ADMAN: an Alarm-based mobile Diabetes MANagement system for mobile geriatric teams

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Abstract

In this article, we introduce ADMAN an alarm-based diabetes management system for the disposal of Mobile Geriatric Teams MGT. The system aims at providing a form of remote monitoring in order to control the diabetes rate for elder patients. The system is multidimensional in a way that it resides at the patient mobile machine from a side, the doctor's mobile machine from another side and can be connected to any other entity related to the MGT that's handling his case (e.g. dietitian).

1 Introduction

One of the main objectives behind the initiation of Mobile Geriatric Teams is to provide specialized services for elder patients at hospitalization phases and to minimize the number of hospitalization days especially at the recovery phase. Since Mobile Geriatric Teams MGT can follow the patient wherever he is, a special follow up technique usually takes place in order to return patients to their homes or elder centers and monitor their stability with the help of their families or the centre's staff. The Mobile Geriatric Teams then make follow up visits and trace the evolution of each case.

Diabetes [23] is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Hypoglycemia, or raised blood sugar, is a common effect of uncontrolled diabetes and leads to serious damage to many of the body's systems over time, especially the nerves and blood vessels. This is why it is important to keep a good glucose levels.

Not controlling diabetes can also complicate medical cases and influence patient's recovery. Usually diabetic patients need extensive care and daily follow up in order to stabilize the case and ensure recovery. Many works discussed the economic burden of hospitalization costs when other solutions could exist. For instance, the works of [2] introduced a study dedicated to avoid the admission of diabetes patients in UK hospitals, other works like [11] discussed the influence of Mobile Geriatric teams on the length of hospital stay among elder patients.

adfa, p. 1, 2011.

In France, the MGT were the core of many studies, such as [4] that aimed at evaluating the performance of the MGT Service at the Midi Pyrénées region and their efficiency in taking care of elder patients in charge. Other research works like [1] have proposed adaptive accessibility while accessing to information sources during the mobility of the MGT members.

In this paper, we aim to help in solving the remote monitoring problem in another direction where we propose a web-based mobile application that helps doctors in following up with their diabetes patients during the recovery period and that alerts them in emergent cases. The application is multi-dimensional in a way that serves the patient from a side, the medical team from another and other sides whenever needed (dietitian, etc.). The application can be downloaded at the patient side where he, a family member or a personal assistant could enter his daily diabetes rates and at the MGT's side where they could monitor the patient's progress or retreat. Other sides such as family members, care specialists and the dietitian can also have access to the system through their mobiles.

The remainder of this paper is structured as follows: in Section 2, we introduce a state of the art about the interoperability of web services then, we present some examples of web applications and multi-tier systems for diabetes management. In section 3, we describe the architecture of our ADMAN system detailing its database and the functionality of its Web services. Finally, section 5 concludes the paper with brief remarks.

2 State of the art

In this section we will start by highlighting the importance of accomplishing our idea by using an interoperable and powerful tool as the web service. First, we will present the web service, its definition, components and advantages like interoperability. Then, we will preview the different research works that presented services to solve the problem of diabetes monitoring, starting with server based mobile applications and continuing with multi-tier systems that connect the patient with the doctor.

2.1 Interoperability & web services

The increasing number of heterogeneous applications and devices used for communication in the internet claims numerous efforts to improve the interoperability [13]. Interoperability is a key feature enabling the interaction between distributed components. In the domain of healthcare, interoperability is the ability of different information technology systems and software applications to communicate, exchange data, and use the information that has been exchanged [7]. Interoperability means the ability of health information systems to work together within and across organizational boundaries in order to advance the health status of, and the effective delivery of healthcare for, individuals and communities [8].

Web services are a natural consequence of the evolution of the web, they represent one of the best technological solutions that can provide a new assured level of interoperability between different applications [18].

Web Services, at a basic level, can be considered a universal client/server architecture that allows disparate systems to communicate with each other without using proprietary client libraries [15].

"Web Services are self-contained, modular, distributed, dynamic applications that can be described, published, located, or invoked over the network to create products, processes, and supply chains. These applications can be local, distributed, or Web based. Web services are built on top of open standards such as TCP/IP, HTTP, Java, HTML, and XML" [9].

The classical architecture of Web services (c.f. fig. 1) is composed of three entities (provider, user, and registry); the service provider builds the service and publishes its description in a registry [19][24]. The user needs are translated into queries that are carried on by the Web Services registry [21]. Once the service is found, the user will obtain direct interaction with the service [12].

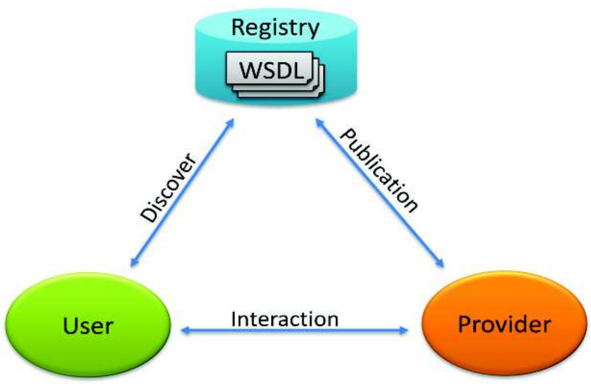

Fig. 1. The Classical Architecture of Web Services

Many research works studied Web services and based their works on their classic architecture such as [10] [20]. Also, in the healthcare area, several works used web service technology in order to solve specific problems such as in [14] that proposed an approach based on Web service technology to solve the heterogeneity of data problems within healthcare information systems.

[17] described a Web service middleware-based framework that supports the interoperable information needs of healthcare organizations.

Another example is presented in [3] who proposed a modeling process for medical e-service.

The interoperability ensured by the Web service is the principal reason that motivated us to use it in our system.

Now, after introducing web services and their capabilities of interoperability, we'll present some of the web applications that were introduced in previous research works for monitoring diabetes from the patient side.

2.2 Mobile Applications for Diabetes Management

With the evolution of mobile health, nowadays, we can find more than 1,000 iOS and Android applications listed on the Apple App Store and Google Play. These applications are specifically designed for diabetes patients or for healthcare professionals treating diabetes.

Through an analytical study, we have followed examples of the evolution of mobile diabetes management software, the first type of mobile applications dedicated for diabetes is concerned in tracking the diabetes measurements through time in order to improve the patient's consciousness and self-management of diabetes glucose readings.

Glucose Buddy [6] is an example of these applications where it allows users to manually enter their glucose measurements, carbohydrate consumption, insulin dosages, and other activities. The system allows entering contextual information related to the measurement time (e.g. before breakfast, after breakfast, etc.).

iGBStar [25] is another example of diabetes management applications that is connected with a hardware solution, where you can connect your mobile to the blood glucose meter and the application makes it easier to collect, view, share blood glucose readings and store their values.

Glooko [7] is another mobile, cloud based diabetes management system that serves patients by seamlessly, easily and quickly downloading blood glucose readings into their mobile devices and accounts. It Saves time and eliminates errors from manual entry.

We have noticed that the presented examples were mainly interested in monitoring diabetes at the patient side for enhancing the patient's self control. These systems have taken into consideration the patient and his diabetes level's evolution but they haven't classified them or connected them in a seamless way with the doctor or any other specialist (e.g. dietitian). Also, these systems didn't consider cases and scenarios where a family member could be interested to be connected and alarmed in the cases of Hypoglycemia or severe insulin increase.

Next, we'll present some of the systems dedicated for connecting the patient results with the doctor in order to ensure diabetes rate monitoring.

2.3 Multi-tier systems for Diabetes Management

In this section, we overview another type of systems for diabetes management that were present in the literature. Their objective is to share the glucose blood readings with the doctor and healthcare professionals in order to enable him to monitor the patient case remotely.

The works of [20] have proposed a Patient monitoring framework that is dedicated for the assistance of diabetes patients. They present a module-based application, divided in 2 main parts, the specialist and the patient. The platform provides statistics created to offer the doctor the progress of each patient and suggestions, in charge of giving the doctor some pieces of advice based on the statistics of the patient.

The application at the patient's side enables communications, diet enhancements and suggestions. The suggestion module lays on the diet module to present suggestions about beneficial food.

The works of [16] have presented a pervasive healthcare platform for diabetes management and that employs sensors for monitoring the patient's heart rate and physical activity. The main goal of the system is to empower patients to manage their life style with respect to diet and exercise hence lowering their risk factors for metabolic syndrome, and to enable physicians to be more effective in helping their patients reach their goals.

The prementioned works have connected the patient results to the doctor using conventional internet applications. Knowing that nowadays, people mostly interact using their mobile devices and that these applications did not adapt with the mobility of the Mobile Geriatric Teams, we have proposed a mobile application that aims at monitoring the patient's diabetes rates remotely by the doctor or specialist.

3 Contribution

In this part, we will start by detailing the architecture of our system ADMAN then, we will describe the components of the ADMAN xml database and finally, we will explain the functionalities of the ADMAN web services.

3.1 Architecture of our application ADMAN

In this section, we will present our system architecture (see fig. 2) that aims to ensure that each measured insulin result is connected between the MGT and the patient.

Our architecture is composed of three main entities:

- Patient: This entity is an elder patient who needs to be taken care of either by a family member or an assistant. The surrounding environment of the patient is important; it helps the family member or nurse to deliver his insulin measurements by using the diabetes measurement machine and his mobile device that contains our ADMAN application.
- Services: this entity is the core of our system. It is responsible for all the computational activities needed to be done in order to connect between the patient and the MGT in a real time basis. The service can analyze the measured results and sort them within predefined rates in order to judge the condition of the patient (hypoglycemia, normal, severe increase).
- MGT: this entity contains the Mobile Geriatric Team that is composed of a secretary, nurse, nursing assistant and physician (generalist or specialist). In our case, the system is mainly interested in being downloaded to the doctor's machine and could also be downloaded to external parties (e.g the dietitian's machine and any other family member that is interested to monitor the patient's case).

The functionality within our architecture goes as follows:

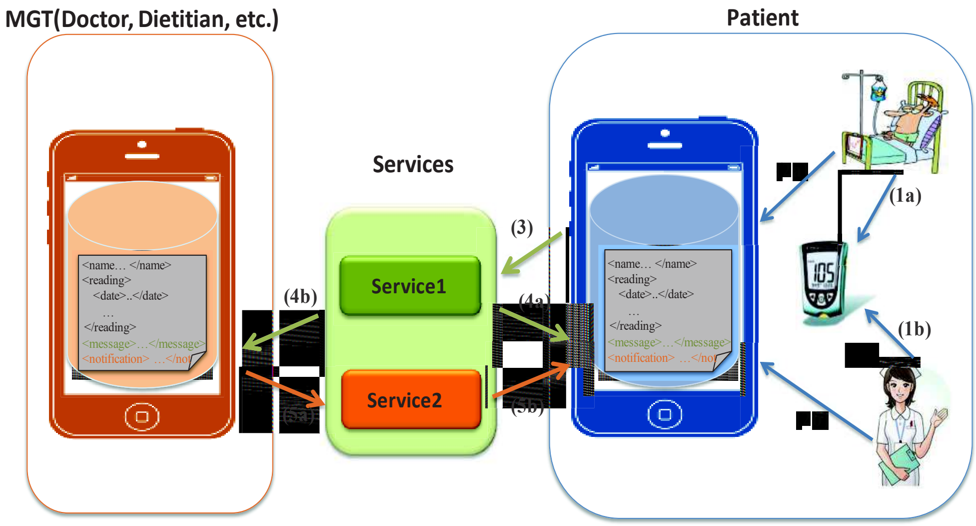

Fig. 2. ADMAN Architecture

(1) As the patient wakes up, he should measure his diabetes rate (1a), this measurement can also be taken by a family member or an assistant (1b).
(2) The rate value is then explicitly inserted to our system by the patient (2a) or by the care specialist or any family member (2b). In an advanced scenario, this rate will be implicitly inserted from the machine.
(3) The measured rate will be transferred to an xml database (c.f. fig. 3). The file contains the reading information for each patient, for more details, see section 3.2.
(4) The transferred results will be uploaded to the web service (Service1) in order to be shared with the doctor's machine (3).
(5) This web service is a black box that takes the measured rate and compares it with different intervals (c.f. fig 4 and section 3.3 for the algorithm) in order to return a textual value that describes the patient's status. The returned value is shared with both sides (4a, 4b) (the doctor and the patient who will view the analysis of the measured result). For more details, see paragraph 3.3
(6) Our first web service will enable both sides to view other analytical reports of the calculated values over time (weekly report, monthly report and a 3 months report).
(7) In the case of Hypoglycemia or severe insulin rate, the doctor and patient will receive push notifications to alarm them for the danger of the case; this alarm will be placed in the message area (4a, 4b).

(8) After receiving the alarm, the Mobile Geriatric Team would make the appropriate action and contact the patient through a notification (5a, 5b) this aims at dealing with the patient's case.

3.2 The ADMAN Database

As shown in fig. 2, the database that our ADMAN system employs is an xml database [26] which is interoperable and light in size. This file contains information about the patient such as his name, reading (date, time and value), massage and notification.

- The first element (name) is the account name of the patient.
- The second element represents the glucose measurement (reading) that the user enters its value explicitly; the system enters the date and time implicitly.
- The third element is the (message) which is filled by the web service side.
- The forth element is the (notification), which is inserted to the system by the Geriatric Team specialist.

```
<patient id = “”>
    <name> … </name>
    <reading>
        <date> … </date>
        <time>  …</time>
        <value> … </value>
    </reading>
    <message alarm = “”> … </message>
    <notification>  … </notification>
</ patient >
```

Fig. 3. XML File of the ADMAN database

The database existing at the patient's side will be also residing at the Mobile Geriatric Team's side, the MGT will eventually manage different accounts for different patients.

3.3 Web Services Functionality

Our ADMAN system depends on 2 web services that have different functionalities:

Service1: It analyzes the measured results. This service will take the measured insulin value as input and will compare it to a group of values in order to output the rating of this result. For more details, see fig. 4 that features the algorithm of rating the measured insulin value.

This service will also pass a message containing the analyzed measured result to both sides the MGT and the patient. Finally, this service will also alarm the MGT and the patient in extreme cases.

```
Input:  value   // value is the Value of diabetes
IF {value <60}
THEN
Result ←  “Hypoglycemia”;
ELSIF {value >60 AND VALUE < 99]}
THEN
Result  ←  “Normal”;
ELSIF {value >100 AND VALUE < 125]}
THEN
Result  ←  “Disturbed value”;
ELSIF {value >126 AND VALUE < 140}
THEN
Result  ←  “Mild increase”;
ELSIF {value >141 AND VALUE < 200}
THEN
Result  ←  “Moderate Increase”;
ELSIF {value >200 }
THEN
Result  ← “ Severe Increase”;
Endif
Return Result ;
IF {Result  = “Hypoglycemia”    or  Result =“ Severe Increase”    }
THEN
Alarm = on;
Endif
```

Fig. 4. Algorithm for analyzing the patient’s diabetes measurements.

Service2: In case of extreme cases, it will pass a message (notification) from the doctor to the patient to help him to react.

4 Use Case

Taking the example of the patient “John Smith” who’s aged 75 years and who’s recovering from hospitalization. A nurse will be passing by him on a daily basis in order to check up his insulin rate measurements and to do some other checkups.

Our application is downloaded on different machines related to different people who are interested in following up the patient’s case (Doctor, dietitian, family member).

On the first day, the nurse measures the patient’s diabetes rate. Supposing that the inserted measurement of his insulin value is equal to ***90***, then the ADMAN’s web service will rate it as a ***normal value*** and will include this result within the xml file that is sent to both sides.

On the second day, the insulin value turned out to be equal to ***57***, then the ADMAN's web service will rate it as a ***Hypoglycemia*** and will send this result and an alarm to the different entities related to the patient.

Here, the doctor will order the nurse to give the patient some sugar and tell her to re-measure the diabetes rate after 15 minutes. Also, he might think of rescheduling the insulin dose taken by the patient. The dietitian can then take an action and send a notification including some directions to the patient. The family member would call in order to check up on his case.

Any action taken can be included within the notification tag of our database. Fig 5 shows an example of a filled xml file coming from the doctor's side and the dietitian side and that is being received by the patient and other users.

This way, the notes taken from this experience would be shared with the family member who will make sure that they will be applied.

```
<patient id = “777”>
      <name> John Smith </name>
      <reading>
            <date> 2015-04-14 </date>
            <time> 08:00:00</time>
            <value> 57 </value>
      </reading>
      <message alarm = “on”> “Hypoglycemia” </message>
      <notification id = “1”> “Please take some sugar and re-measure the diabetes
                               rate after 15 minutes, Please take a lower dose of
                               insulin at night” </notification>
      <notification id =  “2”> “Please make sure that you eat some carbohydrates at
                                dinner ” </notification>
</ patient >
```

Fig. 5. An XML file completed by our ADMAN service.

5 Conclusion

Many systems were proposed to encounter the challenge of diabetes monitoring but none of these systems considered to channel the doctor with the patient in the form of a simple mobile application. In this paper, we have presented the ADMAN system that helps the mobile Geriatric Team members to remotely monitor the daily insulin measurements for diabetic patients. Our objective is to minimize the hospitalization period for elder people while providing them with distant medical surveillance. Our system will also help patients to optimize their self-control and monitor themselves.

One of the limits to the success of our systems is the accuracy of the measured result taken from the machine (normally the MGT depends on values checked up at the hospital).

In future works, our system will take into consideration that different doctors can treat the same patient. Another perspective is taking into consideration the user profile and his medical doses in order to automatically measure the insulin doses to be taken after each measurement.

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