**University of Ghana**

**Department of Computer Science**

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**Mobile Application for Personal Diabetes Management  
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**A project submitted to the department of computer science, University of Ghana, Legon as a partial fulfillment for the award of Bachelor of Science degree in Information Technology.**

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**Declaration**

This project is in the name of the Computer Science Department – University of Ghana, in partial fulfillment for the award of Bachelor of Science degree in Information Technology, supervised by Dr. Jamal Abdulai-Deen.

I hereby declare with the exception of the reference cited, that no prior publication of parts or the whole of this dissertation has been neither made nor presented elsewhere for any award.

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**Abstract**

The introduction of tele-health and mobile health technologies in the delivery of health services have drastically reduced the inconveniences associated with seeking health care. With mobile devices becoming influential aspects of our lives and the internet becoming more and more ubiquitous, it is only right to leverage on the numerous advantages it can bring to the health sector. The proposed project seeks to build a mobile application that allows diabetic patients monitor their progress with well explained charts, notifications, specialist interactions and other implementations that makes the life of a diabetic patient comfortable. Normally, diabetic patients have log books in which they record their glucose levels, blood pressures, weight and other related records. Apart from the error-prone and inconvenient nature of this approach, no effective analysis and guidance mechanisms are provided in the monitoring of patients’ progress. Also, many individuals feel reluctant to going to hospitals and medical centers due to the long hours of waiting for medical assistance and the costs involved. With the advent of mobile health, diabetic patients can seek healthcare at the comfort of their homes, schools and offices through the use of web and mobile applications that allows patients to monitor their progress and also interact with healthcare professionals.

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# Chapter One - Introduction

This chapter introduces the proposed project in terms of its background, problem statement, aims, objectives, scope as well as its limitations.

## Background

Diabetes is one of the most common diseases that claims many lives worldwide every day. According to the World Health organization (WHO), between 1980 and 2014, the number of individuals with diabetes had risen from 108 million to 422 million with its prevalence rising more rapidly in middle- and low-income countries. In 2016 alone, an estimated 1.6 million deaths were directly caused by diabetes, making it the seventh leading cause of death in 2016.

Diabetes is a chronic disease that occurs as a result of the inability of the human body to produce enough insulin, a hormone that regulates blood sugar level or the insulin produced is more than what can be fully exhausted by the body. Since it is directly linked to the sugar content of our meals, it is very easy to acquire diabetes and unlikely to be noticed in its early stages through its symptoms. According to the American Diabetes Association, 7.2 million individuals in the US out of the 30.3 million individuals with diabetes were undiagnosed. Diabetes mellitus can be treated or its outcome delayed if found earlier. It can also be very devastating because it can affect vital organs like the kidney, heart, etc.

### Type 1

This is when the body’s pancreas that is responsible for producing insulin is not able to do so. Also known as childhood-onset, juvenile and insulin-dependent, it is mostly diagnosed in young people. However, Adults are not exempted from its reach. Continuous yearn to urinate, excessive thirst, hunger, unexpected weight loss, blurred vision, etc. are some common symptoms characterizing type 1 diabetes. People having type 1 diabetes are mostly required to take insulin every day to stay alive.

### Type 2

Normally referred to as non-insulin dependent or adult onset diabetes, type 2 diabetes is the commonest and usually occurs in adults. With type 2, the insulin produced by the body’s pancreas cannot be fully exhausted by the body due to aged cells, physical inactivity and excess weight. It has similar symptoms as type 1, but it takes time for them to show making it difficult to be easily diagnosed in the early stages.

### Gestational

Gestational diabetes occur in some women during their pregnancy. This occurrence does not mean that they had the disease earlier on or they will have it after delivery. Nonetheless, it is advisable to be constantly checked by a practitioner because both the child and mother can acquire type 2 diabetes after gestational diabetes. It is directly linked to high levels of sugar above the normal sugar level of the body.

Other forms of diabetes include monogenic and pre-diabetes which occurs as a result of inheritance and conditions in which an individual moves between normality and diabetes.

### Aftermath of Diabetes

Diabetes can affect almost all the vital organs of the body and extend to other parts when its diagnoses and treatment is prolonged. Amputation of the limb is mostly associated with diabetic patients due to nerve damage in the foot. Gradual blurring of vision leading to blindness, stroke, heart problems and making the body susceptible to other forms of diseases.

### Treatment and Diagnosis

Early diagnosis can help treat or prolong the negative aftermath of diabetes. Inexpensive methods of treatment such as blood lipid control, foot care, diabetes-related kidney disease screening, blood glucose control, regular exercises and healthy diets.

Diabetes Mellitus is a deadly disease. However, early diagnosis, intake of healthy diets, regular exercises and checkup can help reduce its prevalence.

## Problem Statement

Imagine how tiring it will be for diabetic patients to manually write down all their recordings in terms of blood sugar, blood pressure, weight etc in notebooks, the calculations they would have to do in order to determine their diabetes progress overtime, the errors they are susceptible to making, the inconsistencies that may arise when they forget to record vital information, the cost and stress involved in transportation to the hospital for appointments, prescriptions and medical checkups and not forgetting the queues they would have to endure at the hospital. Diabetes is a chronic disease which can live with an individual his or her whole life. Therefore, its treatment must be done with motivation, guidance and convenience. The proposed system seeks to provide a system which allows patients to easily and consistently log their medical records information, use interactive and self-explanatory charts to present patients’ diabetes progress and ensure a convenient interaction between a patient a diabetic specialist.

## Aims

The Proposed System aims to help diabetic patients:

* Easily log medical records
* Easily monitor diabetes progress
* Connect to diabetes Specialists
* Maintain good quality and healthy life

## Objectives

* Use simple and user friendly interfaces to help patients log, update and delete their medical records easily.
* Use self-explanatory and flexible chart types like bar, lines and splines to display patients’ medical records (blood sugar level, blood pressure, weight etc.) and also ensure interactivity by allowing patients to display their records in terms of days, weeks, months and years.
* Use push notifications to prompt patients and their specialists when patient’s conditions are above maximum or below minimum levels.
* Connect patients to diabetes specialists through voice communication and chat messaging
* Allows for prescriptions and appointment schedules to be made between patients and their connected specialists.
* Provide up to date information and knowledge on appropriate lifestyle, eating habits and guidance tips on diabetes management from accredited organizations like the American Diabetes Association

## Scope

The system focuses on the comfort, convenience and professional support than can be provided for diabetic patients in terms of managing their progress. It allows for specialists with great knowledge and expertise to contribute their quota in the diabetes management process.

## Limitations

Irrespective of the numerous advantages of the proposed system, there are some limitations it faces.

* The proposed system is a mobile application, thereby alienating patients with desktop computers and most importantly, patients outside the tech world.
* Internet connectivity is a vital component that will make the use of the system very convenient.
* The proposed system does not allow for direct connection between measuring devices and the mobile application. Thus, patients manually log their records using the mobile application.

# Chapter Two – Literature Review

## Overview

The 21st century, indicated by experts as the Information Age is being driven mostly by information and technology. The pace at which the world is changing and advancing is very rapid. Not long ago computers were introduced. Only big companies, universities and the military of certain countries like the United States of America, Russia and Germany were in possession of them. They could fill a whole room and required more power and only highly skilled technicians to operate them. Few years down the line, computers were improved upon, in terms of processing power, memory, storage capacity and size. Computers became less cumbersome to operate, relatively small in size and even more powerful. Individuals with subtle knowledge could purchase and use Personal Computers as they were termed. Computers, primarily desktop computers became very popular. They were and are still even in our homes, schools and work places. They became a necessity for every organization in every line of work. Even though these computers provided more than enough, they were immobile and cannot be used while moving around. Therefore, improvements on them led to the introduction of laptops and palmtops which could be used while moving. Because these mobile devices had batteries, users could use them for some time without connecting to a power source. This brought about convenience, increased productivity from working remotely and flexibility. Finally came the mobile phone which is currently referred to as smart phone, personal digital assistants (PDAs) and wearables like smart watches and glasses. The most important feature that these new and upheld technological devices have in common is mobility with the mobile phone being the most versatile and multipurpose device. The mobile phone is used by all kinds of people in all fields of life. Referred to as mHealth or mobile health, this chapter touches on the influence of mobile devices in the health sector specifically in the management of diabetes.

### What is mHealth?

According to their global survey on eHealth, the world health organization (WHO) defines mHealth as the “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices”. mHealth allows for interaction between patients and their practitioners irrespective of their locations. It leverages on the core functionalities of mobile phones such as voice, video calls and text messaging as well as advanced features like tracking, sensors, wireless technology. Medical records, important signs and other patients’ information can be acquired by a practitioner, prescriptions, diagnosis, appointments and assessments can be done without both parties having to meet physically. Health professionals with inadequate health assistance rely on mobile health to quickly deliver health information, treatment and assistance to patients in remote areas. Nevertheless, most individuals using mHealth are in the cities. It is estimated by the US Food and Drug Administration (FDA) that about 500 million individuals in the world use personal healthcare applications and the number is expected to increase over 1 billion within 5 years.

### mHealth vs Telehealth

mHealth and telehealth overlap in most cases. Nonetheless, there are significant distinctions between them. The world health organization (WHO) defines telehealth as the field that “involves the use of telecommunications and virtual technology to deliver health care outside of traditional health-care facilities. Telehealth, which requires access only to telecommunications, is the most basic element of “eHealth,” which uses a wider range of information and communication technologies (ICTs)”. Therefore the difference resides in the number of platforms on which both technologies are implemented on. mHealth is strictly for mobile devices whiles telehealth can be delivered on kiosks and carts in addition to mobile devices.

### mHealth and Diabetes Management

In the United States alone, approximately 29 million citizens are diagnosed with diabetes. According to the American Diabetes Association “Approximately 77% of American adults have access to a smartphone regardless of socioeconomic status or ethnicity, and more than 50% of smartphone owners use their mobile devices to obtain health information”. The Research And Markets also stated that “The digital diabetes management market is projected to reach USD 19.9 billion by 2024 from USD 6.8 billion in 2019, at a CAGR of 23.8%”. These numbers and projections are due to the contributions from the increasing prevalence of diabetes, rising adoption of internet-based solutions for managing diabetes and the adoption of mobile applications in monitoring and managing diabetes. Diabetes is a chronic disease and can be with an individual until he or she lives the face of the earth. Therefore checks must be put in place to ensure that diabetics receive consistent medical assistance irrespective of their geographical location. Almost half of the world’s population do not receive good and quality health care according to a report from the World Bank and WHO. This can be due to certain factors such as inconveniences at medical centers especially when patients have to join long queues to receive healthcare, inadequate health facilities in remote areas and the cost involved in receiving proper healthcare. Unfortunately, every year, the number of households being pushed into poverty by high expenses on healthcare increases. Transportation costs are often ignored during calculation of expenses but they contribute a lot. Also charges at hospitals or medical centers, especially private ones in communities with luxurious living are outrages. In the Tracking Universal Health Coverage: 2017 Global Monitoring Report, 800 million people spend at least 10 percent of their household budgets on health expenses for themselves, a sick child or other family member. For almost 100 million people these expenses are high enough to push them into extreme poverty, forcing them to survive on just $1.90 or less a day. Diabetic patients requiring constant monitoring suffer more due to their interactions with their health practitioners at these medical centers. Most of the healthcare services delivered to diabetic patients’ overtime are not very sophisticated and can be delivered equally with near excellent alternatives. Monitoring and analyzing the glucose level, blood pressure, body weight and cholesterol of patients can be done easily and without experts’ knowledge. With the appropriate systems and equipment, medical practitioners can prescribe drugs and schedule appointments without the physical presence of patients. Patients can also interact with their practitioners remotely, receive guidance information on their diabetic progress and also schedule appointments with practitioners without visiting any medical center. mHealth is able to provide the required alternative in helping practitioners and patients interact conveniently, affordably and remotely.

## Mobile Applications for Diabetes Management

Over the years, diabetes management and monitoring have been improved upon and made easier with mobile applications providing a plethora of features including convenience, affordability and remoteness. Five mobile applications from the iTunes and Google Play Store are reviewed based on criteria such as affordability, designed for the patient, easy data logging, display of medical records using charts, multiplatform support and connection with practitioners.

### OnTrack Diabetes

Created by Medivo Inc, onTrack Diabetes is a simple and straightforward monitoring application. It is completely offline and stores all data on the user’s mobile device. It is completely free and requires no subscription or any premium account. It provides a user friendly interface for logging records like blood glucose, body weight, blood pressure, body fat, HbA1c, exercise, food and medication. Logging of different record types can be done at the same time and also individually. History on recordings of medical data are provided with dates, time and categories in which they were recorded. Uses simple line graphs to present logged records and signifies high and low glucose ranges.

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#### Pros

* Specifies high and low blood sugar levels
* Presents logged data using simple and straightforward charts
* Provides a user interface which that is easy to navigate and use
* Allows backup of data to SD Cards
* Support different units for the various record types.

#### Cons

* The application does not provide a food database, requiring patients to manually enter their food items
* It is patient centered. No practitioner is connected patients.
* Patients manually enter their medical records

### Glucosio

This mobile application allows users to monitor their diabetic progress using their blood glucose, blood pressure, ketones, cholesterol and more. It is an open source diabetes app for both type 1 and type 2 and it is entirely free. It allows for offline capabilities and easy to navigate user interface. It was Healthline's Top Best Diabetes Apps of 2017 for Android and iOS and winner of Black Duck Software's Top Open Source Projects of 2015.

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#### Pros

* Easy logging of blood glucose, HB1AC, Cholesterol, Blood Pressure, Ketones, Body Weight and other related medical records
* Developed for both type 1 and type 2 diabetes
* Display logged data using daily, weekly and monthly graphs and analysis
* Consists of an assistant section which provides tips and guidance on healthy living
* Allows data Backup to Google Drive and export data to CSV
* Supports both Android and IOS platforms

#### Cons

* Does not allow for multiple accounts to be used.
* Patients are not connected to medical practitioners
* Medical records are manually entered by users

### MySugr

Voted 3 times the top diabetes app by Healthline. Also featured in Forbes, TechCrunch, The Washington Post, MySugr mobile application is a semi free diabetes logbook that helps monitor and magage diabetes data. It comprises of an appealing user interface with a dashboard personalized to the user. The free version consist of many features but not all. The PRO version which unlocks all features goes for $2.99.

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#### Pros

* Available in both iOS and Android
* Tracks food, medications, weight, carbohydrates, bolus, basal shots, blood sugar, and A1C
* Daily, weekly and monthly medical analysis.
* Set challenges to achieve personal therapy goals

#### Cons

* The PRO version which unlocks all features goes for $2.99.
* Highly graphical interface, takes some time to learn
* Patients are not connected to medical practitioners

### Diabetes Tracker

One of the simplest and straighfowared mobile application for diabetes management. Its interfaces are not quite appealing but its functions and features are on point. The application is expected to be improved upon heavily, in terms of user interface, online capabilities and extra features. Developed by Mig Super, it is free and only supported on the Android platform. Allows patients to create and maintain a list of practitioners. Calls can be made from within the application. Patients can also add appointments for these practitioners and keep track of them.

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#### Pros

* Manage your Diabetes levels effectively by tracking your glucose levels. View current, detailed or average readings in a list view or via detailed graphs and reports
* Maintain an extensive list of Doctors and call them from within the app. Add & view all your Current and Previous Appointments so that you never miss any
* Log your Expenses as you spend! View your Total and Average Spend along with the details of each entry
* View reports of all modules in the App Reports section. Click a pic of and save all your health reports, in Lab Reports. Easily share them with your doctor

#### Cons

* Patients are not connected to medical practitioners
* Medical records are manually entered by users
* User interface is too rigid and not appealing

### Glooko

One of the advanced mobile applications that takes diabetes management a step further. It is able to sync blood glucose and insulin data from meter to app in real-time. According to Glooko, 2.2 million patients are registered on their platform and 9000 clinics using Glooko products. It is one of the few mobile applications that connects patients and medical practitioners.

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#### Pros

* Syncs blood glucose and insulin data from meter to app in real-time
* Sets personal reminders to make sure individuals adhere to their care plan
* Information is accessible online to both patients and health care providers
* Quick syncing allows more time for healthcare provider to focus more on collaborating with patient instead of transferring data
* Data can be accessed both online and in the phone app

#### Cons

* Requires sync cable to connect glucose meter to phone to transfer data which costs about $59.95.
* User interface is very appealing however can take some time to understand completely

### Conclusions

mHealth in diabetes management in recent years have improved rapidly and it is expected to improve more due to the numerous merits and contributions it offers in healthcare delivery especially for monitoring and managing diabetes. Even though mobile applications for diabetic management should be patronized, patients should not heavily rely on them for all health services. Regular checkups at medical centers must be done as usual. These mobile applications especially those that connect both patients and practitioners should be regulated to ensure that healthcare delivery for diabetic patients using mobile applications is done the right way.

# Chapter Three – System Analysis and Requirement Specification

In this chapter, the existing system for diabetes management together with its operations and problems are assessed. The appropriate requirements are then suggested with the proposed system.

## Existing System for Diabetes Management

### Classification

Diabetes Mellitus places a heavy burden on health care systems. The systems are required to optimally attend to patients in order to avoid the growth of the disease especially in those at higher risk. Currently, the general system for diabetes management suffer numerous challenges. Improvement in the delivery of health care to diabetic patients in remote areas, regulating medications taken by patients and guiding patients to live healthy lifestyles, making the early use of insulin more flexible and the education of patients on personal diabetes management. According to the American Diabetes Association (ADA), diabetes can be grouped into four clinical classes. Type 1, Type 2, Gestational and other types of diabetes due to other causes such as genetic defects in insulin.

### Diagnosis

When diabetes is diagnosed at the early stages, health professional can contribute greatly in the improvement and preservation of the lives of patients. On the flipside, complications such as the amputation of legs occurs when the disease is diagnosed at the later stages. Diabetes can be diagnosed in three ways, but confirmations must be done on subsequent days unless high blood glucose symptoms are noticed. Oral Glucose Tolerance Test (OGTT), Fasting Plasma Glucose (FPG) and Non-Fasting Plasma Glucose are used to diagnose diabetes. Oral glucose tolerance is rarely used even though it is more exact and sensitive as compared to the others. Fasting and non-fasting plasma glucose diagnosis are preferred for screening and diagnosis because they are affordable and easy to use. The difference between fasting and non-fasting tests lies in the time it is taken after the patients takes a meal. As the name implies, fasting requires the patient not to eat for about 8 hours before taking the test. For non-fasting, the patient can take the test at any time irrespective of the last time the patient ate. The American Diabetes Association states “Hyperglycemia not sufficient to meet the diagnostic criteria for diabetes is categorized as either impaired fasting glucose (IFG) or impaired glucose tolerance (IGT), depending on whether it is identified through FPG or an OGTT: IFG = FPG 110 mg/dl (6.1 mmol/l) to 125 mg/dl (6.9 mmol/l); IGT = 2-h plasma glucose 140 mg/dl (7.8 mmol/l) to 199 mg/dl (11.0 mmol/l)”. Both IFG and IGT does not necessarily imply diabetes, they are rather factors that show the risk of acquiring diabetes and cardiovascular diseases in the future. Officially termed as “pre-diabetes”, research has shown that normal weight loss and drug therapy can help in reducing the growth into diabetes.

### Screening

It can be proven that the merits for handling diagnosis in context of usual clinical care are enormous. “There are no randomized trials demonstrating the benefits of early diagnosis through screening of asymptomatic individuals (10). Nevertheless, there is sufficient indirect evidence to justify opportunistic screening in a clinical setting of individuals at high risk”, stated by American Diabetes Association (ADA). For non-pregnant adults, fasting plasma glucose is recommended. Whiles oral glucose tolerance test is mostly for diagnosis and pre-diabetes.

## Drawbacks of the Existing System

* Unfortunately, it has become a norm or an expected experience for patients to wait in long queues at medical centers before health professionals attend to them. The most irritating part of it is, the problem of the patient might be very simple and can take some few minutes.
* The inconveniences created by these long queues, noise and other activities at these medical centers places more tension and stress on patients and even health personnel.
* Diabetic patients require constant and consistent checks, and this is mostly done with patients meeting with their health professionals physically. Patients living in areas with abundant and readily available health services might not be affected, but what about most individuals living in rural areas.
* The cost involved in acquiring quality health care from professionals is enormous with drugs and transportation contributing greatly.
* Quality healthcare cannot be delivered without mentioning medical centers, however, certain services that are not sensitive if possible can be delivered without patients necessarily visiting these centers.

## Data Collection Methods

The American Diabetes Association’s website provided immense information related to the classification, diagnosis and screening methods for diabetes. For a more practical experience and contribution, several general practitioners from different medical centers were interviewed. IT consultants at the University of Ghana Hospital were also interviewed. Both structured and unstructured interviews were conducted. Medical centers were observed on countless occasions and patients, especially diabetic patients were interview and observed.

## Proposed System

The proposed system merges mHealth (mobile health) and diabetes management together. With a single mobile application, a patient and his or her preferred health practitioner can monitor the diabetes progress of the patient. Patients can easily log their medical records (blood glucose, blood pressure, weight, etc.). Based on the logs, graphs are drawn with colors and symbols indicating normal, low and high levels of their measurements. Patients are allowed to select a specialist from a list of highly skilled professionals and use them as their guides, doctors or advisors. Patients and specialists can schedule appointments with each other with a help of a user friendly appointment calendar, receive prescriptions from their specialists.

## Functional Requirements

The requirements below stipulates what the proposed system should do. That is, what role does the system play in supporting the user to perform his or her tasks?

* The mobile application (Trackbetes) shall allow patients to log their medical records easily.
* The application shall use simple and easy to understand charts to present the patient’s progress overtime.
* It shall prompt patients when measurements of their records are above the maximum or below the minimum.
* The application shall allow a patient to select a doctor from a list of doctors on the system as his or her personal health practitioner.
* It shall allow patients and doctors to schedule appointments with each other.
* It shall enable doctors to view the progress of their patients using charts.
* The mobile application shall enable doctors to prescribe drugs to their patients.

## Non Functional Requirements

* Availability: the patient will be able to use the system anywhere and at any time.
* Security: Authentication services are used to ensure that unauthorized users cannot use the system. Credentials of medical professionals are verified before they are connected to patients.
* Usability: The proposed system shall have a simple, user friendly and appealing interface.
* Performance: It shall be efficient, faster and convenient.
* Testability: It shall allow validation of the modified software.
* Portability: Being a hybrid mobile application, both android phones and apple phones can use it.
* Implementation: The application shall be implemented using the Ionic framework, Angular, Typescript and Cordova for the frontend. Firebase shall be used as the backend and database components.
* Legal: The proposed system shall conform to the regulations and standards for technologies and components used.

# Chapter Four – System Design

## Unified Modeling Language (UML)

Large systems and applications that forms the basis for certain businesses goes beyond excellent codes. They must be structured from beginning to end so that robust execution, security and scalability can be done without disrupting the performance of the system. Visual Paradigm defines it as “s a standardized modeling language consisting of an integrated set of diagrams, developed to help system and software developers for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems”. UML makes use of diagrams to specify the design of software. It allows for communication, exploration of potential designs and validation of architectural design of software. The modeling language is divided into three categories. They are Structure, Behavior and Interaction Diagrams with each category having many diagrams.

### Structure Diagrams

They comprise of Class Diagram, Object Diagram, Component Diagram, Composite Structure Diagram, Package Diagram, and Deployment Diagram.

### Behavior Diagrams

They include the Use Case Diagram (used by some methodologies during requirements gathering); Activity Diagram, and State Machine Diagram

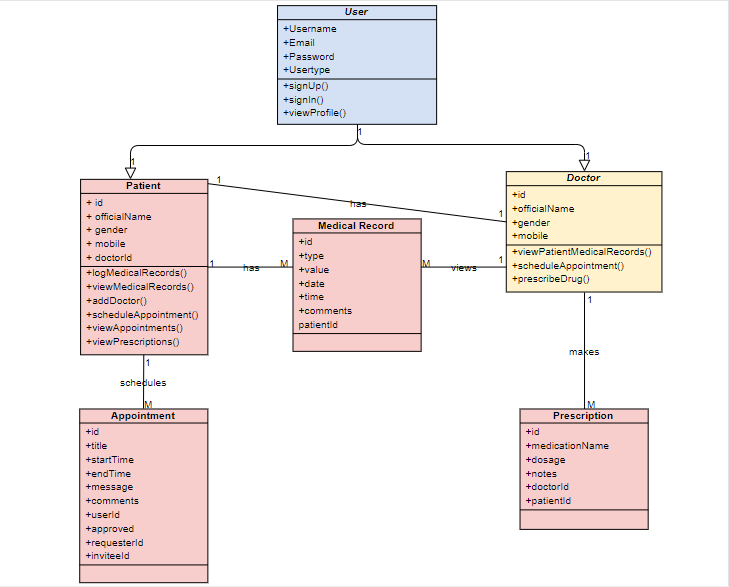
### Interaction Diagrams

These are generated from the more general Behavior Diagram and include the Sequence Diagram, Communication Diagram, Timing Diagram, and Interaction Overview Diagram.

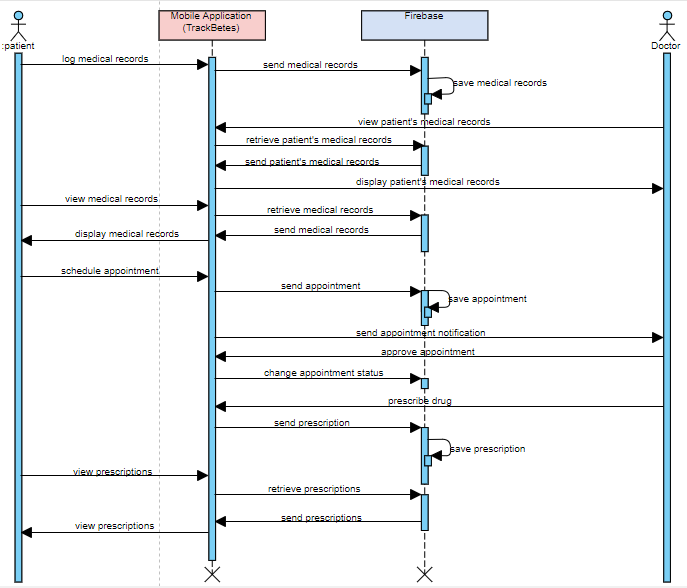
Both Class and Sequence diagrams are used to define the artifacts of the proposed system.

### Class Diagram

This diagram is used to represent object oriented systems. It shows the structure of the system by showing its classes, attributes, operations and relationships between objects.

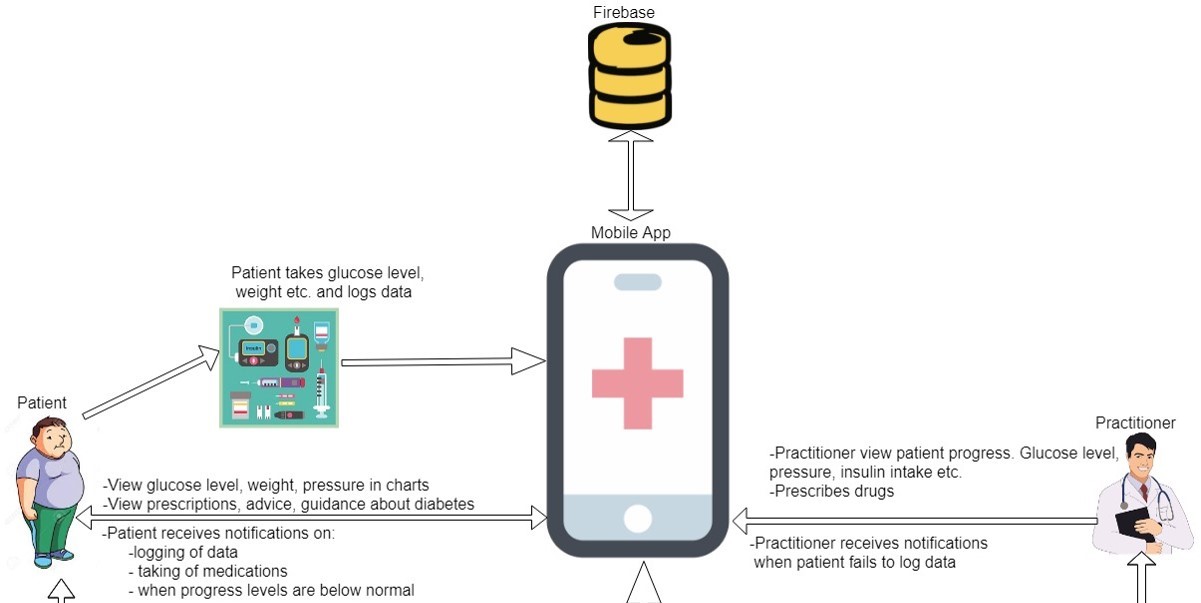


### Sequence Diagram



## System Architecture

The architecture shows the main components of the proposed system and how they interact with each other.



### Modules of the System

* Medical Records Logging
* Progress Tracking
* Personal Assistant
* Patient – Practitioner Interaction
* Notifications

#### Medical Records Logging

Entry of medical data such as

* Blood Sugar level
* Insulin dosage
* Weight
* Blood pressure
* Cholesterol
* Ketones
* HA1C

#### Personal Assistant

* Guidance tips and education on diabetes
* Preferred diets and exercises
* Location of nearby hospitals using google maps
* Medications management

#### Progress Tracking

* Displays medical data such as glucose level, blood pressure, HA1C using charts
* Displays progress bar indicating progress level of patient

#### Patient – Practitioner Interaction

* Allows patients and doctors to schedule and approve appointments with each other.
* Doctor prescribe drugs to patient

#### Notification

* Patient and practitioner are notified when patient fails to log records
* Patient and practitioner are notified when progress levels drop below normal
* SMS is sent to when app is offline

### System Hardware Architecture

Google’s firebase, a mobile application development framework is used to handle both the server and database components of the proposed system. Authentications are handled by the online server and all the data related to the system is stored and retrieved from a real time database.

### System Software Architecture

The ionic framework is used to provide a hybrid mobile application which can run on different mobile platforms. The framework uses angular and typescript to build its user interfaces and uses Cordova plugins to access device features like push messages, camera, Bluetooth, etc.

### Database Management System (DBMS)

The proposed system uses firebase to handle all of its database operations. It stores data using key value pairs, thus following the NoSQL method. It is also a real-time online database, therefore there is a constant and live interaction between the mobile application and the database. It is owned and managed by google, making it more secure, scalable and reliable. Below are screenshots of how data is stored in firebase real-time database.

|  |  |  |
| --- | --- | --- |
|  |  |  |

### Methodology

The proposed system uses the agile approach as its methodology model. The world is changing rapidly and so does the needs of users. The ability of the agile methodology to change at any time when required, to suit user preference makes it very flexible and effective for the development of a mobile application. The proposed system uses a mobile application to provide health assistance to diabetic patients and health practitioners, therefore the system must be flexible and allow for changes to be made easily without affecting its performance.

# Chapter 5 – Implementation

In this chapter, a description of methods employed in the development (coding, testing and implementing) of the design of the proposed system. It provides a detailed description of the system’s installation, documentation and how users are trained to use the proposed system. Application development and testing are the two stages used in the system’s implementation stage.

## Application Development

For developers and programmers, this stage is and has always being the most interesting part of building a system. It comprises of converting the numerous information and intelligence acquired from the requirements specifications, analysis and designing of the system into codes using certain frameworks and programming languages that suit the system in question. In relation to the proposed system, the ionic framework plays a very major role in the development of the application. Being a framework, it combines Angular, also a front-end framework for JavaScript and Typescript, a superset of the JavaScript programming language. With the help of Angular and Typescript, the user interfaces of the application can be modeled and controlled easily. This helps in developing appealing and user friendly interfaces. Ionic, in itself is just a front-end framework, therefore it connects with Cordova in order to gain access to a device’s native features such as camera, Bluetooth, calendar, etc. The backend of the proposed system, taking into consideration the server and the database are handled by Firebase. This is a mobile and web application development platform which makes the development of high quality applications fast, simple and easy. Most of the work is done by the platform, from authentication, databases, analytics and messaging. The proposed system authenticates all of its users with the platform and stores all related data into the database.

## Testing

One of the most important stages in systems development if testing. A fully functional software today might not work tomorrow due to certain errors and bugs in the codes. Systems must be tried and tested many times before it is approved. Thus, if a system is not approved, it must be improved. Using the agile methodology, the proposed system does its testing frequently and at almost all the major stages. It is very important to make sure that users are satisfied with the system being developed. The testing procedures used are:

* Using test data for program testing
* Using test data for link testing
* Full system testing with test data
* Full system testing with live data

The above stated procedures were used in order to:

* Manually check the codes for any error
* Determine errors existing in a module’s code
* Identify errors in combining modules
* Examining what the code does in order to review them for errors

## System Performance

The proposed system provides a convenient and an effective way for diabetic patients to acquire health assistance in terms of monitoring, guidance, prescriptions and more. A greater bond and connection is established between patients and their health practitioners.

## System Implementation and Testing Screenshots

Authentication (Sign In and Sign Up)

|  |  |
| --- | --- |
|  |  |

Patient

Dashboard

|  |  |
| --- | --- |
|  |  |

Medical Records Logging

|  |  |
| --- | --- |
|  |  |

Appointments and Prescriptions

|  |  |
| --- | --- |
|  |  |

Doctor

Dashboard & Appointments

|  |  |
| --- | --- |
|  |  |

Appointments & Patients

|  |  |
| --- | --- |
|  |  |

# Chapter 6 – Conclusion

## Introduction

Helping diabetic patients monitor their progress easily, conveniently and providing health professional assistance forms the main purpose of the proposed system. The overall outcome exhibits that MAPDM (Mobile Application for Personal Diabetes Management - TrackBetes) is plausible, usable and can be implemented. The proposed system helped establish that:

* The proposed system integrates mHealth in diabetes management, which is an easier and convenient way of storing and managing important details of recordings of patients. Charts were used to present these recordings.
* The system relieves the patient off the stress of writing down recordings in notebooks and doing all calculations in order to track diabetes progress.
* With the system, patients can be in the comfort of their homes, schools and work places whiles receiving prescriptions from their health practitioners. Both patients and health practitioners can also schedule appointments with each other easily.
* The proposed system uses a well-organized representation of the diabetic patient’s medical records using charts.

After the proposed system has been tested, accurate results were provided. Users, both patients and health practitioners do not require expert knowledge before effectively using the system. The criteria used to assess the system helped in the acquisition of positive results.

## Challenges

The ionic framework does a lot of background work for the developer. Nevertheless, much effort and time were used to acquire firm knowledge of its main components like Angular, Typescript and Cordova. The ionic framework and firebase have challenges in allowing their different versions to interact easily with each other.

## Project Cost

All the frameworks, languages and technologies used in the project are open source and available for free.

## Recommendation

With inadequate resources especially the required expertise and time constraints, the following recommendations are made about the proposed system.

* Advanced features like wireless synchronization of the system with diabetes measurement devices will be a deal breaker when implemented with the system.
* The user interfaces and charts can be improved upon
* Detailed reports and analytics can be integrated into the system, especially for the health practitioner
* Interesting activities like challenges and games can be added to the system, to make it livelier and attract users’ attention frequently.
* The system requires internet connection to function effectively, offline capabilities can be implemented to allow users without internet connection equal experience.

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# Appendix

## Code Samples

### Index.html

<!DOCTYPE html>

<html lang="en" dir="ltr">

<head>

<meta charset="UTF-8">

<title>Ionic App</title>

<meta name="viewport" content="viewport-fit=cover, width=device-width, initial-scale=1.0, minimum-scale=1.0, maximum-scale=1.0, user-scalable=no">

<meta name="format-detection" content="telephone=no">

<meta name="msapplication-tap-highlight" content="no">

<!-- Latest compiled and minified CSS for bootstrap-->

<link rel="stylesheet" href="https://maxcdn.bootstrapcdn.com/bootstrap/4.2.1/css/bootstrap.min.css">

<link rel="icon" type="image/x-icon" href="assets/icon/favicon.ico">

<link rel="manifest" href="manifest.json">

<meta name="theme-color" content="#4e8ef7">

<!-- add to homescreen for ios -->

<meta name="apple-mobile-web-app-capable" content="yes">

<meta name="apple-mobile-web-app-status-bar-style" content="black">

<!-- cordova.js required for cordova apps (remove if not needed) -->

<script src="cordova.js"></script>

<!-- un-comment this code to enable service worker

<script>

if ('serviceWorker' in navigator) {

navigator.serviceWorker.register('service-worker.js')

.then(() => console.log('service worker installed'))

.catch(err => console.error('Error', err));

}

</script>-->

<link href="build/main.css" rel="stylesheet">

</head>

<body>

<!-- Ionic's root component and where the app will load -->

<ion-app></ion-app>

<!--Bootstrap 4 CDN-->

<!-- jQuery library -->

<script src="https://ajax.googleapis.com/ajax/libs/jquery/3.3.1/jquery.min.js"></script>

<!-- Popper JS -->

<script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.6/umd/popper.min.js"></script>

<!-- Latest compiled JavaScript -->

<script src="https://maxcdn.bootstrapcdn.com/bootstrap/4.2.1/js/bootstrap.min.js"></script>

<!-- The polyfills js is generated during the build process -->

<script src="build/polyfills.js"></script>

<!-- The vendor js is generated during the build process

It contains all of the dependencies in node\_modules -->

<script src="build/vendor.js"></script>

<!-- The main bundle js is generated during the build process -->

<script src="build/main.js"></script>

</body>

</html>

### app.component.ts

import { UserAuthTabsPage } from './../pages/userAuthentication/user-auth-tabs/user-auth-tabs';

import { Component, ViewChild } from '@angular/core';

import { Platform, Nav, MenuController, App, Tabs } from 'ionic-angular';

//import { StatusBar } from '@ionic-native/status-bar';

//import { SplashScreen } from '@ionic-native/splash-screen';

@Component({

templateUrl: 'app.html',

})

export class MyApp {

rootPage:any = UserAuthTabsPage;

@ViewChild(Nav) nav:Nav;

constructor(public menuCtrl: MenuController, public app: App, platform: Platform, /\*statusBar: StatusBar, splashScreen: SplashScreen\*/) {

platform.ready().then(() => {

// Okay, so the platform is ready and our plugins are available.

// Here you can do any higher level native things you might need.

/\*statusBar.styleDefault();

splashScreen.hide();\*/

});

}

//sign out user

signOutUser() {

this.app.getRootNav().setRoot(UserAuthTabsPage);

this.menuCtrl.close();

}

}

### signUp.html

<ion-content padding>

<ion-list no-lines>

<ion-grid padding>

<ion-row>

<ion-col col-1>

<ion-icon name="person" style="margin-top:45px;"></ion-icon>

</ion-col>

<ion-col col-11>

<ion-item>

<ion-label floating>Username</ion-label>

<ion-input type="text" [(ngModel)]="userProfile.username"></ion-input>

</ion-item>

</ion-col>

</ion-row>

<ion-row>

<ion-col col-1>

<ion-icon name="mail" style="margin-top:45px;"></ion-icon>

</ion-col>

<ion-col col-11>

<ion-item>

<ion-label floating>Email</ion-label>

<ion-input type="text" [(ngModel)]="user.email"></ion-input>

</ion-item>

</ion-col>

</ion-row>

<ion-row>

<ion-col col-1>

<ion-icon name="lock" style="margin-top:45px;"></ion-icon>

</ion-col>

<ion-col col-11>

<ion-item>

<ion-label floating>Password</ion-label>

<ion-input type="password" [(ngModel)]="user.password"></ion-input>

</ion-item>

</ion-col>

</ion-row>

<ion-row>

<ion-col col-1>

<ion-icon name="lock" style="margin-top:45px;"></ion-icon>

</ion-col>

<ion-col col-11>

<ion-item>

<ion-label floating>Verify Password</ion-label>

<ion-input type="password" [(ngModel)]="verifyPassword"></ion-input>

</ion-item>

</ion-col>

</ion-row>

<ion-row>

<ion-col col-1>

<ion-icon name="person" style="margin-top:45px;"></ion-icon>

</ion-col>

<ion-col col-11>

<ion-item>

<ion-label floating>User Type</ion-label>

<ion-select interface="action-sheet" [(ngModel)]="userProfile.usertype">

<ion-option value="patient">Patient</ion-option>

<ion-option value="doctor">Doctor</ion-option>

</ion-select>

</ion-item>

</ion-col>

</ion-row>

</ion-grid>

<button ion-button block (click)="createAccount(user)">Create Account</button>

</ion-list>

</ion-content>

### signUp.ts

import { Component} from '@angular/core';

import { IonicPage, NavController, NavParams, ToastController, AlertController, MenuController} from 'ionic-angular';

import { AngularFireAuth } from 'angularfire2/auth';

import { AngularFireDatabase, FirebaseListObservable } from 'angularfire2/database';

import { User } from '../../../models/User';

import { UserProfile } from '../../../models/UserProfile';

@IonicPage()

@Component({

selector: 'page-sign-up',

templateUrl: 'sign-up.html',

})

export class SignUpPage {

user = {

email:'',

password:'',

usertype:'',

} as User;

userProfile = {

username:'',

usertype:'',

} as UserProfile

verifyPassword:string;

//creates a reference variable which consists of an array

//userRef$: FirebaseListObservable<User[]>

constructor(

public navCtrl: NavController,

public navParams: NavParams,

private afAuth:AngularFireAuth,

private toastCtlr: ToastController,

private alertCtlr: AlertController,

private afdb: AngularFireDatabase,

private menuCtlr: MenuController) {

//disable sidemenu on sign in page

this.menuCtlr.enable(false, 'sideMenu');

//creates a node in firebase which holds list of users

//this.userRef$ = this.afdb.list('users');

}

createAccount(user: User) {

let toast = this.toastFunc();

let alert = this.alertFunc();

if(this.validateInputs() && this.passwordMatch()){

this.afAuth.auth.createUserWithEmailAndPassword(user.email, user.password)

.then((data) => {

//adds user profile to firebase database

this.createUser();

toast.setMessage("You can sign into your account");

toast.setPosition('top');

toast.setDuration(3000);

toast.present();

})

.catch(error => {

alert.setMessage(error.message);

alert.present();

})

}else

return;

}

//takes the currently created user's id and creates a user profile

createUser() {

this.afAuth.authState.take(1).subscribe((auth) => {

//set ensures that we have a single version of the data

this.afdb.object(`user profile/${auth.uid}`).set({

'username':this.userProfile.username,

'usertype':this.userProfile.usertype,

});

switch (this.userProfile.usertype) {

case 'patient':

this.afdb.object(`patients/${auth.uid}`).set({

'username':this.userProfile.username,

});

break;

case 'doctor':

this.afdb.object(`doctors/${auth.uid}`).set({

'username':this.userProfile.username,

});

default:

break;

}

});

}

toastFunc() {

return this.toastCtlr.create();

}

alertFunc() {

return this.alertCtlr.create();

}

validateInputs(): boolean{

let toast = this.toastFunc();

if (this.userProfile.username == '' ||

this.user.email == '' ||

this.user.password == '' ||

this.userProfile.usertype == ''){

toast.setMessage('You forgot to enter some details');

toast.setShowCloseButton(true);

toast.present();

return false;

}else {

return true;

}

}

passwordMatch(): boolean{

if (this.user.password !== this.verifyPassword) {

let toast = this.toastFunc();

toast.setMessage('The passwords do not match');

toast.setShowCloseButton(true);

toast.present();

}else{

return true;

}

}

}