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Health Care System Based on Wireless Sensor and Mobile Communications

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Abstract

With health wearable device becoming increasingly popular on the market, health has become a hot topic of concern. In view of the aging process as the population appears empty nest, elderly people living alone health care issues, a three-tier health care system architecture design based on the "health care acquisition layer embedded terminal - server software system layer-routing layer" is presented in this paper. Aiming for systematic design plan, this paper studied the implementation of key technologies including the following part: the physiological parameter acquisition, ZigBee networking, GPRS mobile communication and Bluetooth Low Energy (BLE) etc. System enables the user to sign of physiological parameters of the real-time dynamic acquisition upload, and through the Android APP and Web two ways to remotely view, providing real-time reference data for the user and medical personnel.

Keywords*: Health Care; Internet of things; Mobile communication; Embedded systems; Android*

1. Introduction

With the rapid development of the quality of our life, population aging process speeds up [1]. The results of the 6th census showed that the population aged sixty years has exceeded 200000000, accounting for 1/7 of the total population [2]. Chinese elderly population base was enlarged and rapid growth. At the same time, due to the change of family structure, working and other reasons caused the empty nest, the phenomenon of elderly people living alone there has been sharp increased [3]. The aging of population has become a major social problem that can't be ignored in 21st century, and it is important to accelerate the construction of the old age security system, and the remote health monitoring will be the key link.

Application of wireless sensor like ZigBee[4-5], BLE[6-7], mobile communication, tele-control technology, get real-time acquisition of human vital signs parameters, can effectively prevent rapid response to abnormal conditions[8]. Elderly people and their families can use the remote medical care system to control condition of wearers in real time[9]. And through the network to the terminal acquisition of physiological parameters data uploaded to the medical institutions in a timely manner, they also can obtain analysis and guidance from the medical staff. Health monitoring system not only can effectively monitor the health of the elderly, but also provide real-time and accurate information for their families. Hospitals and other medical institutions will ease pressure.

The rest of this paper is organized as follows. Section 2 introduces Overall scheme design of health monitoring system. Section 3 starts with design of embedded terminal

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system for health monitoring. Section 4 describes the design of server software system. Section 5 describes the design of android application. Experimental results of the proposed method are presented in Section 6. Conclusions and remarks on possible further work are given finally in Section 7.

2. Overall Scheme Design of Health Monitoring System

2.1 System Structure Design

The overall structure of the system is the skeleton of the whole project. Hierarchical design can ensure the stability of the system and the independence of each layer, and improve the structure of the system which can adapt to the changing needs and complex environment.

In this paper, the system is designed as the three layer structure: health monitoring embedded terminal acquisition layer, routing layer and health monitoring center server software system layer, as shown in Figure 1.

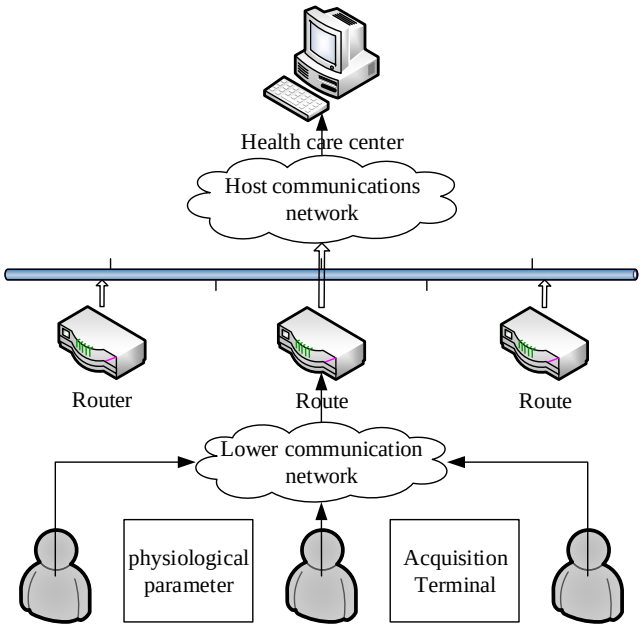


Figure 1. Three Layer Structure of the System

2.2 System Function Overview

Health monitoring is a real-time and continuous monitoring of the user's physiological parameters, as well as to analysis and research the physiological condition [10]. In this paper, a real-time, wireless, multi terminal and remote health monitoring system is designed based on the traditional design which uses wireless sensor and mobile communication technology, to realize the intelligence of the new system, etc. Health monitoring system is mainly divided into three parts: the human physiological parameters information acquisition and transmission part, health monitoring center server software system and multi-terminal information display part. The structure is shown in Figure 2.

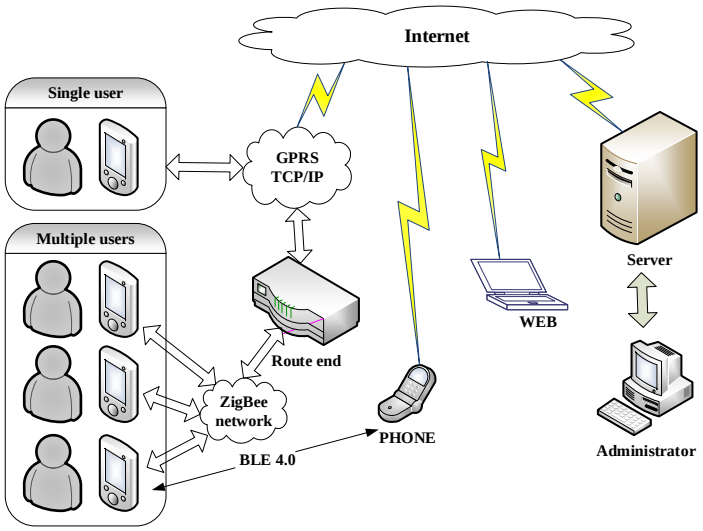


Figure 2. System Structure Diagram

Information acquisition and transmission of human physiological parameters part is mainly composed of the embedded system of health monitoring and routing system. Collection terminal is responsible for the collection of blood pressure, blood oxygen, heart rate and other physiological parameters of the human body. Multiple acquisition terminals and routing form local ZigBee wireless network, complete the summary and processing of information.

Health monitoring center server software system is mainly related to data analysis and processing, database storage query, access to multiple terminals, etc. Socket communication is established between the server end and a plurality of routing end to complete the task of controlling the router and the acquisition of terminals. At the same time the server-side processing the network access from the Android mobile applications and Web page. The server-side is the control center of the whole health care system.

Multi terminal information display part mainly includes the design of human computer interaction interface and data's query and display. Through the Android mobile application and Web browser end user login registration, personal information, data query, history display and other information processing. At the same time, the Android mobile phone application program also has the function of the local Bluetooth pairing with the acquisition terminal, so that it can directly control the acquisition terminal without the network.

3. Design of Embedded Terminal System for Health Monitoring

The embedded terminal system design includes the collection terminal. The design and debugging of the modular hardware PCB circuit of the router and its layered architecture of embedded software system design.

3.1 Platform of Embedded Terminal Hardware

The hardware platform of the embedded terminal hardware platform includes two circuit designs: the collection terminal circuit and the route circuit. The design structure of “STM32F207IG+Multi sensor module” is used to enhance the hardware system's expansibility. Followed the design principle of low power consumption and ease of use, modular is designed.

Circuit design includes power supply circuit, a microprocessor (STM32F207IG) circuit, crystal oscillator clock circuit, reset circuit, general UART serial interface

circuit, JTAG interface, LCD circuit, Bluetooth 4.0 BLE circuit module, ZigBee module, GPRS module circuit(Router), blood pressure, blood oxygen, heart rate module circuit. Collection terminal and routing end of the object are as shown in Figure 3.

(a) (b)

Figure 3. Platform of Embedded Terminal Hardware: (a) Acquisition Terminal, (b) Router

3.2 The Software Structure of Health Monitoring System

The software of the embedded terminal of the health monitoring system is designed with the idea of hierarchical design and modular design. According to the hierarchy structure design is divided into the device function, the device driver, the software interface and the application layer, reduce the system coupling degree. According to the function of each level, the function will be divided into several functional modules, such as the blood pressure module, blood oxygen module, ZigBee module, GPRS module and BLE module. The bottom of the system is equipped with open source lightweight protocol TCP/IP stack LwIP (Light weight Internet Protocol), in order to realize the communication of GPRS network.

The embedded terminal of the health monitoring system is divided into the collection terminal and the route end. The software design roughly the same, the main difference is in the individual function module. The overall hierarchical structure of the health monitoring embedded terminal software is shown in Figure 4.

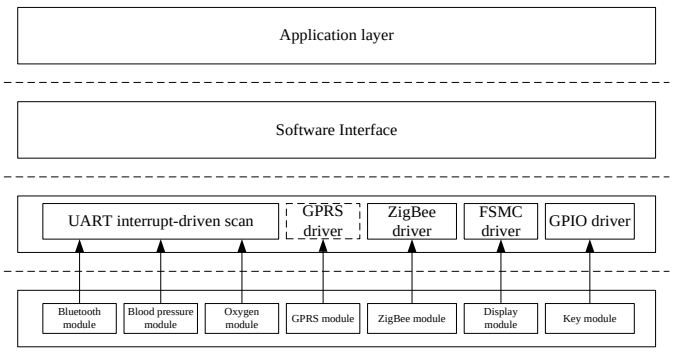


Figure 4. Software Structure of Health Monitoring System

4. Design of Server Software System

Server-side software solves the problem of access, registration, online, for a server to multiple terminal devices. The data of human physiological parameters are received by the embedded terminal of each health monitoring system. And under the control of the health monitoring embedded terminal control command. Software design involves the development of communication protocol between the terminal and the server. Receive

data is in accordance with the agreement in advance, instruction format, etc. the data that have the physical meaning stored in the database. And realize the data on a variety of interface display, query and other operations

4.1 Communication Design

Communication design refers to the establishment of a network communication protocol between the health monitoring center and the embedded router or the acquisition terminal.

The embedded LwIP protocol stack is embedded in the bottom of the embedded software system of the health monitoring system. This lightweight open source TCP/IP protocol stack is characterized by the use of relatively low hardware resources, as far as possible to retain the main functions of the TCP/IP protocol [11]. The Java programming language in the programming language provides the ServerSocket and the Socket class to implement the Socket TCP communication, and the server uses the ServerSocket class to receive the client's connection requests. Finally, the terminal sends a request to the server through the network, to establish a TCP connection.

The communication process in the application layer of the server end and the embedded system in the health care center are shown in Figure 5.

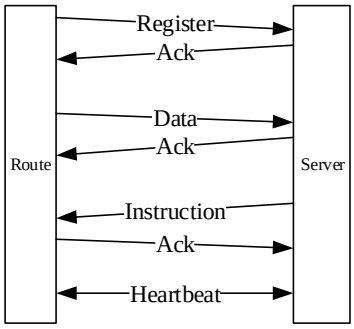


Figure 5. Communication Process

(1) Registration: After the routing is connected with the TCP protocol, the server sends the registration instructions to the server, including the ID address of the router. After the server detects the registration instructions correctly, the route is put into the online list and sent to the route end to confirm with the instruction Ack;

(2) Data: the router upload the human physiological parameters collected in the ZigBee LAN to the server, Send Ack command after the server is confirmed;

(3) Command: server side to the acquisition terminal sends instructions such as the correcting time instruction. Sends data to the router in the ZigBee network, by the router forwarding, the acquisition of the terminal after receiving instructions to return the confirmation instruction Ack;

(4) Heartbeat: to maintain the TCP persistent connection, the routing and server side Send heartbeat commands in the interval, as a basis for the existence of persistent connection.

The system uses unified communication instruction format. The lower communication network (ZigBee network, the collection terminal and the routing) and the host communication network (GPRS network, the routing and server side) communication instructions are made by package head, address code, packet length, function code, parameters and check. The function code determines the specific function of the

instruction, and the parameters are different according to the function code. Communication instruction format is shown in Table 1.

Table 1. Communication Instruction Format

Field	Explain
Package head	2 bytes, fixed
Address code	4 bytes, Routing address
Packet length	2 bytes, From the function code to the length of the check
Function code	1 byte, Registered, Heartbeat, Data, system clock adjusting, etc.
Parameters	N bytes, According to the function code
Check	2bytes

4.2 System Data Design

Health monitoring center server software system is based on the B/S(Browser/Server) structure of the Java Web system software, it used the open source framework S2SH (Struts2+Spring+Hibernate).

The system has realized the users' access to the health monitoring system anytime and anywhere, and to understand the operation of the embedded terminal and the physiological parameters of the users.

The software system mainly includes the function modules such as login, user basic information, data statistics and setting. User access to the correct server network addresses using the browser. After entering the login screen, Users need to enter the account number and password. Web login screen is as shown in Figure 6.

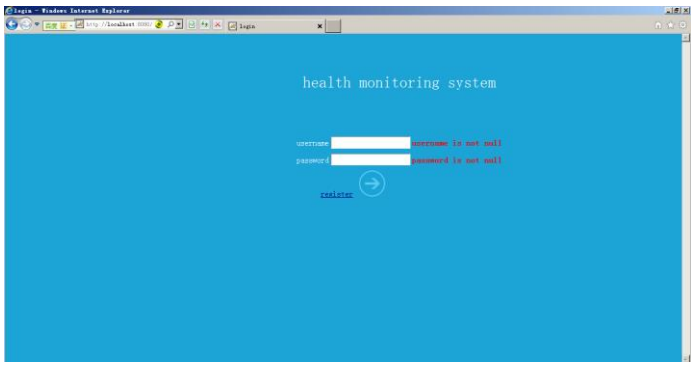


Figure 6. Web Login

User logged into the site. Basic information shows the user's personal information, the use of equipment information, health records, etc. Personal information interface as shown in Figure 7.

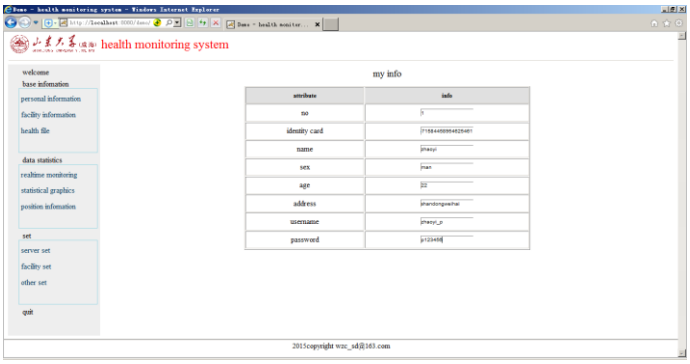
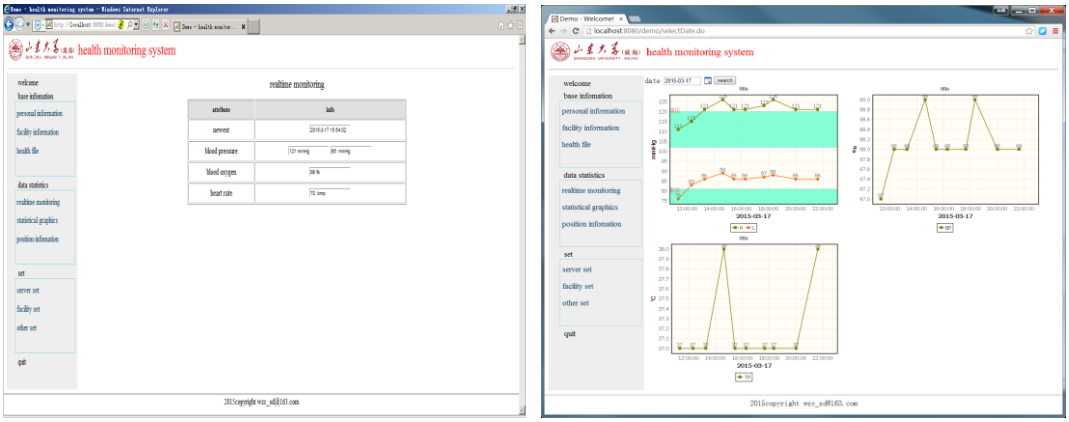


Figure 7. Personal Information

The data statistics section shows the data information of the user's health monitoring embedded terminal. There are real-time data, historical data stored in the database, etc. Query terms by datetime picker; Table query results will be displayed in the form of curve at JFreeChart control. Interfaces are as shown in Figure 8.



(a) (b)

Figure 8. Data Display: (a) Real-time Monitoring, (b) Data Statistics

5. Android Application Design

Mobile phones become an indispensable tool for people's lives. This paper develops a health monitoring APP of Android-based operating system which allows users to more easily and quickly realize the health monitoring and control.

APP of health monitoring system includes the function modules such as Bluetooth, real-time monitoring, historical data, personal information and setting. Among them, the Bluetooth read function to achieve pairing with embedded acquisition terminals, to get the local information. Other functional modules are connected to the server indirectly through the network to obtain the information. The android application is shown in Figure 9.

Figure 9. APP which is Designed for this System: (a)Android Login and Main Menu, (b) Historical Data Curve, (c) Real-time Monitoring and Personal Information

6. Experimental Results

Debugging is mainly to make the acquisition terminal, routers, Android mobile terminal, server and other parts of the connected and achieve normal communication. All physical connections are shown in Figure 10. Each module has been tested. After starting the server and configuring the network, all the components can be connected to the server.

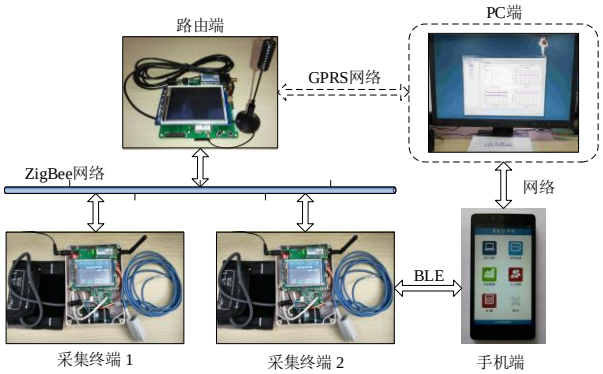


Figure 10. Overall System Debugging

In experimental of measurement accuracy, we used the professional measurement equipment. The finger oximeter YX301 and OMRON Electronic sphygmomanometer HEM-7052 are to compare the measurement results. Experiment 1 select a user to measure at the same time in seven days, the experimental data are shown in Table 2. Experiment 2 select three users and used the system to measure and compare in a short time in one day. The experimental data is as shown in Table 3. From the experimental results we can see that the parameters of the system measurement data and medical equipment measurement are small in error, and the measurement accuracy is high and stable. In the process of experiment, the local equipment, server software system and mobile phone application program run well.

Time heart rate (BMP) blood oxygen (%) systolic / diastolic blood pressure (mmHg)

Table 2. A User to Measure at the Same Time in Seven Days

Time	heart rate (bmp)	blood oxygen (%)	systolic/diastolic (mmHg)
3.11	73 73	98 97	126/76 125/76
3.12	73 72	98 99	128/80 126/79
3.13	70 69	97 98	122/73 123/70
3.14	76 76	98 98	130/81 127/77
3.15	73 71	99 98	125/74 124/73
3.16	77 77	98 99	132/80 130/80
3.17	74 73	99 98	124/74 123/75

Table 3. Three Users and Used the System in A Short Time

	heart rate (bmp)	blood oxygen (%)	systolic/diastolic (mmHg)
1	75 73	98 97	126/76 125/76
2	73 72	99 99	118/69 117/69
3	70 69	99 98	135/80 136/82

7. Conclusion

This paper presents a novel health monitoring system based on wireless sensor and mobile communication aiming at solving the problems of health care for more and more elder who lives alone, but also cater to the modern people on the growing of the concept of health. In this paper, the related technologies are wireless sensor networks, mobile communication and so on. The software and hardware of the system are designed and completed. By tested, the system runs stability, and the functions need required to design.

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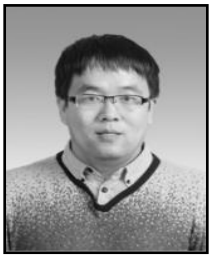

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