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Mobile health applications to support the diabetic patient and the doctor

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Abstract: The Repository of services (web-applications with a unified interface) is proposed for patient care (care services), for planning and carrying out of treatment (treatment services) and to ensure the functioning the entire system (management services). Treatment of diabetes becomes personalized and customized because it is possible to build and adjust their treatment plan and workflow by selecting the necessary services for the individual patient, for the doctor and for application management which to be executed on cloud resources. It provides the secure, safe and committed healthcare to diabetes sufferers at any point of the country by creating facilities for everybody to check glucose meter (GM) and other vital parameters (say, blood pressure-BP) data at home and to make these data to be evaluable for his doctor in the form of the updating Electronic Health Records (EHR).

1. System destination

1.1. Topicality

In the world today there are approximately 346 million people with diabetes 1 and 2 kinds (respectively about 10 % and 90 % of the total number of patients), the disease severity of which varies on the level of sugar in the blood. About 10 % of them die every year, with 80% of deaths occur in countries with weak economies and (as a consequence) with the poor organization of health care.

Most often people suffer from diabetes, at the Middle East and North Africa. For example, among the Egyptian there are 11.4 % of diabetics, among Saudis - 16.8 % of the people, in the United Arab Emirates - 18.7%. A high percentage of diabetic patients (> 16 %) were are also among the residents of the U.S. and Canada, but because of a well-organized health care (although diabetes is treated very difficult) the relative mortality among these patients below.

1.2. A review of available solutions

Despite the presence of a large number of mobile applications developed for Apple's iPhone, Google's Android, BlackBerry and Nokia Symbian and available today for people with diabetes (such applications are about 200 names!), there are some inconsistencies between the evidence-based clinical guidelines to the basic functions and features such applications [1-3] and the actual functionality of existing mobile applications that can be found at online stores.

Experts in diabetes care are recommending patients to use mobile means for self-monitoring the following important factors:

- «personalized" medical information, provided to the patient, with feedback to the doctor;
- monitoring the state of patients and immediate help to him in emergencies;
- monitoring the doses of insulin and consumed medication;
- social and psychological care;
- control diet used;
- monitoring of the patient's weight;
- control of physical activity;
- other therapeutic treatment measures (leg care , eye care);
- immunization;
- prevention of disease complications.

Today in the world there is no mobile application that supports all of the above recommendations of doctors. Existing applications can be divided into three classes according to their functionality [4].

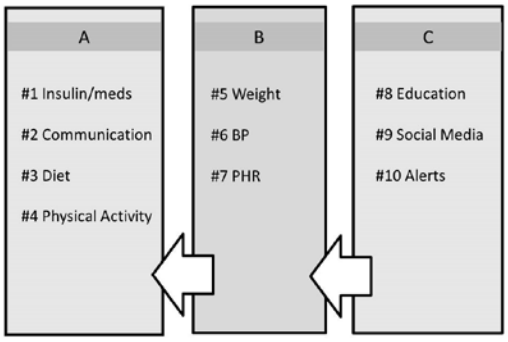

Figure 1. The functionality of mobile applications of different classes

In class A applications four basic functions are implemented being shown in Fig. 1. Class B applications includes the functionality of self-monitoring of weight, blood pressure monitoring, and synchronization with a personal electronic health record (PHR) . Applications of A and B classes today are much more widespread (see Table 1) than the C class applications with features of personalized medical information, social integration, threat alerts, and emergency assistance. For example in Fig. 2 the menu of the mobile class A application is shown.

Figure 2. Illustration of the class A application functionality: main menu (left), food registration (center), and feedback on diet goals (right).

Table 1. Data on the most famous mobile applications for diabetics

The application	Functionality	Prise
iPhone		
MyTelcare Diabetes Pal	It helps to monitor, analyze and transmit data on the glucose level in the blood, the used drugs and the diet manually and automatically with Telcare devices	Free
Dbees app	It supports the treatment of diabetes Type 1 and Type 2. Helps keep track of receiving insulin and pills, the use of insulin pump therapy and diet. Synchronizing with online accounts.	Free, but a patient must to register online
Glooko (with additional cable)	It allows to transfer data directly from the meter on the patient's iPhone. Compatible with glucometers: Contour, Freedom Lite, Freestyle Lite, Ultra2, UltraLink and UltraMini	Free + $40 cable
UTS Diabetes for iPhone	It allows you to monitor the state of the patient and may share measured results with his doctor, relatives, and friends via the online service	$9.99
	www.utshealth.com	
Diabetes Manager	Data about the level of glucose in the blood is automatically transferred from the meter to the application. The test results will remain and can be visualized. The application can help the patient to analyze the trend of his disease development and abnormalities in his state, even when the patient moves.	$27.85
Android		
OnTrack Diabetes	It is an application to help diabetics manage their diabetes by tracking various items such as blood glucose, food, medication, blood pressure (BP), pulse, exercise and weight.	$27.85
Windows Mobile		
Diabetes Pilot for Windows Mobile	It allows you to record and analyze your glucose, food, medication, exercise, and other diabetes data while the patient is on the go.	$39.99
Diabasics	It is a nice program that lets necessary information to the patient need for proper diabetes management. It logs blood glucose levels, carbs and fat eaten and, if the patient is insulin dependent, the amount of insulin he injected.	$29.95
Health Engage Diabetes	It is designed as a comprehensive tool for Type 1 or Type 2 diabetics. Users of all ages can manage and organize all of the data (glucose, insulin, diet, medications, test, etc.) needed to manage and improve their condition and easily generate graphs and reports which can be printed out or shared electronically with their healthcare professionals.	Desktop: $59.99

1.3. Recommendations for improvement

Natural is the prospect of uniting all application functions of class A, B and C into one integrated, multi-functional and adaptive application. The above classification of mobile applications can be useful for developers of applications and is designed to draw their attention to the less common and less until the

work of mobile applications that would be better than now take into account the recommendations of doctors. First of all, we are talking about the absence of «personalization" of medical information provided to patients and the practical absence of means of integrating patients into social networks, the potential of which has remained largely unexplored.

It should be noted that the development of mobile applications for diabetes is actively continuing. For example, the U.S. National Science Foundation has allocated $ 1.2 million in 2012 to develop a new mobile application designed for patients with diabetes. Applications will be created by the Polytechnic Institute in Worcester (MA) and the School of Medicine that is acting as a part of the University of Massachusetts. The new application is planned to develop in four years. The first two of them will go to the development of a prototype, and the remaining time - to test the application in the School of Medicine at the University of Massachusetts.

2. Goals of development

The aim of the project is to create a cloud infrastructure **Mobimed** for serving nationwide patients suffering from diabetes , based on mobile applications that provide :

• Excluding readmissions
• Promoting health and daily activity:
  • elimination of symptoms and exacerbations (**hypoglycimia**)
  • ensuring normal growth and development of children
  • ensure the normal course of pregnancy in women
• Support for normal or near-normal blood sugar levels (**< 7 %)**
• Prevention or elimination of disease complications.

3. System description

3.1. System Architecture

The cloud infrastructure Mobimed through secure channels is associated with the platform Mobimed, in which mobile applications for patient and physician, as well as the server processing module are operated (Fig. 3).

The main link of the Mobimed platform is a server that is used to store and process data with information on the status and stage of the disease patients. Data from mobile phones (tablets) of the patient and physician are sent to the server over a secure layer Soker (secured sockets layer-SSL) Web connections, providing a standard level of safety inherent in today mobile data network.

In the same server personal medical health records (PHR) of patients with individual treatment recommendations are stored, been compiled and constantly corrected by doctors. Data from the server is transmitted also in the opposite direction: from the server to the patient's and physician's mobile devices. The database of PHR patients provides continued access for patients and physicians, as well as for emergency doctors, if there is a need in their services.

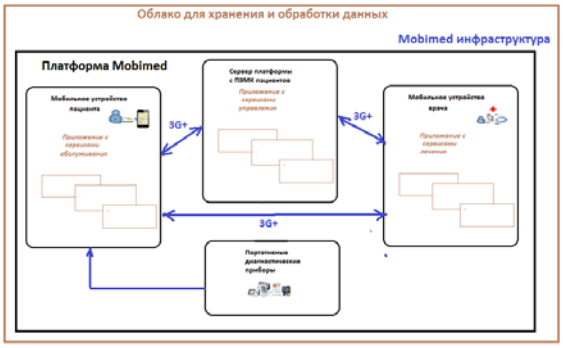

Figure 3. The Mobimed system architecture

The system had to be designed to ensure the confidentiality of patients' data. The mobile phone had no readily individually identifiable information stored about the patient, as results were only tied to a specific patient at the server. This mapping associated patients with a unique numeric Bluetooth identification of the patient's medical device and was known only to the server (fig.4).

Figure 4. Checking glucose meter (GM) by a patient

The system will be developed on the base of Service-oriented computing (SOC) which represents a new computing paradigm that utilizes services with unified interfaces as the basic constructs to support the development of rapid, low-cost and easy

composition of distributed applications even in heterogeneous environments. All major computer corporations, including BEA, IBM, Microsoft, Oracle, HP, SAP, Intel, Cisco, Juniper, SAP and Sun Microsystems, have moved towards the SOC paradigm.

According to SOC paradigm the building software applications from services require loose coupling between used services in such a way that the services have little knowledge about each another. The minimum interconnection services provided by the division on a functional basis. Having a strong interconnectivity between services is the basis for combining them into a single service.

The main services (functions) of the planned applications for a patient, for a doctor and for the operation of the Mobimed system are presented in Tables 2-4.

It is possible to develop services in i parallel independently of each other, to replace them in the application, to adapt to the changing condition of the patient and the new doctor's recommendations.

There is need to develop or choose the means of the formal description of the application at the level of business process integration (Service Mashup or Service Composition) of selected services, such as language-based BPEL. It is also necessary to develop a method of forming task flow for the automatic execution of the selected service composition (workflow) with the provision for the developer to form a visual services graph and edit it , to simplify the deployment and change the scale of creating mobile applications.

As of today the most prominent technology based on SOC is **Web Services**, a set of open specifications that focuses on interoperability and compatibility with existing infrastructures. A Web service is a specific kind of service that is identified by a URI, whose service description and transport utilize open Internet standards. Interactions between Web services typically occur as SOAP calls carrying XML data content. Interface descriptions of the Web services are expressed using Web Services Definition Language (WSDL). The Universal Description, Discovery, and Integration (UDDI) standard defines a protocol for directory services that contain Web service descriptions. UDDI enables Web service clients to locate candidate services and discover their details. Service aggregators may use the Business Process Execution Language for Web Services (BPEL4WS) to create new Web services by defining corresponding compositions of the interfaces and internal processes of existing services. One of the most important aspects in SOC is aggregation (composition). The public interfaces exposed by each service allow for the composition of the latter in complex workflows, in order to implement functionalities that reuse those that are already offered by the single services. At the present service composition can be done in two different approaches: orchestration and choreography. In orchestration a single service, called orchestrator, is responsible for composing and coordinating the other services in order to complete the desired task. Choreography, instead, describes the interactions between the various services, which execute a global strategy in order to achieve the desired result without a single point of control. For these reasons it is said that orchestration offers a local viewpoint whereas choreography offers a global viewpoint. At the present the most credited language for dealing with service orchestration is WS-BPEL (BPEL for short). On the other hand, the reference language for choreography is WS-CDL. Service Oriented Computation deals with implementing the core services, and Service Oriented Composition/ Management about managerial tasks (WS-BPEL, WS-CDL), and Service Oriented Communication would relate to message routing (WS-Addressing, WS-Reliable Delivery, etc.).

Service - oriented approach to the design of mobile health applications provides:

• Reduction of time of the project, or the "time to market";
• Increase developer productivity
• Less expensive services integration in the application;
• Increased reuse of services;
• Regardless of the platform, tools and development languages;
• Increased scalability to create mobile applications;
• Improved manageability created applications.

3.2. Application Services for the patient

To build a single, integrated, multi-functional and adaptive application that supports the treatment of diabetic patients, it is recommended to implement following ***patient's services***, which best meet the recommendations of experts in diabetes [2,3]:

▪ Measuring disease indicators at home by connecting some devices (blood glucose meters, insulin pump, etc.) to patient's smartphone or tablet.

▪ Data collection, aggregation and processing with forming doctor's recommendations for proper disease treatment and evaluating changes in the dynamics patient's health status.

▪ Providing health information and patient's actions in emergency situations when he needs consultation or contact with health centers and clinics.

▪ Remote treatment monitoring with help of sensitized glucometer-insulin pumps, equipping them with GPS/GPRS modules.

▪ Integrating into social networking for receiving by a patient comprehensive information on treatment of diabetes and share own expertise in this area.

▪ Synchronizing with a Personalized e- Health Records (PHR), waged by patients and doctors.

▪ Extreme Warning and Emergency Information, when a doctor (and / or ambulance staff) will be immediately informed if vital patient's parameters get close to a dangerous point.

3.3. Application Services for the doctor

To ensure effective communication the patient with the physician it is expected to develop a special application and download it to doctor's smartphone (tablet). it is recommended to implement the following ***treatment services,*** listed below:

▪ Remote monitoring of the patient's status in any place and at any time.

▪ Preparing the Treatment Plan (roadmap) and placing it on the server, taking into account individual feathers of patients and their personal allergy records.

▪ Communicating with a patient and possibility to arrange a personal meeting with the patient at his home or in a medical facility.

▪ Providing medical information about recommendations on the treatment of diabetes and patient's actions in emergency situations.

▪ Using PHR for circulation and accessibility of medical data about the patient.

3.4. Services for server management and running

The functioning of the platform *Mobimed*, including the server, is provided an adequate choice and implementation of following ***management services***:

▪ Accessing to the data of portative diagnostic devices and their transmitting to and storing in a server.

▪ Supporting PHR, filling its fields and read data from PHR.

▪ Service compositing and editing formal description of the treatment process graph.

▪ Transiting from the formal description of the chosen sequence of services composition to the flow of the tasks performed by the application in hand, taking into account the data required for the implementation of individual services (services) and using established protocols and standards information.

▪ Support for the electronic prescription (ePrescription) when patients bay medicines, been prescribed by a doctor, at home through any pharmacy, which will has access to ePrescription.

3. Innovation and implemantation

The proposed *Mobmed* system for supporting the patient and the physician in the treatment of diabetes ***differs from some available mobile applications*** of the similar appointment in the following important features:

1) We are talking about *the specialized system with multiple applications,* which provide the interaction of the doctor and the patient in the treatment process. The basis of this interaction is a personal electronic health record (PHR) , which contains the patient's vital signs recorded with portable devices, that are connected to patient's phone (tablet), patient treatment plan, proposed by a doctor, the results of this plan implementation and changes in the patient's state.

2) Mobile applications for the patient, physician and system management *have a service - oriented architecture* that accelerates the process of creating and making them flexible, served to modernize and adapt to the tasks for supporting individual treatment plans for patients by scaling the services: eliminating some of them, adding new ones, replacing one to the other of the same purpose.

3) *The Repository of services* (relatively simple ready-made programs with a unified interface) is established for patient care (care services), for planning and carrying out of treatment (treatment services) and to ensure the functioning the entire system (management services).

4) Usage o*f mathematical prediction of time series* is proposed for foreseeing the dates of potential crisis of the patient and warning about this his doctor.

5) Based on the recommendations of medical institutions, compiled the list of each type of services, resulting in a proposed mobile applications after the implementation of functionality surpass existing prototypes for the most popular platforms iOS and Android.

6) Depending on particular requirements the *Mobimed* system *can be scaled* from the corporate (national) scale of the care of patients with asthma to the scale of supporting profile patients in a particular region.

It is estimated in the World that thanks to new information technologies the cost of medical care for the elderly can be reduced by 25 % and mortality of chronic patients by 30%. In addition, these technologies will improve the efficiency of healthcare in the countryside, far from the cities where every doctor will be able to serve twice as many patients, and in conditions of the acute shortage of doctors in the periphery it becomes possible to seriously improve health outcomes.

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