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Innovative ZigBee Technology in Wireless Homecare Monitoring

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Abstract— *An aging population rate and sedentary lifestyle are fueling the prevalence of chronic diseases such as cardiovascular diseases, hypertension, and diabetes. The aging population has 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 necessary to have a home healthcare system to monitor the health status of the elderly peoples and provide some medical recommendation and remind the family members in case of health abnormality. The traditional homecare 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. This paper describes the use of 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 homecare 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.*

Keywords— *Biosensor, ZigBee, Healthcare, vital.*

1. INTRODUCTION

The elderly people in every county are steadily rising. According to the WHO, cardiovascular disease causes 30 percent of all deaths in the world. Diabetes currently affects 180 million people worldwide and is expected to affect around 360 million by 2030. More than 2.3 billion people will be overweight by 2015. A rapid rise in debilitating neuro-degenerative diseases such as Parkinson's and Alzheimer's is threatening millions more [1].

There are 77% of elderly people with one or more chronic diseases. The post prevalent disease is hypertension, followed by arthritis, cardiac disease and diabetes mellitus. 74% population of the elderly people prefers 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. 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 healthcare system development over the past decade. Based on the different communication systems, the research papers on health care system can be divided into two parts: one is wired homecare system and 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, and 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. 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 diseases over time. In addition, the proposed system also can provide the necessary alert and therapeutic recommendation for 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 [16]-[20].

1.1 Methodology

1.1.1 System Architecture

This paper presents two types of non-invasive vital sign sensors including infra red body temperature sensor and multi-sensors measuring heart rate, blood pressure and

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blood oxygenation (SPO2) level. The pulse oximeter attached to the patient's finger measures heart rate and SPO2. A cuff pressure sensor on the patient' supper arm measures systolic and diastolic blood pressure. The proposed homecare system shown in fig. 1 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. 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 elder's family members.

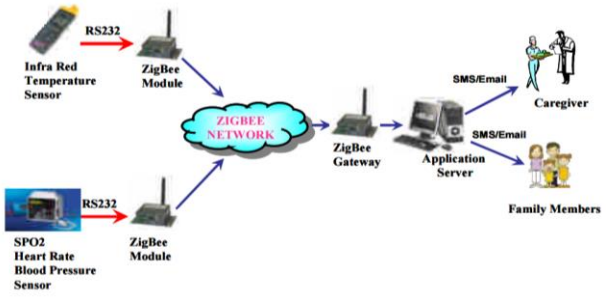

Fig. 1: Homecare System Architecture

Most of the existing vital sign 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.

1.1.2 ZigBee Wireless Sensor Network

ZigBee IEEE 802.15.4 is a new wireless network standard used for wireless sensor network. ZigBee standard has a characteristic of low power consumption (years cell life), low cost and low data rate (250 kb/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 strength of ZigBee, it acts as 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.

1.1.3 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. 2. 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.

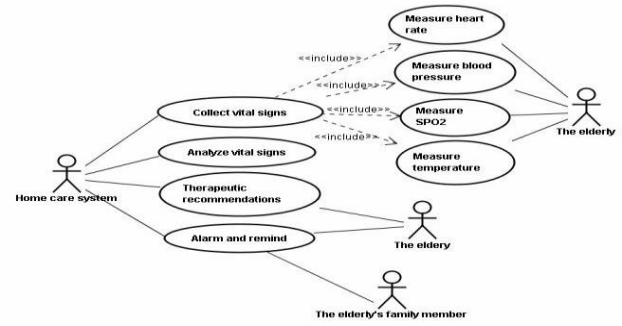

Fig. 2: Alarming Mechanism Activity Diagram

Table 1: Alert and Remind Detection Parameters

Alert Type	Detection Parameter
Low SPO_2	SPO_2<90%
Heart Rate	100bpm
Body Temperature	39ºC
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	

1.1.4 Implementation

The developments in the system 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.

1.2 Results and Discussion

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

In 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.

2. CONCLUSION

To improve the quality of life for the elderly people 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 standalone system. The digital gap still exists between young generation and older generation in the 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.

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