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Providing a Telemedicine system for Diabetic Patients for Controlling the Blood Sugar Level with solving the Scalability problems

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Abstract*— *One of the diseases in which patients need intensive care and supervision is Diabetes and controlling the bold sugar level. In this paper, a telemedicine system is proposed to be used by diabetic patients for caring themselves, by which the patient may supervise and control his blood sugar level by his mobile phone. In this paper, first we would describe the system and compare its capabilities with common treatment methods and previous telemedicine systems. Then we would review one of the fundamental issues in telemedicine which is scalability, which is not usually mentioned in telemedicine systems and which may be solved by a general architecture of grid.

Keywords—*Telemedicine,Mobilephone,Internet,patient*

I. Introduction

Ormationanddevelopment ofurbanizationphenomena, changes dietarypatterns and reduction of proper movement and physical activity have created favorable conditions for increasing the blood sugar level and having diabetes. Problem in body's fuel system which is due to lack of Insulin is called "Diabetes". Insulin is the hormone, which is produced by Pancreas, the digestive enzyme producing organ, and it is vital for energy absorption of nutrients.

Different types of diabetes are:

- Insulin-dependent diabetes or Type 1: in this type of disease, either the patient's body produces a little amount of insulin or doesn't produce insulin at all or due to lack of insulin, it is impossible to control the blood sugar level. Usually this type of diabetes happens before age of 40 and the peak of its incidence is at about age of 14.
- Insulin-independent diabetes or Type 2: in this type, the pancreas produces insulin but not that much to control the blood sugar level and on the other hand the body cells resist against insulin. This type usually appears in people above 40.
- Diabetes in pregnancy: Gestational diabetesusually appears between weeks of 24 and 28 of pregnancy and generally disappears after the childbirth. Since in all types of diabetes, the sugar level or glucose of blood increases, symptoms and results of all of them are the same.

Diabetes type 1, cause the complete destruction of insulin-producing beta cells in pancreas. If not treated, the lack of insulin leads to large increase of blood sugar level which may cause many complications in long term and cause destruction of body organs. The appearance of these complications may be postponed or decreased by continuous insulin therapy. In fact, the treatment of this disease is through daily and frequent measuring of blood sugar level and at least 3 times injection of insulin (or using insulin pump) in order to keep the blood sugar level in the allowed range. Anyway, this treatment method may cause Hypoglycemia. Hypoglycemia or low blood sugar is the most important problem happening in diabetes and it often occurs due to treatment by insulin. Hypoglycemia means blood sugar is less than 80 milligrams in deciliter or blood sugar is 90 milligrams in deciliter with symptoms such as increase of heart beat, hunger, dizziness, vibration, anxiety and nervous moods, perspiration, drowsiness, confusion and difficulty in speaking.

The main causes of Hypoglycemia are:

- High dose injection of insulin or consuming blood sugar-lowering medication such as Sulfonylureas and other medications such as thiazolidinedione may cause hypoglycemia while consuming with other medications.
- Increase in physical activity or exercising
- Delaying food eating or elimination of meals
- Consuming low volume meals
- Severe consume of Alcohol

So, it is required that insulin diet, injection amount and time must be set accurately. In the common treatment method , the patient usually measures the blood sugar level by a glucometer and writes the result with other details such as daily blood sugar level measurement results and current treatment , body weight , number of insulin injection , blood pressure and other items which may be effective on the blood sugar level in a notebook . then , the patient would show his notebook to the doctor every three months and the doctor , after reviewing , would give necessary recommendation about amount of insulin for injection and other issues to the patient. This method has some deficiencies (weak points), any kind of significant change in data, such as capacity of having hypoglycemia during the night, may not be identified until 3 months. In addition, the patient may manipulate the recorded blood sugar level, in order to show that he has achieved a better control in blood sugar adjustment. In fact the patient's notes may not be accurate, it may be possible that the patient's notes to be destructed due to neglect.

These problems caused the telemedicine systems to be designed to help diabetic patients in managing themselves. These systems include electronic record of patient status, and systems which automatically measures the blood sugar level by Glucometer and saves it.Direct contact of body with glucometer deviceand automatic recording of blood sugar level prevent the

mistakes happened in common method by patients in recording the data or manipulation of data. These devices are able to measure the glucose continuously and save them. This device is consisted of a sensor and a small monitor. The sensor is places beneath the skin by a needle and measures the between tissue glucose. After 72 hours, the data may be transferred to a computer and observe the fluctuations of blood sugar during past few days as a diagram. Constant measuring of blood sugar enables the patient and the doctor to closely observe the effect of insulin, exercise, food, medication and other factors. These information may be used for adjusting the dose of insulin or medication according to the consumption of different foods as well as correcting high or low blood sugar in some hours of day which it is not possible to measure the blood sugar by the patient (such as during the sleep).

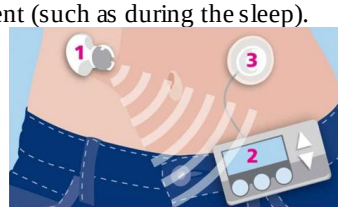

Figure1. blood sugar measuring device

some of the more developed devices the blood sugar level will be measured and the daily information would be sent to a central server for doctor observation. It must be noted that if the data is being sent for the doctor repeatedly, we must ensure that the data is up to date and not being repeated. Anyway the best way is that patient has no interference in data transfer, since if the responsibility of connecting the patient's system to the server is upon the patient, the updating of information may not be done regularly. In another word, since the connection of device to server for data transfer is upon the patient, this connection may not be done regularly by the patient because of inattention or other reasons. In the past the available technology for transfer such as ordinary modems in which the start of data transfer was by the user, were used.

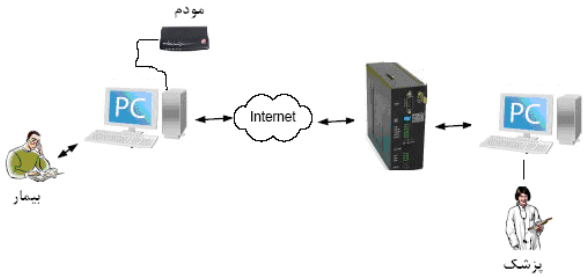

Figure2. Mobile Telemedicine system for Diabetic Patients for Measuring the Blood Sugar Level and with ability to be transferred by the patient

In comparison with previous systems which used fixed line modems for data transfer, we propose a method for direct transfer of data from blood sugar measuring device and daily recorded information which uses one of wireless transfer technologies, GPRS. In this method the patient doesn't have to type the blood sugar amount manually or do anything for regularly connecting to the server. By using a mobile phone, the doctor may easily contact the patient by sending a SMS or a voice call. Since this system is placed in a mobile phone, it is very light and easy and the patient may carry it easily.

II. system Details

II.I GPRS

GPRS is an added value service in second generation of mobile phones which provides the ability to send and receive information or data over the mobile phone network. For using this technology, we must have a PDA or a mobile phone which supports this service and the operator which is able to provide this service must be available. This public service is radio packets which in fact are the completion of circuit switching information.

In general, this service has 3 advantages:

1- It enables us to be connected to Internet constantly and it not required to connect to the ISP every time.
2- This service has a higher speed than the normal data communication lines in mobile. The normal mobile lines has the maximum speed of 9.6 kBit/sec and they can use the maximum speed of 14.4 Kbit/sec. but GPRS may easily connect us with speed of 40Kbit/sec to internet which has a speed 4 times than the speed of normal mobile data lines.
3- You pay the amount of communication according to the amount of information being sent and received to the operator not the duration of connection to internet.

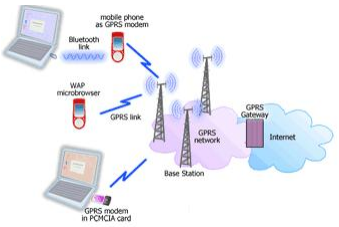

Figure3. Structure of GPS Telecommunication System

The blood sugar measuring devices are extensively available same as figure 4.

Figure 4. blood sugar measuring device

This device may easily be installed in a mobile phone which is able to transmit the data by GPRS service. Before measuring the blood sugar, the patient must connect a cable between the blood sugar measuring device and the mobile phone. The software installed in the mobile phone reads the data from the measuring device and save in the device, then guide the patient by asking some questions about way of living and general health with diet and physical activities. Then the data and daily notes are immediately transferred by GPRS service to a server, as shown in fig. 5.

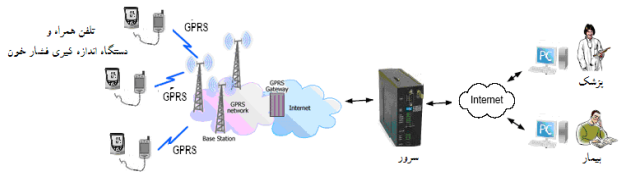

Figure5: the method of data transmission in diabetic patients' automatic management system.

The mobile phone transmits the data from the blood sugar measuring device with the information the patient has noted during the day to the server. Then the information may be observed by the doctor or the patient by a browser.

The mobile phone software displays a chart of patient's blood sugar amount in which the blood sugar allowed range determined by the doctor is specified. This chart is the continuation of the charts from data of previous week. The data are taken two times in a day, morning and afternoon and recorded in the chart. The chart includes two main parts , one the exact amount of measured blood sugar and the other one the amount of decrease or increase in blood sugar which are all extractable from the chart. This simple feature of the chart enables all patients even those who have little literacy to follow the chart and monitor the intensity of decrease or increase of blood sugar during the week and then according to them do necessary actions.

Secure web pages enable doctors and patients to observe the patients data by using a browser through a computer connected to Internet. The patients may also write extra comments on these pages and send them for the doctor. The doctor may send a SMS or contact the patient to inform him that he has received the information. They may also change or set the range of labels on the chart shown in the mobile phone. Meanwhile the doctor's monitor enables him to view the information in different shapes such as a list of raw data, a collection of charts or a summary of patient's blood sugar during the day , as shown in figure 6.

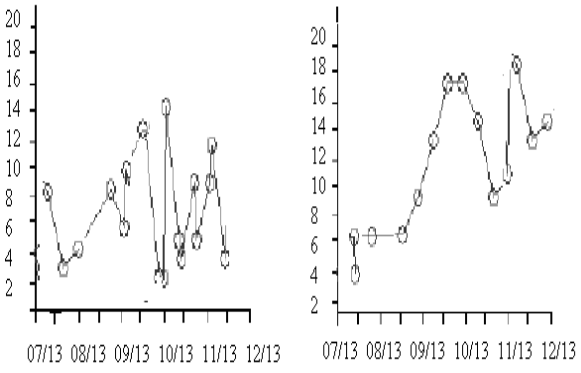

Figure6. a sample of information shown in doctor's monitor

The blood sugar read, would be categorized according to the time of measuring during the day. In another way of displaying the read data, it is according to the patient's daily notes such as insulin amount, diet and exercise.

The software installed on the patient's mobile phone enables the patient to send the information easily through GPRS service on the mobile phone network and without patient's visiting, which is more optimized than the previous telemedicine system considering speed and time loss.

III. Scalability of proposed system

According to researches, a little number of people who live in villages has proper access to medical news and special cares. One of the goals of telemedicine is to provide and deliver remote medical information and special services to distant places which helps a lot in this regard. The new progresses in the field of developing technologies with large bandwidth for using in mobile telephone, have led to simplification of access to information anywhere and anytime and developing new dimensions in telemedicine. Thus unlike most of telemedicine systems, it is not required that the doctor to be present in the hospital for a long time.

One of the properties of the telemedicine system is its extent of use or coverage range or scalability. In the studies done on the telemedicine so far, the scalability was not considered much. While this issue is very vital if we want to expand the application range of telemedicine in the future.

III.I Obstacles in scalability

With increase of telemedicine units, the center in the central hospital may become a neck point for the system. Thus, it is probable that we want some specialist to consult in several centers in hospitals, thus we have to extend the system in large scale for hospitals cooperation across the country. Usually, in telemedicine architecture, the specialists have to attend in the hospital center while receiving the data. While sending the consult for patients in the minimum time is an important issue. Anyway, there is this limitation that with increasing requests, the access to professionals may not be possible in the center.

One of the solutions for solving scalability issue of telemedicine systems is using processing of distributed data and saving them. One solution that may be used for realization of this issue is using Grid computing theory which may be done by implementing a Grid network. Although there are other ways managing the distribution of diabetic data, but using Grid architecture is more appropriate because of being public. In this way the data and other sensors may be combined easily with other diabetic data, for example using a location information service in this system enables us to locate the patients which have severe hypoglycemia and have attacks in the minimum time. The GPRS telephone interface mentioned above may be considered as an interface for Grid network. This mobile phone service may be used for monitoring and controlling wider range of diabetic patients which have other diseases such as Asthma and high blood pressure, in which self-management of patients will be optimized by increase of interaction between the patient and the doctor and providing more data of the patients status.

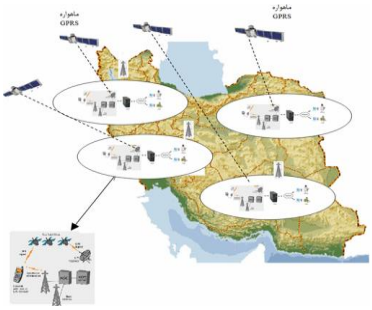

Figure7.scalability of proposed telemedicine system for controlling the blood sugar level of diabetics patients

IV. Conclusion

A telemedicine system for diabetic patients for caring themselves must be capable of safe and on time delivery of data to the doctor. It must also be portable and appropriate, so that the patient would be eager to use it. The system presented in this paper which works based on the mobile phone GPRS service may provide all the mentioned advantages of a telemedicine system for diabetic patients with a low price.

One of the important properties of this system is by automatic process of data; the doctor would be assisted in the final decision. The measuring of blood sugar control may be extended in a way that it would be done instantaneously as soon as the data is received, so that the smallest changes would be informed to the doctor in minimum time.

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