Abstract—M-health system has been defined as combination of “mobile computing, medical sensor, and communications technologies” for health-care. As a mature short-range wireless technology, Bluetooth has been used in healthcare areas to improve the flexibility for patients, medical doctors or nurses to access the health service. This paper addresses the Bluetooth connectivity issues on a specific implementation of a mobile diabetes management system.

Key words: Bluetooth, profile, m-Health, telemedicine, data acquisition

1. INTRODUCTION

M-health system has been defined as combination of “mobile computing, medical sensor, and communications technologies” for health-care [1]. A diabetes m-health application may provide diabetics and medical personnel a closer link without consideration of their locations with the fact that large amount of people suffering diabetes and a huge spending from health care providers on diabetes and its complications. Diabetes can not be cured till now, but researches have shown a tight management can reduce diabetes complications and give diabetics an easier and longer life [2] [3] [4].

According to the data obtained, the diabetes management system could make an appropriate medical decision to specific diabetics. Therefore, one essential element of diabetes management system is to collect adequate information from diabetics. In this paper the Bluetooth connectivity issues of a data acquisition system in Mobile Diabetes Management Internetworking System (MDMIS) was presented. This data acquisition system provides diabetics a wireless, automatic and intelligent data collection, consequently with an instant support to keep the patient aware his/her disease status and updated medical suggestions.

2. Mobile Diabetes Management Internetworking System

The MDMIS system aims to improve diabetes control by providing a portable, secure and universal access to diabetes management service for both diabetics and medical care suppliers. The MDMIS consists of a medical control centre, patient stations, physician stations, medical administration stations, and system maintenance stations.

- A patient station is a computing device for a patient to transmit measurements to the medical control centre, browse or analysis his/her own health status with the aid of tools the MDMIS provided. In addition, it can get medication instructions from medical control centre, a physician or a medical administrator.

- A physician station is for a physician to browse, analysis patients’ current health situation, and give medical suggestions to a specific patient. A physician can also manage patients’ account information.

- A medical administration station is for a medical administrator to edit medication rules and medicine records. Moreover, a medical administrator can monitor the general physician’s operation and give a new appropriate medical suggestion.

- A system maintenance station is for a system maintainer to do maintain work, such as check the user operations records, maintain the users account, edit general address, occupation information etc.

- The medical control centre includes a master station and a medical database. The medical database stores users account information, medication rules, and patients’ records. The master station accepts remote or local stations’ request, processes data and provides intelligent data analysis tools for the other stations.

By applying emerging wireless technology, MDMIS is able to provide the users a roaming environment to
access medical services. The system architecture for MDMIS is shown as in Figure 1.

![Figure 1. System architecture of MDMIS](image)

3. DATA ACQUISITION IN MDMIS

Similar as other m-health applications, the measurements records are very important for the afterward data analysis. Hence, a convenient data acquisition system is vital for the MDMIS system. As we know, the traditional paper recording work has several shortcomings: first, patients must read the data from meter and these data will then be written to the database eventually. This brings the possibility of mistakes during these readings; second, besides the papers consuming for recording, it is a time consuming work for users to read and write, reread and rewrite to the medical database for data analysis. Lastly, it brings inconvenience for patients while the mature wireless computing technologies have been available.

Therefore, a short-range wireless technology has been introduced in MDMIS. Bluetooth was chosen for this application because of its lower power consumption and extensive choices of Bluetooth chips and products.

3.1. Requirement analysis

After the diabetics measured his/her blood glucose level, the records can be sent out to the medical control centre for further storage and data analysis. In this scenario, a blood glucose meter is local with the patient while the medical control centre is remote.

3.2. Methodology of Bluetooth connectivity

It is not ideal for a glucose meter to send data directly to the medical centre because generally there is the limited computing capability of medical sensors. However, with the consideration of high availability of Bluetooth mobile phones and its powerful computing ability, a mobile phone is chosen as the middle data relay in this case.

To make the devices easier to interoperate, the concept of Bluetooth profile is introduced. A Bluetooth profile specifies the minimum requirements that the Bluetooth device must support for a specific usage scenario. So the Bluetooth device following the profile can interoperate with peer devices. Some profiles define the core requirements for Bluetooth devices and are available by default. Other profiles define the least requirements for the Bluetooth devices to support particular applications [5].

In this development scenario, SPP (Serial Port Profile) was selected since many existing commercial glucose meters have a serial communication interface and large amount of Bluetooth devices support SPP profiles. SPP profile defines the requirements for Bluetooth devices necessary for setting up emulated serial cable connections using RFCOMM between two peer devices [6].

In our research, Sony Ericsson P800 has been chosen as the data acquisition platform, MediSense Optium was chosen as the glucose meter, ConnectBlue cB-SPA32i as the Bluetooth adapter. Figure 2 shows an integrated Bluetooth glucose meter.

![Figure 2. Integrated Bluetooth glucose meter.](image)

3.3. Data process

There are several stages for the connectivity between a glucose meter and a mobile phone via Bluetooth communication channel. The mobile phone is the active party to call data from the glucose meter:

- Search and identify the relative Bluetooth glucose meter. The data acquisition software will search all the available Bluetooth devices at first time. The user then can specify the desired device to identify which data device to be connected. The Bluetooth address will be saved locally within the Bluetooth device after a successful pairing. Afterwards, it is not necessary for the user to identify the medical sensor again and the software will directly go to the search and connection process.
- Build Bluetooth connection channel. This means the data acquisition software has found the specific
Bluetooth sensor, and try to build the communication tunnel for data transmit.

- Reading data. As soon as the Bluetooth communication tunnel is built, the data acquisition software will send command to inform the glucose meter to send data. If it is a legal command, the meter will be ready to send the measurement records.

- Close the Bluetooth connection. When the data acquisition software receives indication of the end of data transmit, the software will close the Bluetooth link to save energy.

After the measurement from the meter is received, there still need the following process:

- Initial data processing. The data will be processed before being sent to the medical control centre. The reasons are: (1) filtering the useless data since not all the data received are for the measurement; (2) first-hand data analysis. The software will tell user immediately that the measurement is too high or too low accord the predefined medical rules; (3) uniform the format of data to be sent to the medical centre to alleviate the load of the master station.

- Send data to the medical control centre. The software will initiate the GPRS or 3G connection to send data through Internet to the medical centre.

- The master station sends the analysis result and possible medication change to the patient station.

4. RESULT

The whole MDMIS system has been implemented and assessed within the university. Current work is on clinical trial in a NHS hospital. Here are some results from the test. Figure 3 shows the data acquisition software was closing the Bluetooth connection after a data call. Figure 4 shows the data collected from the glucose meter. Figure 5 shows the data was sent to the medical centre and the indications from the master station to the patient.

5. DISCUSSION&CONCLUSIONS

A Bluetooth connection form mobile diabetes management system has been successfully built. This can be the foundation stone and feasibility research for a real commercial Bluetooth glucose meter. Based on same theory, other Bluetooth medical sensors can be made to enhance the chronic disease management research. Currently our work is doing a real embedded Bluetooth meter and implementing a clinical trial with a NHS hospital.

ACKNOWLEDGMENT

The authors would like to thank Orange UK for their support to this research.

REFERENCES


