Real Time E-health System for Continuous Care

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ABSTRACT - Chronic diseases, such as heart disease, stroke, chronic respiratory disease and diabetes are the leading cause of mortality in the world. In this paper, we introduce a low cost, secure medical platform for mobile and desktop operating systems able to monitor vital parameters and predict a patient's health status. The prediction on a patient's health is made using an effective approach capable of processing big medical data and observing the data flow. The purpose of the system is to keep under control chronic-diseases and to transform the patient's life by assuring them the safety and permanent correct treatment they need. Moreover this system can be easily transformed into a great tool used for patient rehabilitation. Although it can be regarded from many points of view, this paper is oriented towards the system description and components, big data analysis as well as some aspects regarding energy consumption and autonomy.

Keywords – chronic diseases, e-health, immediate response, permanent watch, future prediction, complex rules, cloud storage

1. INTRODUCTION

Taking into consideration the evolution of technology when it comes to the medical world, making life easier for patients is no longer only possible, but also compulsory. Nowadays, we can rely not only on monitoring a patient, but also taking action in the shortest time. Common diseases among the elderly include hypertension, diabetes, heart failure, and other chronic diseases. Patients with these diseases can live normal lives, but they must regularly monitor their conditions. Self-monitoring is a growing trend, and if medical professionals could analyze the supplied physiological information, they could more effectively prevent diseases and disease-related complications [1].

Focusing only on people suffering of chronic diseases, thus on patients who should be permanently supervised, a history of the diseases evolution would be helpful not only for the particular patient, but also for those having similar symptoms. Recent advances in computing technologies including body sensors and wireless communications have revealed the possibility of providing remote health monitoring (RHM) to patients at high risk of falls and with chronic diseases. The body sensors deployed in, on, or around the human body are able to measure the fundamental health parameters in a situation where large sized and standard medical examination equipment are not available; the pervasive use of mobile phones and the ubiquity of Wi-Fi connection enable medical informatics to overcome the time and location barriers [2].

In the WHO European Region report for 2008 is specified that 86% of deaths are attributable to chronic diseases [3]. Most of the past health care system research efforts were focused on sensor networks design like routing, MAC design, and sensor nodes deployment. In those designs, sensor data are transmitted to remote server through access devices. Tasks like sensor data storage, patients' health states determination, and notifications are conducted by a central server while gateway only acts as an intermediate device. The response delay includes network delay and central server delay [4].

Cloud storage is able to avoid data being delayed or useless data to be stored. This is how only relevant information can be kept and how immediate measures can be taken in case of any kind of emergency. More importantly, there is no use of involving hospitals, to find out information that can be easily received by always collecting a patient's data. Next to that, cloud computing simplifies information sharing among various healthcare institutions involved in the care process, which is of utmost importance in healthcare. Healthcare cloud has a great market potential given the fact that less than 7% of the US hospitals have a functional and integrated electronic medical record solution [5].
Although it may seem obvious, the continuous care a chronic disease sufferer needs is often overlooked. Helping them by taking action not only in case of an emergency, but whenever a treatment needs change or receiving information that can lead to something unexpected may turn out to be more important than focusing a doctor's entire energy only on a more severe point in somebody's disease.

This paper is based on a solution that represented Romania to the Imagine Cup Worldwide Final, Sankt Petersburg, 2013 [6].

2. SYSTEM DESCRIPTION

An integrated healthcare system that enables health monitoring and disease management in the home environment has been a major research area for healthcare researchers [7]. Besides being watched over only at home, it is even better to be certain of your health any place and at any time. Moreover, changing the

treatment according to the patient's needs, enables him to be aware of his health state and thus makes him more confident.

This section describes the complex e-health platform, beginning with the physical components, continuing with the software part and in the end the way the entire system works.

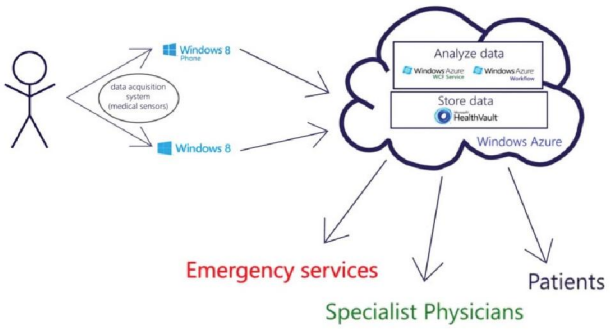

Figure 1. Overview of the system

2.1 Data acquisition system

The physical part of this complex system consists of:

1) *E-health sensor shield* used to monitor in real time the health parameters of a patient. This can be seen as the "center" of the hardware where all the sensors used into our prototype version of the system get engaged in collecting information.
2) *Arduino Module* used for programming the e-health sensors and also used for the power supply of the entire data acquisition system
3) *Sensors* (for example: Pulse and oxygen in blood, airflow, body temperature, electrocardiogram, glucometer, galvanic skin response, blood pressure, patient position)
4) *Bluetooth Module* used to detect and connect to available devices available in the area.

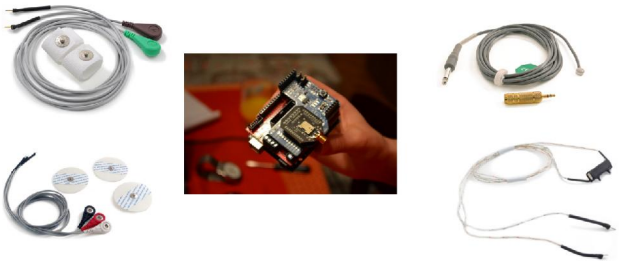

Figure 2. Data acquisition system

According to the patient's diseases and the doctor's recommendations, a certain group of sensors can be used. The sensors shown above have been used only to prove the applicability of the system and a sufferer is able to choose his/her own set of sensors. This particular kit can be found at [8]. Because of high-technology used today in the medical field, there are sensors that can be worn without any discomfort. There are also smartphones that have embedded sensors and that can be used for a medical purpose such as this system.

Modularity and flexibility are two of the relevant characteristics of this system. The first characteristic is proven by the possibility to use a large diversity of data acquisition systems. The platform is considered flexible because of the different types of diseases that can be kept under control.

It is important to have a clear image of the physical components and the way they are connected.

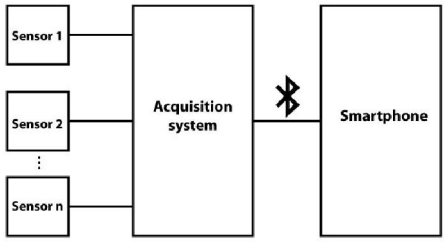

Figure 3. Hardware communication

2.2 Software components

To be able to keep a close connection between physicians and patients, the system offers applications for a variety of devices. These applications are mainly intended for the doctors. Patients can use a simple smartphone application.

1) *Smartphone application – Patient* - collects medical data from the sensors and sends them forward to be analyzed and stored in the cloud; localizes the person in case of an emergency situation; offers a brief preview of the patient's data

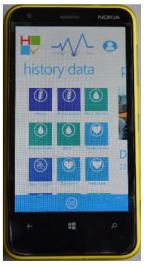

Figure 4. Patient application - screenshot

2) *Smartphone/tablet application – Physician* – enables the doctor to always know the health parameters of any patient under his supervision and receives notifications according to his preset criteria/rules; provides a map to the patient in case of an emergency situation

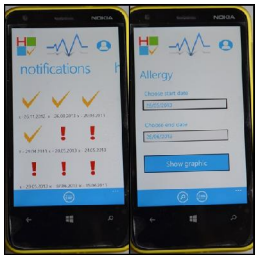

Figure 5. Physician application – screenshot

3) *Desktop application – Physician* – this application creates the environment for the doctor to create complex criteria, individualized for each patient. These rules will trigger notifications if they are exceeded. The interface is user-friendly and the physician can visualize his rules by simply dragging and dropping blocks.

Figure 6. Desktop application – screenshot

4) *Website* – offers a secure way for both patients and physicians to access the data from any public location; this represents a start point for creating a health community.

2.3 Software architecture

For a better visualization for how the system works, we will use the next picture:

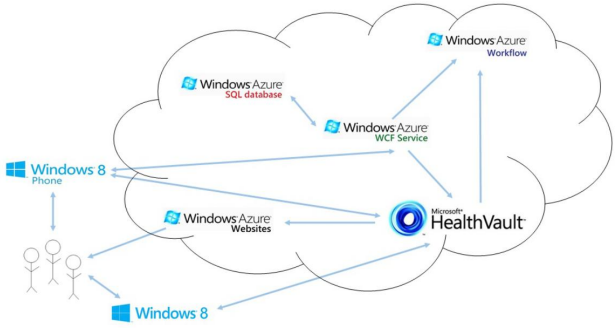

Figure 7. Information flow and Architecture

The medical data is acquired from the sensors worn by the patients via Bluetooth and transmitted to their smartphone, as describe below. From there, the information is forwarded into the cloud where it is analyzed in specific ways.

The main software technologies that assure the security and the performance of the solutions are:

HealthVault – all health information is stored into this safe medical database offered by Microsoft authorized in all E.U. Countries and in the U.S. This offers security for every connection in the system, the patient being the one granting only the rights he wishes to his personal doctors.

WCF (Windows Communication Foundation) Service – represents the middle layer of the system that assures the interaction between client applications, database and data analyzer

Windows Workflows – the technology on top of which is created the data analyzer where physician can create complex rules that are individualized for each patient.

3. SYSTEM DATA FLOW

The software system follows the idea of trading systems that are used on a regular basis by brokers all over the world. They offer efficient prediction with a high level of security. As brokers, the physicians are able to create complex rules in which they can correlate different health parameters.

These criteria set by the doctors can generate two types of notifications. First, there is the General Notification that announces the doctor that certain limits have been exceeded, but nothing urgent has happened. These kinds of notifications may lead to the change of the treatment or may require unplanned medical tests. Secondly, there are the Emergency Notifications that can announce both physicians from the community that are available in the vicinity and the ambulance. To know exactly to whom these notifications must be sent, it is necessary that the system localizes the doctors. In this purpose, the application uses its GPS feature, that also helps know the location of the patient in need. The two points given by the GPS system makes it easy to provide the physician with a map that show the way to the patient. The Emergency Notifications come from any patient and that requires immediate care. When approaching a patient in a delicate situation, the doctor receives a small health profile to know what action to take.

Because the patient has to permanently wear the sensors and data is retrieved in real time, the amount of data that should be collected is huge. Knowing the normal limits of the health information for each category of supervised parameter, there is no use of collecting everything the sensors receive. However, it is relevant to keep the data that show alarming fluctuations and sometimes some changes that are not normal, but that can lead to the discovery of a new disease.

Having the ability to analyze Big Data is of limited value if users cannot understand the analysis. Ultimately, a decision-maker, provided with the result of analysis, has to interpret these results. This interpretation cannot happen in a vacuum. Usually, it involves examining all the assumptions made and retracing the analysis [9]. This is why the physicians have only to supervise their patients and take the right decisions in case of any kind of notifications.

Furthermore, the system presented may help not only patients as individuals, but it can also come in handy for statistics and research projects. In this purpose, by collecting patient's health information with their approval and anonymizing them, they can then be transmitted to those institutions with interest in medical and pharmaceutical research and investigations.

Another direct advantage offered by big data analyzes is the reduction of energy consumption. The system discussed in this paper offers also a level of abstraction in terms of filtering on the smartphone. It is not only aimed for collecting information, but also to be a first step in the data processing flow. In practice, this means a decrease of data transmitted to cloud with an average of 30% - 70%, these percent being found in the energy consumption.

4. CONCLUSIONS

In this paper we have presented a health-platform aimed to improve not only the lives of chronic-disease sufferers. Besides the improvement of the decision-making process based on the personal history of the patient, which is a common feature on monitoring systems, this medical platform assures that the decision is taken at the proper time by continuously analyzing data in real-time. The distinctive element in the current paper is the way in which the data is analyzed based on the complex criteria that the physicians can create.

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