)

5.3 Subsystem Decomposition

The PAMA (Assistant Mobile Application) system is broken down into subsystem components to manage and reduce the complexity of the system. Figure 5.2 presents the subsystems:

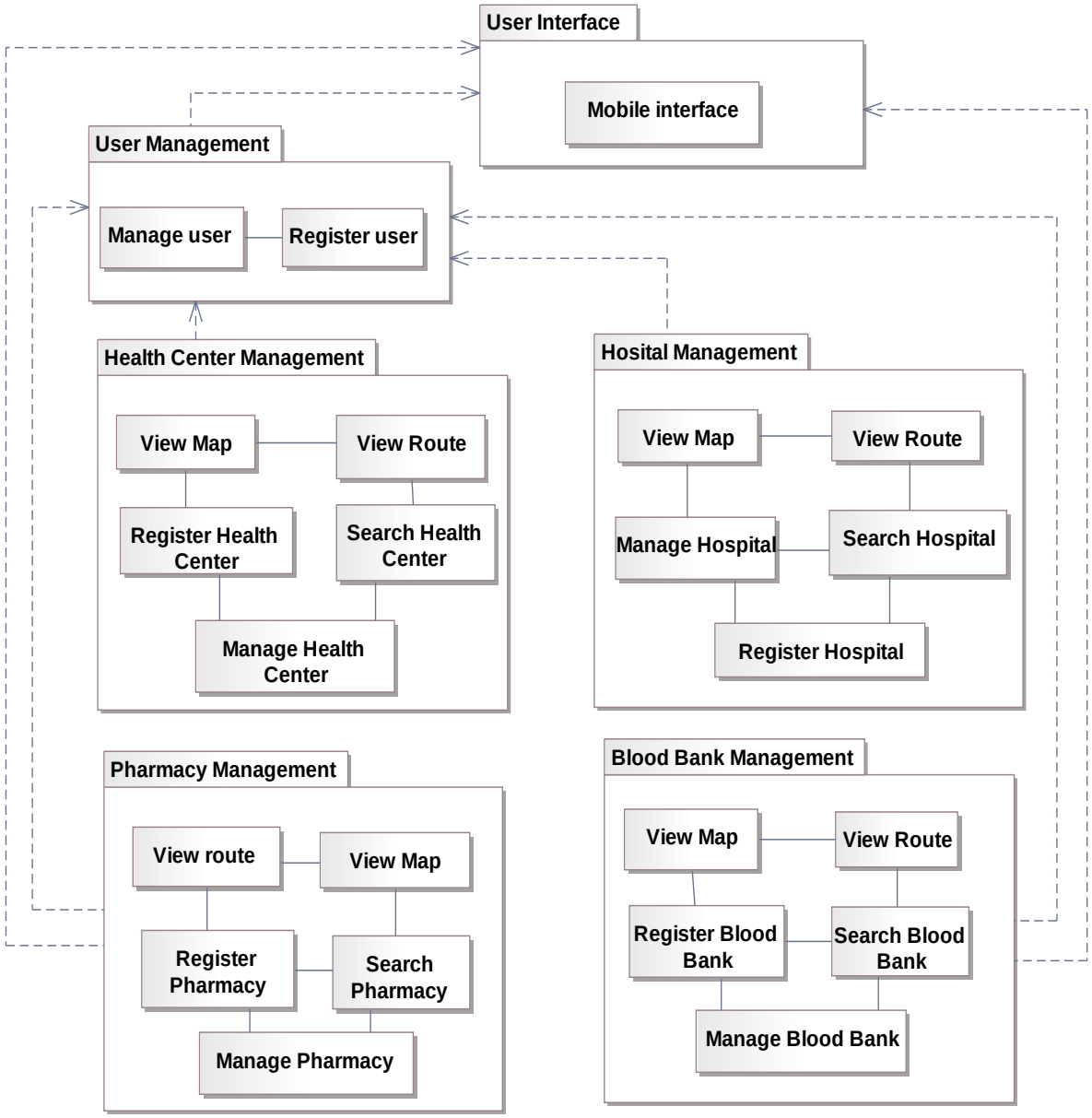


Figure 5.2: Subsystem Decomposition of LBPAMA

User Management subsystem enables the system administrator register users and provides methods to add, update, delete and search information related to the users of the system.

Hospital sub system enables administrators to register, update and delete hospital related information and it enables patient to search nearest hospital information and enables patients to view the nearest hospital location on a map based on user preferred service type of hospital and the sub system enables patients to view the route on a map from current location to the nearest hospital.

Health Center sub system enables administrators to register, update and delete health center information and it enables patient/user to search nearest health center information and enables patients/users to view the nearest health center location on a map based on his/her choice of health center service type and the sub system enables patient/user to view the route on a map from current location to nearest health center.

Pharmacy and blood bank sub systems, the sub systems enable administrators to register, update and delete pharmacy and blood bank information respectively and they are responsible for patients/users to view maps of the nearest location and to view roue on map from current location of his/her to nearest location.

5.4 Hardware /Software Mapping

This section shows the relationship among the nodes and the independent components in the system. The system contains five hardware components: mobile device, computer device, web server map server and database server. The computer device contains the web browser that enables system users to access the application server according to their privilege through HTTPs. The mobile device contains a mobile web application that enables system users to access the application server. The map server provides mapping and routing services and the web server contains the application logic and uses Glass Fish Server to handle requests sent from users through HTTPs. And finally, there is the database server that is used to perform tasks such as data analysis, storage, data manipulation, archiving, and other non-user specific tasks.

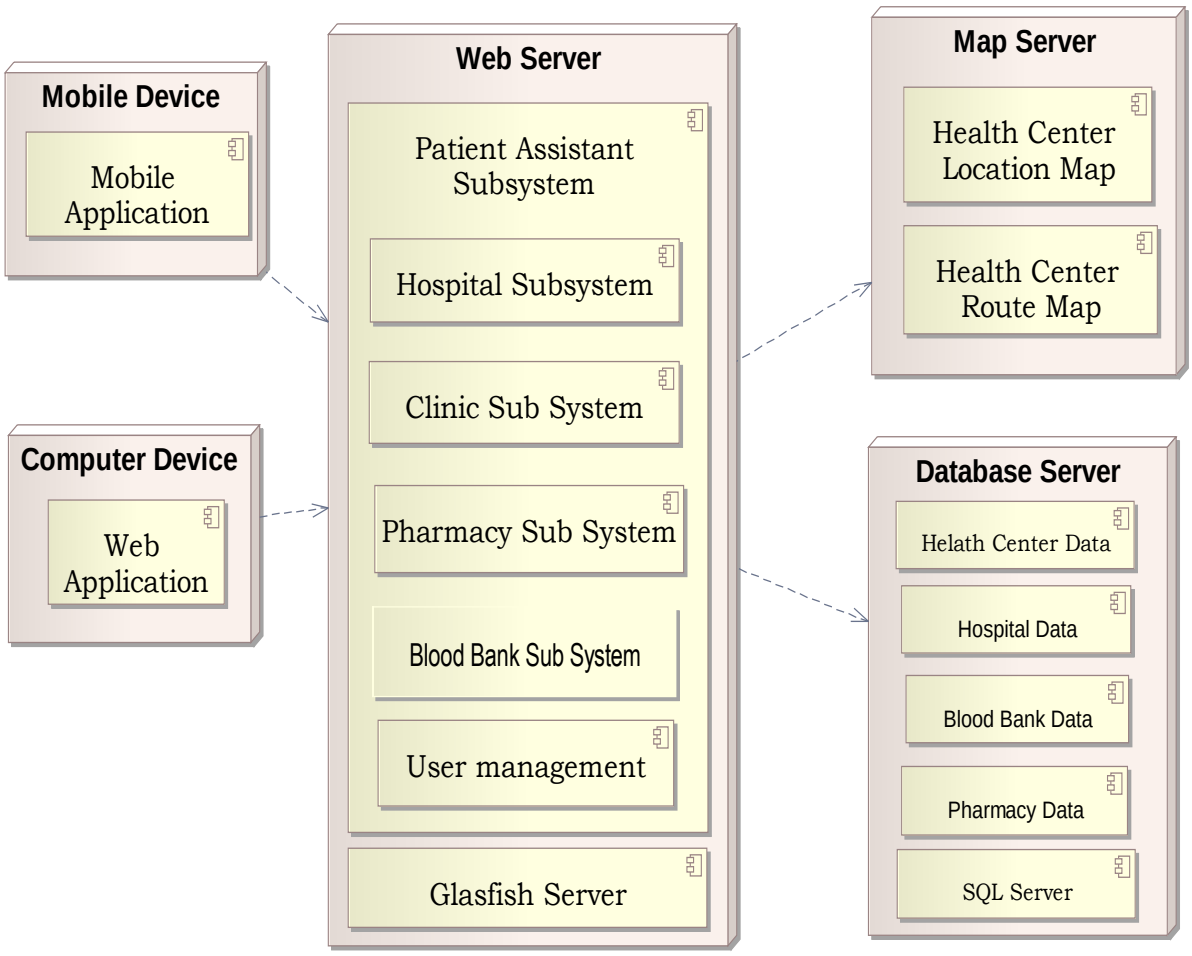


Figure 5.3: Deployment Diagram of LBPAMA

5.5 Persistent Data Management

Persistent data management deals with how the persistent data are stored and managed. Information related to health facility such as, hospital, health center, pharmacy and blood bank and other related information are persistent data and hence stored on a database management system. This persistent data allows all the programs that operate on the PAMA data to do consistently. And storing data in a database enables the system to perform complex queries on large data sets. In order to store data persistently in a database, those entity classes identified in analysis model of class diagram of PAMA system are transformed into tables and attributes of the classes are also mapped into tables fields. Figure 5.4 shows the system's relational model that handles data relation, integration and persistent data management.

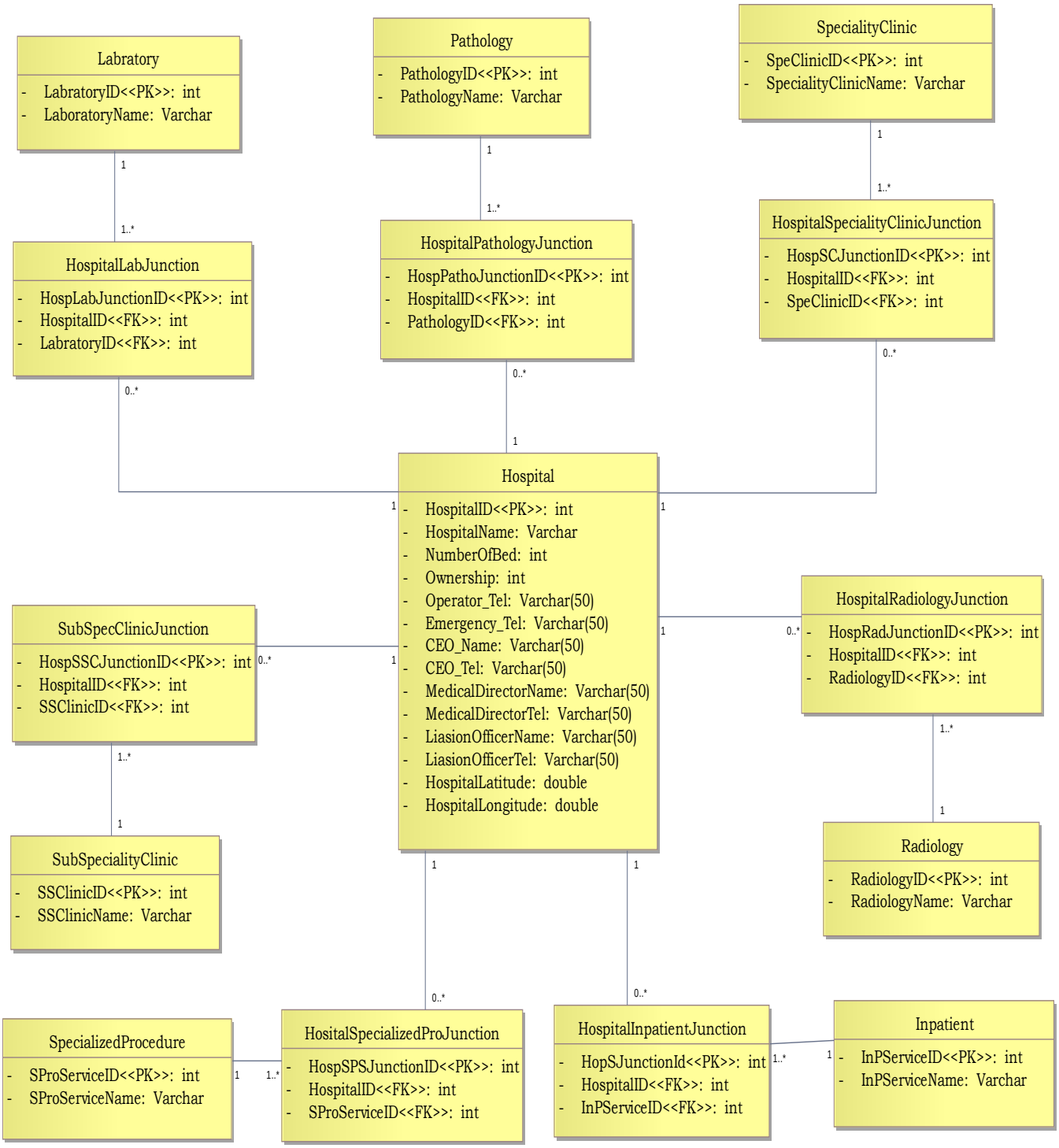


Figure 5.4: Persistent Data Management for hospital sub system

5.6 Access Control Policy

Access control is a security technique that can be used to regulate who or what can view or use resources in a LBS Patient Assistant Mobile application. The application has two groups

of users with different accesses privileges to different services and data. The access control matrix defined for the system is shown in Table 5.1.

Class	**Actor**	
	Administrator	**Patient/User**
User Management	CreateAccount()	
	UpdateAccount()	
Hospital	Register Hospital Service()	
	Update Hospital Service()	
	Search Hospital Service()	SearchHospitalService()
	View Hospital Service()	ViewHospitalService()
	ViewLocation()	ViewLocation()
	UpdateLocation()	
	ViewRoute()	ViewRoute()
Health Center	RegisterHealthCenterService()	
	UpdateHealthCenterService()	
	SearchHealthCenterService()	SearchHealthCenterService()
	ViewHealthCenterService()	ViewHealthCenterService()
	ViewLocation()	ViewLocation()
	UpdateLocation()	
	ViewRoute()	ViewRoute()
Pharmacy	RegisterPharmacy()	
	UpdatePharmacy()	
	SearchPharmacy()	SearchPharmacy()
	ViewPharmacy()	ViewPharmacy()
	ViewLocation()	ViewLocation()
	UpdateLocation()	
	ViewRoute()	ViewRoute()
Blood Bank	RegisterBloodBank()	
	UpdateBloodBank()	
	SearchBloodBank()	SearchBloodBank()
	ViewBloodBank()	ViewBloodBank ()
	ViewLocation()	ViewLocation()
	UpdateLocation()	
	ViewRoute()	ViewRoute()

Table 5.1: Access control matrix of Location Based Patient Assistant Mobile Application(LBPAMA)

CHAPTER SIX

PROTOTYPE DEVELOPMENT

6.1 Development Tools

The system can run on desktop and on android mobiles that support wireless/Wi-Fi connection. This part of the document states about various tools that are used to design and implement the proposed system.

Glassfish Server

GlassFish Server Open Source Edition provides a server for the development and deployment of Java Platform, Enterprise Edition (Java EE platform) applications and web technologies based on Java technology.

Android SDK

Android is a software stack for mobile devices that includes an operating system, middleware and key applications. This Android SDK is used to develop mobile side part of the proposed PAMA.

Netbeans IDE

NetBeans is an Integrated Development Environment (IDE) and platform. This IDE is used to develop server side of PAMA using Java programming languages.

JavaServer Faces (JSF)

JSF (JavaServer Faces) is a Java Web application framework which used to build server-side UI components as well as in web applications. It contains a different set of APIs, with these developers, can manage custom tag library and UI components for developing the JSF interface.

Sparx Systems Enterprise Architect

Sparx Systems Enterprise Architect is a visual modeling and design tool which uses to design software system.

Microsoft SQL server

MS SQL Server is a relational database management system (RDBMS) developed by Microsoft. This product is built for the basic function of storing retrieving data.

Microsoft Windows 10

Microsoft Windows 10 (64 bits) operating system is used for the PAMA server.

Wireless LAN (Wi-Fi)

Wireless LAN (Wi-Fi) is used as a communication infrastructure between the mobile device and the Location Based Service PAMA server.

6.2 Application Environment

Login

The PAMA has web application side and mobile application side; the web application side can be accessed through http://localhost/PA/login.xhtml URL. On this page, the administrator authenticates to access any other links/pages of the application.

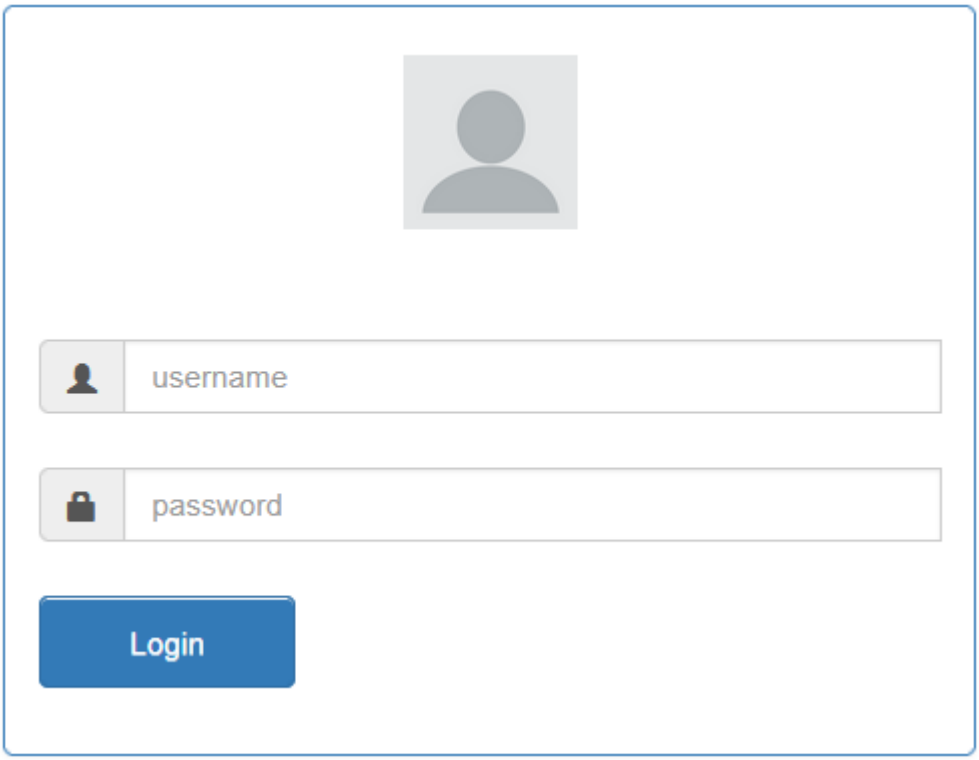


Figure 6.1: Screenshot of Login page on computer device

Home

On this page, the patient/user can access the other links/pages without any authentication on mobile device. To create connection between access point and device, user's or patient's mobile phone Wi-Fi should be on.

Figure 6.2: Screenshot of Home Page on Mobile Device

And the administrator can access different modules of the web application on computer device after authenticated successfully.

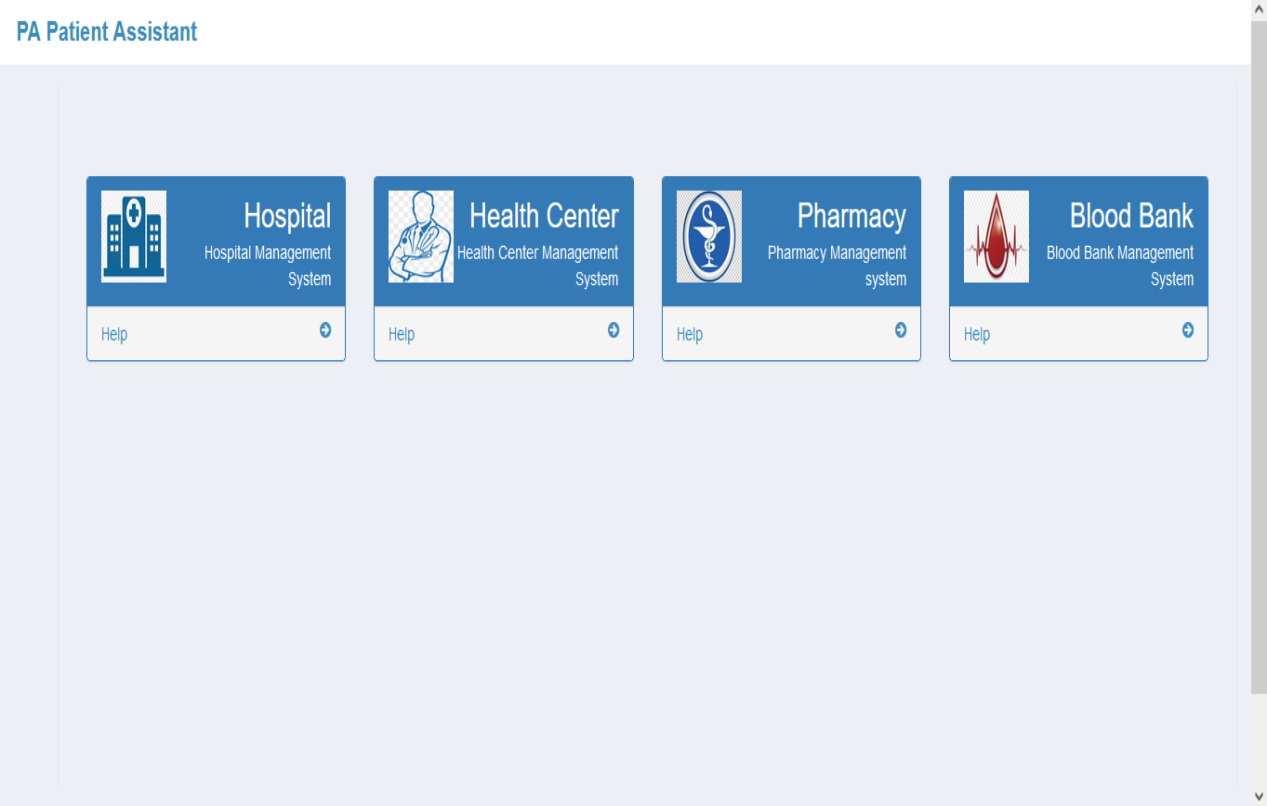


Figure 6.3: Screenshot of Home Page on computer Device

Search

This component is responsible to show health facility service type when the patient selects the preferred health facility service on his/her mobile device. Screenshot of search Hospital service on Mobile Device is shown in Figure 6.4.

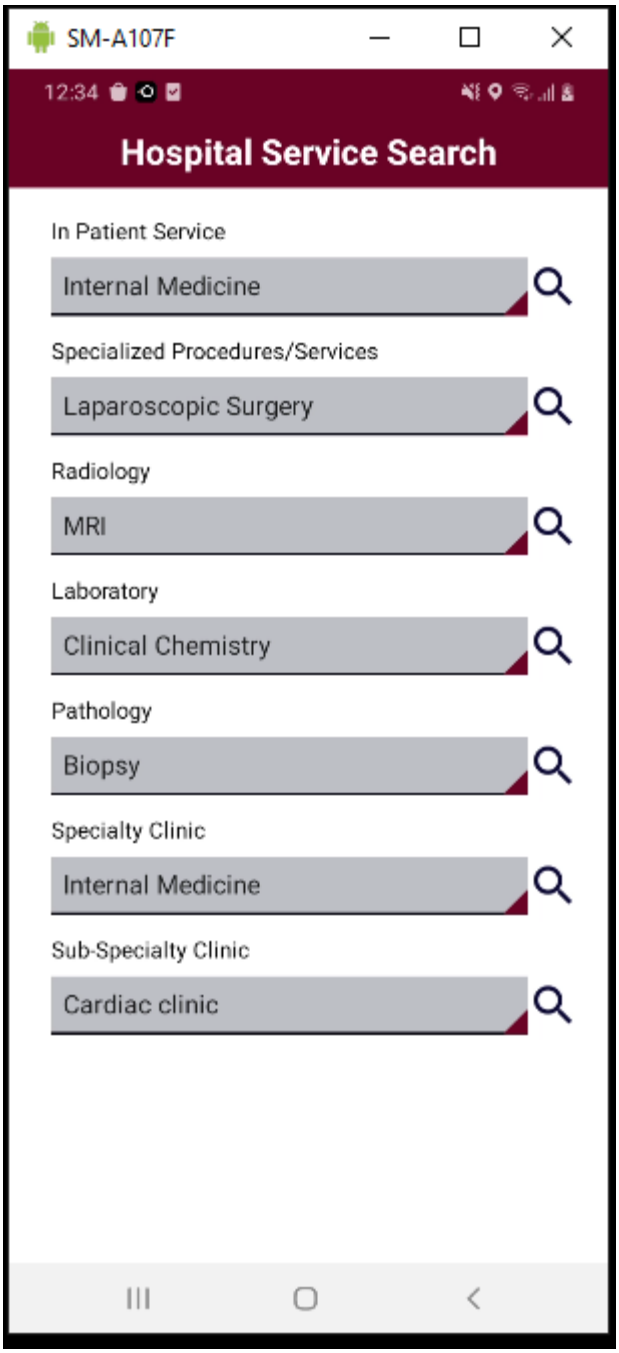
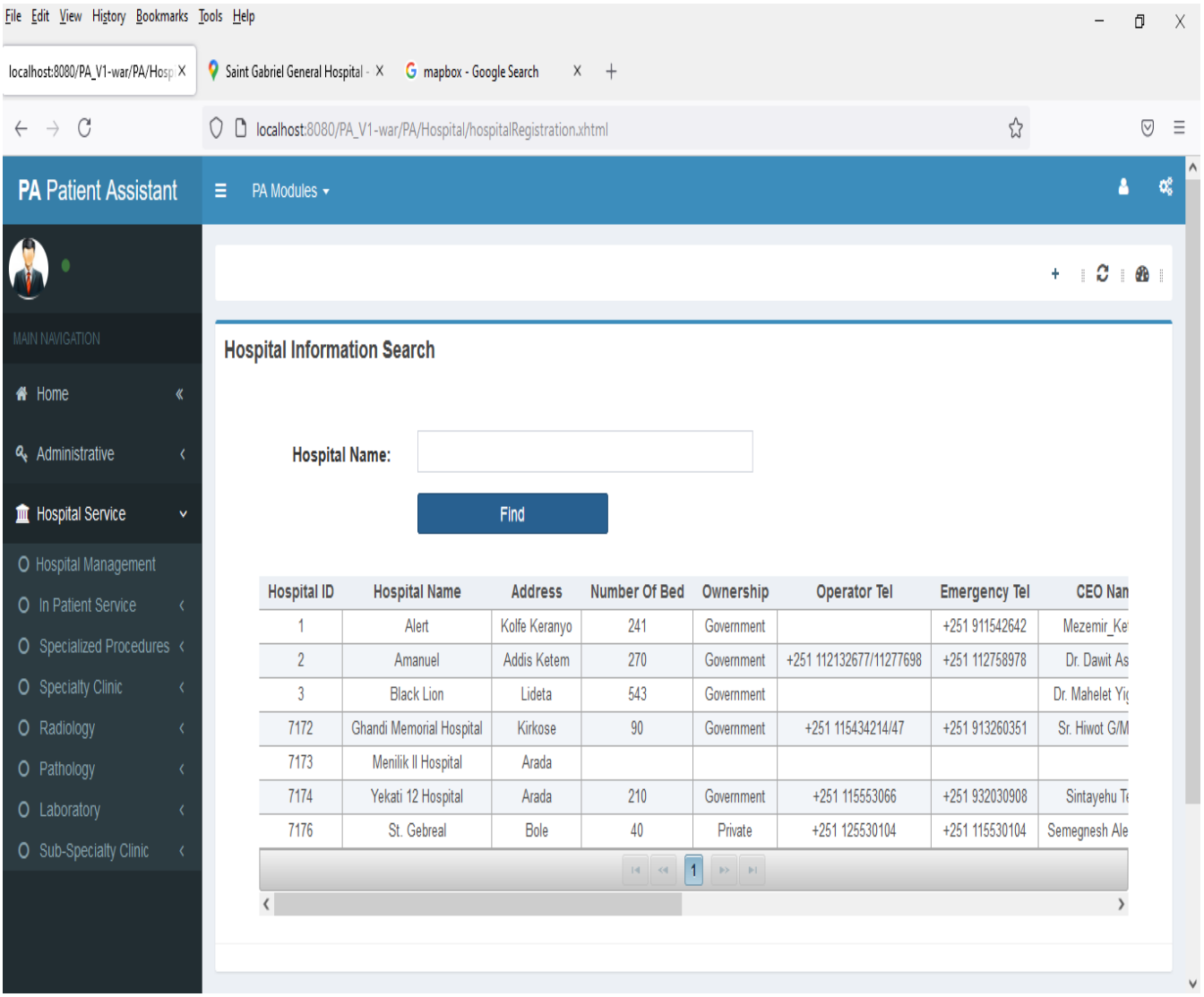


Figure 6.4: Screenshot of Search Hospital service on Mobile Device

View detail information

The PAMA has web and mobile sides, the web part of the system is accessible by authorized administrator and the mobile part of the system can accessed by patient or administrator without any authentication. The following Figure 6.5 shows the administrator of the system

can view detail information of hospital using web application of the system and the patient can view detail information of hospital using mobile application of the system.



Screenshot of viewing hospital information on computer device

Screenshot of viewing detail information of Hospital on Mobile Device

Figure 6.5: Screenshot of viewing detail information

View map

The following Figure 6.6 shows the map of the nearest hospital that provide the user selected service on mobile device.

View route on a map

The following Figure 6.7 shows the route on a map on mobile device from patient location to the nearest health facility.

Figure 6.6: Screenshot of viewing map of nearest Hospital on Mobile Device

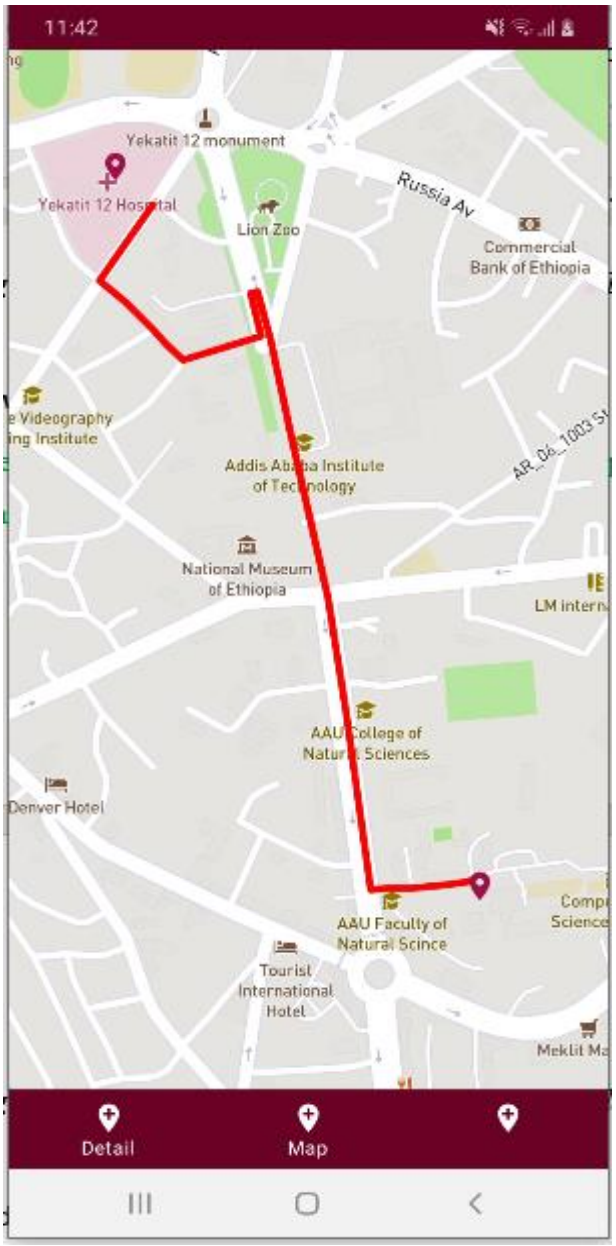


Figure 6.7: Screenshot of viewing route map of Hospital on Mobile Device

Searching Map of Health Facility Location

This component is responsible to display the location of the health facility on a map. To view the map of the location of the health facility, administrator should select the preferred module of Patient Assistant Application from homepage of web application as indicated in Figure 6.3. After do this the administrator can search and view the location of the health facility on a map. Figure 6.8 shows the location of hospital that searched by administrator.

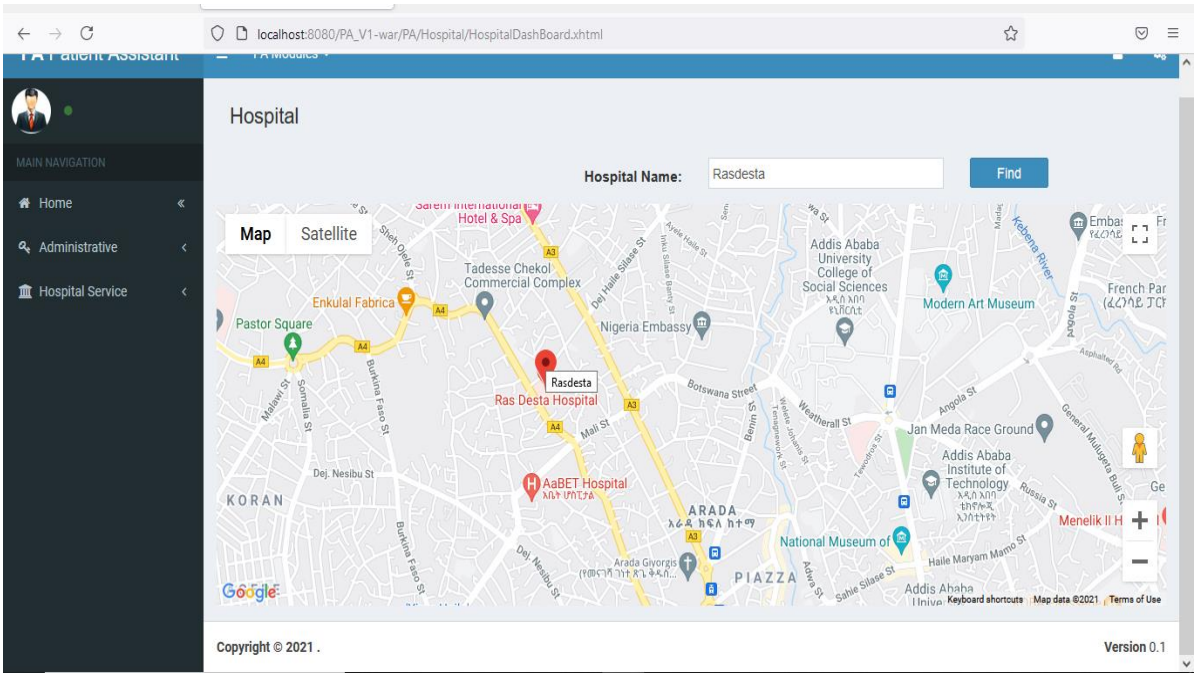


Figure 6.8: Screenshot of searching hospital location on computer device

Adding information

On this web part of the application, the administrator can insert health facility information through web URL and after logged in the system successfully. On the following Figure 6.9 the administrator can add necessary information of hospital.

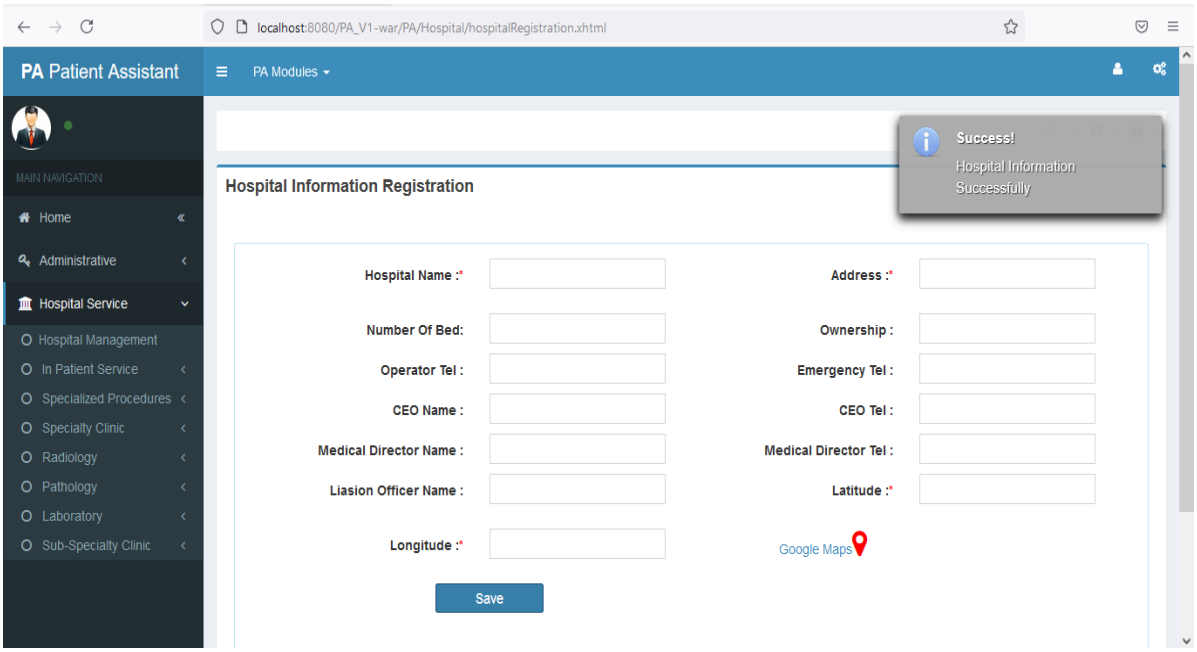


Figure 6.9: Screenshot of adding Hospital information on computer device

Manage information

On this part of the application, the administrator can manage health facility information through web URL and after logged in the system successfully. On the following Figure 6.10 shows the administrator can manage hospital information using computer device.

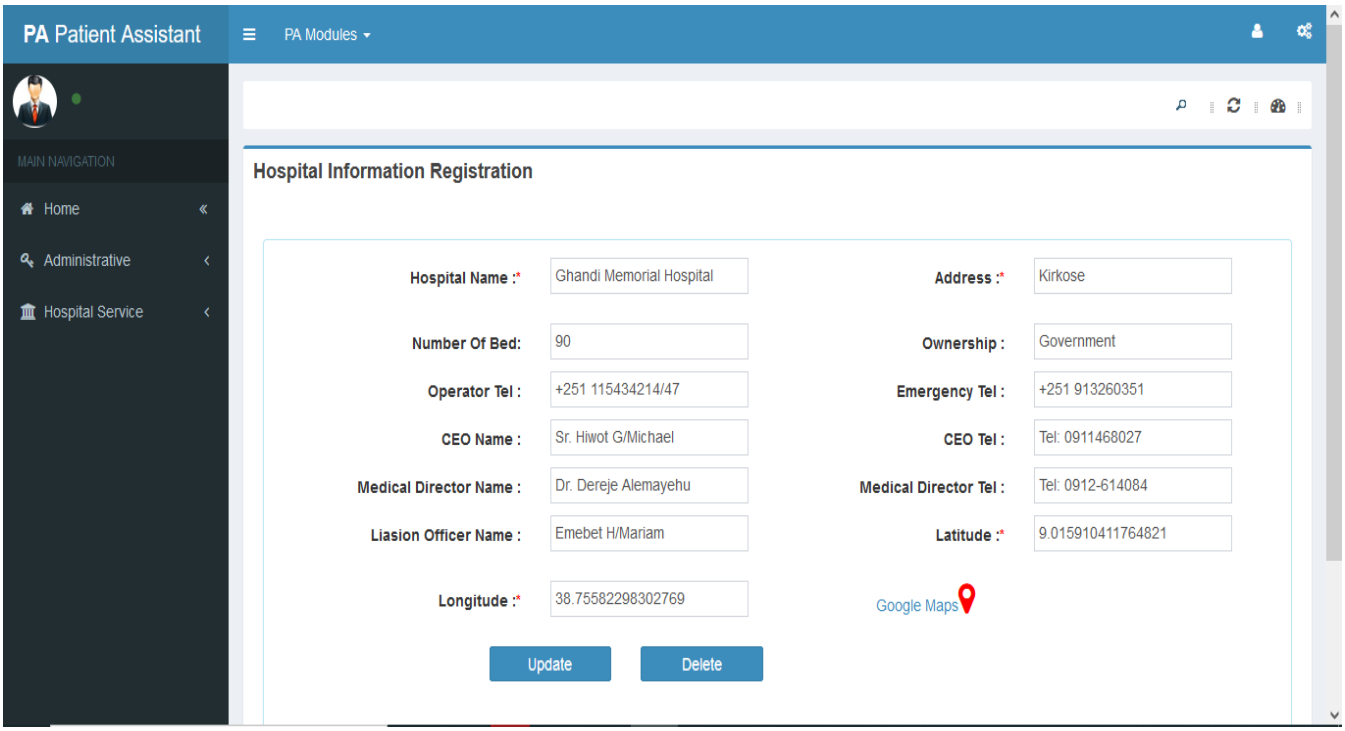


Figure 6.10: Screenshot of managing Hospital information on computer device

6.3 Application Testing

Testing is the process of evaluating the functionality of a software application focusing on finding the bugs, whether the developed software meets the specified requirements or not, and identifying the defects to ensure that the product is defect free so that quality product is delivered. It is also a task carried out keeping in mind meeting the functional requirements enumerated in Requirements Analysis Document. Software testing is very important because it is very important to ensure the Quality of the product, it's important to ensure that the application should not result into any failures, to ensure that product works as user expected, to detect defects early, which helps in reducing the cost of defect fixing, to point out defects and errors that were made during the development phases and ensures an effective performance of software application or product. For this project conducted usability testing and functionality testing to evaluate the overall performance of the developed system.

Functionality Testing

The general purpose of software functionality testing is to verify if the product performs as expected and documented, typically in technical or functional specifications. During functional testing process input forms are also validated to check for invalid inputs and orphaned pages, navigational links and buttons are also tested. Hence to test the proposed PAMA application, functionality testing is carried out by feeding the input and validates the output from the application.

Usability testing

Usability Testing is a critical software testing technique, in which basically the testers validate the usability or it tests whether the interface of the application or the software product is user-friendly or not and it tests whether the software is easy to learn. Usability testing can be highly effective and beneficial in fixing all the problems that user may face even before the system is finally released to the user. This may result in better performance and a standard system. In addition, it can help discovering potential bugs and potholes in the system which generally are not visible to developers and even escape the other type of testing. Hence, usability testing is carried out on the users in Addis Ababa City to evaluate how the interface of the application is user-friendly to patient or administrators and to validate the quality, ease of use and functionality of the proposed application.

Test Result and Discussion

During the prototype evaluation, evaluated both the mobile side and web side of the prototype application evaluated. Due to consideration of the factors of time and effort 52 most accessible and available participants are invited into the usability evaluation. We have used questionnaires to capture the user feedback and convenience sampling technique to select representative number of participants. The web part of the application evaluated by 2 Ethiopian Ministry of health workers and the prototype tested on Opera, Firefox, Chrome web browsers. The mobile side of the application evaluated by 20 software developers and 30 different mobile application users are chosen based on the mobile phone type that they used. The prototype test was conducted on different Android mobile phone types (Samsung, Sony, Techno Nokia) and all of the respondents' phone should support GPS and wi-fi.

Before the usability evaluation process all the participants are informed the purpose and prototype of the application then, participants were provided with respective questions. The questionnaires were distributed among the users in the form of hard copies as indicated in Appendix A. A five levels scale is from 1 to 5 (Strongly agree=5, Agree=4, Neutral =3, Disagree=2, Strongly disagree=1) is used for the responses of the questions.

The result of the users' feedback obtained from 52 respondents presented below in Table 6.1 summarizes web side users of the prototype and Table 6.2 summarizes mobile side users of the prototype.

Question No.	**Participant Responses**				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	1	1	0	0	0
2	2	0	0	0	0
3	0	0	0	0	0
4	1	1	0	0	0
7	1	1	0	0	0
8	2	0	0	0	0
9	0	1	1	0	0
10	0	0	0	0	0
11	0	1	1	0	0
12	0	2	0	0	0
Total	**7**	**9**	**4**	0	0

Table 6. 1: Detailed summary of questionnaire result (Ministry of health employees)

Question No.	**Participant Responses**				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	42	8	0	0	0
2	47	3	0	0	0
3	23	27	0	0	0
4	32	16	2	0	0
5	43	7	0	0	0
6	35	15	0	0	0
7	48	2	0	0	0
8	12	32	6	0	0
9	2	7	23	13	5
10	12	25	11	2	0
11	0	15	19	14	2
12	0	17	21	12	0
Total	**296**	**174**	**82**	**41**	**7**

Table 6.2: Detailed summary of questionnaire result (mobile users)

Generally, based on Table 6.3, shows that 29.17% of mobile users and 49.33% of web users are strongly agree that means the prototype well organized, compatible and fulfills the functionalities, 37.5% of mobile users and 29% of web users are agree on the prototype, 16.67% of mobile users and 13.67% of web users are neutral, 6.83% of mobile users are disagree on some parts of prototype and 1.17% of mobile users are strongly disagree.

Generally, the result of the evaluation in terms of usability attribute of effectiveness, efficiency and satisfaction indicated that the developed prototype interface is user friendly, easy to use, easy to learn, comfortable to use and it is important to assist patients to get current location related information. From the total respondents 6.83% of disagree and 1.17% of strongly disagree among all quality attributes indicates, the prototype needs for further improvement to ensure the effectiveness and efficiency of the prototype.

Answer	**Web user**		**Mobile user**	
	Number of Marked answered by users	Percentages (%)	Number of Marked answered by users	Percentages (%)
Strongly agree	7	29.17	296	49.33
Agree	9	37.5	174	29
Neutral	4	16.67	82	13.67
Disagree	0	0	41	6.83
Strongly disagree	0	0	7	1.17

Table 6. 3: Analysis of Testing

CHAPTER SEVEN

CONCLUSION AND FUTURE WORK

7.1 Conclusion

Location based mobile applications has played a significant role to get exact and relevant location related information of peoples and materials.

Various public and private health facilities are found in Ethiopia, but most of them do not have adequate services to treat patients. Getting exact and relevant information of location, route and services of the health facilities is important to get effective treatments on time. However, there is no adequate mechanism to access relevant information related to location, route and service types of the health facilities in the country. The earlier proposed location based patient assistant systems have limitations: to provide relevant information of health facilities depends on choice of patients' health facility service type, to access more than one health facilities in a single system and to use free optimal route service provider API.

This project is aimed to developing LBS based mobile application and a desktop web application to reduce the problem of getting important information related to health facilities. The mobile side of this application can help patients to: get information about the location of nearest health institution; get optimal route to travel to the nearest health facility and getting exact information of the nearest health facility based on patient's current location and choice of health facility service type. And the desktop web application helps authorized persons to manage health facilities information.

This application could be applied in different areas and could be used by different users to provide important information related to health facilities. Patients, government and non-government organizations can get important information about the health facilities related to location, type of services, route and other information and helps to take important decision without wasting their time and cost.

The application functions evaluated using different software testing methods and the result shows that the proposed application provides an effective solution to provide location based health facility information.

7.2 Future Works

To strength the system and to improve the usability, the following functionalities which related to patient assistant system should be considered in the future:

- Other health facilities incorporate into the application to increase the functionality of the system.
- Accepts patient's symptoms and recommend to the nearest health facility location.
- Identify patient disease from his or her symptoms and recommend precondition and post condition information.
- Alert user's location to his/her family member in the case of emergency.

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Appendix A: Questionnaire

Addis Ababa University

College of Natural Sciences

Department of Computer Science

Purpose of the questionnaire

The purpose of this questioner is to assess project prototype on Patient Assistant Mobile Application using LBS. Your participation will help us understand the performance of this work and find holes for further improvement.

We also would like to assure you that the response will be kept confidential and it will only be used for academic purposes.

Patient Assistant Mobile Application using LBS

The purpose of Patient Assistant Mobile Application using LBS is to enable patient/user to get relevant information about the nearest health facility such as: to get detail information of health facility like Hospital, Health Center, Pharmacy and Blood Bank; to select available hospital or health center service type; to display nearest location and optimal route between current location and nearest health facility location on a map depends on user/patient choice of health facility service type.

Instruction:

The questionnaires prepared for booth mobile users and web users of evaluators. And please put (✓) on the level you agree for each evaluation question. The level scale is from 1 to 5. (Strongly agree=5, agree=4, neutral =3, disagree=2, strongly disagree=1).

NB: Web part of the prototype evaluators please jump Question number 6 and 7

No.	Evaluation Questions	Levels				
		1	2	3	4	5
1	The system has user friendly interface					

2	The Menu Items are well organized and functions are easy to find?					
3	Do you think you able to use the system without the support of technical person?					
4	The system performs accurately the intended task					
5	Can the system show the route between current and destination location on a map?					
6	Can the system allow to see the destination location on map?					
7	Are you satisfied by overall functions of the system?					
8	The error message of the system is clear and it helps to fix problem easily					
9	The system recovers easily whenever you make a mistake using the system					
10	Are you confident to use the system?					
11	Do you think various functions of the system are well integrated?					
12	The response time of the system is good?					

Annex B: User Manual

The main purpose of this user manual is to helps or guides the user to use the patient assistant application properly. The user manual of the patient assistant application has two part, the first part describe how the web user uses the system and the second part describe how the mobile user uses the system properly.

1.1 Web User Interface

Login to Patient Assistant Web Application

To access the patient assistant web application, after you enter the correct username and password press login button. If the credentials are valid the system redirects to dashboard page as shown in Figure 2. If it fails to validate it shows “Incorrect Login” error message (Figure1).

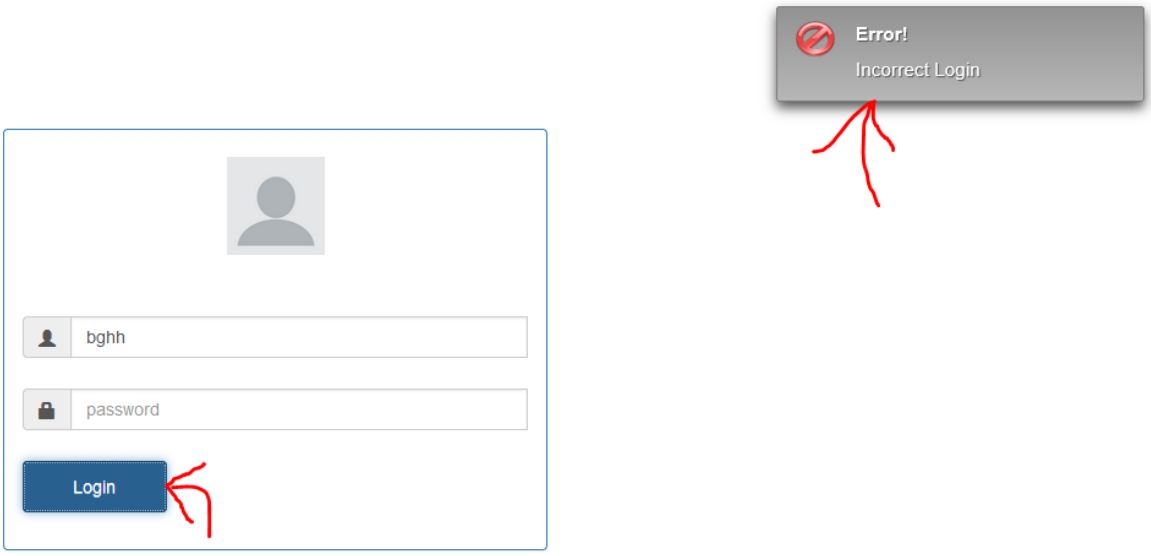

Figure 1: Login page

Selecting Health Facility

To select health facility service, after you logged in successfully the system click on available health facility services (Hospital, Health Center, Pharmacy or Blood Bank) from dashboard as you want.

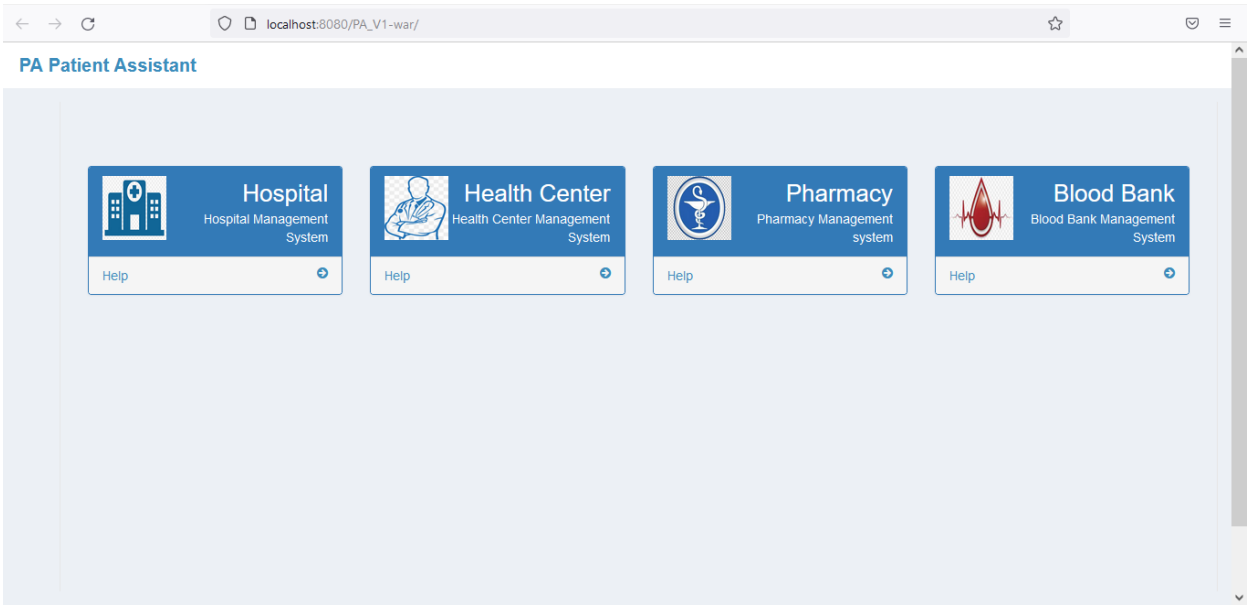

Figure 2 Health Facility Dashboard

Managing user

To manage user, after you select health facility service from dashboard as displayed in Figure 2, you should select "User management" list from left side content page that indicated in number 1 of Figure 3.

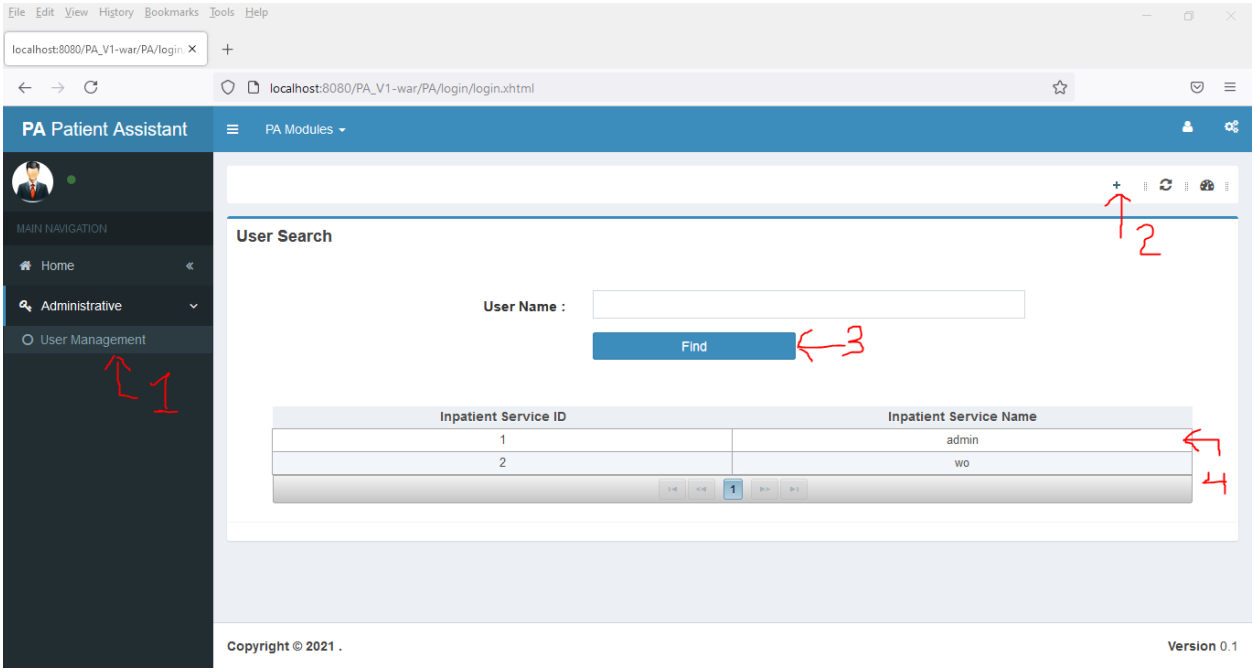

Figure 3: User search page

To register new user, you click on “+” button as shown in number 2 of Figure 3 to show user registration page. And you can fill the fields with necessary information and click “Save” button as shown in Figure 4. After you do this correctly, “User Created Successfully” message displayed that represented by number 1 of Figure 4.

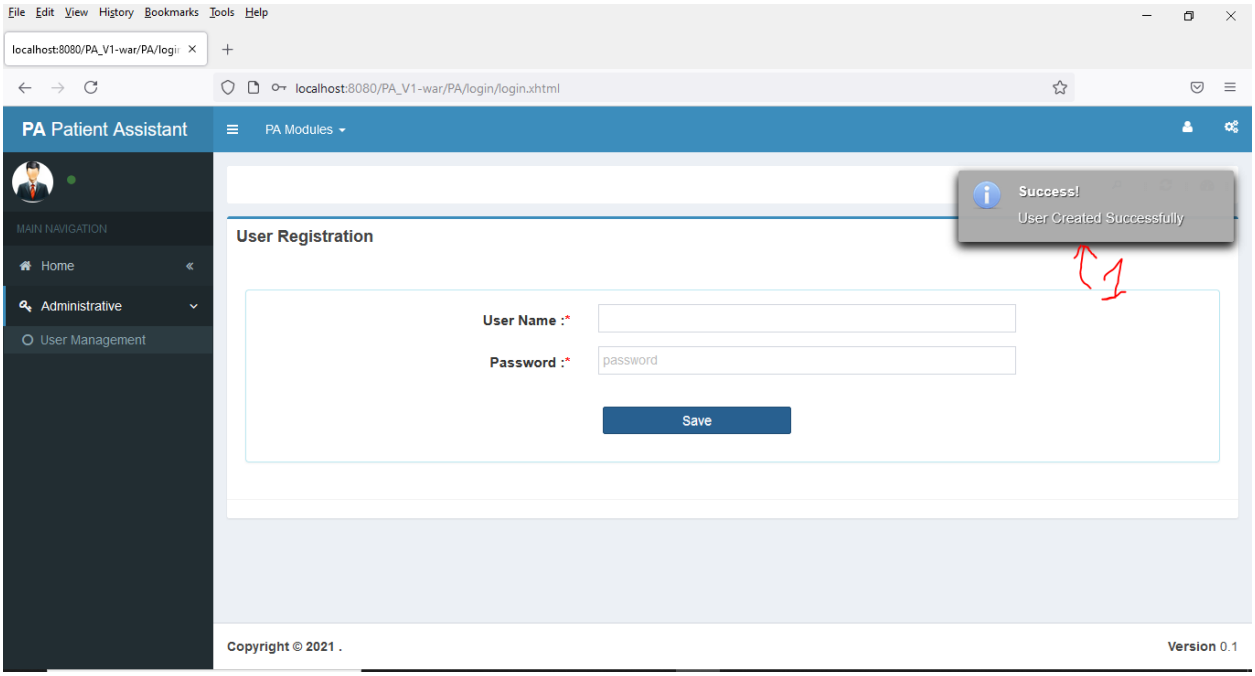

Figure 4: User Registration page

If you want to update or delete user, click on “Find” button as indicated in number 3 of Figure 3. After do this, you can search the user that you want to modify or delete and click on grid that represented by number 4 of Figure 3. After clicking on grid, user registration page will be displayed and you can click on “Update” or “Delete” button if you do this correctly “Success message” will be displayed (Figure 5).

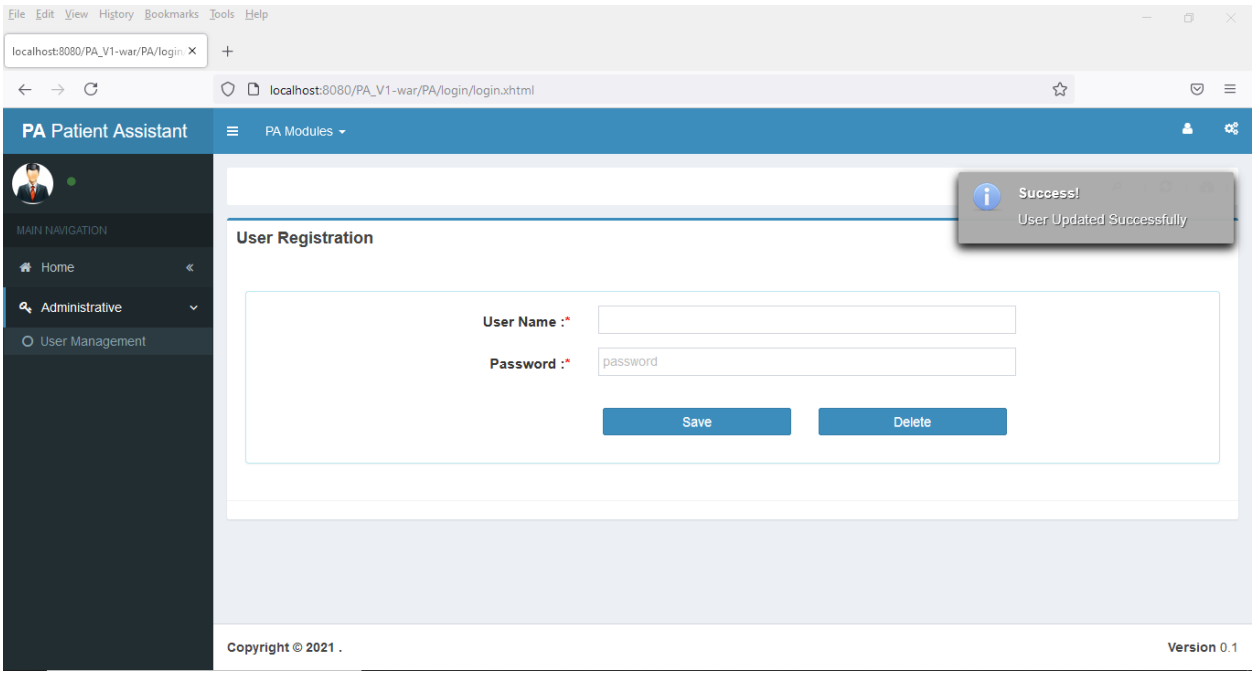

Figure 5: User Update or Delete Page

Searching Hospital Location

The search hospital location page is opened automatically after the administrator select hospital service from the dashboard. On this page administrator can search hospital location by hospital name and can view the hospital location on a map.

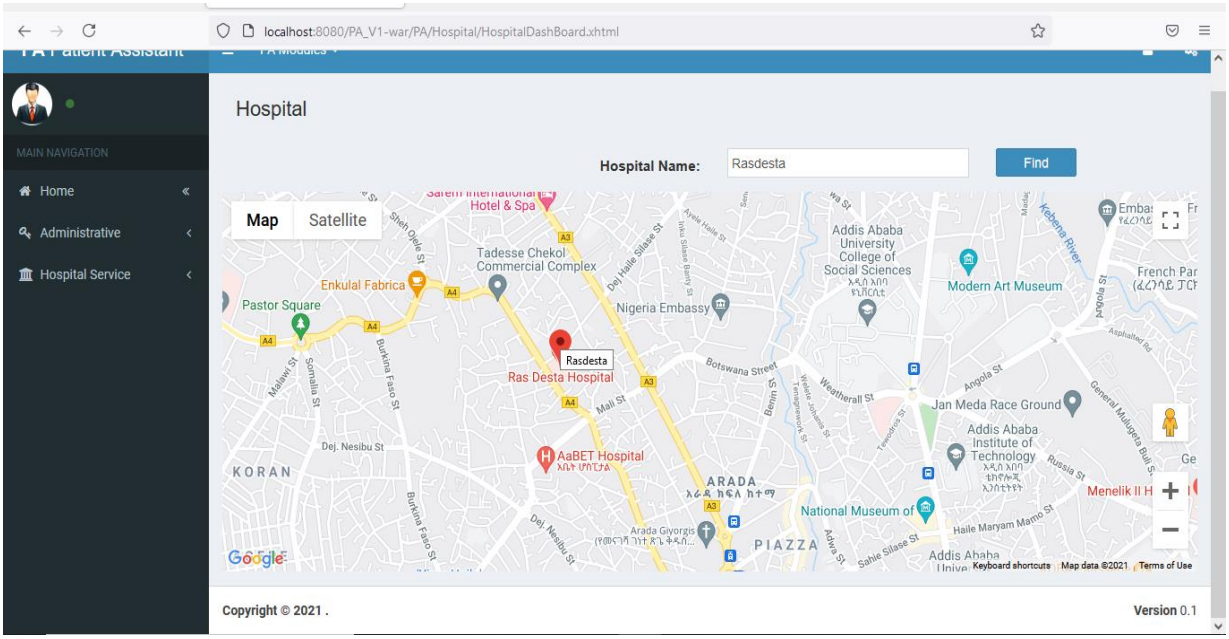

Figure 6: Hospital Location Search Page

Managing Hospital Information

To manage hospital information, first you should select hospital sub system from dashboard and select “Hospital Management” form left side bar that represented by number 1 of Figure7.

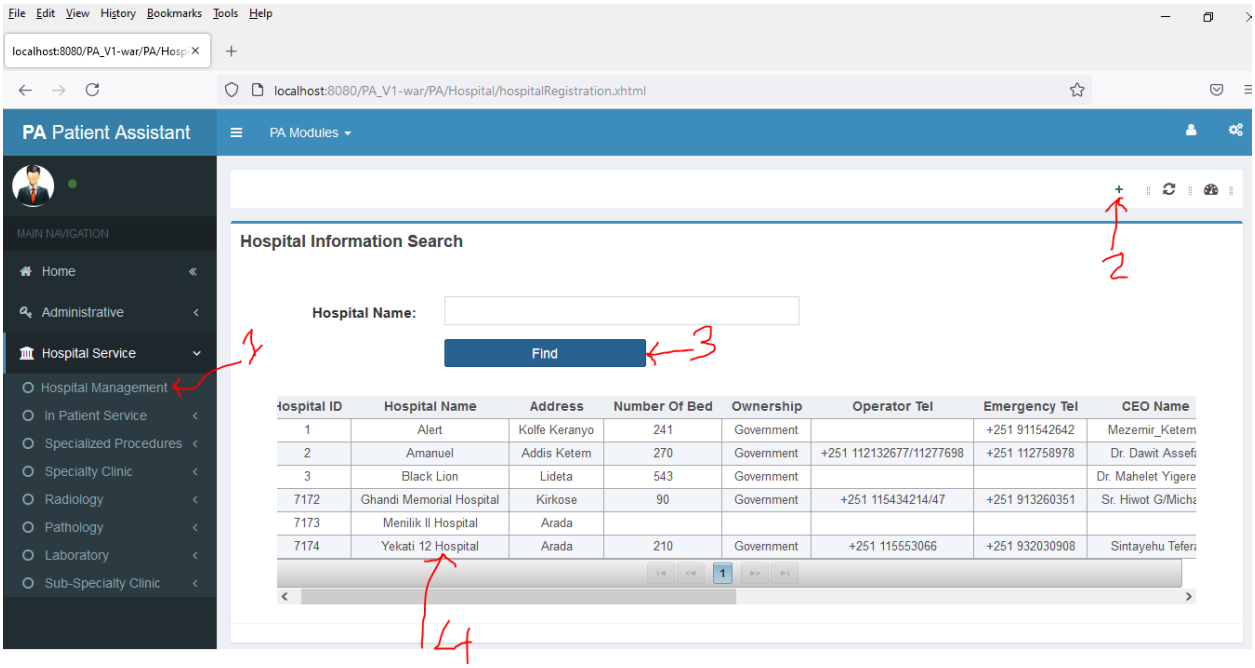

Figure 7: Hospital Information Search Page

To add new hospital information, you should select “+” button from tool bar as indicated number “2” on Figure 7. After do this, hospital information registration page will be displayed as indicated in Figure 8 and fill detail information of hospital. After you finish the registration correctly, click on “Save” button then the system stored hospital information in the database and “Success” message will be displayed (Figure 8).

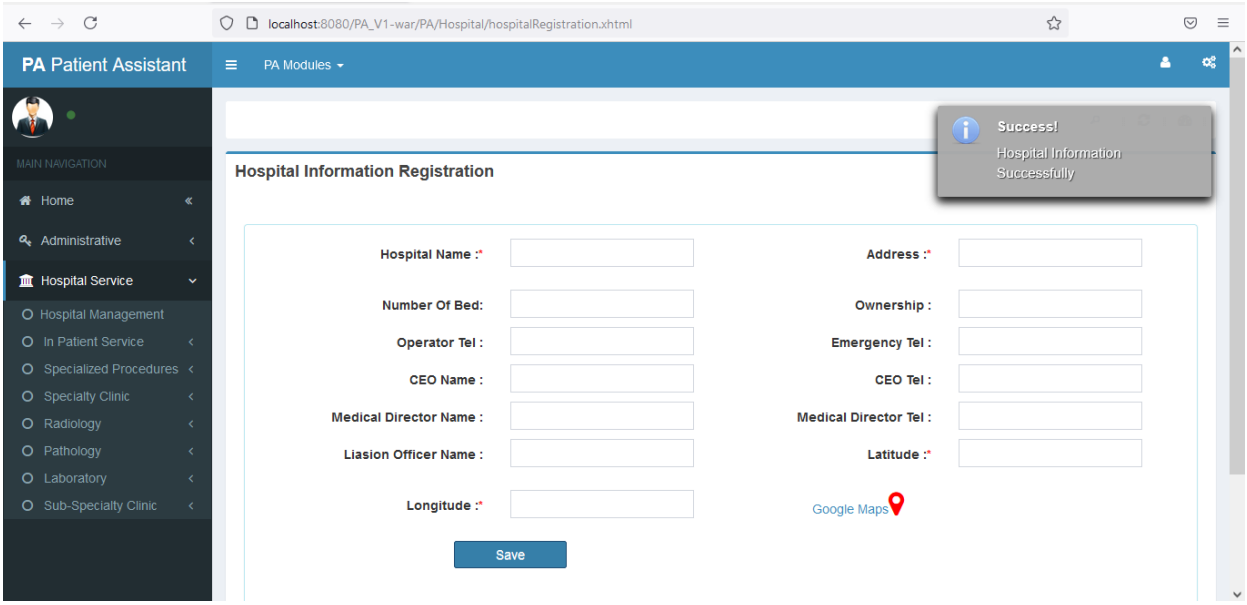

Figure 8: Adding Hospital Information

To update or delete hospital information, click on field that you want to update or delete as indicated in number 4 of Figure 7, then hospital information update or delete page will be displayed as indicated in Figure 9.

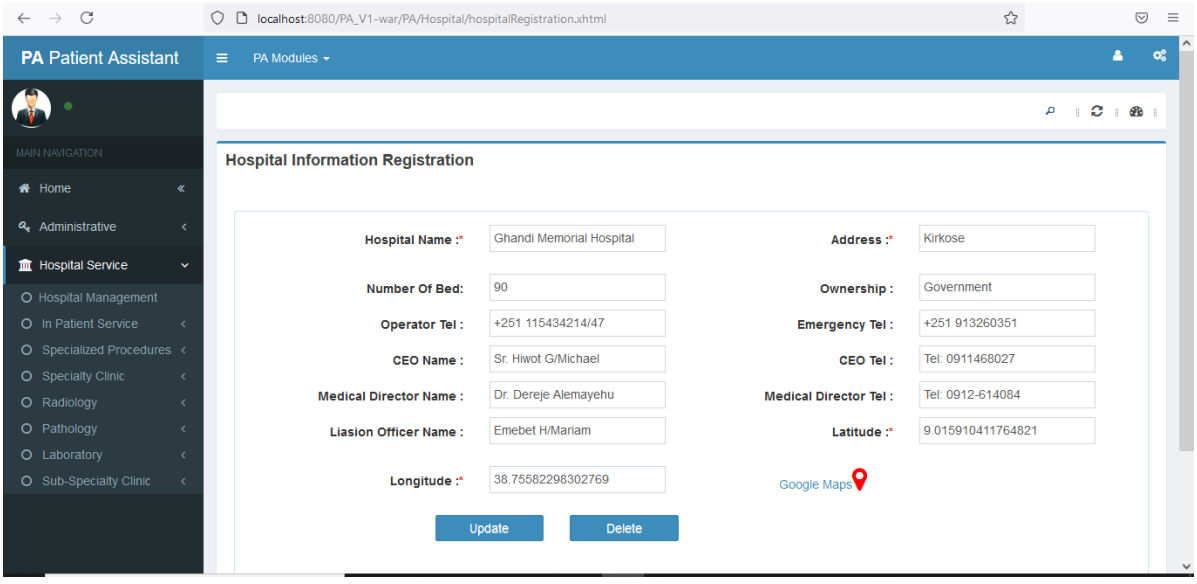

Figure 9: Update or Delete Hospital Information

Mapping Inpatient Service to Hospital

In order to map Inpatient Service type to hospital, first you should register inpatient service type. To register, update or delete service type of health facility you can apply the same step

as described in “Managing Hospital Information”. After you do this, select “Inpatient Junction” that represent in number 1 of Figure 10 and click on “+” button from tool bar.

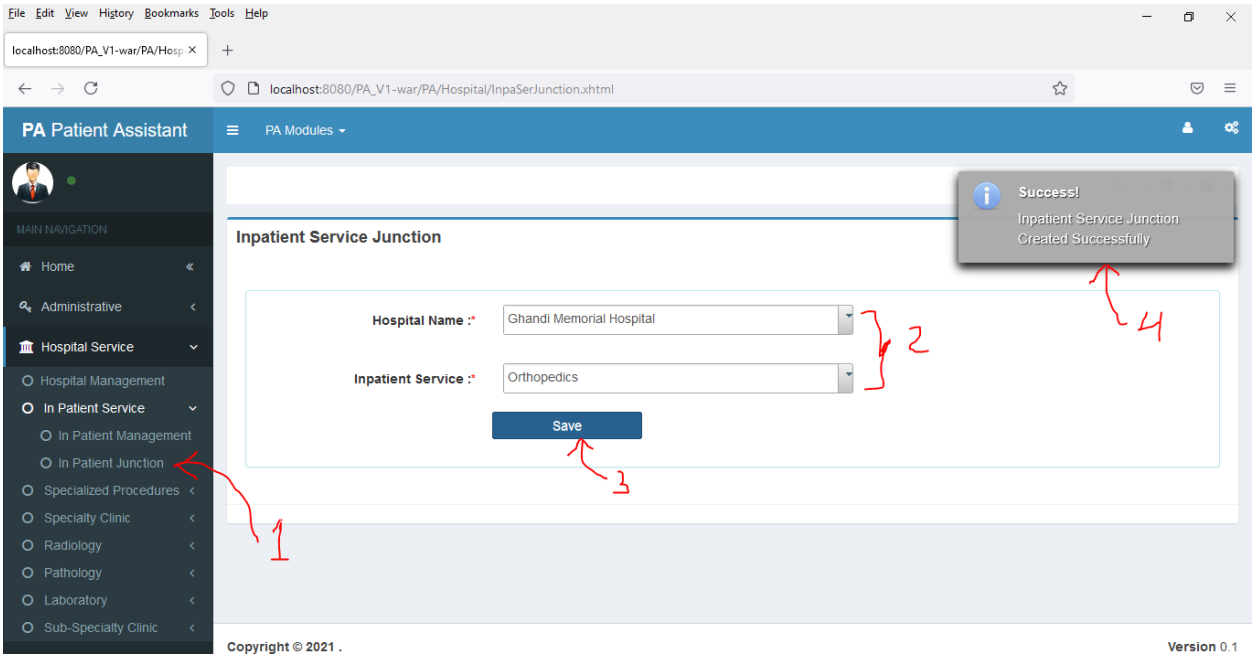

Figure 10: Inpatient Service Junction Page

After Inpatient Service Junction page displayed as shown in Figure 10, select hospital and Inpatient service type from list box that represented by number 2 of Figure 10. Then click on “Save” button that represented by number 3 of Figure 10 to store the information on the database. Finally, “Inpatient Service Junction Created Successfully” massage will be displayed as represented on number 4 of Figure 10. If Inpatient service cannot correctly mapped, then “Inpatient Service already mapped” error message will be displayed as shown in number 5 of Figure 11.

To map other services, you can apply the same step as described in “Mapping Inpatient Service to Hospital”.

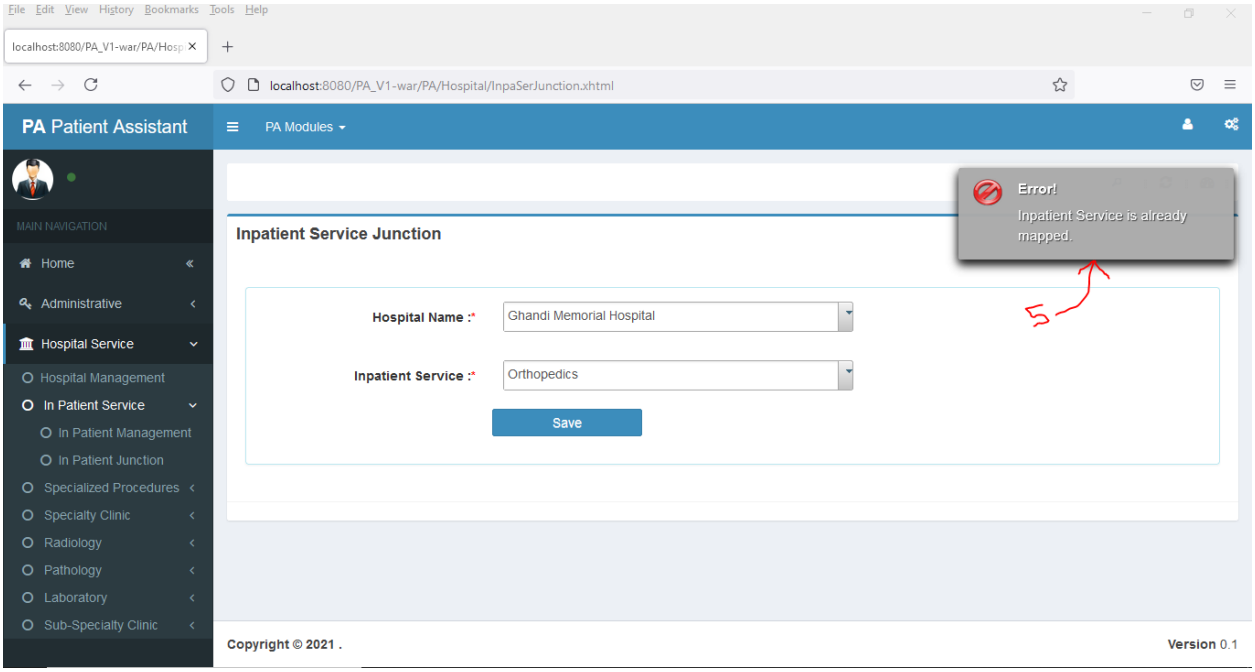

Figure 11: Inpatient Service Junction Page

1.2 Mobile User Interface

Download and Open Health Facility Services

To start the application first you should open your phone wireless connection and download and install the application from the link https://drive.google.com then launch the app by clicking on the icon “PA”.

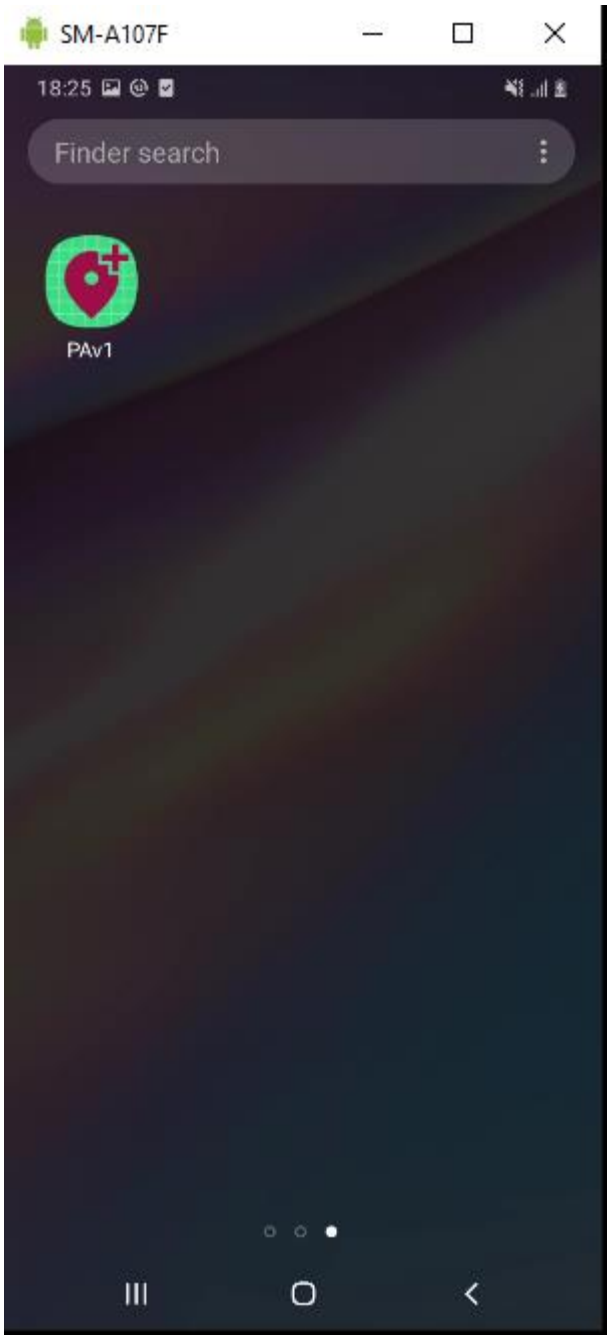

Figure 12: App on mobile device

After you open the application, to select health facility service click on your preferred health facility service type that found in your phone home page.

Figure 13: Home Page on Mobile device

If you click on the health facility service type that you preferred as indicated in Figure 13 and if your phone GPS service off the application, ask you to “On your GPS service” (Figure 14).

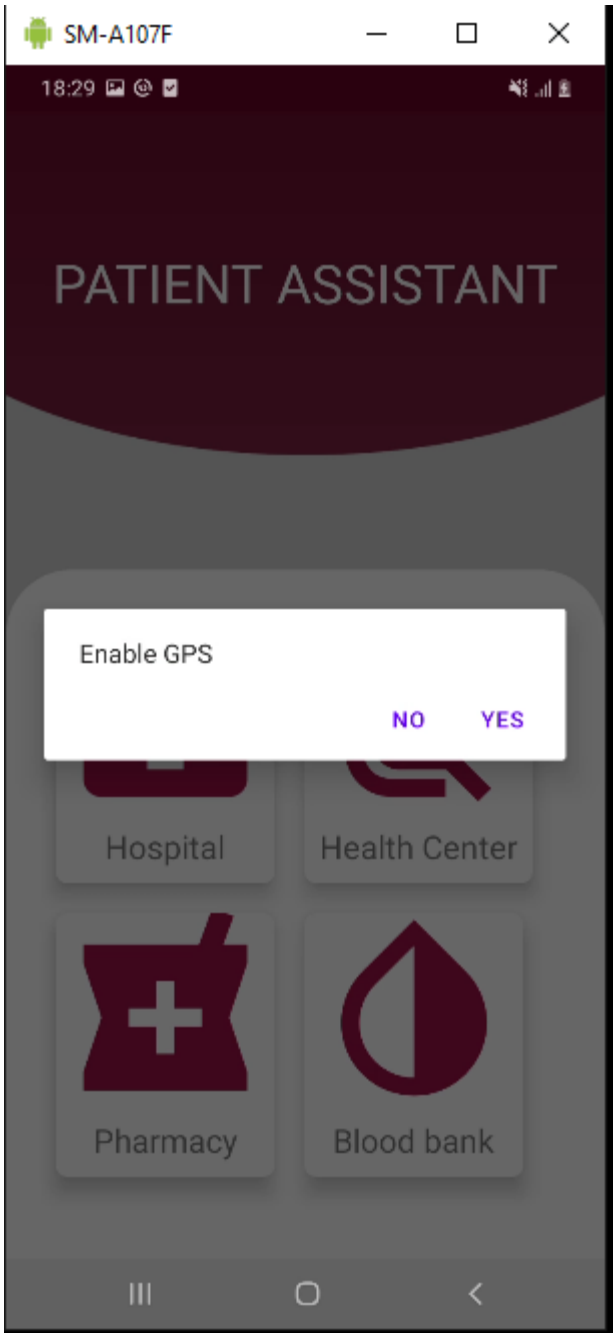

Figure 14: Enable GPS Message

Finally, if the application can get your current location coordinates from GPS service, the selected health facility search page displayed as indicated in Figure 16. Otherwise, the application shows toast message “can’t get your current location” as shown in Figure 15.

Figure 15: Can't Get Current Location Message

Searching Hospital Service

To search hospital service first you should select “Hospital” from mobile application home page and select hospital service type from the list as indicated in Figure 16. After you select your preferred hospital service type, click on search icon that found in front of each hospital service.

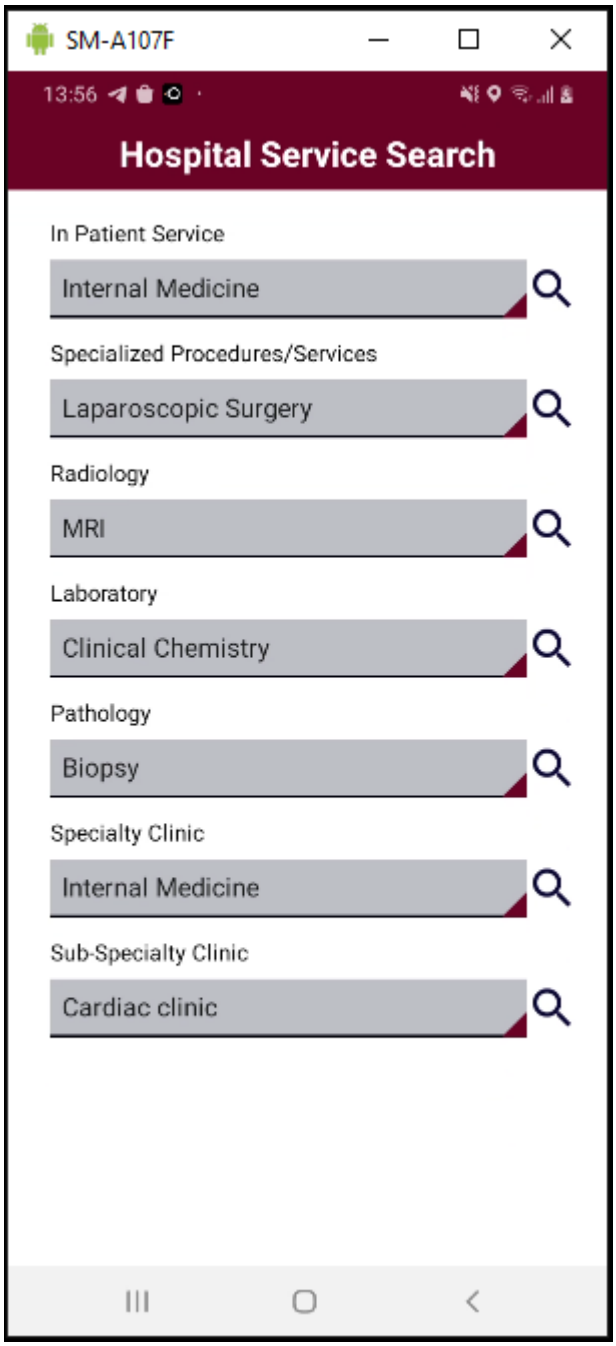

Figure 16: Searching Hospital Service

Viewing the Nearest Hospital Information

After you click on search icon which found in front of each hospital service, the nearest hospital detail page will be displayed as shown in Figure 17.

Figure 17: Detail information of nearest hospital

In order to view Map or Route of the nearest hospital you should select “Map” or “Route” button from bottom navigation respectively.

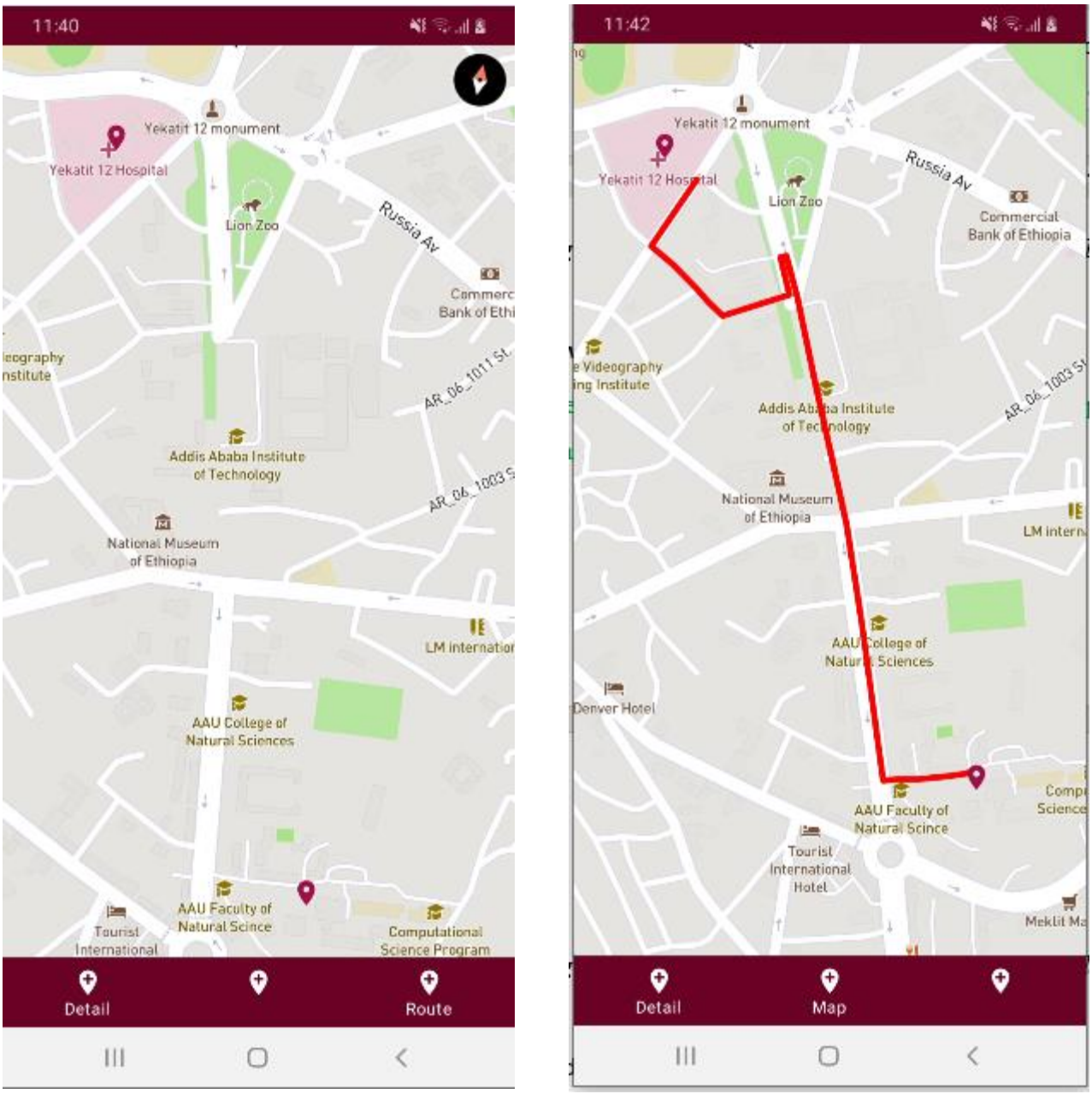

Figure18: Map and Route of Nearest Health Center Location