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Design of Distributed Remote Real-Time Monitoring and Control System Based on Internet

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ABSTRACT

Distributed remote real-time monitoring and control system is based on the ideas and framework of the Internet of Things, composed by the three parts: Zib Bee distributed wireless sensor network, Embedded WEB server based on ARM and GSM for network access services. The system can real-timely monitor the remote environmental parameters and configure the remote equipments. Zig Bee wireless sensor network which uses a star configuration can real-timely transmit the collected data to the embedded system server. Users can get the remote environmental parameters or control the working status of the remote equipments by accessing the embedded WEB server which uses the structure of B/S. GSM network access services can provide the voice and SMS inquiry services and control the working status of the remote equipment for users. For reducing the communication data, the system uses a mechanism with querying, regular report or exception report, which can be widely used in family, warehouses and greenhouses, etc.

Keywords: *Internet of Things; ZigBee wireless network; WEB server; GSM module; Real-time monitoring and control*

1. INTRODUCTION

Internet of Things (IOT) at the international level is also known as the “sensor network” and “Smarter Earth”. Kevin Ashton of Massachusetts Institute of Technology (MIT) is considered the father of the concept “Internet of Things” which was coined in 1999. Definition as per Kevis Ashton is as follows: all things are connected to the Internet via sensing devices such as Radio Frequency Identification (RFID) to achieve intelligent identification and management [1]. Mainly through the wireless sensor, RFID, infrared sensor, global positioning, sensor and other technology, according to the agreed protocol, put any items connected to the Internet together, to exchange information and communication in order to achieve intelligent identification, positioning, tracking, monitoring and management, consequently to make object intelligence and realize communication and dialogue between objects with each other, so as people and objects can also be achieved [2]. The characteristic of the IOT is comprehensive sense, reliable delivery, intelligent processing [3]. With the rapid development of modern technology and the IOT technology continues to mature, makes wireless sensor network has been a very wide range of applications in areas such as environmental monitoring, industrial and agricultural production and military. Some monitoring point location is relatively remote, how to transmit the monitoring-data real-time and accurate to the monitoring center is a hot issue.

This system is based on the ideas and framework of IOT, for the application of real-time monitoring and control on the remote plant’s environmental parameters. Use Zig Bee wireless network technology to build a distributed wireless sensor networks, Zig Bee coordinator, GSM module, audio broadcast, Double Tone Multiple Frequency (DTMF) decoder and Embedded WEB server are controlled by LPC2292. It can transmit the data collected by the wireless sensor network from select the existing Ethernet or Global System of Mobile communication to remote terminal. For reducing the communication data, the system uses a mechanism with querying, regular report or exception report, which can be widely used in family, warehouses and greenhouses, etc.

2. HARDWARE ARCHITECTURE OF SYSTEM

The hardware block diagram of this system is shown in Figure 1. It is mainly composed of three parts, which are Zig Bee wireless monitor and control networks platform, GSM network platform and embedded control system. The system's main function is transmitting the monitored-data to the users via the existing GSM network or Ethernet.

a. ARM7 Embedded System Circuit

ARM7 embedded system uses LPC2292 produced by Philips. The LPC2292 is based on a 16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support [4]. This chip’s peripheral modules are very rich and it has a powerful processing and control capacity. This microcontroller is particularly suitable for automotive and industrial control. Use it to build control system, it will be not only smaller, cost-effective and have a reliable

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performance. LPC2292 minimum system circuit is shown in Figure 2.

U1 (LM2575) is a switching regulator produced by the U.S. National Semiconductor Corporation; the output voltage is 5V and the maximum output current up to 1A. U2 (LM1086-3.3) and U3 (SPX1117-1.8) are Low Dropout regulators (LDO). The output voltage of U2 is 3.3V, and the maximum output current is 1.5A. It can provide a stable power supply for embedded system, ISD4004, Zig Bee module and GSM module. The output voltage of U3 is 1.8V, its features are high output current, high output voltage accuracy and high stability, etc. In addition, this regulator chip also has overflow protection and superheat protection. In this system the digital part and the analog part is isolated by L2 (10mH), L3 (10mH), C9 (104) and C10 (104). The reset circuit is constituted by U4 (SP708S) and U5 (74HC125), it can provide a stable and reliable reset signal for this system.

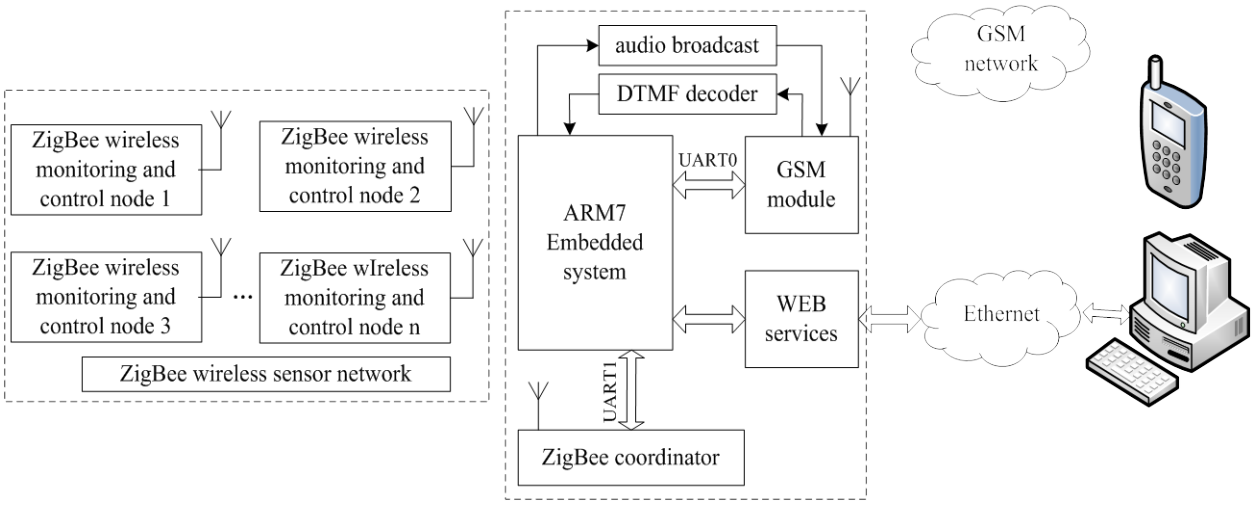

Fig 1: Hardware block diagram

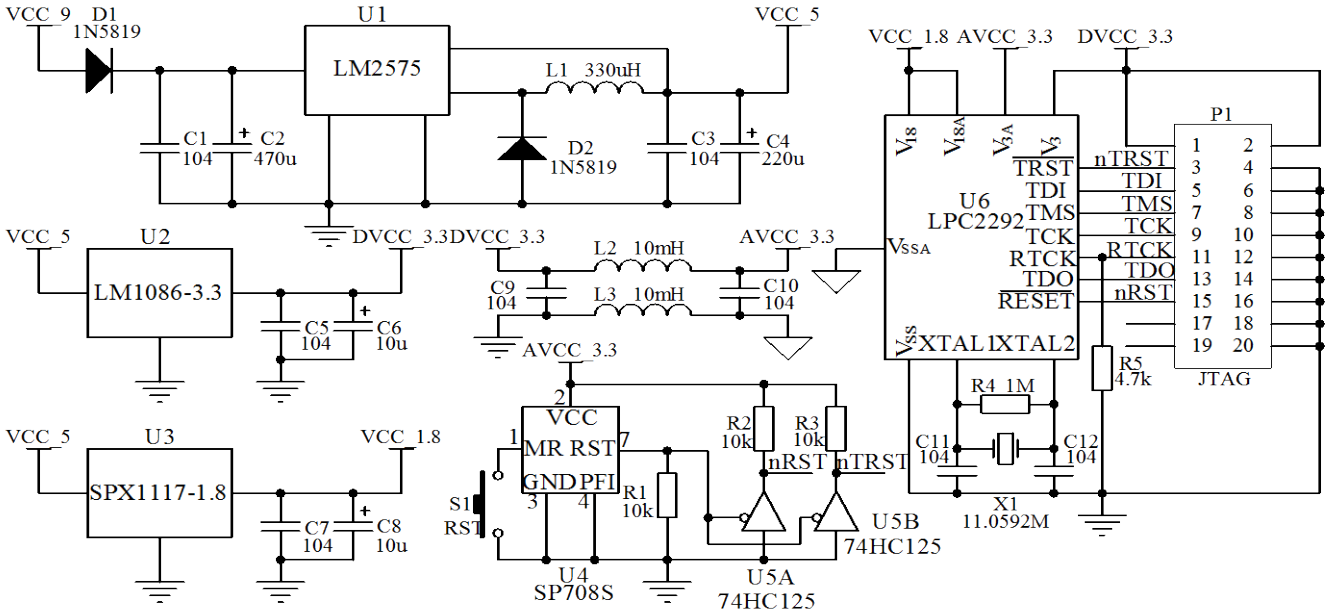

Fig 2: LPC2292 minimum system circuit

b. Embedded GSM Network Platform

GSM module uses EM310 produced by Huawei. It has voice calling, GPRS data transfer and Short Message Service (SMS) function. Users can query the state of remote object from dialing the phone number or sending a SMS. When the system detects that the working status of the remote device is abnormal, it will send a SMS through EM310 to the specified mobile phone user.

EM310 and LPC2292 can transfer the data with UART0, which communication rate is 9600bps and the form is 8-bit asynchronous serial. EM310 module's inputs and Outputs are all TTL, so it can connect with LPC2292 directly. Figure 3 shows the main interface circuit of EM310 and LPC2292. In this figure, R8 (5.1k) and C19 (10μF) can provide a negative pulse low level lasts more than 50ms, it can power on EM310 automatically. When the module is successfully powered on and registered the network, the LED1 will flicker with the frequency of 3s.

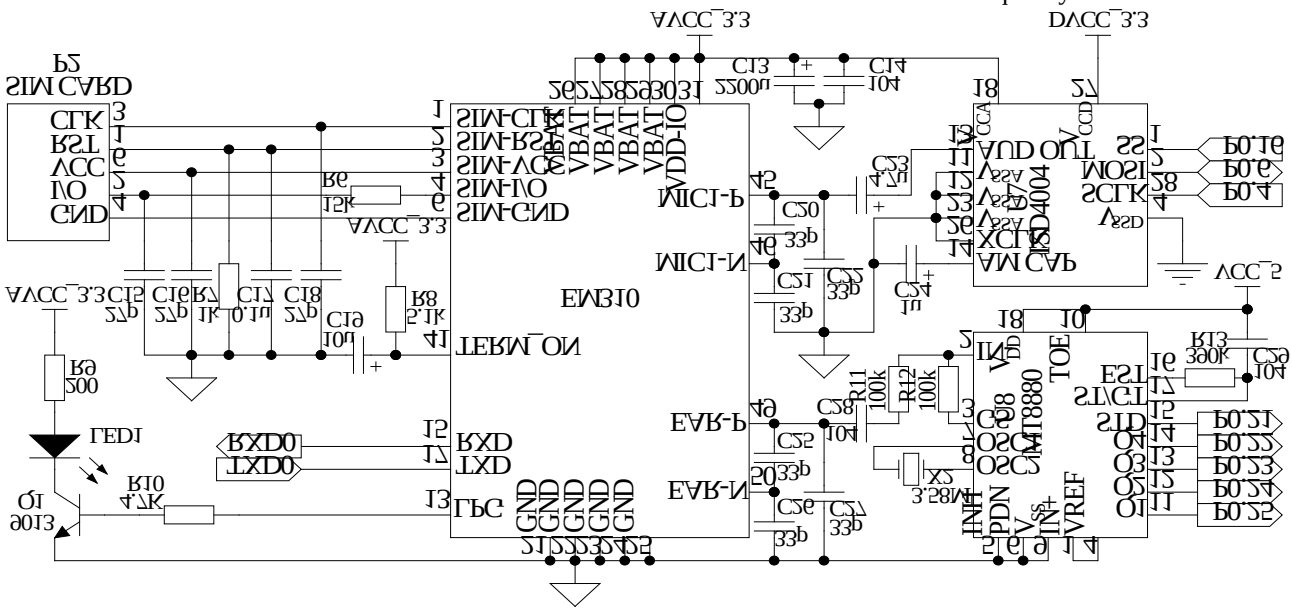

Fig 3: The main interface circuit of EM310 and LPC2292

U7 (ISD4004) is a single-chip voice record/playback device produced by U.S. ISD Corporation. Voice and audio signals are stored directly into memory in their natural form, providing high-quality, solid-state voice reproduction [5]. We programmed the prerecorded voice to U7. When the users log into the system through the phone, he can operate the system according to the voice prompts. U8 (MT8880) can decode the user's key operation, and put the result to LPC2292. LPC2292 response to the appropriate operation based on the results of the decoder.

c. Zig bee Wireless Monitoring and Control Network Platform

Zig Bee technology, whose standards in hardware and software are established by IEEE802.15.4 [6] and Zig Bee Alliance, exhibits properties of low power, low cost, small size, and large sensing range, etc. It can work on 2.4GHz which is internationally free with data transmission rate is up to 250kbps. Using. Zig Bee network sensor to replace traditional wire connection system can achieve the high security and reliability of the observation system on the basis of the low cost [7]. In this system the Zib Bee wireless monitoring and control network is composed by Zig Bee module, sensors, control switches and power supply system. The Zib Bee module (C51RF-2530) which uses CC2530 chip with 8051 core is produced by Wireless Dragon Communication Technology. C51RF-2530 works on the frequency of 2.4GHz, and can fully meet the IEEE802.15.4 standard and ZigBee2007/PRO protocol stack. All the Zig Bee modules in the system composed of a star network. First, Zig Bee wireless monitoring and control node transmits the collected data to Zig Bee coordinator, and then the Zig Bee coordinator will transmit the received data to the embedded systems through the serial port UART0. Users can query the data by accessing the embedded system. In addition, the control instructions, issued by users, after processed by the embedded system will send to the one of the monitoring and control nodes through the Zig Bee coordinator. The main interface circuit of Zig Bee wireless monitoring and control network is shown in Figure 4.

In Figure 4, Zig Bee wireless monitoring and control node 1 monitor temperature and humidity of the environment. Temperature and humidity sensor AM2311 is produced by Ao Song, it can communication with CC2530 via I^2C bus. Users can pre-set a threshold of the temperature and humidity. When the temperature or humidity collected by AM2311 exceeds from the threshold, the Zig Bee module will turn on or turn off the air condition or fan automatically to regulate. At the same time this information will be sent to the designated mobile phone user via SMS. The others Zig Bee wireless monitoring and control nodes can monitor and control other parameters of the environment with the appropriate sensors. The control principle is similar to the Zig Bee wireless monitoring and control node 1. Hence it is not described in detail.

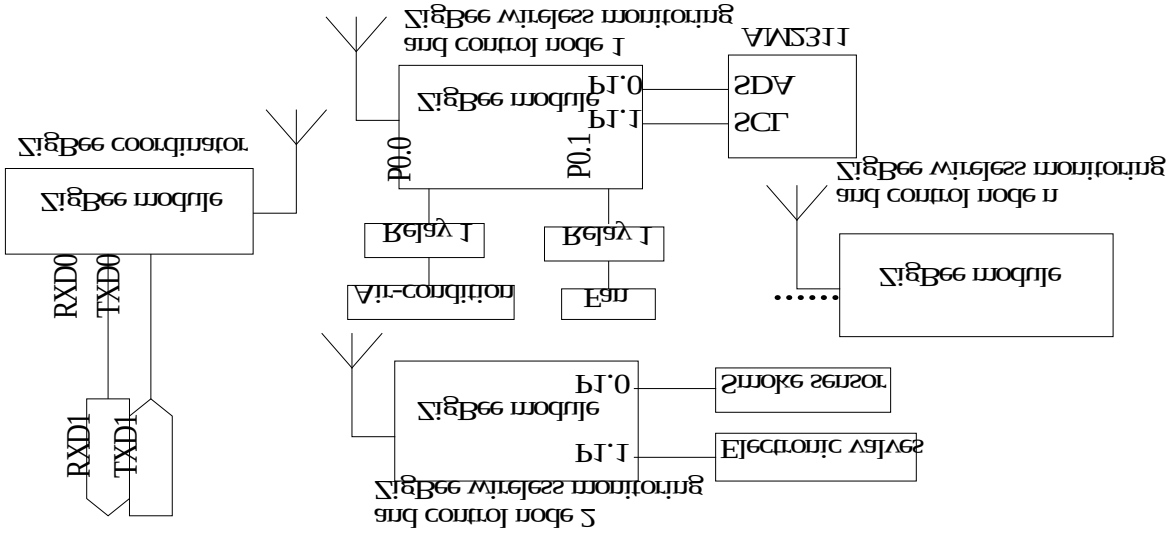

Fig 4: The main interface circuit of ZigBee wireless monitoring and control network

3. SOFTWARE DESIGN AND IMPLEMENTATION

In order to facilitate transplantation, the CC2530 Micro Control Unit (MCU) is written in C language. ARM7 embedded system is developed and based onμC/OS-II core.

a. The Program of Zig bee Wireless Monitoring and Control

The program of CC2530 MCU is developed by IAR software, mainly realizes the environmental parameters' measurement and send the data to Zib Bee coordinator; and also responsible for controlling the devices' state of monitoring and control node. The program's flow chart of CC2530 MCU is shown in Figure 5.

In this flow chart, the system completes initialization and entry the network at first. After the program will run in a loop state, according the judgment system can select the appropriate operating.

Zig Bee coordinator sends the data which is collected by wireless monitoring and control node to LPC2292 through serial port. The control instruction comes from users is also through Zig Bee coordinator to sending to the corresponding monitoring and control node.

The send function of coordination is as follow:

void Sample App _Send Flash Message (uint16 flash Time);

The receive function of coordination is as follow:

void Sample App _ Message MSGCB (a fIn coming MSG Packet _t *pkt);

b. GSM Module Controller Program

GSM module exchanges data through the serial port with LPC2292. The control program's flow chart of GSM module is shown in Figure 6.

In this Figure, the system completes initialization of the serial port and GSM module at first, and then the program will run in a loop state. According to the judgment, system can select the appropriate operating. The concrete realizations of the program are as follows:

```
InitSerial0 (); // Initialize the serial port 0
Send string (AT); // Send AT commands
Send string (AT_E); // Close Echo
Send string (AT+CMGR=1); // Read the new SMS
Send string (AT+CMGD=1); // Delete SMS in the
        SIM // card
```

Send string (ATH); // answer the phone
Send string ("AT + CMGS = 41"); // send a message

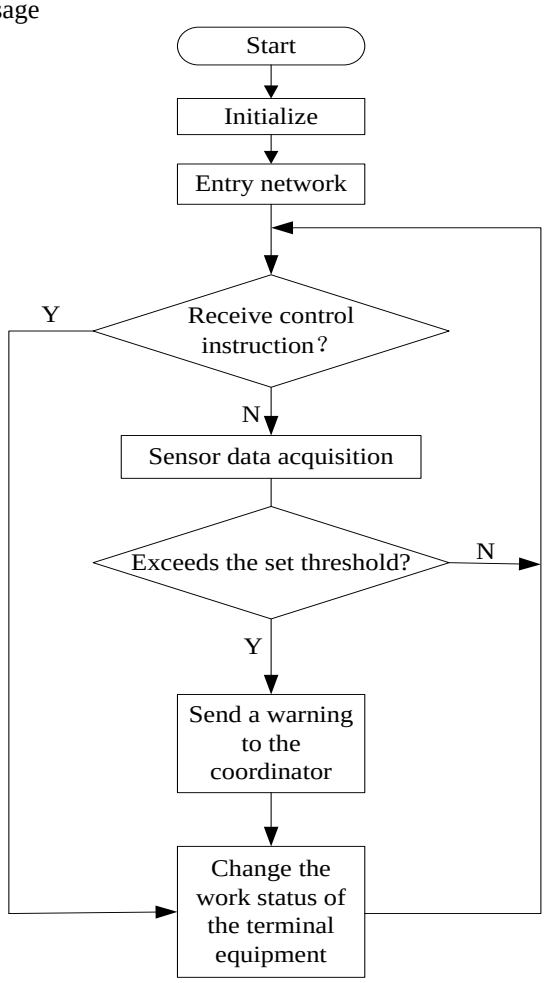

Fig 5: The program's flow chart of CC2530 MCU

c. The Program of Embedded Web Server

WEB services using the TCP/IP protocol, realized by the embedded Ethernet controller chip RTL8019AS. The RTL8019AS is a highly integrated Ethernet Controller which offers a simple solution to implement a Plug and Play NE2000 compatible adapter with full-duplex and power down features [8]. It connects with the LPC2292 through external bus. The connection diagram is shown in Figure 7. System uses 16-bit bus for data exchange with RTL8019AS. RTL8019AS's I/O address is from 0x00300 to 0x0031F, so when SA8=1, SA5=0 the RTL 8019AS was selected and it's data address is from 0x83400000 to 0x83400001F. The NET_RST is a out pin of LPC2292, it can provide a reset signal for RTL8019AS [9]. INT0 is an input signal for external interrupt.

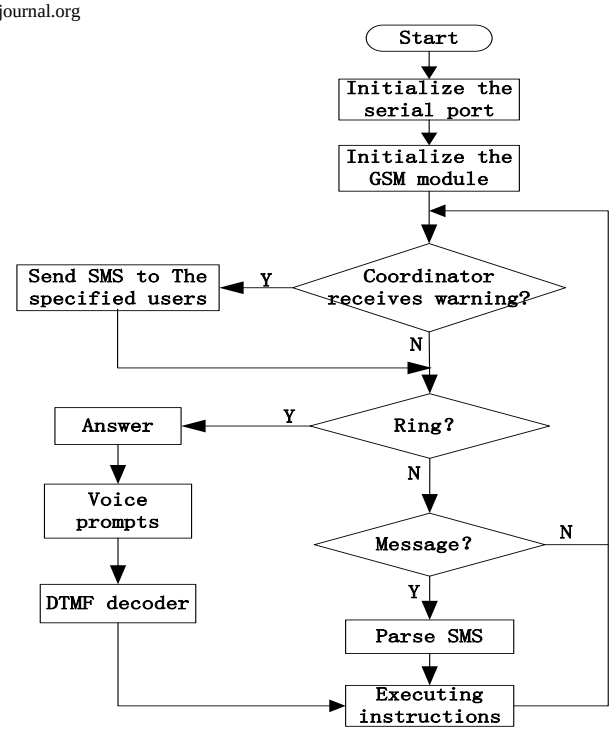

Fig 6: The control program's flow chart of GSM module

WEB service is developed by the environment of ADS1.2. The TCP/IP server program is written by creating aμC / OS-II task. Call the Socket API interface function for the corresponding operation of the network. The concrete realization is as follows:

s=*socket (0,0,0); // Establish a communication based on
// TCP Socket

ei=listen((SOCKET*)&s,1); // Listening the Number of
// connections

Temp = accept ((SOCKET*) & s, (struct sockaddr*) &
cliaddr, & addrlen); // Accept the connection
// requests from client

Close (Temp); // Disconnect

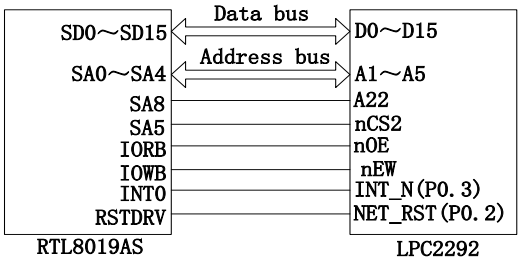

Fig 7: The connection diagram of RTL8019AS and LPC2292

4. CONCLUSIONS

The distributed real-time remote monitoring and control system based on Internet of Things can realize the network control. This system exhibits properties of low power, low cost, wide measurement range, and good robustness, etc. Use GSM and WEB service network, Users can real-timely obtain the remote environmental parameters and control the working state of the equipment without inspecting the field. This system has a highly scalability, different environmental parameters monitoring only equipped with the corresponding sensors, and it has a wide range of applications.

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