Design and Development of Forest Fire Monitoring Terminal

Wu Fengbo,Lv Xitong,Zhang Huike
Information and Telecommunication Engineering College
Xi'an University of Science & Technology
Xi'an, China
wufengbo@xust.edu.cn;
15289286926@163.com

Abstract— Forest fire causes serious harm, in order to achieve real-time monitoring of forest environment, this paper designs the forest environment monitoring system which consists of three parts,environmental data collection node,environmental monitoring terminal and environment data server.The forest environment data acquisition nodes expand their peripherals as environmental acquisition modules,such as wet temperature, smoke concentration, light intensity and flame, these collection nodes through ZigBee networks send the collected information to the environmental monitoring terminal;The environmental monitoring terminal using STM32 as the main controller, summary and processing analysis the data uploaded by the collection nodes , and then send the data to the remote server through the GPRS module;The server receives the environmental data uploaded by the environment monitoring terminal and through the data fusion algorithm uses the data collected by the sensors to output the three fire levels of the forest area.The results indicates that the forest fire monitoring system works stably which enables the collection of environmental data as well as the functions of remote sending and remote alarming.

Keywords- Forest fire;Environmental monitoring; Data collection;Alarming.

I. INTRODUCTION

In recent years, with the continuous expansion of human activities, human beings have used excessive resources for exploitation, serious environmental pollution, and extreme destruction of forests [1]. As a result, global warming has occurred, land area has continuously decreased, and natural disasters have been reduced. With an upward trend, monitoring and prevention of disasters have become an urgent task.

The forest environment is relatively complex,among the various factors that harm forest resources, fire is the most dangerous and destructive,it not only burns wood, injure wild animals and other organisms, but also destroys the forest's regenerative capacity and destroys the regulation of forest water and soil conservation,causes further deterioration of the human living environment.However, large forest cover, the environment is relatively fragmented, so care complex and costly.In order to solve the problem of protection of forest resources, reduce the impact of natural disasters such as fire on the forest environment, inspect the current status of forest environment, combine embedded, Internet of things, wireless communication technology, wireless sensors, design a set of energy-saving and environmental protection, stable performance, simple operation, and the forest environment monitoring system that can realize remote sharing of data has practical application value.

II. OVERALL SYSTEM DESIGN

The forest environment monitoring system consists of three parts: data acquisition node, monitoring terminal and environmental monitoring data server. Multiple data acquisition nodes and monitoring terminals implement data transmission from the data acquisition node to the monitoring terminal through zigbee [2]. Through GPRS wireless transmission module and remote server for data exchange [4]. The system composition is shown in Figure 1.

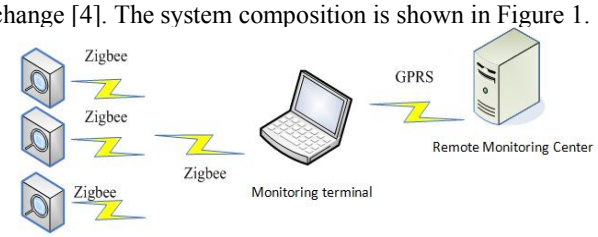

Figure 1. Block diagram of forest environmental monitoring system

III. HARDWARE PARTS

The system hardware structure is divided into two parts: data acquisition node and monitoring terminal.

A. Data acquisition node hardware design

Collecting data acquisition node is part of the forest environment, responsible for collecting smoke,temperature and humidity,flame, light intensity data,and transmits the data to the monitoring terminal via the wireless module.The data acquisition node takes CC2530 as the core and expands memory, data acquisition sensors, power supply, and wireless communications. Data acquisition node hardware block diagram shown in Figure 2.

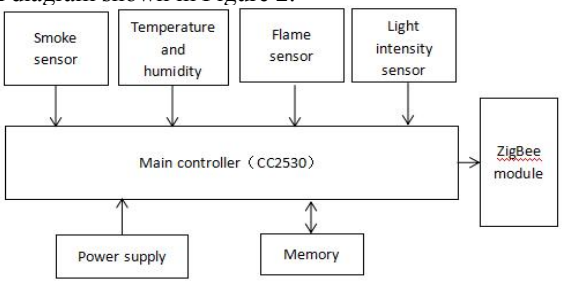

Figure 2. Hardware diagram of data acquisition node

- Data acquisition node processor CC2530

The main control unit selects the CC2530 module. The CC2530 module is selected because the module not only contains the antenna part of the chip that processes the collected data but also has ZigBee transmission. The other main reason is that the power consumption of the acquisition module is low. In sleep mode, the two sections are on the 5th. The battery can be used by ZigBee nodes for half a year to

978-1-5386-7413-0/18/$31.00 ©2018 IEEE
DOI 10.1109/SNSP.2018.00017

two years [5]. It is especially suitable for forest environments where power supply is difficult.

- Wet temperature acquisition module

Wet temperature sensor adopts SHT10, SHT10 is patch type wet temperature sensor, full-scale calibration, two-line digital output, low power consumption 80uW (12-bit measurement, 1 time/s); humidity measurement range: 0~100%RH; temperature measurement range: -40~+123.8C; humidity measurement accuracy: ± 4.5%RH; temperature measurement accuracy: ±0.5C.

- Smoke concentration acquisition module

The working principle of the MQ-2 gas sensor is that if the sensor detects the presence of flammable gas in its environment, its conductivity will change, the higher the flammable gas concentration, the greater the sensor conductivity.According to this principle, a corresponding circuit can be designed to convert the change of conductivity into a signal corresponding to the gas concentration.The material used in the MQ-2 sensor is tin oxide (SnO2), which has a low conductivity in air.MQ-2 is ideal for the monitoring of flammable gases. The monitoring range of smoke is 100 ~ 1000pm and the cost is low. It is suitable for the monitoring of gas leak monitoring devices and flammable gases such as smoke concentration.

- Light intensity acquisition module

The light intensity measurement module used in the system design is BH1750FVITR.The BH1750FVITR is a 16-bit digital environment monitoring light intensity sensor with a high resolution and a monitoring range from 1 to 65535lx, capable of monitoring changes in light intensity over a wide range.The sensor has the following characteristics: wide measurement range; high precision; small error, error floating in ± 20%; by the infrared change is small;no need to connect other devices; support 1.8V logic input; with the human eye on the spectrum of similar sensitivity; output corresponding light intensity value; using light noise to achieve stable measurement function.Widely used in automotive positioning recognition, LCD display, digital products, computers, mobile phones, game consoles and other equipment.

- Flame collection module

The flame sensor selected in the system design is the sensor type matched with the core control chip CC2530 in the data acquisition node,the sensor can monitor flames around 80cm and light sources from 760nm to 1100nm. It is mainly used for the detection of flame and fire source. Its sensitivity can be adjusted through potentiometer adjustment. The sensor is particularly sensitive to the flame spectrum.Using LM393 output monitoring signal, good waveform, easy to observe.

- Data transmission module

The paper selects ZigBee communication method [6]. Forests are generally vast and far away from residential areas. The designed terminals must fully cover the entire forest area, and must pay attention to the capacity of the established network and remote communication problems.At the same time, due to the complex forest environment, it is necessary to use a longer period of time after the equipment has been completely installed. In order to facilitate the maintenance at a later time, the sensor type with low power consumption must be used.Intricate environments also hinder post-maintenance, so choosing a network transmission method that can be automatically repaired is what the system design requires [7].

- Power module

The working voltage of CC2530 is 3.3V, which can be converted into 3.3V by DC-DC using 5V voltage. Considering the application scenario of the system, that is, the power supply in the forest environment is difficult, there are also three AA batteries available for power supply.

B. Monitoring terminal hardware design

The hardware control unit of the forest environment monitoring terminal is STM32; the coordinator in the data acquisition node is connected to the STM32 through the serial port; the environmental monitoring terminal uses the GPRS wireless transmission module to send the information to the remote server.

STM32 is designed for low-power, high-performance, low-cost embedded applications[8].The system chosen STM32 belong STM32F103 "enhanced" series, clock frequencies up to 72MHz, is similar products in the highest performance code execution from Flash memory, power consumption 36mA, is the market's lowest power 32-bit product.The core is an ARM 32-bit Cortex-M3 CPU with three low-power modes: sleep, stop, and standby mode.The Flash program memory has a storage range of 32K bytes to 128K bytes, the SRAM has a range of 6K bytes to 20K bytes, and the AD port has 18 channels and can measure 16 external and 2 internal sources.With a channel DMA controller, supported externally: Timer, ADC, SPI, I2C and USART.With serial line debugging and JTAG interface, it has the advantages of low power consumption and multiple interfaces. The model selected in this design is STM32F103ZET6.

- Serial connection design

The CC2530 module of the data acquisition node is connected to the STM32 of the environmental monitoring terminal through the serial port, and the ZigBee module [9] on the CC2530 connected to the STM32 implements the reception of data sent by all data acquisition nodes.Then it is transmitted to the STM32 through the serial port. The STM32 receives the data and processes it accordingly, which facilitates the remote transmission in the next step.

- GPRS data transmission module

The communication module is a system selected SIM900A GPS /GPRS module program, SIM900A supports GPRS multi-slot class 10/class 8 (optional) and GPRS encoding format CS-1, CS-2, CS-3 and CS-4.Its working frequency band is EGSM 900MHz and DCS1800MHz, this module not only can carry on the telephone and short message communication, but also support TCP/IP agreement [10], can carry on the wireless network transmission of the data.The WF-SIM900A controls the modules by transmitting standard AT commands through the serial port.

C. Monitoring data server

The data processing server [11] is the core of the forest environment data analysis and processing, mainly completes the data receiving, analysis and judgment, feedbacks the results to the environmental monitoring terminal, database design, etc., and the software sub-function modules work together to realize the forest environment data.

IV. SOFTWARE DESIGN

The system software design mainly includes three parts: forest environment data acquisition node software, environmental monitoring terminal software, and forest environment data server software. The relationship among the three is shown in Figure 3.

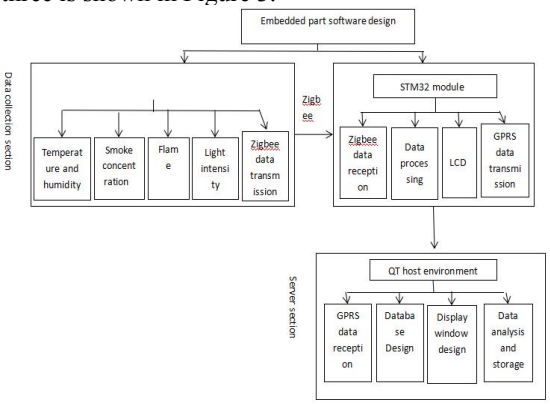

Figure 3. The relationship among data acquisition node, environmental monitoring terminal and remote server

A. Data acquisition node software design

The ZigBee networking process in the forest environment consists of the following components [12]:the coordinator establishes a new sensor network, coordinator and node working process introduction and mutual communication between networks.The coordinator serves as the master node for the forest environment collection and has the role of establishing a network, centralized management of routing and terminal node data, and so on.The topology structure used in this paper is mesh, so the routing nodes in the network can send their own data to the coordinator, and can also forward data from other nodes to the coordinator.After the terminal node is initialized, it begins to search for the network, and if it is found, it sends a request for network access. If the search fails, it becomes an isolated node.The work process of the node is similar to that of the coordinator. The difference is that the coordinator issues a control command. If it is not the node's task, it will forward it to the destination node using the corresponding routing algorithm. If it is, the set operation is performed.

B. Monitoring terminal software design

Taking into account the conservation of power consumption, the environmental monitoring terminal adopts a periodic monitoring mode in the system design, that is, data monitoring of the data acquisition node is implemented according to the specified sampling period, and the sampling period is driven by the timer of the environmental monitoring terminal STM32.When receiving the signal from the interrupt controller, the STM32 is awakened and sends a sampling signal to the data acquisition node. After receiving the feedback, the data acquisition node sends the collected information to the coordinator, and the coordinator sends the data to the STM32 for processing and analysis through the serial port. The data acquisition node then enters hibernation again.

C. Data processing server software design

The data processing server is the core of the forest environment data analysis and processing. It mainly completes the monitoring of terminal upload data reception, data analysis and judgment and early warning, database design and other work, the software coordination among sub-function modules to achieve the forest environment data processing server function.The server receives the data sent by the environmental monitoring terminal and compares it with the data set by the program, and concludes that if there is an abnormality, the server will generate an alarm and send the abnormal status to the environmental monitoring terminal. The environmental monitoring terminal will check its status. Reminder information is displayed on the LCD screen and alarm messages are sent to guardians via GPRS.

The forest environment data server software designs a QTcpServer class, creates an instance of the QTcpServer class, binds the server's address, listens for IP and port numbers [13], and uses QT's signal and slot mechanisms [14] to implement connection requests and data processing. Data communication software flow chart shown in Figure 4.

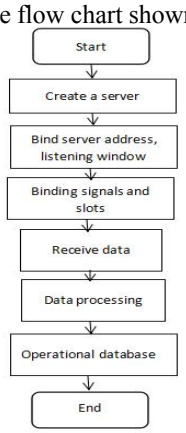

Figure 4. Software flow chart of server data communication

The main interface design of the forest environment monitoring server mainly includes two sub-homepages: each node collects data information and alarm information.Among them, the data information of each collection node reflects the value or current status of the four sensors connected to each node, and the server name and the IP address corresponding to the server.

V. PERFORMANCE TESTING

The forest environment collection node, environmental monitoring terminal and server three joint testing, as shown in Figure 5 forest fire monitoring system physical connection diagram, the figure was marked with the data

acquisition node, environmental monitoring terminal, GPRS transmission module and server-side Callouts.

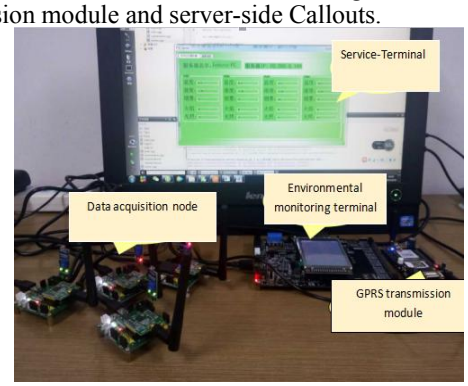

Figure 5. Physical map of forest fire monitoring system

The test of the forest data collection node module must first satisfy the sensor function of each collection node module and then perform the overall test on the system. As shown in the temperature and humidity sensor test.

TABLE I. COMPARISON OF ACTUAL MEASUREMENT DATA WITH TEMPERATURE AND HUMIDITY METER MEASUREMENT DATAD

Number		1	2	3	4	5
Temper	Test data	20.5	20.4	21.3	22.0	20.5
（℃）	Thermometer	20.4	20.4	21.5	22.5	20.4
	Difference	0.49	0	0.98	2.45	0.49
Humidity	Test data	25.3	24.9	25.9	24.5	29.4
（%）	Thermometer	25.5	25.1	26.0	24.5	29.5
	Difference	0.78	0.79	0.38	0	0.34

In order to verify the performance of the flame sensor, a node was selected as the test. In the absence of a flame, the communication module transmits the flameless state information to the detection terminal main control module, and the interface of the liquid crystal screen and the data server of the environmental detection terminal is displayed as a flameless state. During the test, the flame state is simulated by a lighter, and when the flame state is detected, an alarm occurs in the processor module of the acquisition node. At the same time, the serial debugging assistant will also show that the flame is close.

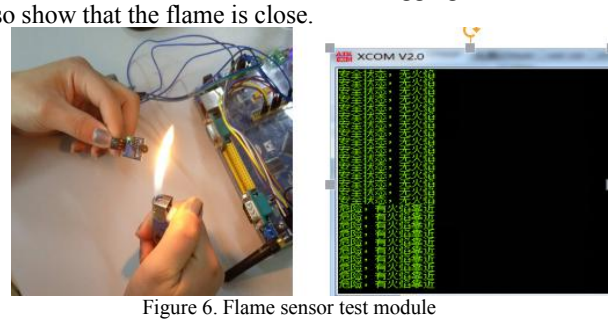

Figure 6. Flame sensor test module

The forest area staff and supervisory personnel enter the server system by logging in their own account passwords to monitor the forest environment parameters in real time remotely.In order to verify the practicality of the system, we went to Xi'an Xingqing Park to test the trees with more obstacles and entered the server system through the login interface. Here we can see the values of each sensor collected by each collection node through the environmental monitoring terminal.The input of sensor data into the neural network forest fire warning model[15] can predict the three states of forest fire: open flame, smoldering and non-fire [16]. We can observe the monitoring interface in Figure 7 on the server on the PC.

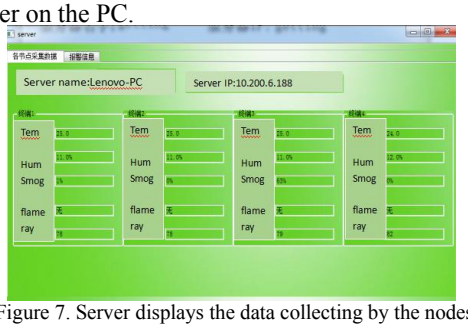

Figure 7. Server displays the data collecting by the nodes

VI. CONCLUSION

Tested in the forest environment of the park, the forest fire prevention monitoring system is stable in operation and can realize the collection and wireless transmission of forest environment parameters, data sharing and remote monitoring.The collection node can realize the collection and upload of various parameters of the forest environment; the environmental monitoring terminal can realize the analysis of the data sent by the multiple collection nodes; the remote monitoring server can realize the reception of the data uploaded by the environmental monitoring terminal, as well as the analysis and judgment and the danger alarm. Tips provide reliable protection for the normal forest environment.The system performs well in real-time and humane monitoring and has a wide range of social use value.

REFERENCES

[1] Tao Hengqi, Liu Wencong.Applications of Wireless Sensor Network on Forest Monitoring [J].Measurement & Control Technology,2018,02(002):5-7.

[2] Meng Qing, Han Yulong. Design and Implementation of the Forest Fire Monitoring System Based on ZigBee[J].Automated Instrument,2017,38(08):8-13.

[3] Wang Shuangshuang, Ren Zhikai. Design of Forest Environmental Monitoring System Based on ZigBee Wireless Sensor Network[J]. Information Recording Material, 2017,18(04):52-53.

[4] Wu Fengbo, Zhang Huike. Design of Automatic Solar Tracking System[J]. Journal of Northwest University: Natural Science Edition, 2016, 46(6): 837-840.

[5] Han Hui, Xie Nan, Gong Xiugang, et al. Monitoring System of Vegetable Greenhouse Based on ARM and Qt[J]. Journal of Shandong University of Technology(Natural Science), 2015(3):53-55.

[6] Su Po. Forest fire monitoring system based on ZigBee wireless sensor network [D]. Chang’an University, 2015.

[7] Liu Jie. Design of wireless monitoring system based on solar energy for forest environment[D]. Nanjing University of Aeronautics and Astronautics, 2013.

[8] Cao Youlin. Design of Remote Data Acquisition System Based on ZigBee and GPRS[J]. Microcontrollers & Embedded Systems, 2012, 12(12):71-73.

[9] Guo Ruixing, Wang Qingsheng. Research and Improvement of ZigBee Routing Algorithm [J]. Computer Development & Applications, 2011, 24(5):32-34.

[10] Li Jihuang. Design and Application of ZigBee Wireless Sensor Network Node [D]. Huazhong University of Science and Technology, 2012.

[11] Wang X. Research on forest fire monitoring based on Internet of things technology [D]. Central South University of Forestry and Technology, 2011.

[12] Wu Fengbo, Zhang Huike, Zhou Yunru. Design of Communication Base Station Monitoring System Based on ARM and 3G Technology[J]. Wireless Network Technology, 2016(18):1-3.

[13] Wu Fengbo, Qiang Yunjun. Design of Remote Wireless Temperature and Humidity Measurement and Control System Based on ZigBee Technology[J]. Journal of Northwest University Natural Science, 2008, 38(5): 731-734.

[14] Tan Juanjuan, Yao Weimin. Cross-Platform Screenshot Software Design Based on Qt[J]. Industrial Control Computer, 2013, 26(12):4-5.

[15] Zhao Ying, Chen Shujuan. Fire alarm system based on multi-sensor data fusion[J]. Modern Electronics Technology, 2010, 33(24):173-175.

[16] Zhou Xiaolin. Research on multi-sensor data fusion fire alarm system based on neural network [D]. Changchun University of Science and Technology, 2012.