



**HEALTH CARE MONITORING USING WIRELESS SENSOR NETWORK  
(H-CARING)**

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## ABSTRACT

The development of Health Care Monitoring Using Wireless Sensor Network is an ultimate solution to achieve the goal of universal health care for everybody due to accidents and various diseases. This project can measure several medical parameters such as body temperature, oxygen percentage in blood and heartbeat. All the parameters will be displayed on Personal Computer (PC) at centre unit by using GUI. This project consists of two parts which are hardware design and software development. The hardware design is divided to two modules; slave module for measurement of several parameters of patient and master module for collecting real time parameters. Zigbee technology is preferred in the wireless communication design due to effectiveness, performance, and durability. Two different types of microcontroller are used to control the operation of control center and remote. Global System for Mobile (GSM) features in the design to relay the message automatically to authorized user about the condition of patients.

## ABSTRAK

Pembangunan Pemantauan Penjagaan Kesihatan Jauh menggunakan rangkaian pengesan tanpa wayar merupakan penyelesaian muktamad untuk mencapai matlamat penjagaan kesihatan universal untuk semua orang akibat kemalangan dan pelbagai penyakit. Projek ini boleh mengukur beberapa parameter perubatan seperti suhu badan, peratusan oksigen dalam darah dan denyutan jantung. Semua parameter akan dipaparkan pada Komputer Peribadi (PC) di unit pusat dengan menggunakan GUI. Projek ini terdiri daripada dua bahagian iaitu reka bentuk perkakasan dan pembangunan perisian. Reka bentuk perkakasan terbahagi kepada dua modul; "*slave*" modul untuk mengukur beberapa parameter pesakit dan "*master*" modul untuk mengumpulkan parameter masa sebenar. ZigBee teknologi diutamakan dalam reka bentuk komunikasi tanpa wayar kerana keberkesanan, prestasi, dan ketahanan. Dua jenis mikropengawal yang digunakan untuk mengawal operasi pusat kawalan dan pedalaman. Sistem Global bagi Mobile (GSM) digunakan di dalam reka bentuk untuk menyampaikan mesej secara automatik kepada pengguna yang dibenarkan tentang keadaan pesakit.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

Nowadays, the average lifespan has increased due to the improvement of medical care and as a result of an increase of the disabled population for aged people. In addition, due to social development, the number of disabilities as a result of various diseases or due to accidents is increasing [1]. For this reason, a simple but efficient system is required to monitor the conditions of patient continuously.

The current monitoring systems used by hospitals are mostly based on cable connections. The size and power consumption are often too large and not easy to carry. They also require to be used next to the patient, reducing the mobilities of patients and medical staff, increasing their burden and risk. The old systems have become unsuited to today's real-time, continuous, long-time monitoring.

Remote and wireless health care at home or in the hospital is an important technology with many advantages. Firstly, people can monitor their physiological parameters at home without the necessity to go to the hospital from time to time;

Secondly, people who carry the sensing devices can move around freely without the obstacle from complex connecting cables; and finally, doctors in the remote server centre can watch the patient's health condition closely and hence provide real-time advices for the patients' recovery and long-term care [2].

The wireless technology is now widely being used in communication area to facilitate information transfer and exchange in wireless sensor network. One of its usages is in promoting remote monitoring health care for patients. The system integrates the medical knowledge base wireless sensor network to upgrade the existing health care to stay in touch with medical officer, patient and authorized user. With the advances of wireless and mobile communication technologies, sensor network, and wearable medical devices, emerging applications that will potentially improve general living standard in underserved populations need to be developed and implemented. However, some of underserved areas in the world do not have communications infrastructure to be able to benefit from remote health monitoring systems.

Health care monitoring using wireless sensor network is a wireless based biomedical monitoring system. Since the wireless technologies is now widely used in communication area to facilitate information transfer and exchange, the wireless technology is applied in this system in order to eliminate the use of wire and electrodes so that the patients can move freely without something attach to their body. These technologies are currently being applied to improve healthcare around the world.

The aim of the project is to develop and implement the health care monitoring using wireless sensor network. This system is equipped with several sensors such as TSiC 301 and oximeter which can measure several parameters. PIC18F4525 and PIC18F252 are embedded at central and remote respectively to control the system operation. In addition, the Graphic User Interface (GUI) and Graphical Liquid Crystal Display (GLCD) are used as an output to display the parameters so that the patients can

be monitored either at hospital or at home. The Zigbee-based technology is used in order to transmit and received data wirelessly between central and remote.

## **1.2 Project Objectives**

The main objective of this project is to develop a Health Care Monitoring Using Wireless Sensor Network. This system can measure several parameters of patient such as heart beat, blood pressure and body temperature and send these data continuously to the central unit so that these parameters can be displayed and stored at the central unit.

In addition, to provide a simple, high performance and stand alone system, wireless technology using Zigbee-based sensor network is used and allows patients to move freely without any cable attach to his body.

## **1.3 Project Scope**

In order to achieve the objectives of the project, the scope of the project are summarized as follow:

- Microcontroller system to control the operation of control centre and patient remotes. It is integrated with some extra component to increase the functionality

and execute at high frequency to improve the performance of the system so that the system is more reliable and efficient.

- Sensor module to acquire medical parameters from patients. The sensors used are more sensitive for more accurate results.
- Zigbee system to transmit and receive data wirelessly in a long distance so that the system is portable and easy to be operated.
- GUI and Graphical LCD are used to display and update the parameters of patients in a real-time.
- GSM system to send a message to authorized user using mobile phone.

#### **1.4 Thesis Outline**

This thesis is divided into seven chapters. The contents of each chapter are summarized as below :

Chapter 1 is an introduction which discusses the current technology used in health care monitoring system. It consists of the overview of the project objective, scope of project and summarizes of the content of thesis.

Chapter 2 is the literature review which elaborates the recent research on the technology and it emphasizes the use of Zigbee in various applications. Explanation will be focused on the related field of health care monitoring and wireless sensor network. Some literature reviews of current existing projects based on health care monitoring and hardware review of prototypes are also be discussed.

Chapter 3 is the system architecture of project. It explains the operation of this project. Block diagram for each module are discussed in this chapter.

Chapter 4 is the hardware design which discusses the details of hardware design of each module. The connections of hardware are shown in circuit schematic diagram.

Chapter 5 indicates the software development for each module. The flow chart diagrams are shown in this chapter for the simple explanation.

Chapter 6 presents the testing and evaluating results of each module. The entire integrated modules operation is also discussed in this chapter.

Chapter 7 concludes the outcome of this project. It also includes the recommendations on this project for future works to upgrade the system performance.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter elaborates the recent research on the technology and emphasizes the use of Zigbee in various applications. Explanation will be focused on the related field of health care monitoring and wireless sensor network. Research and findings have been conducted in order to design and develop Health Care Monitoring Using Wireless Sensor Network that will suit the aims and objective in this project. All the related research papers and journals will be discussed in this chapter.

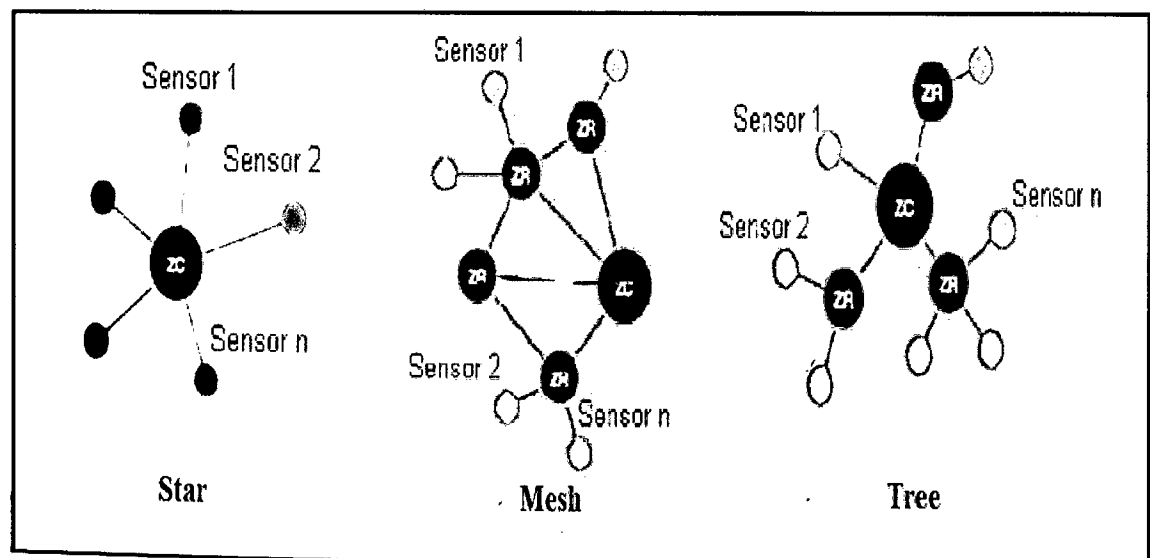
#### **2.2 Zigbee Technology**

There are various types of wireless technologies are available such as Bluetooth, Infrared (IR), Radio Frequency (RF) and other which have been explored by the

most people in modern society. However, Zigbee is the type of wireless sensor network system which chosen by researchers in order to employ the designs. ZigBee is the only standards-based wireless protocol technology that addresses the unique needs of remote monitoring and control and sensor network applications.

The ZigBee wireless standard enables broad based deployment of wireless networks with low cost, low power solutions providing the ability for devices to run for years on inexpensive batteries in a typical monitoring application. The ZigBee standard operates on the IEEE 802.15.4 physical radio specification and operates in unlicensed bands including 2.4 GHz, 900 MHz and 868 MHz.

In the structure of ZigBee networks the devices can be of tree types; Zigbee Coordinator (ZC), Zigbee Router (ZR) and the Zigbee End Device (ZED) [4]. With these types of devices, a ZigBee network can be configured in three topologies which star, a mesh (peer -to- peer), or a cluster tree as shown in Figure 2.1.



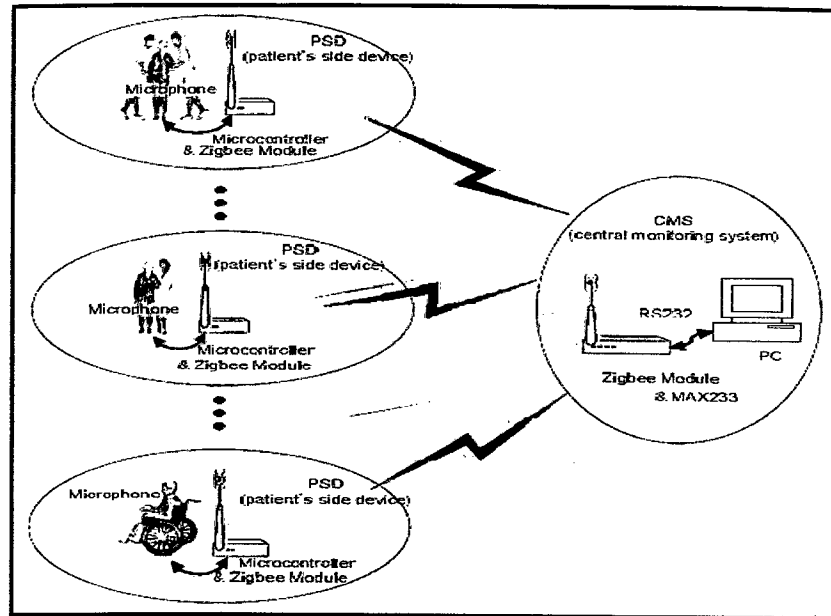
**Figure 2.1 : Topology types for wireless sensor network**



### 2.3 Zigbee-based Sensor Network

Based on [1], the main purpose of this research is to develop a monitoring system which can monitor heart rates of rehabilitation patients' who are taking physical therapy inside a rehabilitation center in a hospital and generate a warning signal if the patient's heart rates is not in normal range. The design of Patient's Side Device (PSD) consists of a contact-type microphone to detect patient's heart sound, a signal processing hardware for signal conditioning of heart sound and calculating heart rate and a Zigbee module to communicate with the Centre Monitoring System (CMS) periodically.

The CMS was designed to monitor multiple patients simultaneously and generate a warning signal if necessary. It consists of a Zigbee module and microcontroller to communicate with all PSDs periodically and a Microsoft Windows-based personal computer (PC). The heart rate information for each patient are collected by a Zigbee module and transferred to monitoring software in the PC that displays the current heart rates for all patients and generates warning signal if the heart rate is out of predefined range. Figure 2.2 shows the whole configuration of Zigbee network-based multi-channel heart rate monitoring system for exercising rehabilitation patients.



**Figure 2.2 : Configuration of Zigbee network-based multi-channel heart rate monitoring system for exercising rehabilitation patients**

From [4], a new application that uses ZigBee radio modules was presented for implementation of a distributed system intended for continuous measurement and monitoring of radiation level in surveillance area. The hardware configuration of the proposed system comprises also the sensors mounted on remote modules. The development board is connected to PC through the serial interface. The remote modules periodically read the signals from sensors and send the result to the controller board that display the received data on a LCD panel.

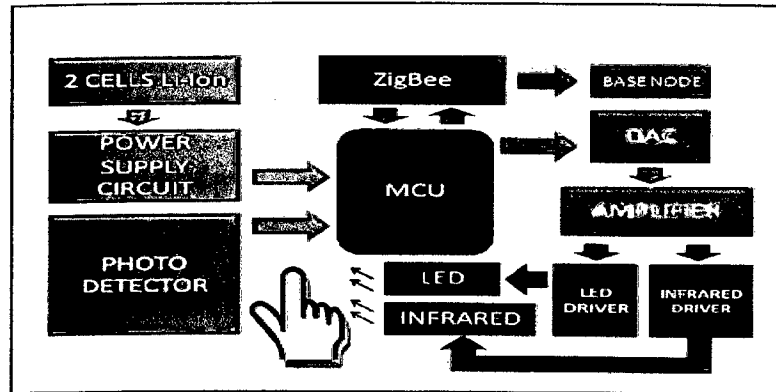
Zigbee is the suitable for wireless sensor networks due to the very low power consumption. The main advantages of Zigbee in comparison with the other technologies such as Bluetooth and WiFi, are flexible network architecture, low cost, and compatibility of equipments from diver producers. The comparison can be referred in Table 2.1.

**Table 2.1 : The comparison of Zigbee and other wireless technology**

	ZigBee	Bluetooth	Wi-Fi
Standard	802.15.4	802.15.1	802.11b
Memory requirements	4-32KB	250KB+	1MB+
Battery life	Years	Days	Hours
Node per master	65,000+	7	32
Data Rate	250Kb/s	1-3 Mb/s	11Mb/s
Range	300m	10-100 m	100m

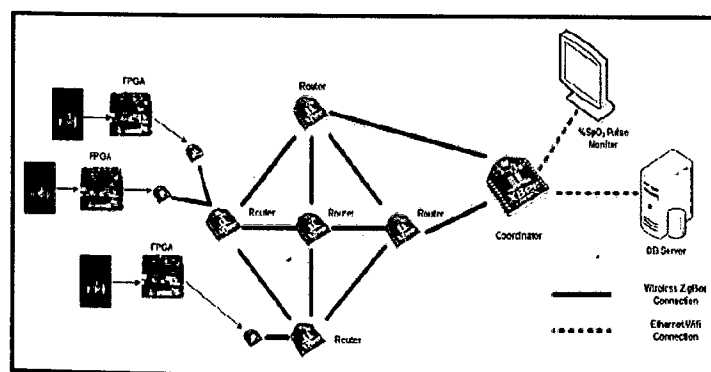
According to [6], the main purpose of this research is to develop a portable real-time wireless health monitoring system for remote monitoring of patients' heart rate and oxygen saturation in blood. The system was designed and implemented using ZigBee wireless technologies. All pulse oximetry data are transferred within a group of wireless personal area network (WPAN) to database computer server.

The sensor modules were designed for low power operation with a program that can adjust power management depending on scenarios of power source and current power operation. The sensor unit consists of : (a) Two types of LEDs and photodiode packed in Velcro strip that is facing to a patient's fingertip, (b) Microcontroller unit for interfacing with ZigBee module, processing pulse oximetry data and storing some data before sending to base PC, (c) ZigBee module for communicating the data of pulse oximetry, (d) Base node for receiving and storing the data before sending to PC. The system architecture can be referred to the Figure 2.3.



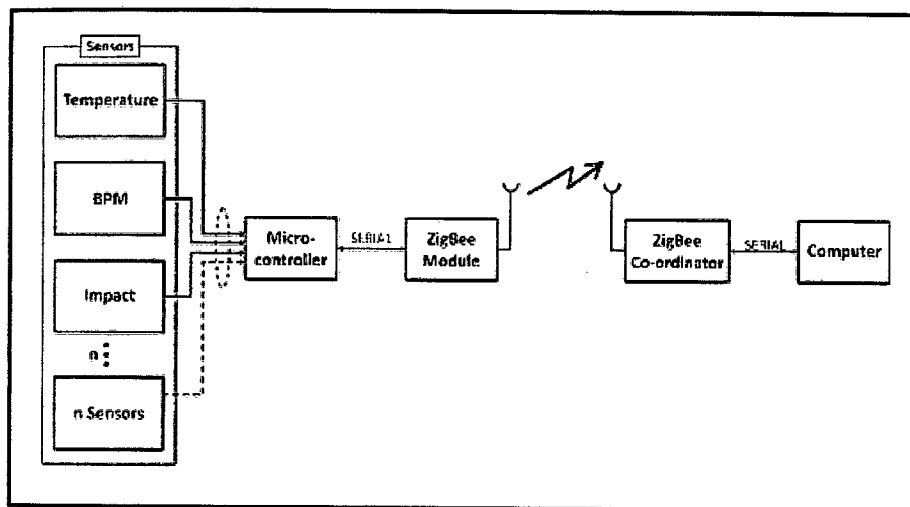
**Figure 2.3 : System architecture of wireless wearable pulse oximeter for health monitoring using ZigBee wireless sensor network**

From [7], this work presents the adaptation of a conventional pulse oximeter to suppress its wire, sending data in real time through a wireless sensor network. The network architecture can be referred in Figure 2.4. Data can be stored in a PC, allowing the review of monitored data and with these data future medical research can be started. Zigbee is the selected communication protocol used in the wireless sensor network. Bluetooth is not selected because it requires higher power consumption than Zigbee. Another difference is that Bluetooth devices use a point to point directive whereas Zigbee devices constitute a mesh network enabling flexible connection of new sensors.



**Figure 2.4 : Global system and network architecture of the design of a wireless pulse oximeter using a mesh ZigBee sensor network**

Alternatively, [8] was designed and developed a Zigbee smart non-invasive wearable physiological parameters monitoring device has been developed and reported in this paper. The system can be used to monitor physiological parameters, such as body temperature and heart rate of a human. Using several sensors to measure different vital signs, the person is wirelessly monitored within his own home. An impact sensor has been used to detect falls. The device detects if a person is medically distressed and sends an alarm to a receiver unit that is connected to a computer. This sets off an alarm, allowing help to be provided to the user. The system hardware of this Zigbee based wearable physiological parameters monitoring system can be referred in Figure 2.5.



**Figure 2.5 : Functional block diagram of system hardware of a Zigbee based wearable physiological parameters monitoring system**

Likewise, [11] had found a method by using the combination of ZigBee and wireless LAN architecture to realize a remote medical monitoring system. This system can collect various types of information from patients, achieving the remote medical care at home. It can promptly reflect the patient's status to doctors and the patient's families as well as coping with possible emergency situations.



## 2.4 Serial Communication

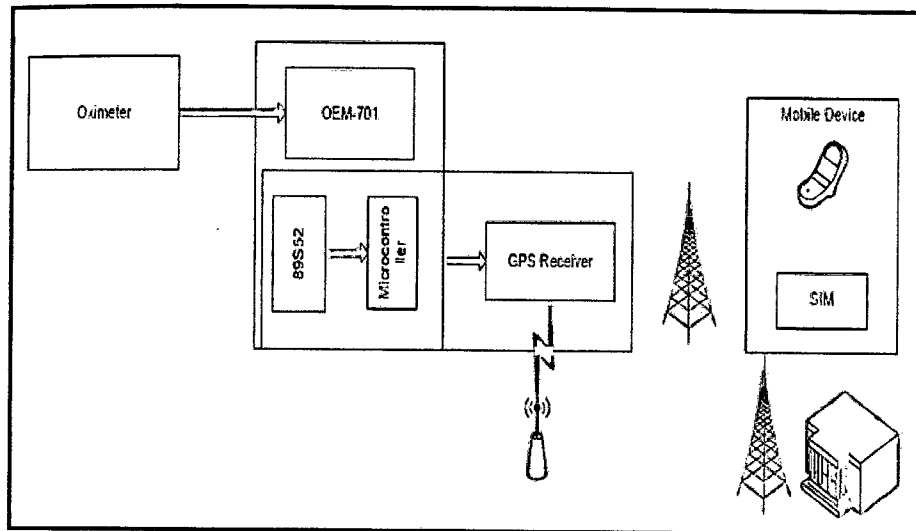
Based on [5], serial port is used in order to display the parameters on Personal Computer (PC) because it allows user to change the serial port number (COM1, COM2), baud rate, data bit size and parity bits. The port number is used to change the serial port. This serial port communication such as RS232 is needed to interface between microcontroller and PC for further processing and analysis. In addition, PIC18F4620 is used as microcontroller which is built-in USART support (RS 232) and Analog to Digital Converter (ADC) so, it will eliminates the need of design separate ADC circuitry. Furthermore, the PIC18F series has a large number of I/O ports which come handy for debugging and other applications.

## 2.5 Global System for Mobile (GSM) Technology

Based on [9], this paper is present the design and implementation of a Remote Patient Monitoring (RPM) system based on wireless technology using a cellular phone which is to send an SMS (Short Message Service) to the medical staff. The proposed system combines two commonly used technologies namely, Global System for Mobile (GSM) and Global Positioning System (GPS). The system monitors patient's health status, such as SPO<sub>2</sub> (oxygen percentage in blood), heart rate, and temperature.

In case the value for any of these parameters exceeds preset critical values, the position parameters, from the attached GPS module, are transmitted to pre-defined phone number in form of SMS using a GSM module. All the information obtained from the human body using a DSP (Digital Signal Processing) and an oximeter is then

transmitted to the microcontroller system as digital values. The values obtained from DSP like SPO<sub>2</sub>, heart rate and temperature is also displayed on to the attached LCD in alphanumeric form. Figure 2.7 shows the system architecture of this remote patient monitoring.



**Figure 2.7 : Remote patient monitoring architecture**

According to [10], the paper proposed an alert system that able to monitor the heart beat rate condition of patient. The heart beat rate is detected using photoplethysmograph (PPG) technique. A heartbeat sensor circuits which adopted photoplethysmograph (PPG) technique is designed using MPLAB software. Signals detected are then processed and analyzed before sent via SMS to alert medical experts or family members. It is beneficial in terms of cost, no complicated settings, save time and even very helpful for patient whom lives alone. This signal is processed using PIC16F87 microcontroller to determine the heart beat rate per minute. Then, it sends sms alert to the mobile phone of medical experts or patient's family members, or their relatives via SMS. Thus, doctors can monitor and diagnose the patient's condition continuously and could suggest earlier precaution for the patients themselves. This will