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An Interactive Health Caregivers System for Diabetic Patients

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Abstract. To reinforce the mutual healthcare communication between diabetic patients and caregivers, we designed and implemented a novel Interactive Health Caregivers System (IHCS) with push-pull operations. This system is expected to improve the self-care quality of diabetic patients. IHCS located in a GPRS environment could establish the mutual communication between medical communication medical devices and caregivers, thereby creating a healthcare system based on push-pull operations. This study adopted the push-pull technique for controlling signals, actively turning on medical devices, and performing mobile healthcare functions that are authorized by users. This system, with numerous enhanced functions specifically designed for healthcare purposes, could respond to many emergent scenarios. The proposed IHCS was built by making use of existing medical devices (e.g., GPRS blood glucose meter) and coupled with the integration with cloud platforms and telecare Android apps.

Keywords: mutual communication, interactive health caregivers system, self-care, diabetic.

1. Introduction

Aging societies and onset of chronic disease at younger ages are getting important social issues. The latest survey published by the International Diabetes Foundation indicates that diabetes has become one of the most threatening of these chronic diseases [1]. Diabetes is currently an incurable and chronic disease that requires long-term healthcare, and demands that patients control their blood glucose within a normal range through diet control, exercise, and medication. Loss of control not only results in chronic complications (e.g., blindness or stroke), but can also lead to immediate danger. Therefore, the world is facing a critical issue: to lower or defer incidence rates of chronic disease and to solve issues related to long-term care. Numerous studies have indicated that behaviour change is the most effective precaution and self-care method for chronic patients [2-4]. Although patient behaviour changes seem to be very personal, family caregivers' acknowledgement of patients' positive behaviour changes could effectively enhance the quality of patient self-care. Therefore, we design and implement a prototype of an IHCS for diabetic patients and caregivers to increase self-care quality by adoption of the Message Queue Telemetry Transport (MQTT) technology. IHCS can show patient's current information to their caregiver, such as patient's current measurements information, status, etc.

2. Background

Research has suggested that long-term blood glucose control is an effective method to reduce and defer chronic complications of diabetes. Thus, most diabetic patients monitor their blood glucose concentrations by themselves using medical devices. With development of mobile applications being highly competitive, many researchers adopt existing internet communication technologies, such as Bluetooth and wireless local area networks (WLAN), to propose healthcare systems [5-7]. These systems improve convenience and lower

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recording errors. However, since existing internet communication technologies are still restricted by distance and location, most existing healthcare monitoring systems only provide one-way transmission of simple measurement data that is uploaded and recorded for follow-up visits and lab analysis. In the last few years, researchers and developers have applied push and pull technology in various systems [8, 9]. But these systems only use message transmission technology to access server databases. When the patient gets an abnormal measurement, their caregiver cannot immediately get the state of patients.

This study proposes use of MQTT technology to establish an interactive health caregivers system, let the family caregiver of the diabetic patients can get near real time information on patients' health conditions. The MQTT technology is an Internet of Things (IoT) lightweight messaging protocol for sensors and mobile devices. It can receive real time information feeds from mobile devices. Since using the MQTT technology can allow direct communications between patients and their caregivers via mobile devices, the proposed system can track patient status and confirm whether telecare messages have been reviewed. Medical devices and mobile phones with MQTT technology enabled can then communicate via IHCS. After patients measure their physiological parameters, IHCS notifies caregivers of any abnormal situation. When the patient gets abnormal blood sugar value, the IHCS will immediately notify their caregivers, to remind caregivers concern the patient. Thereby promoting the positive behaviour change of the patient.

3. Materials and Methods

3.1. Mobile Devices

Recently, numerous concepts have been proposed that adopt mobile medical devices for delivery of medical and wellness-related services. However, these new concepts often require long-term validation and verification to realize their full potential. To avoid these restrictions, the IHCS proposed by this study was designed and implemented using GPRS BGM equipment that complies with ISO 15197, the Health Insurance Portability and Accountability Act as well as 256-bit encryption. With a GPRS blood glucose meter, the IHCS collects patients' blood glucose data, and uploads it to a cloud server via GPRS. Subsequently, the data is analyzed by the IHCS and sent back to the patients, or in a scenario where a patient's health condition is critical, the IHCS will notify selected family caregivers.

The GPRS BGM equipment included in the IHCS is an Android-based mutual communication medical device. Upon authorization of the patient, blood glucose measurements are uploaded to the server automatically, the BGM equipment receives related responses sent from the server. Moreover, IHCS also supports Android telecare smartphone apps.

3.2. IHCS Architecture

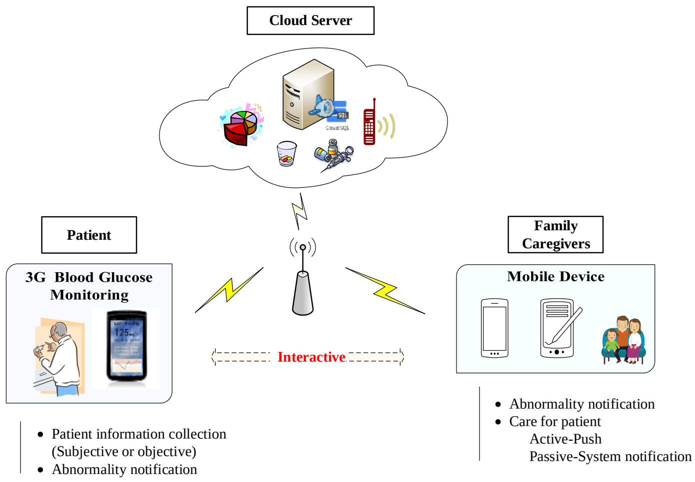

Fig. 1: The IHCS architecture.

As shown in Fig. 1, the IHCS consists of three platforms: GPRS BGM equipment for patients, a cloud server platform that integrates the main functions and a telecare Android app for caregivers. The Google App

Engine (GAE) cloud server is the core of the IHCS. It stores demographic data of patients, data and permissions of authorized family caregivers.

3.3. The MQTT Alert Service (MAS)

We use the MQTT technology to push message to mobile devices, to establish the interactive model of IHCS core function. The IHCS use Node.js on cloud server, Objective-C and Java on smartphone and medical devices to implement MQTT protocol for MAS function. As shown in Fig 2, MQTT is a machine-to-machine for Internet of Things protocol. The MQTT is a lightweight topic-based publish/subscribe messaging transport. Every subscriber needs register to the Broker, setting what the messages they want to receive. Publisher is the source of the message; it will send a message to the Broker. The Broker has to manage all subscriptions to the topics. In the IHCS, we use the MQTT technology to implement near real-time two-way communication. When the medical devices or the smartphone application sends the request to the IHCS through the MAS function, the MAS will push the message to the related devices. After these related devices execute the operation, they will send back the result to the system through the MAS function. For example, we using the MAS provide the finding the nearby medical institutions to the patients. When the patient needs to seek medical attention in an unfamiliar environment, they can use these function to quickly find the nearby medical institutions avoiding danger. Moreover, when the patients need the family caregivers' help, they can call the specific or the nearest family caregiver through the MAS.

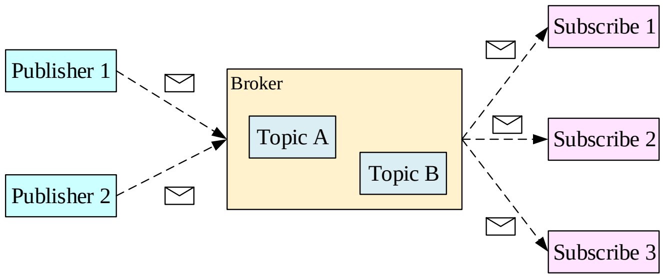

Fig. 2: MQTT publish/subscribe messaging transport.

4. Results

As shown in Fig 3a, in this case, the patient gets the abnormal blood glucose value 224 mg/dl. The MAS pushes the reminder message, "In High Range! Drink Water and Rest. Test again after 2 Hrs", to the GPRS BGM. Let the patients pay attention to their own health. Simultaneously, the MAS pushes the reminder concern message, "Dear Tina, Kun get 224 mg/dl value before Snack at 07-09/14:34. The value is in high range", to the selected family caregivers' smartphone (see Fig 3b). With the system proactive notification, family caregiver can immediately know the unusual circumstances of patients; moreover, the e-CITS will also automatically set the next measurement. As shown in Fig 3c, the GPRS BGM will remind the patient measure at the set time.

(a) GPRS BGM (b) caregivers' smartphone (c) GPRS BGM

Fig. 3: Screenshots about system message after measuring: (a) the measurement remind message on the patient's GPRS BGM, (b) the blood glucose abnormal message about the patient on the family caregivers' smartphone, and (c) the IHCS measurement remind message.

In addition to the enhanced functions discussed above, the IHCS system also builds some basic functions of the other general healthcare system (such as the online wellness diary and the calendar function). The blood glucose daily can display the patients' blood glucose record and friendly blood glucose level charts. Moreover, the IHCS also provides calendar function, the patient and family caregivers can set up appointment, medication, measuring reminder, etc.

5. Discussion

Different from other typical medical notification systems, IHCS adopts MQTT technology to let caregivers know the patient needs emergency treatment in the event of critical abnormalities. The use of this system significantly reduces diabetes-related risks. As the IHCS is still in an experimental prototype stage, we will consider improving the IHCS to provide caregiver information after confirming the patient has received medical treatment. Currently, the anomaly detection service that are used to provide judgment on the level of abnormalities in the proposed IHCS are based on international standards and discussion results with professional doctors. Nonetheless, blood glucose levels vary with locations, nationalities, ages, and lifestyles. Insufficient information results in IHCS's inability to conduct in-depth investigation and observation on factors that involve population in different areas and of different ages. IHCS is now being analyzed to maximize its potential in practical applications, and we will continue to collect authorized blood glucose data and refine the anomaly detection service with the help of data mining.

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