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Multi-Functional Environmental Monitoring and Alarm Experimental Device Based on the OneNET Cloud Platform

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Abstract: This paper introduces a multi-functional environmental monitoring and alarm device. With an STM32 microcontroller as the control core, the device integrates multiple sensors for environmental parameter collection, and realizes wireless data transmission through the ESP8266 WiFi module. It connects to the OneNET cloud platform for device management, data monitoring, and alarm information push. Practical verification shows that the device features accurate sampling, timely response, stability, and reliability. The production process of the device closely combines theory and practice, meeting the teaching needs under the new engineering education model. It can be used as experimental teaching equipment; meanwhile, aligning with the development direction of environmental monitoring technology, it is suitable for environmental monitoring and early warning in daily life, and has broad market application prospects.

Keywords: Sensor; Environmental monitoring; OneNET cloud platform; Microcontroller control

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1. Introduction

Traditional environmental monitoring and alarm devices mainly rely on sensors to monitor environmental parameters in real time, including air quality, noise, temperature, and humidity, and analyze changes in the data. Once an abnormal situation is detected, the device immediately triggers an alarm and sends alarm information to relevant personnel through sound and light signals, ensuring timely response and handling of environmental issues. This technology not only improves the efficiency and accuracy of environmental monitoring but also helps mitigate and prevent environmental pollution, providing strong support for the construction of ecological civilization.

However, traditional environmental monitoring and alarm devices have limitations, such as reliance on manual sampling and lack of real-time performance and continuity. These devices usually have single functions, lack intelligent analysis and remote monitoring capabilities, and cannot meet the diverse needs of the Internet of

Things (IoT) era.

To better adapt to the era of the IoT, we have conducted interdisciplinary technology integration and research, and designed a multi-functional environmental monitoring and alarm device based on a cloud platform. China Mobile's IoT Open Platform (OneNET Cloud Platform) is an open platform and ecological environment built based on IoT technology and industrial characteristics. It is compatible with various network environments and protocol types, supports rapid access of various sensors and intelligent hardware and big data services, and has the advantages of safety, stability, ease of use, and high scalability. Based on the OneNET cloud platform, this environmental monitoring and alarm device adopts a modular design, each module has an independent function and can be freely combined and expanded according to user needs [1]. At the same time, the device integrates multiple sensors and data processing technologies, enabling it to monitor environmental parameters such as temperature, humidity, and gas concentration in real time, and provide users with functions including real-time data monitoring, alarm information reception, and remote device control [2]. This design greatly improves the device's reliability, flexibility, and convenience.

2. Overall design idea

The device adopts a master-slave mode. The slave device is installed in the area requiring monitoring, collects environmental data through sensors, and transmits the data to the slave control unit. The slave control unit determines whether to issue an alarm signal, adjust the brightness of the supplementary light, and upload the measured environmental data to the cloud platform via the wireless WiFi module. The cloud platform sends the measured environmental data to the master device for display and synchronizes it to the WeChat applet. The WeChat applet is equipped with control buttons and voice recognition to control the supplementary light of the master device, which is transmitted to the master control system through the cloud platform and WiFi module for control. This facilitates remote monitoring of environmental parameters [3,4].

3. Hardware design

3.1. Overall hardware structure

The model consists of two sets of devices: master and slave. The master device uses an STM32F103RCT6 mini development board with a Cortex-M3 processor core. This 32-bit microcontroller is based on a high-performance RISC core and has rich peripheral interfaces and functions (such as USB, SPI, I2C, SDIO), which facilitate communication and data transmission with other devices, making the development project more flexible and scalable.

The slave device uses an STM32F103C8T6 minimum system board, also with a Cortex-M3 processor core. This micro-control system supports sleep mode, stop mode, and standby mode, which can significantly reduce power consumption. Meanwhile, the system achieves an excellent balance in startup time and multiple wake-up event functions.

The master device module includes a master control unit, an OLED display, and a communication module, among which the OLED display and communication module are connected to the master control unit. The master control unit interacts and communicates with the cloud platform through the communication module, and uses the OLED display to show environmental data from the cloud platform, including temperature, humidity, and harmful gas concentration.

The slave device module includes a slave control unit, a communication module, a sensor unit, and a slave supplementary light. Both the sensor unit and the communication module are electrically connected to the slave control unit. The sensor unit communicates with the cloud platform through the communication module and uploads the detected data to the cloud platform. In addition, the slave supplementary light is turned on/off according to the values from the sensor unit. The sensor unit includes a smoke sensor, a temperature-humidity sensor, and a photosensitive sensor. The overall hardware structure diagram of the system is shown in **Figure 1** [5,6].

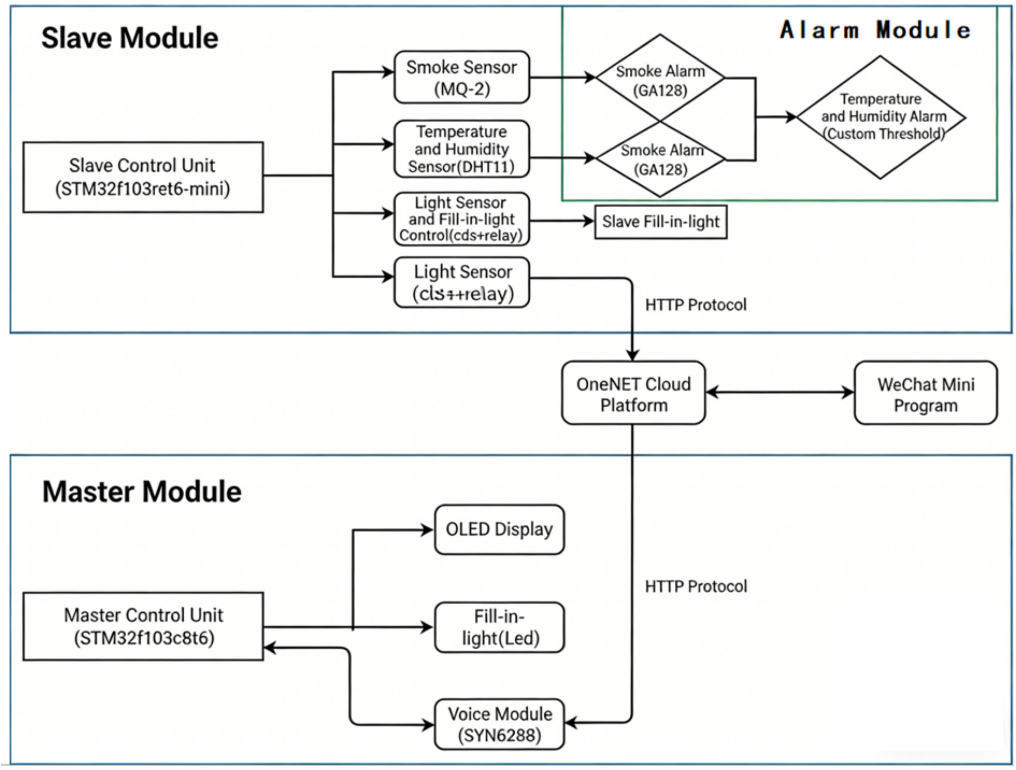

Figure 1. Hardware structure diagram.

3.2. Deployment of the slave microcontroller

The product can measure, record, and transmit various environmental parameters (such as temperature, humidity, gas concentration, and light intensity) through sensors. From the operation mode of various sensors, temperature sensors can use thermistors or thermocapacitors to sense temperature changes, while gas sensors can use chemical reactions to detect the concentration of specific gases. The development of these sensor technologies forms an important foundation for environmental monitoring systems such as this product [7].

The slave device performs the function of environmental monitoring, with sensors distributed on it. According to the required functions, it includes a DHT11 temperature-humidity sensor, an MQ-2 smoke sensor, a photosensitive sensor, an active buzzer, and early warning LED lights, which are connected to the corresponding pins of the STM32.

Two early warning LED lights (light (temperature), light (smoke)) provide early warnings for high temperatures and smoke concentration exceeding the threshold respectively. When both reach the early warning standards, the buzzer (BUZZER1) sounds an alarm. The photosensitive resistor provides light-sensing function. When the light is insufficient, the supplementary light (light) is turned on. The ESP8266 WiFi module in the figure provides a connection between the device and the cloud platform, which will be elaborated in the software design section.

The received sensor data needs to pass through a signal processing module to extract useful information and eliminate noise interference. The theoretical basis of signal processing includes digital signal processing, filter design, noise suppression, etc. Through digital signal processing technology, this product can sample, quantize, and encode the collected analog signals, converting them into digital form for analysis and processing. At the same time, filter design can filter out unintended signal components, thereby improving the accuracy and reliability of the data. The application of such signal processing technologies ensures the quality and stability of sensor data [8,9].

3.3. Deployment of the master microcontroller

The master device mainly provides users with viewing functions, including an OLED display, an ESP8266 WiFi module, and a supplementary light (for aesthetic purposes) controlled by the applet. The circuit schematic diagram of the master device is shown in **Figure 2**. The OLED display refreshes the relevant data monitored by the slave device in real time for users to view timely.

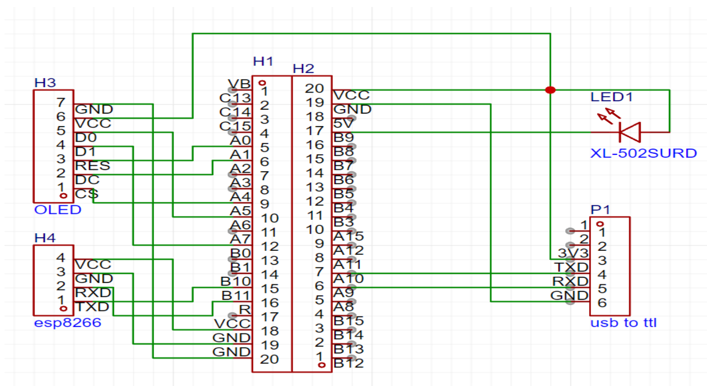

Figure 2. Circuit schematic diagram of the master device.

4. Software design

4.1. Interaction between the OneNET cloud platform and the device

OneNET is a PaaS IoT open platform built by China Mobile. The platform helps developers easily realize device access and connection, quickly complete product development and deployment, and provides comprehensive IoT solutions for intelligent hardware and smart home products. As long as the terminal device can connect to the network, it can access the platform by organizing data packets through any of the methods such as HTTP, EDP, and MQTT. This platform has eight functions: dedicated network and number, massive connections, online monitoring, data storage, message distribution, capability output, event alarm, and data analysis. It has been applied in various commercial fields such as environmental monitoring, remote meter reading, intelligent hardware, connected cars, and logistics tracking [10].

The OneNET cloud platform has a very powerful architecture, helping individual and enterprise users manage their products more comfortably and conveniently. Its architecture is shown in **Figure 3**.

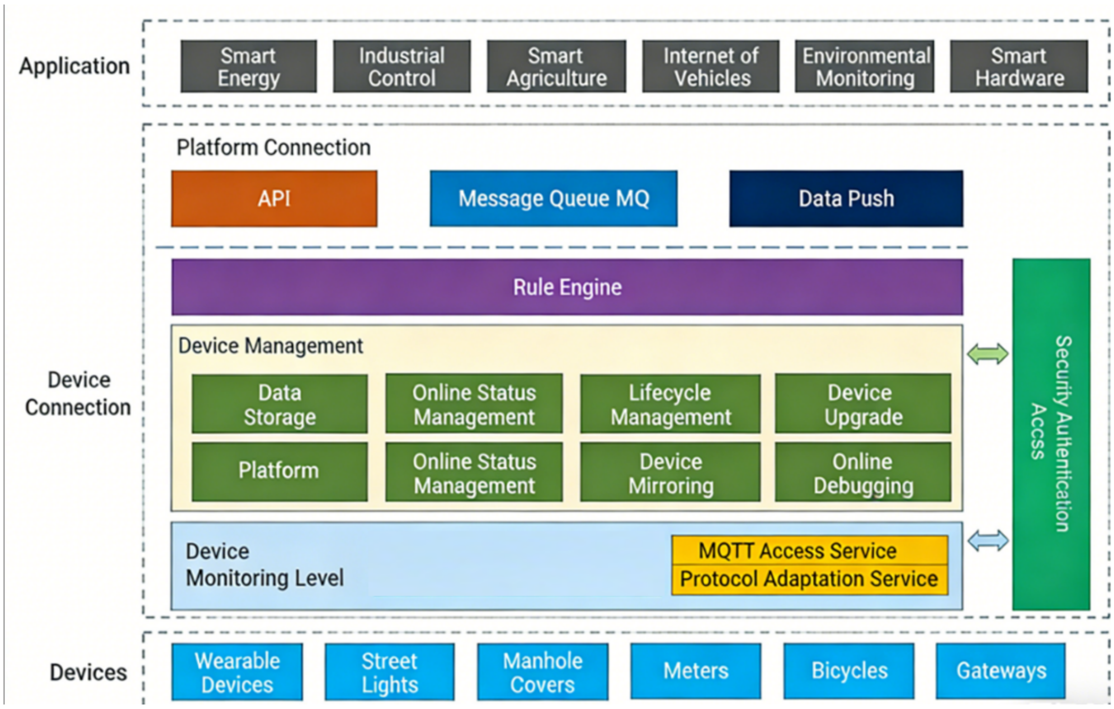

Figure 3. OneNET architecture diagram.

4.2. ESP8266 WiFi module

The WiFi module is built on wireless local area network (WLAN) technology. The IEEE 802.11 series standards used specify the operating frequency band, transmission rate, security, and other aspects of the WiFi module. The WiFi module used in this product transmits data using radio frequency signals. The involved modulation and demodulation technologies (such as OFDM and PSK) and channel coding technologies improve the reliability of data transmission. At the same time, the WiFi module of this product uses WPA and WPA2 security protocols to ensure data confidentiality and integrity [11,12].

The system interacts with the OneNET cloud platform through WiFi connection. By burning the ESP-AT command firmware into the ESP8266 module (as shown in **Figure 3**), it is configured to connect to the cloud platform. This module has powerful functions, low price, small size, and ease of use. It can provide WiFi connection functions for the external host MCU, thus easily realizing cloud connection and low-power operation. In this system, the module performs serial communication with the microprocessor and WiFi communication with the OneNET cloud platform, thereby realizing communication between the cloud platform and the microprocessor.

4.3. HTTP protocol

The hypertext transfer protocol (HTTP) is the communication protocol used between the microcontroller and the cloud platform through the WiFi module in this experiment.

HTTP is a simple request-response protocol, which usually runs on TCP. It specifies what messages clients can send to servers and what responses they can receive. The headers of request and response messages are given in ASCII format; while the message content has a MIME-like format.

In OneNET, devices are supported to report data using HTTPS/HTTP2 protocols, with fixed access addresses, standardized access data, and systematic return code design, facilitating the realization of various data transmission and control between devices and the cloud platform [13].

4.4. WeChat applet

The WeChat applet is designed using WeChat Developer Tools and written in JavaScript. The page design includes a home page and a voice control page. The home page contains the display of various data (such as temperature, humidity, and smoke concentration) and a button control section. The monitoring data is directly read from the OneNET cloud platform and refreshed at 3-second intervals, facilitating users to monitor the data in real time. The voice control interface integrates Baidu AI intelligent speech recognition and synthesis technology, providing users with a variety of interactive experiences [14,15].

According to the above principles, the system configures ESP8266 WiFi modules in the master and slave devices respectively. Based on the HTTP protocol, the slave device continuously transmits monitoring data to the cloud platform through the module, and the master device continuously reads data from the cloud platform through the module and displays it on the OLED screen. With the cloud platform as the center, the master and slave devices form a remotely interactive system. The WeChat applet allows users to view monitoring parameters anytime and anywhere. The speech synthesis technology of Baidu AI Open Platform is applied to the WeChat applet, enabling users to remotely control the brightness of the master device's supplementary light through voice via the WeChat applet, enhancing the user experience.

5. Conclusion

The designed environmental monitoring device can detect environmental parameters such as temperature, humidity, and smoke concentration in real time. It can be used in many fields such as residential life, laboratory safety, and public place safety, featuring strong practicality. Meanwhile, it has high scalability and can be expanded with other devices to provide monitoring data for environmental detection-related experiments. In addition, the design and production process of the device involves knowledge from many engineering professional courses, integrates the concept of new engineering, and can be used for teaching purposes to help students better master professional knowledge in practice.

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Disclosure statement

The author declares no conflict of interest.

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