

MOBILE DIABETES APPLICATION

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MOBILE DIABETES APPLICATION

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MASTER OF SCIENCE

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ABSTRACT

In recent years, Diabetes is becoming a serious health challenge. The prevalence of diabetes has increased with accompanying increases in body weight and diminished physical activity and with increased automation. Effective blood glucose control is essential to maintain good health. However, to monitor blood glucose levels regularly one should go to healthcare center and it's not possible because of all manner of real time interfaces. To ease this process in this paper, we propose an interactive self-management mobile application where you can monitor Blood Glucose and Blood Pressure values and check all your health-related activities regularly. MobiDiaBTs keeps track of the factors that affect a patient's glucose levels and help patients to make informed choices about his/her diet and treatment from the data collected and sends warnings and recommendations based on the values. It also helps to interact with other patients in a reliable and secure communication.

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1. INTRODUCTION

The prevalence of disease is increased dramatically with westernized lifestyle, automation and lack of physical activity these days. Diabetes is the one of the most common disorder associated with long term complications. It occurs at every age, in people of every race, and of every shape and size. American Diabetes Association (ADA) did an individual case study and the research is showing that lack of diabetes care is mainly due to the availability, affordability, and adequacy of health insurance for people with diabetes [1], lack of knowledge about healthy eating, Limited access to healthy foods and clinical services. Diabetes can be effectively managed, but medical care and supplies needed to monitor, and control blood glucose levels are expensive [2]. To handle this situation a handy Self-management evidence-based prevention of diabetes program is required to manage the patients' health of all kinds.

Mobile phone usage among adults and adolescents is becoming nearly ubiquitous. Enhanced usability and pervasiveness of mobile devices have resulted in renewed interest in and development of new health care applications. Continuous monitoring of patient's health with chronic illness will enhance the quality of life. Although there is now a wide body of literature on the use of mobile devices in self-management of diabetes, present knowledge about good practice in designing integrated health applications seems rather limited [3]. MobiDiaBTs is built on the Mobile technology, an accessible resource to all sectors of the people with general language without Medical/Professional terminology. Developed user friendly applications more with the Images/pictures. This application can be installed in the low-priced mobiles and in that way can be reached out to the poor patients too.

MobiDiaBTs was a diverse diabetes mobile application. It helps for personalized diabetes Self- management based on the data collected from the individual participants combined with

clinical diabetes recommendations and warnings. where people can track their Blood Glucose, Blood Pressure, Food intake's, Activity performed, medication and often based on patient's data personalized predictions, make more informed decisions throughout the day about how to balance your food, physical activity, and medicines to maintain the patients' health and, we integrated the application with a social networking communication. Users have shown tremendous interest in using social media as a major communication tool to interact with healthcare and public health systems. We use a semantics-based approach to help users find appropriate peer patients to build friendship and provide peer support based on their health concerns and social behaviors [4]. Users can send the "Add friend" request to their trusted persons and only they can see the information posted by you to protect the privacy.

The rest of the paper is organized as follows. Section 2 surveys the related work. Section 3 describes the details of the proposed system and its enabling technologies. Section 4 presents the implementation and evaluation of the proposed mechanisms. Concluding remarks are provided in Sections 5.

2. RELATED WORK

The increased prevalence of diabetes and required intensity of disease management programs are straining health systems, especially in primary care where there is lack of Resource, time with patients, near Availability of health care [5]. Technologies provide highly scalable new approaches to Diabetes self - management. Hundreds of software applications exist to Diabetes self-management. In July 2009, we found 60 diabetes applications on iTunes for iPhone; by February 2011 the number had increased by more than 400% to 260. Other mobile platforms reflect a similar trend [3]. Researchers showed that positive results were reported in the usage of the applications, knowledge of the disease, improving self-management skills and personalized education.

Mobile application developed must be very innovative to transform health care from reactive and facility-based to a preventive, proactive approach that is person centered and utilizes appropriate technologies [6]. As of 2018, Best applications to Self-manage diabetes are Glooko, Health2Sync, Glucosio, Calorie Counter, Diabetes Tracker, mySugr BG Monitor, BeatO, Glucose Buddy, DiabetesConnect, Diabetes: M. The overall functionalities of these apps are mainly Diet recording, Weight management, Blood glucose monitoring. Some of them are tracking Ketones, Cholesterol and Nutrition facts and helps to eliminate unhealthy foods and includes Visual vital stats about health including current and Past trends.

Also, with the advancement in technology, and an effort to involve younger patients, social media is slowly being stable channel for communication and connection with patients and among themselves. In addition to the above-mentioned applications there are some application/blogs specialized in Social connectivity Diabetes Mine [7], Diabetes Daily [8], Tudiabetes [9], DiabetesConnect [10], Sixuntilme [11]. Here Patients share all health-related issues, treatment tips,

results. A significant potential lies in the ability to communicate with individuals in real-time, be able to capture data, and provide decision support [12]. This communication helps the patient feel better because nobody can understand the problem of a patient than another patient.

Despite of many useful existing applications, in this paper I wanted to present the application which was easy to access with minimum skills. This application was designed with more images and visual data than language and for low cost mobiles to reach to all grades of people. In the above-mentioned applications, the ones which have all the features are paid applications perhaps to store and maintain the data. We used Firebase database here which helped to release the application free of cost, Mainly, this application is targeted for patient use, the care provider, or both, promoting communication, sharing of information and decision-making.

3. METHODOLOGY

3.1. Structure of the Application

The Proposed framework of the application is shown in the fig 1. The goal of the project is to build a cost-effective mobile application for Self-management of diabetes, we included Blood pressure in our application because it also plays prominent role in controlling the blood glucose levels. Applications includes several components as shown in the below picture.

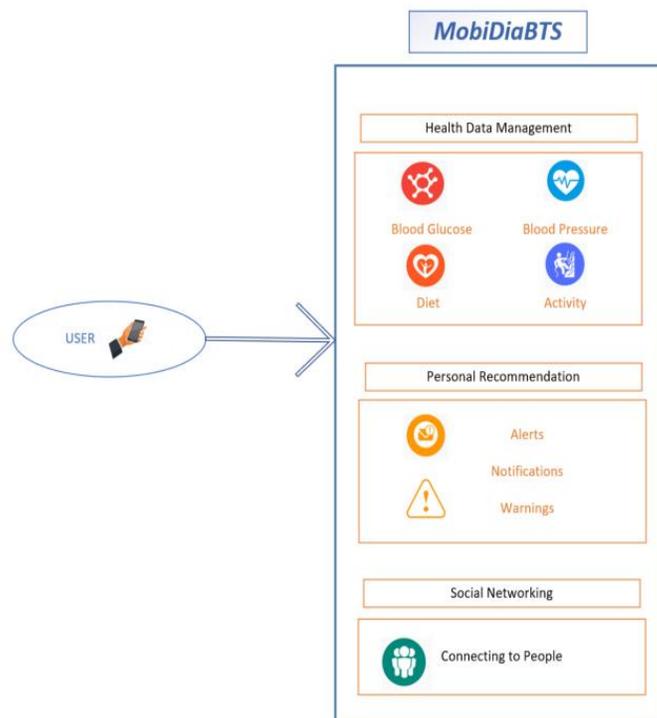


Figure 1: Prototype of MobiDiaBTS

With the use of increased technology, the health care is transformed from facility based to preventive and personalized. Making cell phone as a platform, we can monitor users' Glucose, BP values, physical activities, Diet and lifestyle. Patients get their blood glucose values from the Glucometer or some other medical device that can be used to calculate Glucose levels at home. They input the values pre-meal and the post-meal every day to continuously monitor the levels. Along with that we also send notifications to input their Diet, Activity and Sleep which plays vital

role in maintaining the optimal glucose values. Making the recorded values as evidence we can give the personalized lifestyle recommendation based on their physical condition, personalized health risk prediction, Reminders and warning if their values are abnormal are sent to the patients which helps to continuously monitor and maintain a healthy lifestyle. With the guidelines of American Diabetes Association (ADA), we apply recommendations to the patients based in their recorded data. Here we consider different types of food the patients in take, and the physical activity levels, regular blood glucose and BP values they record and the medications they take etc. This approach helps the patients how the diet and activity should change depending on the condition of the patient.

3.2. Database

The main purpose of this database section is to get in details of how the database is designed to store the inputted Blood Glucose, Blood Pressure, Diet and Activity Values and at the same time to push recommendations, warning and Notifications based on the store data.

3.2.1. Database Design

In this application, the most challenging part is store data and make the personalized recommendations based on the values. Here we used Firebase real time database to store the values. Firebase is a cloud-hosted database which allows users to securely connect to database from client side. Firebase is a NoSQL, No Table database where all the information is saved as JSON objects which hold Key – values. Whenever data is added to the JSON tree, it becomes a node in the existing JSON structure with an associated key. The keys in the topmost level is like tables in SQL database. Here it considers the user ID as the Key value. The figure below shows NoSQL JSON Database for the MobiDiaBTs application. The figure shows the tables that we used in our application. Firebase real time database API's allows only operations that can execute

quickly. So, millions of people will have great experience without compromising on responsiveness.

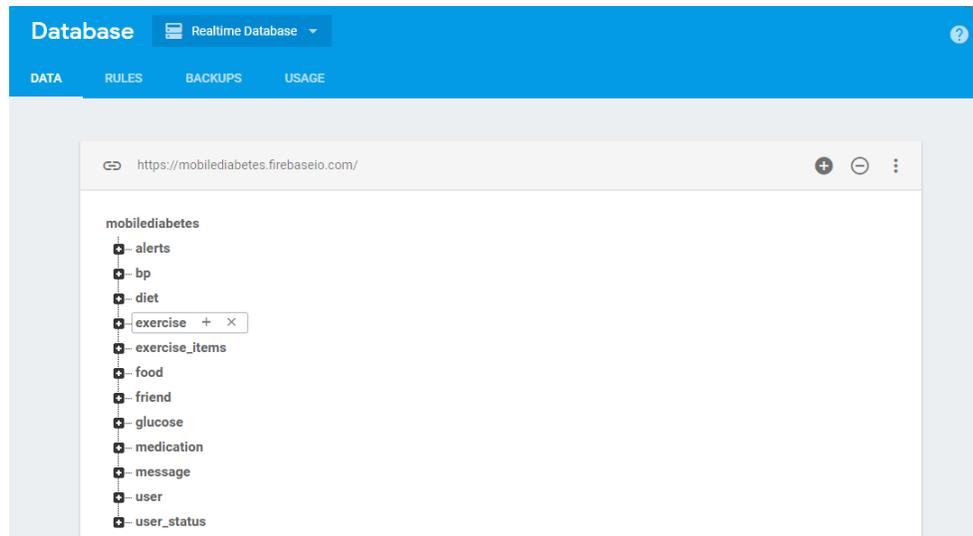


Figure 2: Database structure

3.2.2. Alerts Node

‘Alerts’ stores the records related to alert messages, notifications and warnings which are triggered when the Blood Glucose and pressure values are abnormal.

3.2.3. BP

‘BP’ stores the recorded BP levels at each time for each user.

3.2.4. Diet

‘Diet’ stores the record of food consumption for each user for specific day and their consumed calories.

3.2.5. Exercise

‘Exercise’ stores the record of Activity details and calories burnt for each day by the user.

3.2.6. Glucose

‘Glucose’ stores the record of Blood Glucose levels for each user.

3.2.7. Medication

'Medication' stores the record of medicines taken by the user for both Diabetes and BP on daily basis. Records are stored in the database.

3.2.8. Message Node

Messages node is where we'll be hosting all the messages in that conversation. we can include data like attachments, documents, media etc. using Picasso library. We used "MP Android chat library" for chatting purpose

3.2.9. Friends list

Each person has a unique ID and can connect with each other to discuss about the health-related issues. In this node, friends list is stored.

3.2.10. User Node

Users node has the list of users who has the application and connect with each other by adding to the friends list to have conversations.

3.2.11. User Status

In this node, we can check whether the friend is available now to chat or not. If not, we can send notification and they can check in their messages while they are using the application.

4. IMPLEMENTATION

We Implemented MobiDiaBTs and is deployed to a set of Android phones and tablets. It implements most of the mentioned features. Once the manual data is collected from the User/patient it checks the values and provide a semantic based reminders, warnings and recommendations. Social Networking feature helps to connects patients by adding as friend and can chat with each other not only with language also with pictures. We used Firebase Database [16] to store the data, push notifications and Cloud messaging and used Android SDK (Version 26) to create an interface. For tools we used Android Studio 2.2 to develop the application.

4.1. User Interface

Figure.3 Shows the prototype of the application. Once the user Registers and Logs in, the Dashboard consists of the following modules namely Overview, Glucose, Medication, Exercise, Diet, BP, Social, Alerts, Profile.



Figure 3: User interface of the application

4.1.1. Blood Glucose

When we click on the Glucose Icon, user is presented with the interface as shown in the fig a. where they select the Date, record the blood glucose values indicating (Pre-meal/Post-meal. This value is then stored in the database which is used for generating overview charts and for personalized suggestions. The User is reminded to enter Glucose details both Pre-meal and Post-meal at a specified time daily using Cron Jobs.

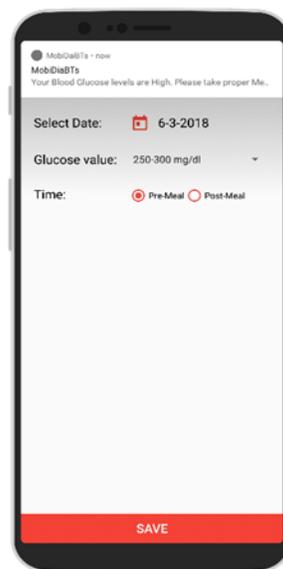


Figure 4: Blood Glucose interface

4.1.2. Medication

Medication module helps to keep track of all the medications they take daily related to Blood glucose and BP. User selects the Date, medication for Blood Glucose and Blood Pressure and the dosage that they take daily. We also provided the option to enter the insulin values. By Storing the data collected and is compared with the Rules generated by ADA [2] to give personalized recommendations to increase/decrease specific tablet dosage based on recorded BP & Glucose values.



Figure 5: Medication interface

4.1.3. Exercise

In this module we track the user's daily activity. User can enter the present and past activity too by selecting the date. They have given the option to select type of exercise, based on the exercise selected from the dropdown and the time entered, calories burnt is generated automatically. The user is also given the feasibility to create and save new exercises which were not seen in the list. All this data is further stored in DB for personalized suggestions.



Figure 6: Exercise interface

4.1.4. Diet

In the Diet module, User selects the date, the time of meal like Breakfast, Lunch, Snack and dinner, Food name, and quantity. Based on these details, the food calorific value is automatically generated, and this calorie intake is stored in the DB as well as using Card View and Recycle View the items consumed are displayed on the Diet screen for the rest of the day. Thus, the user can compensate for over-diet/under-diet for that specific day. Also, when the user receives alert saying Glucose levels are high, patients can come here and check which foods are rich in calorie and sugar which helps them to control that diet next time. If the consumed food is not available in the list, User can create new items and use calorie counter to count the calories [13] and add that to the list. Thus, all food intake is tracked for better management and recommendations.

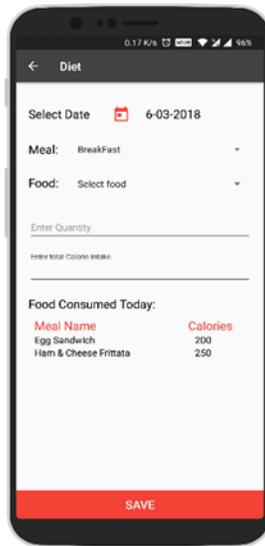


Figure 7: Diet interface

4.1.5. BP

From a dietary standpoint, BP and Blood Glucose are closely related. So, Monitoring BP and maintaining healthy values helps to maintain glucose values and prevents cardiovascular diseases. User gets the values from the sphygmomanometer and check [14] to understand the values. User is presented with the following screen where they select the Date and records BP value and the time of the recorded value (Pre-meal/Post-meal). The User is reminded to enter BP details both Pre-meal and Post-meal at a specified time daily. This value is then stored in the database which is used for generating overview charts of the past 10 days data. Based on the graph personalized recommendations were send to the patient to maintain their diet and activity to control their values and be healthy.

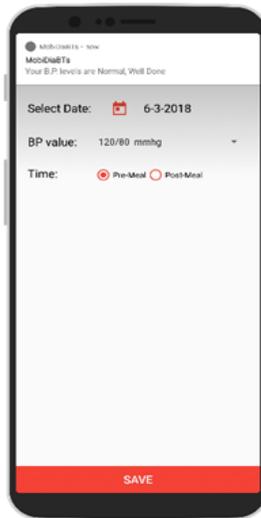


Figure 8: Blood Pressure interface

4.1.6. Overview

Overview module of the application looks as shown in the fig., Here we have four tabs one for Blood Glucose, Blood Pressure, Diet and Activity. This is the place where we go and review our past recorded values. For Glucose and BP, it considers the history of 7 (a week) recorded values are shown in a graphical format [15]. This lets the User have a better understanding of their health condition. They can compare between each graph how Bp is showing when Glucose levels are high and on the same day how their calorie consumption and calorie burnt are, which helps them to get better understanding of where they need to improve to maintain the values in the optimal range. Adding to that one other advantage with graphical overview is, when the patient goes for a clinic visit it helps the doctor to better understand how patient is doing each day in that concise visit time and helps to give more informed suggestions.

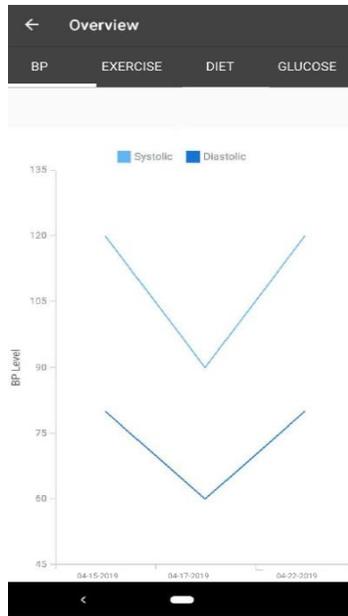


Figure 9: BP overview

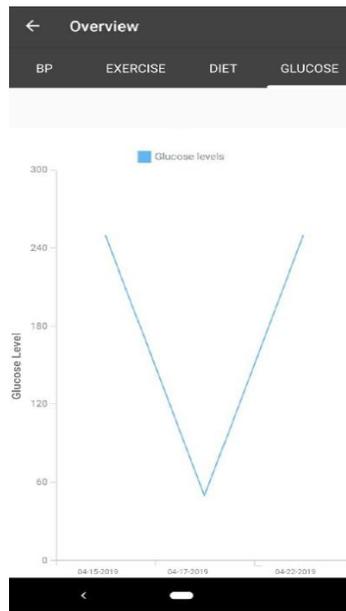


Figure 10: Glucose overview

In the same way, we have a graphical view of past 10 recorded values for Diet and Activity, by looking at the graph, this gives a better understanding of which foods are rich in nutrition values with less calories to maintain good health.

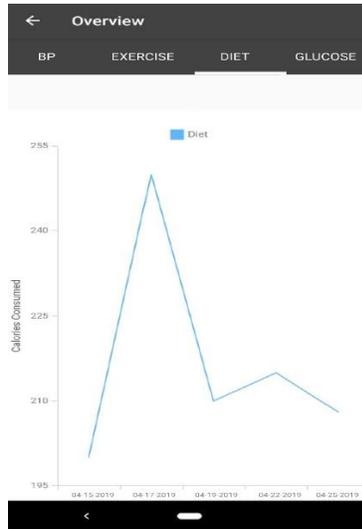


Figure 11: Diet overview

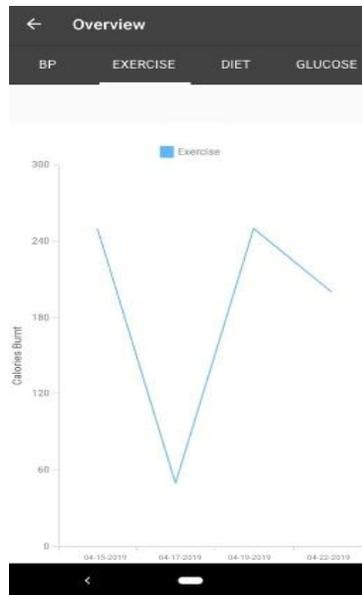


Figure 12: Exercise overview

4.1.7. Social Networking

MobiDiaBTs allows users to connect with fellow users and share their experiences and discuss their health-related issues. One user can get in touch with other user by clicking on “Add Friend” icon and providing either the name or email id of the other person. Here we are also concerned about the Security and the privacy policy, A user can only engage with you if you accept them as your friend. Social connectivity helps the patients to self-manage diabetes and motivation from one another helps to be proactive. Below Fig a Fig b and Fig C shows the interface of how to “Add Friend” Connect with them and “Delete Friend” from your list.

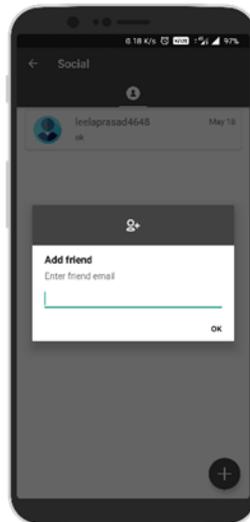


Figure 13: Adding friend

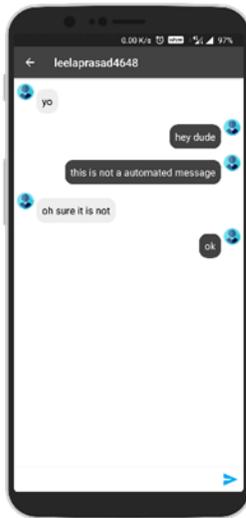


Figure 14: Conversation

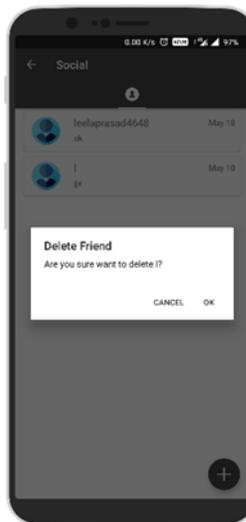


Figure 15: Delete friend

4.1.7.1. *Firebase cloud messaging (FCM)*

We used Firebase Cloud messaging to send notification messages to the other patient/user. An FCM implementation has two main components for sending and Receiving the messages. To send messages we use a firebase Admin SDK or FCM server protocols. To Receive messages Android, IOS or Web Client (JavaScript) applications. We also implemented Images chatting using “Android Picasso library” to make the application accessible to minimum language skilled people.



Figure 16: Firebase cloud messaging

4.1.8. Alerts

This module sends Alerts, warnings and Notification to the user based on the high/low Blood Glucose, BP values. The alerts system works seamlessly across all the time zones. The

application server keeps track of recorded data of individual user and alerts the user when levels are abnormal. This facilitate a way that lets users to maintain safe levels of blood glucose and blood pressure. Alerts are displayed in the application as shown in the figure.

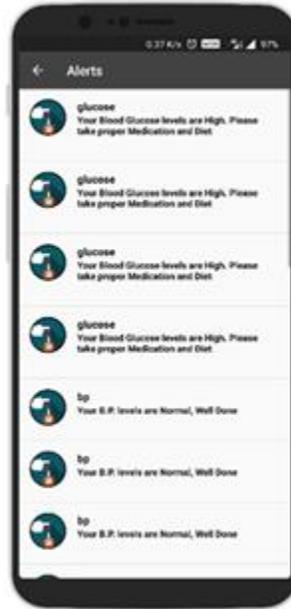


Figure 17: Alerts

The alerts are facilitated by job scheduling tools, we use Cron-jobs a popular framework for triggering jobs and Firebase cloud messaging. The values entered by the users are stored and these jobs are triggering some scripts to execute. The scripts in turn executes and send push notification to each individual user based on their data. An example of popping up notification is shown in Fig a. When the user recorded value is in the optimal range, the User receives alerts stating good BP/Glucose levels. This is the section where the User finds his/her ontology based personal recommendations.

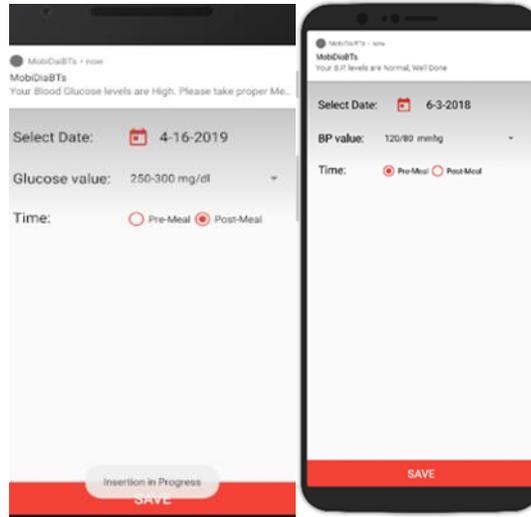


Figure 18: Notification alert triggered when cron-job is executed

4.1.8.1. Cron-jobs

Here we would like to show the process how these Cron – jobs are created and verified. Cron-jobs is a time-based job scheduler and is used to set up and maintain software environments to schedule jobs (commands) to run periodically at fixed times, dates, or intervals. It is helpful in our application to do the repetitive tasks timely and like downloading files from the Internet and sending notifications at regular interval.

4.1.8.2. Create a Cron-job

To create a cronjob go to <https://cron-job.org/> [16] and click on Create cronjob button. It will redirect you to the page shown in fig. This page prompts you to enter the job details such a title, URL of the scripts which executes the job in our case we need to create a script that tracks blood glucose levels and send push notification to specified users. In the schedule section we can schedule the time when job needs to trigger.

Create cronjob

Fill in the following form to create a cronjob. We support http and https URLs. In case the URL is password-protected (e.g protection), please supply the username and the password.

Note: You can specify advanced settings after adding the cronjob by editing it.

Title, Address

Requires HTTP authentication

Username	Password
<input type="text" value="....."/>	<input type="password" value="....."/>

Schedule

Every 15 minute(s)

Every day at 0 : 00

Figure 19: Create a cronjob

4.1.8.3. Latest events

We can also check the status of the events in latest events sections. This shows the jobs that are executed daily and status of the jobs. The following figure shows the latest events in our application.

Latest events

	Descriptions	Date	
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/fo...	Today, 12:31:01	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/bp...	Today, 09:01:04	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/gl...	Today, 09:01:04	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/fo...	Today, 08:31:02	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/gl...	Today, 08:01:04	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/bp...	Today, 08:01:04	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/ex...	Today, 07:01:04	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/fo...	Yesterday, 20:01:04	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/ex...	Yesterday, 15:40:39	Details
	Cronjob execution: Successful (200 OK) https://us-central1-mobilediabetes.cloudfunctions.net/api/fo...	Yesterday, 12:31:02	Details

Figure 20: Latest events

4.1.8.4. Cronjobs Scheduled

We can also view list of Cron jobs that are scheduled for execution. A list of jobs is shown in the below figure.

Cronjobs				Create cronjob	
	Title, Address	Last execution	Next execution		
	BPPost https://us-central1-mobilediabetes.clou...	Today, 09:01:04 Successful (4,4 s)	18.06., 09:00	History	Edit
	BPPre https://us-central1-mobilediabetes.clou...	Today, 08:01:04 Successful (2,7 s)	18.06., 08:00	History	Edit
	AutomationTest https://us-central1-mobilediabetes.clou...	Yesterday, 15:40:39 Successful (3,8 s)	Today, 15:40	History	Edit
	Exercise https://us-central1-mobilediabetes.clou...	Today, 07:01:04 Successful (2,4 s)	18.06., 07:00	History	Edit
	FoodBreak https://us-central1-mobilediabetes.clou...	Today, 08:31:02 Successful (2,5 s)	18.06., 08:30	History	Edit
	FoodDinner https://us-central1-mobilediabetes.clou...	Yesterday, 20:01:04 Successful (3,8 s)	Today, 20:00	History	Edit
	FoodLunch https://us-central1-mobilediabetes.clou...	Today, 12:31:01 Successful (3,3 s)	18.06., 12:30	History	Edit
	GlucosePost https://us-central1-mobilediabetes.clou...	Today, 09:01:04 Successful (2,6 s)	18.06., 09:00	History	Edit
	GlucosePre https://us-central1-mobilediabetes.clou...	Today, 08:01:04 Successful (4,2 s)	18.06., 08:00	History	Edit

Figure 21: List of Cron - Jobs

4.1.9. Profile/Settings

In this module, we store all the information user has provided during registration namely age, height, weight, sleep information and contact details. The user can update the details at any point of time. This data is thereby, used to calculate the Body Mass Index (BMI) of the User to understand his/her physical/health characteristics for more personalized recommendations which helps to self-management of diabetes.



Figure 22: Profile settings

5. CONCLUSION AND FUTURE WORK

5.1. Conclusion

MobiDiBTs gives individuals with Diabetes an opportunity to be involved and engaged actively in Self-management and lead a healthy lifestyle. We used an ontology model to give the personal recommendations based on their lifestyles. This application also connects people with social networking feature. Leveraging the social feature people can connect with fellow patients to get recommendations and discuss on their health condition and activity helps to enthusiastically participate in activities. Continuous monitoring of the health with this application helps to lead an enhanced healthy lifestyle.

5.2. Future Work

Mobile technology is growing rapidly and changing our world and mainly smartphone technology is increasing and changing everybody's lifestyle. People are tending to share more through social networking than talking to the people standing before you. In that manner they are sharing the sensitive matters related to health conditions. Disclosure of personal health information to untrusted parties can lead to serious consequences. So, protecting the health information, might be challenging. Therefore, applying semantics-based secure social networking to connect the patients can be considered as an advancement to this application.

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