Design of Indoor Environment Monitoring System Based on Internet of Things

Hang Ji*, Haoming Zhang, Kai Zhou and Ping Liu
Chinese people's Liberation Army Academy of Artillery and Air Defense Hefei, AnHui, 230031, China
*Corresponding author e-mail: jihang098@qq.com

Abstract. In view of the current emphasis on people's indoor environment, an indoor environment monitoring system based on the Internet of Things and sensor technology was designed and developed. The real-time system by a plurality of sensor nodes collect indoor environment parameters, data transmitted to the mobile terminal after the fusion. Users can view indoor environment real-time data and historical data through remote terminals. Experiments show that the system can realize real-time monitoring of the indoor environment. The system of high reliability, low cost, low power, easy to operate.

1. Introduction
With the improvement of quality of life in our country, people are concerned about the indoor environment more and more, most people spent more than eighty-five percent of their time indoors. The indoor environment is directly related to the level of human health. The bad thermal environment will affect people's working conditions. The harsh air environment causes people to develop respiratory infections, asthma and even cancer. Therefore, it is a very meaningful job to monitor indoor environmental parameters and improve the indoor environment.

In recent years, due to the miniaturization, inexpensiveness, and intelligence of sensors, intelligent indoor environment monitoring has become possible, becoming a hot technology for smart homes. Domestic and foreign smart homes developed earlier. In the late twentieth century, Western developed countries established an indoor air quality monitoring center for testing the government's indoor air data. The Xian Xiaodong project team proposed the use of wireless sensor networks to build an indoor environmental disaster monitoring system. Through the analysis and processing of the collected data, early warning and forecast of indoor environmental disasters are achieved, and GSM transmission of early warning messages. However, it has not yet been able to display indoor environmental parameters in real time. This paper improves on this by the use of Android applications.

This design uses current technology has matured to 4 m × 6 m office as a test target, for temperature, humidity, light intensity, PM2.5 four parameters and environmental studies to design an indoor environment monitoring system.
2. System design

The collection of various parameters of the room environment is collected by the sensor nodes distributed in the room; the collected data is sent to the control node via the zigbee network, the data is converged and forwarded to the remote terminal, and the alarm data is displayed, recorded and set by the line data.

![Monitor flow chart](image1)

**Figure 1.** Monitor flow chart

The indoor environment monitoring system consists of remote terminal, control node, ZigBee wireless network and sensors. The remote terminal is used for Android mobile phone and APP to generate data display and control decisions; ZigBee network includes a main node and several sub nodes. The main control node is responsible for the routing and transmission of data flow. Through the Zigbee network, each sensor node plays the role of the coordinator. On the other hand, the remote terminal is connected by the cellular network. The sensor nodes include the sub modules such as light sensor, temperature sensor, and dust sensor and so on.

![System structure](image2)

1. Temperature sensor, 2. Pm2.5 sensor, 3. Light sensor, 4. Master control node, 5. Humidity sensor.

**Figure 2.** System structure
2.1. Design of node layer

(1) Information collection node

The sensor nodes of this system adopt a universal design and integrate zigbee and mcu modules. The cc2530 unlimited serial communication module is based on the Zigbee2007/PRO protocol of the CC2530. Mesh network networking has the ability to self-organize and self-repair networks, and it can dynamically switch to another channel to work after being disturbed. Through the connection of multiple sets of different sensors to complete the real-time collection of various data in the room. This design uses a single-chip modules microcontroller STM32F103VFT6 STMicroelectronics STM32 series. The chip uses an ARM CortexTM-M 332-bit RISC core with a total of 80 pins in the LQFP100 package. 25MHz crystal clock used by the system master, the PLL frequency to 168MHz as the CPU system clock. Fully meet the needs of the system and controls the acquisition unit in communication. The battery module is R6-40BS battery Deer cards.

Since the node uses an ordinary AA battery, for a long-term use, the power consumption of the node is reduced as much as possible through a series of measures. The first setting is the stm32 sleep mode: an internal wake-up event is generated through a customized delay interval timing, and then the shutdown state is completed. Secondly, for the CC2530 chip used for wireless transmission, since the power consumption during wireless transmission is large, it is necessary to ensure that it is in a dormant state when there is no transmission task. When the STM32 wakes up and completes data acquisition, it wakes up the CC2530 again. After delaying for 10ms, the system will switch the CC2530 to sleep mode until data transmission is completed. Taking 30s as the sampling interval, it is estimated that single-cell Shuanglu R6-40BS batteries can be used continuously for more than two months.

(2) Master control node

This node mainly includes ZigBee module, cellular network module, one-chip computer module, clock module, power module, debugging interface and so on. The ZigBee module adopts CC2530 as a network coordinator to complete the information flow of each node. The cellular network module uses the SIM900A module, based on the GPRS network service, to realize the information transmission and reception with the remote terminal through the TCP/IP protocol and the AT command. The SCM module adopts this design and adopts STMicroelectronics STM32 series micro-control STM32F103VFT6, which is responsible for executing control decisions and sending control instructions. The clock module uses the DS1302 clock chip for system timing and synchronization.
2.2. Transmission layer design
ZigBee is a wireless connection with low power consumption, low cost, short delay, no network capacity, reliable and secure. Based on ZigBee's powerful networking capabilities, each sensor node can be wirelessly connected. This connection networking is flexible and has considerable scalability and stability. This system uses a mesh mesh network as the network topology of the system. The network thus configured can be freely added and deleted, and other nodes are automatically adapted to the new topology. It also has the advantages of low transmission power and low power consumption.

Node 0 is the main control node. It integrates GSM module and ZigBee module. It is the starting point of the network and maintains the routing of the entire ZigBee network. Node 1 is the PM2.5 sensor node which is closer to the main control node in the experimental room. The PM2.5 acquisition module, the ZigBee module and the acquisition and conversion module are integrated, and the ZigBee router mode is used to communicate with the main control nodes, and the other messages are forwarded; node 2 is a humidity sensor; node 3 is a temperature sensor; node 4 is light sensing.

2.3. Application layer design
The remote handheld terminal software is installed on Android mobile phone based on the bex5 development platform, receiving cellular mobile data from the main control node. The MVC idea was adopted in the design to separate the business from the logic. The function of the system realizes the remote monitoring, recording, alarming of the indoor air quality key parameters and the decision-making control of related equipment. Software can draw and display data curves for different environmental information. The main interface is shown in Figure 6.
It is easy to query historical data. Database using open-source database MySQL, indoor air quality parameter data can be stored in the database, and you can use SQL language and writing fast access to data.

3. System test

![Test room](image)

- **Date:** April 26, 2018
- **Time:** 17:01

**Environmental parameters**
- Temperature: 21.1°C
- Humidity: 63.0%
- Pm2.5: 59.3μg/m³
- Light intensity: 103lux

![historical data](image)

![Figure 6. Mobile app main interface](image)

**Figure 6. Mobile app main interface**

![Figure 7. Historical Data Display Interface](image)

**Figure 7. Historical Data Display Interface**

The test experiment was conducted at a staff office at 451 Huangshan Road, Laoshan District, and Hefei City, Anhui Province.

Using the above-designed monitoring system for on-site application testing, real-time collected data of the liquid level and soil temperature and humidity data are shown in Figure 7. As can be seen from Figure 7: parameter information acquired in real time, accuracy, and aspects of the communication distance, meet system design requirements.

The temperature sensor was tested using a controlled cooling heating device. The maximum error in temperature measurement was 0.4°C and the error range was relatively small.
4. Epilogue
Articles to solve the problem of indoor environmental information monitoring system uses networking technology using STM32F103VFT6 as the master chip, and set up monitoring systems and indoor collection.

Real-time information on the phone display, when an exception occurs air quality phone will alert the user. Test showed that: according to the design requirements to achieve real-time online monitoring of soil, air and environmental data, remote control of decision-making, historical data query, warning output function. The system has very good scalability, and can further cooperate with the controlled cooling heating device to build an intelligent adjustment system for indoor thermal comfort. It has a good application prospect in the field of smart home.

References
[1] Björn Butzin, Frank Golatowski, Christoph Niedermeier, Norbert Vicari, Egon Wuchner, “A model based development approach for building automation systems”, Proceedings of the 2014 IEEE Emerging Technology and Factory Automation (ETFA), pp. 1 – 6, 2014.
[2] Nagesh Kumar D. N., “ARM based remote monitoring and control system for environmental parameters in greenhouse”, Electrical, IEEE International Conference on Computer and Communication Technologies (ICECCT), pp. 1-6, 2015.
[3] Andrei Drumea, Robert Dobre, “Clicks counting methods for a scope knob,” HIDRAULICA Magazine, vol. 4/2013, pp. 79-84, November 2013.
[4] Abraham S, Li X. Design of A Low-Cost Wireless Indoor Air Quality Sensor Network System [J]. International Journal of Wireless Information Networks, 2016, 23 (1): 57-65.
[5] Jian Shi, Mian Guo. Embedded Digital Oscilloscope Based on STM32 and μC/OS-II [J]. Applied Mechanics and Materials, 2012 (190-191): 1129-1135.
[6] Riliskis, L. Osipov, E. Symphony. A Framework for Accurate and Holistic WSN Simulation [J]. Sensors, 2015, 15: 4677-4699.