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GSM BASED INTELLIGENT WIRELESS MOBILE PATIENT MONITORING SYSTEM USING ZIGBEE COMMUNICATION

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Abstract: Miniaturization of biomedical sensors helped 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. This paper deals with one of such Medical Application of Wireless Networks.

Keywords: *Zigbee, Medical monitoring, Sensor Node, Heart Rate, Temperature.*

1. INTRODUCTION

In view of the ever-growing age median among travelers, a health monitoring application is becoming more of a necessity in large capacity aircraft environments, providing safety to passengers with actual or chronic risks, and reducing risk and cost for long-range aircraft operations. Considering the technological advancements in embedded sensor devices a portable medical monitoring enclosure has been developed to provide with the flexibility of low cost and high accuracy measurement equipment in avionic environments. several types of health monitoring sensor modules can be integrated in a compact portable enclosure - such as Electrocardiogram, pulse rate, blood pressure, oximetry, temperature. In addition, a control board was designed and implemented with the purpose of interfacing and processing the data arriving from the sensor modules, and their transfer to a standard RS232 interface. The board was designed for low power operation at the minimum output data rate. To this end, maximum measurement time and also low sampling rate regarding the continuous health monitoring measurements (ECG, Oximetry) were considered. A two layered (Master-Slave) microcontroller architecture was configured to process the sensor output frame and embed relevant information, such as seat number, in order to make storage and data retrieval possible over a large network. A graphic display was also integrated with the aim of projecting passenger health state and triggering alarms when necessary. The medical box is connected to a wireless optical data network inside the aircraft cabin providing maximum flexibility. Although the primary purpose of the system realized was the alerting of trained onboard staff about a broad spectrum of possible health failures, remote health monitoring at ground presents itself as a possibility under the network infrastructure already in place.

ZigBee is an emerging wireless network which possesses the traits of short distance, low speed, low power, less complexity and the function of geo-Iocation. It has obvious advantages in the aspect of equipment consumption, system costing, interference immunity and BER. ZigBee is adequate for the establishment of medical surveillance network in LAN which can link with existing PLMN, WEB and other communication network, interconnecting LAN of ZigBee as an entirety to overcome the defect of existing medical surveillance network. This system is convenient and efficient in nature and has no influence on patients' daily life, so it increases interaction between patient and doctor which made surveillance has real instantaneity. And it ultimately prevents heart disease and avoids unexpected tragedy practically. Fig.l shows typical architecture of PATIENT monitory system which is suitable for hospital based on ZigBee. The patients wear lowcost sensor node, when they move in the coverage area of network, sensor nodes will collect their PATIENT data timely and sent the data to router node of ZigBee. Router nodes join up Internet, satellite and other network by way of sink node of ZigBee inside the network and transfer PATIENT data to management center of hospital. Doctor can check patients' ECG message via management center at all times, and make diagnosis analysis to patients' condition

2. HARDWARE IMPLEMENTATION

The communication module used in this paper is CC2420---Texas Instruments' first RF transceiver chip that is suitable for ZigBee products. CC2420 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 CC2420 by SPI interface, and can read and writing inner registers of CC2420, realizing the Wireless transceiver of information. It can get information such as psychological parameters from external sensors by ADC and DAC modules.

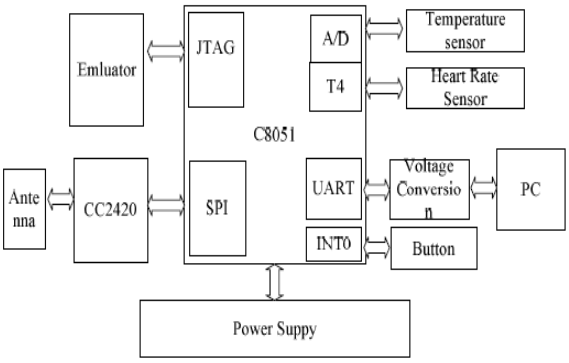

Figure 1 A Wireless Patient Monitoring System Model

It is connected with the simulator and PC by JTAG and UART series interface, therefore realizing the download and on-line debug of programs. Through the external interrupt, it could control the calling button to get the calling information from patients, and process by interrupts.

Many of the digital resources could only be used through four I/O ports: P0, P1, P2, and P3. Every pin of P0, P1, P2, and P3 could be defined as the I/O pin of general ports, and could be allocated to a digital peripheral or a function. The flexibility of the allocation of resources is realized by using priority crossbar decoder. In this system, peripherals that need I/O ports are UART0, SPI0, T4, and INT0. The allocation of pins is showing in Fig. 2 according to the order of priority cross switch configuration of C8051F021.

3. THE SYSTEM DESIGN

Our system applied DTW method to recognize human activities of daily living. We used two feature sets to the classifier such as database and test data. We kept signals to the reference databases from two healthy subjects, male is 24 years old and female is 23 years old. Train data were recorded from different human activities.. By the way, test data were the test signals inputs. These test signals were recorded every two seconds (sampling time 70ms). Each test signal was computed in DTW method with ten activities reference database as follow DTW method computed two signals per time: test signal and reference database signal. So, DTW was used for ten times per each test signal. In this method, we got ten optimal warp paths as above-mentioned. After that, we found the minimal value from these ten optimal warp paths. The purpose of the project is to that tracks human movements and behaviors for rehabilitative purposes. We applied Dynamic Time Warping (DTW) to recognize human activitiesof daily living. Different movements are considered and were kept to reference databases signals. This project consists of two parts: transmitter and receiver.

A transmitter part is the device mounted at the user's waist within a pager case measuring 90x40x20 mm. The whole device weighs approximately50 g including batteries. A sensor used in this device is a 3-axial accelerometer. The signals from the accelerometer are transmitted wirelessly to a personal computer in receiver part using Zigbee 2.4GHz. A personal computer only requires visual basic program to recognize our system. DTW is used to match the signals from different behaviors in online with the databases. DTW will find a minimal path between two time series: the test signal and the reference database signal. This minimal value can classify a kind of activity of that test signal. The experiment shows 91 percent accuracy in recognizing these behaviors.

By allocating ports P0.1, and P0.2 to UART0, it could realize the communication with PC. Ports P0.2 to P0.5 are allocated to SPI interface to communicate with CC2420. P0.6 and P0.7 are external interrupt1 and 2 respectively, which are allocated to calling button S1, and controlling button S2. P1.0 is used as timer/counter T4, and is connected with external heart rate sensor to realize the gathering of heart rate signals. P3.0 to P3.4 are used as general digital I/O port, and are connected with CC2420 to realize the control of CC2420. P3.6 and P3.7 are used as the port for external interrupt 6 and 7, and are allocated to SFD and FIFOP.

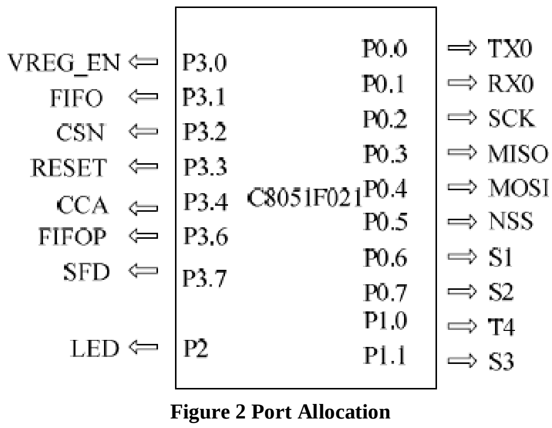

Figure 2 Port Allocation

Microcontroller configures the internal registers of CC2420 through the SPI interface, and reads RXFIFO and writes TXFIFO. Their connection is shown in Fig. 3. Signals SFD, CS, FIFO, FIFOP, SO, SI, and SCLK are used in the communication.

The CS signal is set low to start a SPI operation, and the operation becomes higher at the end of CS. SFD is the flag for the received flame. SFD is set high when the physical layer recognize effective data frame, and will jump low after receiving all data frame.

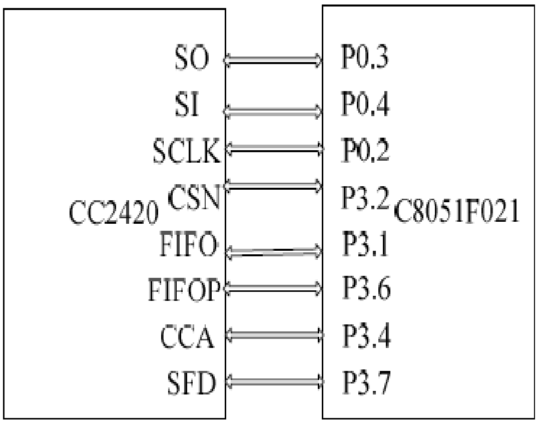

Figure 3 Interfacing SPI and Controller

FIFO and FIFOP are status indication signals for the physical buffer. If there is data in the FIFO buffer of CC2420, pins of FIFO are set high; otherwise, they are set low. Pins of FIFO are set high when the data received in FIFO buffer exceeds a threshold, or after CC2420 receives a complete flame. The threshold can be set through registers of CC2420. CCA pins are set high when there are signals in the channel, and are only valid in the receiving state.
8 symbol cycles after CC2420 enters the receiving state, effective channel status signals will be on the CCA pins. Fig. 4 demonstrates the timing diagram when microcontroller read and write the RXFIFO of CC240 by SPI.

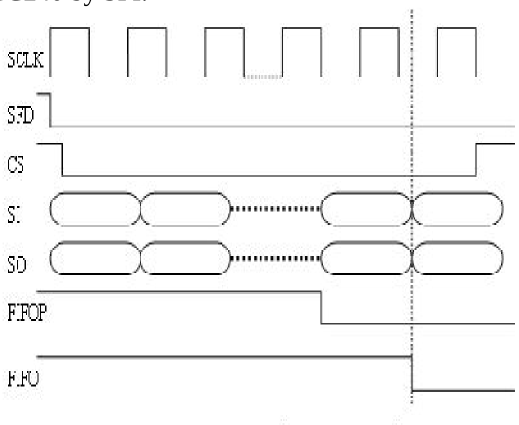

Figure 4 Timing Diagrams

This paper realizes the real-time body temperature monitoring by highly precise thermistance. The heart rate detection module collects heart rate information of patients by heart rate sensor ZZ-9953, and sends the information to the master chip. ZZ-9953 converts patients' heart rate signals into electrical impulses, and outputs heart rate impulses through three linear amplifiers composed of six-inverting CD4069, and through two pulse shaping. The pulse signal is inputted the counter T4 of C8051F021.
The timer T3 sets certain time; during which T4 collect the number of heart rate impulses by counting, therefore calculating heart rate per minute. The heart rate detection circuit is shown in Fig. 5.

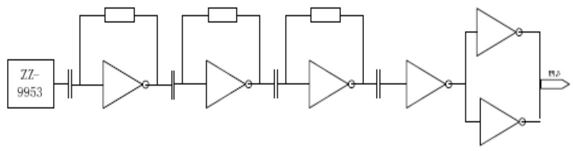

Figure 5 Sensor Internal Architecture

Fig. 6 Shows the Block Diagram of the Proposed Patient Monitoring system.

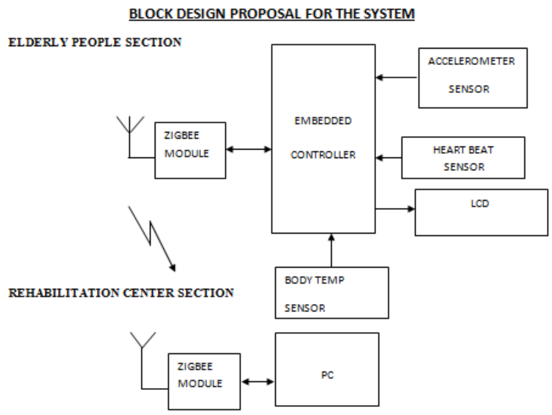

Figure 6 Block Diagram for the Proposed System

4. SOFTWARE 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.

Then it will allow new devices to be added in this network to construct the network. After constructing the network, coordinators begin to work, waiting for other monitoring terminals to be added in the network, or transceiver data[3].

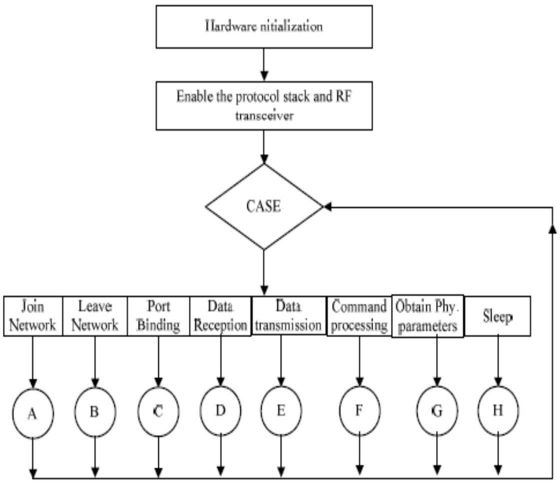

Figure 7 Proposed Flow Graph for Software design.

After the monitor terminal is powered, it initializes hardware and protocol stack, then progress into the main program loop. First, it enters the join network status to check whether there are neighbor lists in the nonvolatile memory. If there are, it demonstrates that this device used to be added into the network. Then it executes the re-enter process to link the parent equipment (coordinator or router) to add into previous network.

If the neighbor lists are empty, or if the re-enter process failed, the device will scan the channel first, trying to find a nearby coordinator or router.

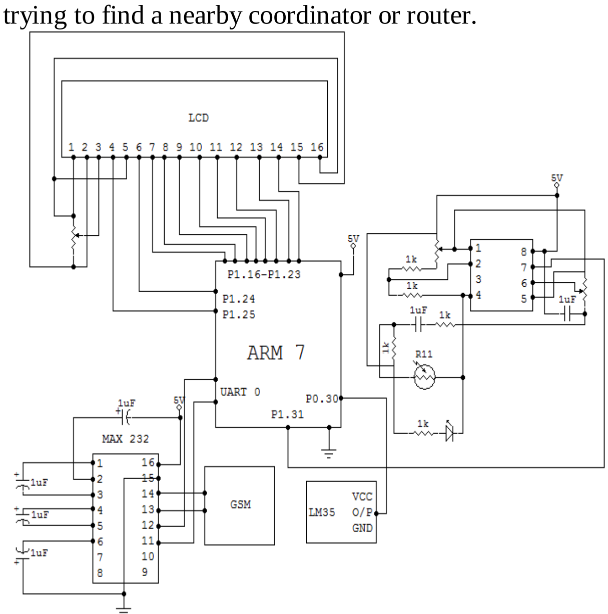

Figure 8 Circuit Implementation

This terminal device will broadcast bacon frames to measure and collect nearby data from coordinator or router. If there exists potential parent equipments, it will take out one according to given algorithm as its parent equipment, and then send a request to join the network. After getting the response from coordinators or routers, it will get an available network address from coordinator or router as its identity in the network.

At the same time, it will add the coordinator or router as its parent equipment to its neighbor lists. In the normal execution of the next starts, it will automatically attempt to rejoin the network [6] [7]. The Main Program Flowchart of Monitoring Terminal is shown in Fig. 7. The Circuit Implementation for this system is shown in Fig. 8. The Developed module is shown in Fig. 9.

5. Conclusions

Health monitoring application is mainly proposed to provide alerts for medical health monitoring staff for the patients when needed. The real-time monitoring system for cardiac patient physical states is based on wireless sensor network technology. It can be taken by patient and keep the patient movement intact because it is miniature and portable. The system can monitor and record the physical states and movement parameters real-time, and then provide an auxiliary means for the correct diagnosis of doctor. With the intelligent diagnosis software, the sign of acute disease for patient can be found early, and then the patient can be helped in time, the sudden death of patient can be avoided.

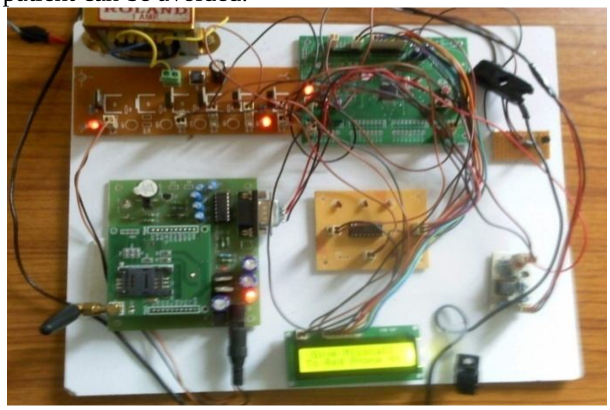

Figure 9 Snap Shot of the Developed Module

Figure 10 GSM Feedback Message Example

The output of GSM message feedback is shown in Fig.10. It gives the Details of the Patient health periodically to the registered mobile number.

The Zigbee technology can be suited for short distance communication, and the transmission distance is limited only about 200 meters, and then it can be suitable for in-patient monitoring. The system is important to be applied to patient care. 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.

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. 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.

Tests find that this system can successfully set up the Zigbee star 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. By extending other sensor module, it could realize the monitoring of more psychological parameters and reliable transmission.

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