ZigBee-Based Wireless Homecare System Implementation

Ching-Show Lin, Pan-Chio Tuan, Chun Pei, *Member, ISG*

***Abstract*—The aging speed of the population. in Taiwan has been rising rapidly over the past decade. According to the official census, 77% of elderly people have one or more chronic diseases and most of them prefer to stay at home for the rest of their lives rather than go to long term care institution or nursing home. Based on this reason, it is urgently necessary to have a home health care system to monitor the health status of the elderly and provide some medical recommendation and remind the family members in case of health abnormality. The traditional home care system was sensor independent or used RS232 connector to link with computer to manage the vital signs. These biosensors were fixed at some place and less mobile. The paper is to use ZigBee based wireless devices to integrate the biosensors to monitor the vital data such as body temperature, blood pressure, heart rate and SPO2 at anytime and anywhere. The proposed home care system not only can popup alerts if the vital data is abnormal but also can send the email and simple message to notice the default family members.**

I. Introduction

The number of elderly people in Taiwan, as with many other countries is steadily rising. In 1993, the aging rates measured in terms of the percentage of population aged 65 or older reached 7% and increased to almost 10% by 2006 as shown in Fig. 1.

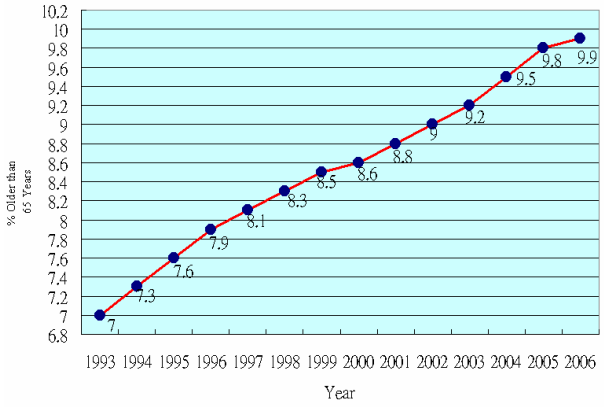

Fig 1. The aging speed of the population in Taiwan

According to the aging speed, this figure is predicted to reach 14% in 2015 and will make Taiwan enter the aged society. At the same time the crude birth rate has been rapidly declining. In 1951 it was 50 per thousand compared to less than 9 per thousand in 2006. The consequence of this combination of an increasingly aging population and a falling birth rate is that the dependency ratio of adults to elderly people will increase rapidly from 13% in 2004 to 25% within 10 years. In effect this means that in 2015, 4 adults will be required to support each elderly person in Taiwan [1]. Inevitably, this phenomenon will create a major burden for most of families. In recent years, Taiwan has being paid more attention and invested a lot of resources to deal with this problem.

There were 2.26 million elderly people in Taiwan in 2006. There were 77% of elderly people with one or more chronic diseases. The post prevalent disease was hypertension, followed by arthritis, cardiac disease and diabetes mellitus. 74% population of the elderly people prefer to live their home together with their children. Only 26% would like to live alone or go to long term care institution or nursing home [2]. Most of the elderly people still want to stay at home for the rest of their lives. The huge healthcare needs of elderly people who suffer with chronic illnesses and disabilities create a major social burden for many families. Taiwan government has made a lot of efforts to promote the policy of aging in place and active aging and also has being provided the subsidies to community care and home care services in the recent years. According to our survey, most of the community care units bought blood pressure and blood glucose sensors to monitor health status for the elderly, which are done by volunteers and recorded in the notebook manually. It was not only inconvenient but also cost a lot of manpower to do this job.

To improve the quality of life and health for the elderly is a global issue. Many of researchers have being engaged in homecare system development over the past decade. Based on the different communication platform, these research papers on homecare system can be divided into two parts: one is wired home care system, the other is wireless one. Some researchers designed a gateway to collect the vital data measured from the different sensors and developed a web-based system for health management [3]-[6]. The users can access the health record anywhere an Internet is available. On the other hand, the evolution of wireless technology is also extremely fast-paced. The benefits of wireless technology are portable, convenient, easy to install and low cost. Recently, a lot of researches shifted to develop the wireless homecare system. They used different wireless platforms such as WAP, Bluetooth, GPRS, 3G, WLAN to transmit vital data and remotely monitor the health status of the patients. Most of researches have demonstrated these systems can work well [7]-[14]. ZigBee wireless protocol is another competitive choice to be used in the wireless sensor network for its lower power consumption and lower cost.

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Based on the reason, the purpose of the study is to use the ZigBee wireless communication, measurement and monitoring technologies to track and evaluate health status of the elderly people with chronic disease over time. In addition, the proposed system also can provide the necessary alert and therapeutic recommendation and notice the caregiver or family members of the elderly at the right time if any abnormal vital data happens. The family members can be aware of the health status of their parents and care about them in time.

The paper is organized as follows. Section I introduces the background and motivation. Section II describes the proposed homecare system architecture, ZigBee wireless sensor network and system function requirements using UML diagrams. Section III demonstrates the implementation results and makes a discussion. Finally, the paper concludes with Section IV and comes up with future work.

II. METHODOLOGY

A. System Architecture

In this study, we integrated two types of non-invasive vital signs sensors including infra red body temperature sensor, and multi-sensors measuring heart rate, blood pressure and blood oxygenation (SPO2) level. The pulse oximeter attaches to the patient's finger and measures heart rate and SPO2. A cuff pressure sensor on the patient's upper arm measures systolic and diastolic blood pressure.

The proposed homecare system is based on client-server architecture. The client node is responsible for acquiring data from vital sensors and transmitting them through wireless ZigBee communication devices. And, there is a server application which displays the vital data came from the client node, shows alerts and sends mail and simple message to the caregiver and the elderly's family members. The system architectures are shown in Fig. 2 and Fig. 3 respectively.

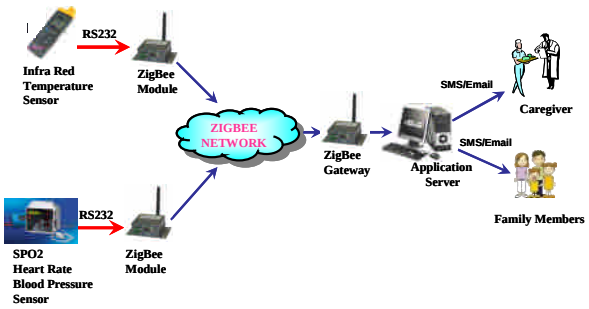

Fig 2 Homecare System Architecture

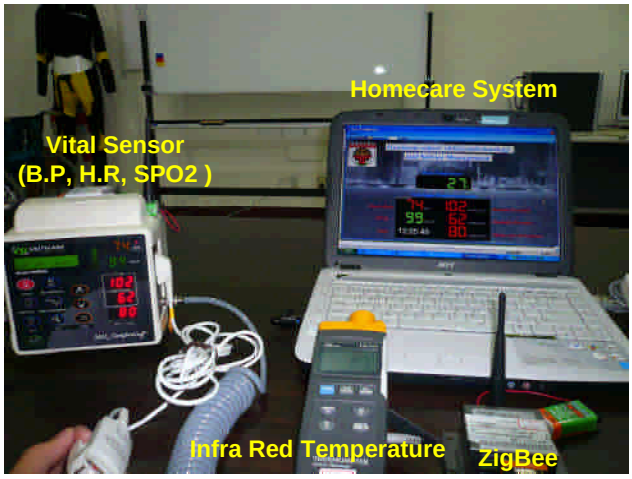

Fig 3 Homecare System Architecture

Most of the existing vital signs sensors present conventional and reliable signals acquisition capabilities. Nevertheless, this kind of sensors usually is not developed aiming the connectivity. Most of these sensors are historically RS232 serial port based. Aside from that, these sensors were made by different vendors and each vendor is used to develop its own proprietary communication protocol. Therefore, it is always a big challenge to integrate these stand alone sensors.

B. ZigBee Wireless Sensor Network

IEEE 802.15.4/ZigBee is a new wireless network standard for sensor network. ZigBee standard has a characteristic of "three low" of low power consumption(years cell life), low cost and low date rate(250kb/sec) and also has longer communication distance(>70m) than Bluetooth. In addition that, the performance and reliability of ZigBee wireless networks have been verified in field tests in Japan. The following results were obtained [15]:

1. A wireless sensor network can sample from more than 20sensor nodes in 2 seconds period and works well.
2. 99.5%-99.99% reliabilities can be achieved if wireless nodes were set properly.
3. The ad-hoc ZigBee network can make a node join very easily and fast.

Due to ZigBee's strength as mentioned above, it will be the most potential candidate in industrial wireless sensor network. As a result, the work uses ZigBee devices to integrate the biosensors and design a wireless homecare system for the elderly.

C. System Functions Requirement

The work used Unified Modeling Language (UML) to describe the system functions. We applied the Use Case Diagram to elicit the system functions requirement. Each Use Case presents the system function and has been implemented in the system development process. As shown in Fig.4, the proposed homecare system has the following functions: measuring, collecting, analyzing vital signs and therapeutic recommendations and alarming. In addition to wireless monitoring the vital signs, the system can send the email and simple message to their family members in case of any abnormality. Their family members can receive the

health status message anywhere and anytime and can pay more attention to their parents especially who live alone. The alarming mechanism is described by Activity Diagram as shown in Fig.5. The alert detection algorithm is also listed in Table 1. According to the medical record of the elderly, these detection parameters can be adjusted easily if necessary in the software design.

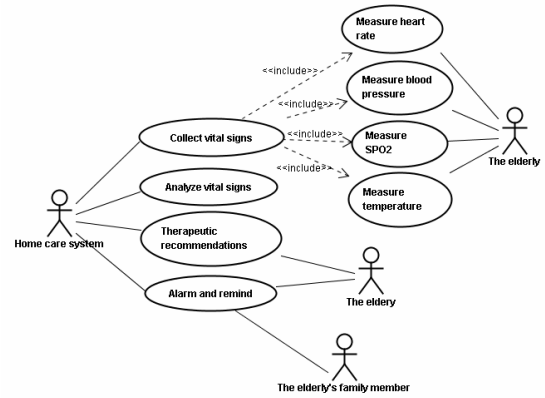

Fig. 4 Use Case Diagram of homecare system

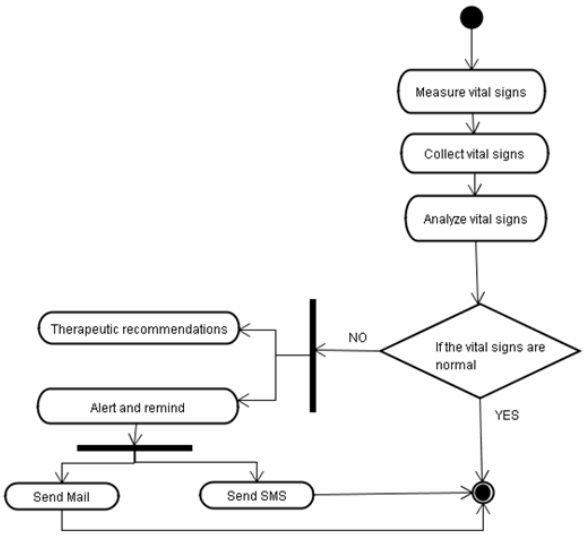

Fig. 5 Activity Diagram of homecare system

Table 1 Alert and Remind Detection Parameters [12]

Alert Type	Detection Parameter
Low SPO_2	SPO_2<90%
Heart Rate	100bpm
Body Temperature	39°C
Systolic B.P.	>140mmHg
Diastolic B.P.	<70 mmHg
*New Classification of BP levels by WHO, 1999 *These are defaults values, they can be adjusted based on the additional input from the patient medical record	

D. Implementation

The system development is still ongoing. So far, we have integrated two types of sensors in our implementation: infra red thermal sensor, heart rate, blood pressure and SPO2. The measured vital data is transmitted to the master computer by the way of wireless ZigBee devices. Then, the graphic user interface (GUI) is also developed to display the real-time vital signs and alerts. The server application software utilizes C# programming language. As for the notice function of alert and remind detection, the study used Google mail server to send the email and integrated SKYPE4COM API to send simple message service for the sake of ease of use and less cost.

III. RESULTS AND DISCUSSION

The homecare system was implemented as previously described. The server application software utilized C# programming language to develop. .As Fig. 6 shows, the Graphic User Interface of the homecare system can display the vital signs real time.

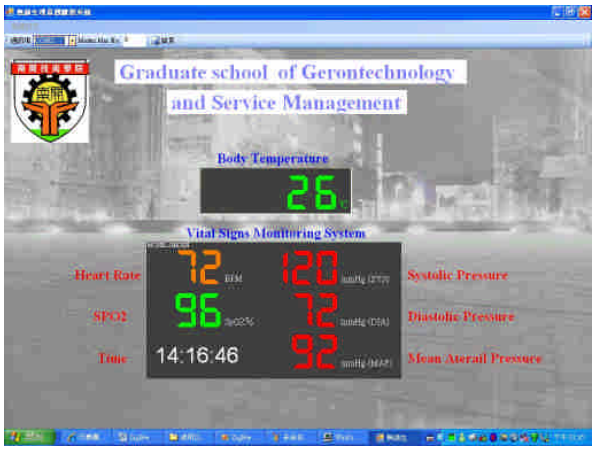

Fig. 6 Graphic User Interface of homecare system

If the vital signs exceed the detection criteria as listed in Table 1, the system will popup alerts and sound to remind the user to take the medication on time or give a therapeutic recommendation such as seeing a doctor. The display is shown in Fig. 7. In addition, the system also sends a simple message and email to the family members through Internet. And the family member can call home to provide care about their parent especially who live alone.

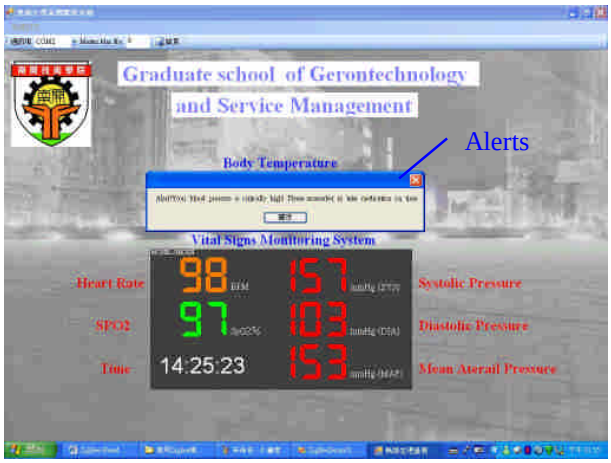

Fig. 7 Alert display in case of abnormality

Fig. 8 Send simple message to notice family members

At the beginning, the proposed system implementation seems trivial as only system integration is involved. However, as we proceed with the work, we found that different sensors have different data formats. The system integration has to accommodate these different data formats via RS232 connector interface combining with wireless ZigBee communication devices.

IV. CONCLUSIONS AND FUTURE WORK

Improving the quality of life for the elderly is becoming an essential task for society today. Technical aids are required allowing people to live independently and safely in their private home as long as they wish. In this study, we have developed a wireless homecare system that can wirelessly monitor vital data of the elderly at home and notify caregivers and family members in real time in case of abnormality. However, the only precondition the system can work well is that the system has to be installed in personal computer connecting with internet. Otherwise, the elderly just use this system as a stand alone system. The digital gap still exists between young generation and older generation in Taiwanese society. In addition that, the system is also costly and it is quite difficult for the elderly to afford to buy it without hesitation. Based on this reason, the proposed homecare system is more suitable to be used in community-based care model. Accordingly, the financial load will be shared and make the system easy to use and promote widely.

To achieve this goal, our future work is to continue the development of the system by integrating the other sensors such as the blood sugar sensor and the RFID sensor for the purpose of the identification in a modular way. And, easy to use and friendly touch screen technology will also be adopted to replace the traditional mouse-driven interface and would decrease the learning curve for the elderly. In addition, the whole performance of the proposed system will be tested and evaluated in a real operation condition. Lessons learned from these trials will be used to modify the next version of the system.

ACKNOWLEDGMENT

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