Design of a Wireless Medical Monitoring System

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Abstract: Modern wireless communication consists mainly some technologies that provide solutions to the wireless data transmission network, such as: GSM, CDMA, 3G, Wi-Fi these solutions make network work with high efficiency and good quality, but still with high cost. So it was difficulty in popularizing in with low cost and at the circumstance of infrastructure less or infrastructure destruction. By utilizing the wireless technique to transmit information between medical sensor and monitoring control center, the free space of patients is enlarged, and the efficiency of the modern management of hospitals is improved. Besides, the problem of the lack of unremitted real-time care for every patient, which is caused by the shortage of health care members, is also solved. Therefore, the portable wireless medical monitoring products will become popular in the future market. Nowadays, there are various kinds of wireless communication protocols. But since the main task of a monitoring terminal is to realize the transmission of signals such as heart rate, body temperature, and calling signals---the data traffic is not heavy. In this paper, the real-time monitoring system for monitoring the patient's physical states using wireless sensor network technology is illustrated.

Keywords: Temperature, Heartbeat, Sensor, Transmitter, Receiver.

1. Introduction

Traditionally, the medical measurement system can be expensive and a medical measurement system can be difficult to access for a needed patient. Moreover such a system is neither compatible with the PC and communication standards nor is it easily upgraded. In addition, a special patient may need a medical measurement system to monitor one's body condition even if that individual is located in the hospital. Based on these requirements and available technology, our design provides a convenient operational procedure utilizing an embedded circuit board and Web server to provide a remote electrocardiograph measurement.

Typically, an electrocardiogram is generated by a nerve impulse stimulus to a heart, whereby the current is diffused around the surface of the body surface. The tiny current at the body surface will build on the tiny voltage drop, which is a couple of μV to mV with an impulse variation.

This very small amplitude of electrocardiograph needs to be amplifying a couple of thousand times for recording and displaying. Simultaneously, the amplified signal is then inputted into an analog to digital conversion and through the digital interface inputted into an embedded circuit board. The embedded circuit board uses client-server network programming to transmitting this digital medical signal to the remote database by wireless or wire networks.

In recent years, with the miniaturization of biomedical sensors, the fast development and popularization of information processing and wireless data transmission technology, the research of wireless Medical Monitoring System has became a hot topic. By utilizing the wireless technique to transmit information between medical sensor and monitoring control center, the free space of patients is enlarged, and the efficiency of the modern management of hospitals is improved. Besides, the problem of the lack of unremitted real-time care for every patient, which is caused by the shortage of health care members, is also solved. Therefore, the portable wireless medical monitoring products will become popular in the future market Nowadays, there are various kinds of wireless communication protocols. But since the main task of a monitoring terminal is to realize the transmission of signals such as heart rate, body temperature, and calling signals---the data traffic is not heavy. Moreover, because the monitoring terminal is worn on patients, which needs to be supplied by battery, it puts a high demand on the reducing of power dissipation of wireless transmission module. Having taken these comprehensive factors into consideration, this paper chooses the ZigBee technology as the wireless communication protocol.

In field modern wireless communication, GSM, CDMA, 3G, and Wi-Fi become the mainstream solution of wireless data transmission network because of their high speed and reliable quality. They also have the shortcomings of high cost, so wider application would cause a great waste of resources, and they cannot be promoted in small regional, low speed data communications. Multi-point short-range wireless data collection and transmission network will be the best solution. Short-range wireless communication can adopt different network technologies, such

as Bluetooth, IEEE802.11, and Home RF, Infrared. Compared with long-distance wireless communication network.

This paper presents the design proposal of hardware and software of information terminal (a machine) and wireless receiver module of multi-point short-range wireless data collection and transmission network, which provides a low-powered and high-performance wireless data communication system, works in the ISM（Industrial Scientific Medical) Band. The main technology is the ZIGBEE technology which is the 2.4GHz, IEEE 802.15.4-compliant transceiver for developing our application.

The ZigBee Alliance is a group of companies that maintain and publish the ZigBee standard. The term ZigBee is a registered trademark of this group, not a single technical standard. The Alliance publishes application profiles that allow multiple OEM vendors to create interoperable products.

ZigBee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. The technology is intended to be simpler and less expensive than other WPANs such as Bluetooth. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory.

ZigBee operates in the industrial, scientific and medical (ISM) radio bands; 868 MHz in Europe, 915 MHz in the USA and Australia, and 2.4 GHz in most jurisdictions worldwide. Data transmission rates vary from 20 to 250 kilobits/second.

The ZigBee network layer natively supports both star and tree typical networks, and generic mesh networks. Every network must have one coordinator device, tasked with its creation, the control of its parameters and basic maintenance. Within star networks, the coordinator must be the central node. Both trees and meshes allow the use of ZigBee routers to extend communication at the network level.

2. Implementing the Design

The communication module used in this paper is EM250---Texas Instruments' first RF transceiver chip that is suitable for ZigBee products. EM250 operates in the unlicensed 2.4GHz frequency band, and uses direct sequence spread spectrum baseband modem, whose chip-rate and effective data transfer rate can reach as high as 2MChips/s and 250kb/s respectively. The control chip uses Silicon LAB's C8051F021. C8051F021 is a model that belongs to C8051F series, a fully integrated mixed-signal micro-controller. It has a high-speed 51 core, 64K bytes of FLASH memory, and hardware implementation of the SPI Interface.

The wireless monitoring terminal block diagram is shown in Fig.1, whose core is the C8051 MCU. It is connected with EM250 by SPI interface, and can read and writing inner registers of EM250, realizing the Wireless transceiver of information. It can get information such as psychological parameters from external sensors by ADC and DAC modules.

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An ADC is defined by its bandwidth (the range of frequencies it can measure) and its signal to noise ratio (how accurately it can measure a signal relative to the noise it introduces). The actual bandwidth of an ADC is characterized primarily by its sampling rate, and to a lesser extent by how it handles errors such as aliasing. The dynamic range of an ADC is influenced by many factors, including the resolution (the number of output levels it can quantize a signal to), linearity and accuracy (how well the quantization levels match the true analog signal) and jitter (small timing errors that introduce additional noise). The dynamic range of an ADC is often summarized in terms of its effective number of bits

(ENOB), the number of bits of each measure it returns that are on average not noise.

An ideal ADC has an ENOB equal to its resolution. ADCs are chosen to match the bandwidth and required signal to noise ratio of the signal to be quantized. If an ADC operates at a sampling rate greater than twice the bandwidth of the signal, then perfect reconstruction is possible given an ideal ADC and neglecting quantization error. The presence of quantization error limits the dynamic range of even an ideal ADC, however, if the dynamic range of the ADC exceeds that of the input signal, its effects may be neglected resulting in an essentially perfect digital representation of the input signal.

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This paper provides the design of a Medical Monitoring Terminal use EMBEDDED CONTROLLER and Zigbee technology (EM250 Single-Chip ZigBee which is of 2.4GHz, IEEE 802.15.4-compliant transceiver). The Monitoring Terminal can detect the patient's real-time body

TEMPERATURE, HEART RATE and transmit them to the control center.

The core of wireless medical monitoring system is the design of wireless monitoring terminal, and the development of system software. The monitoring terminal generally consists of three modules the sensor module, the control module, and the wireless communication module. The sensor module is used for acquiring medical information from the outside, and then converts them to digital signals. The control module is which is in charge of coordinating the task of different modules, controlling the sensors, processing data, and executing communication protocols. The wireless communication module mainly deals with the wireless transmission of information.

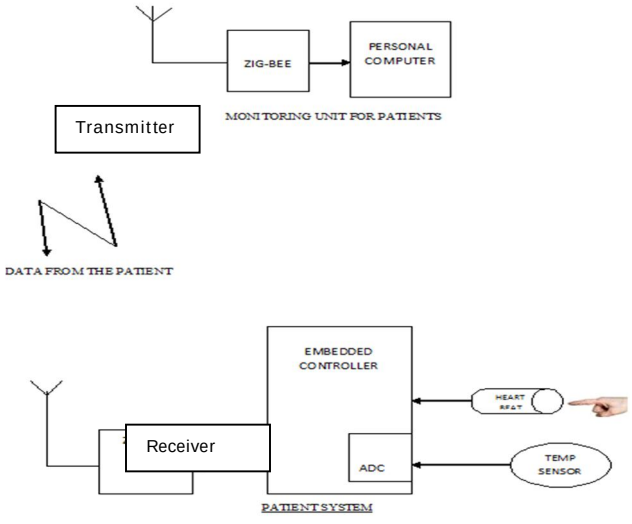

Figure 1 Block Diagram of the Proposed System

Software Co-Design

Construction of the system in the ZigBee wireless network used the star topology. There are two devices in the ZigBee star network: ZigBee coordinator and ZigBee terminals. Zigbee terminal devices realize the monitoring and transmitting of psychological parameters; ZigBee coordinators realize the management of the entire network, the collecting and processing of data, and send the data to the monitor computer. One coordinator and several terminals are allowed in a network. In this system, the hardware of the two devices is the same, but the software is different [2].

When constructing the network, the coordinator powers up first. After that, the coordinator initialize hardware such as UART, SPI, clock, memory, enable stack, and RF transceiver to set various parameters. Then, it begins to scan and construct the network. As one step of scanning, the coordinator sends the request frame from the first channel of the current frequency range. If there is another coordinator in the same channel, it will respond to the request, and this channel will be considered to be busy. Then it will change to another channel and repeat this process until it does not receive

any response that request for its frames. Once one channel is found to be empty, it will choose a random personal region network PAN ID, and begins to monitor this channel.

3. Results and Conclusions

Fig. 2 shows the Designed patient monitoring system which is connected to PC/Laptop. Fig.3 Shows the Output of the LCD screen on the monitoring system to indicate the scanning data of the patient health parameters like temperature, Pulse, etc. Fig.4 shows the resultant information transmitted to the PC/Laptop and the data that a Doctor can get about the patient health from our designed system.

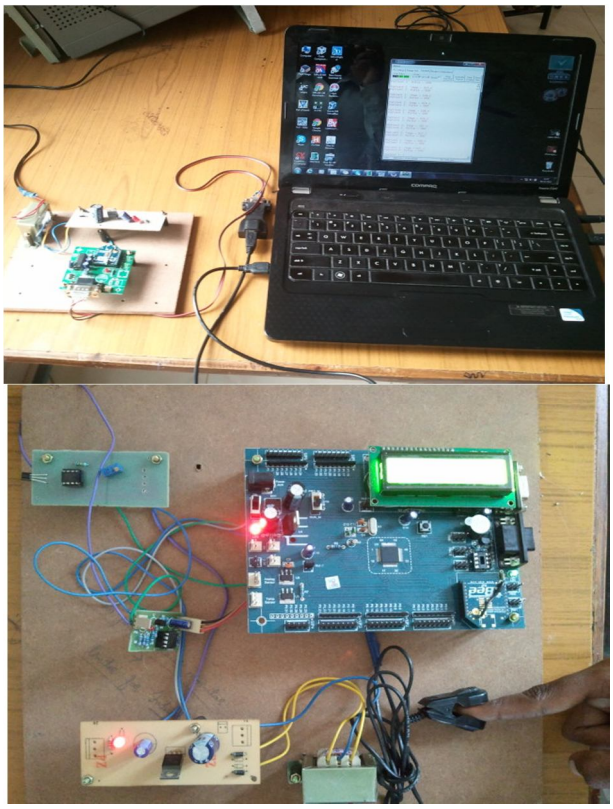

Figure 2 Designed health Monitoring system

Tests find that this system can successfully set up the Zigbee star network. The monitoring terminal can precisely check the heart rate and body temperature of patients, and send them to coordinator and then surveillance center through wireless network. The error of the monitored body temperature, heart rate, and other information is very slight, which satisfies practical usage, and meets the demand of the design.

Figure 3 Output on the LCD on the Scanning system

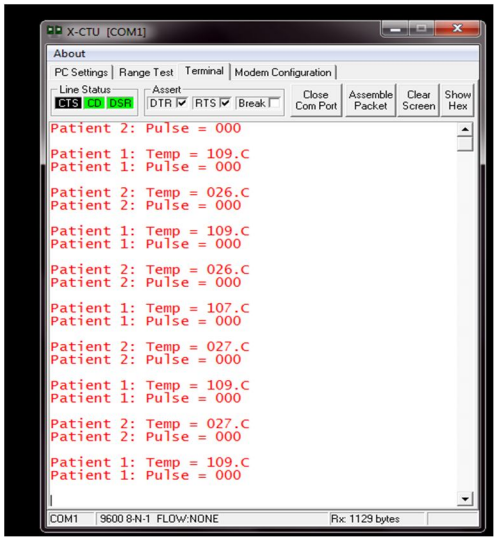

Figure 4 Output shown at PC (Base Station)

By extending other sensor module, it could realize the monitoring of more psychological parameters and reliable transmission. Since this system only realized the detecting and transmission of heart rate and body temperature, and the detection accuracy is not enough. The next step focuses on how to improve the detection accuracy, how to realize more reliable transmission of data, and extend more sensor module, so as to conduct further research on the monitoring of more psychological parameters. At the same time, due to the limitation of the master chip, the power dissipation of routers and terminal device is not low enough. More work should be done concerning this aspect to further reduce the power dissipation and lower the cost.

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