Design of Intelligent Lighting Control System Based on MQTT Protocol and Wireless Technology

Feng He, Biyue Diao, Benjie Zhou, Lin Zhang

School of Optoelectronic Engineering, Chongqing University of Posts and Telecommunications, Chongqing 400060, China

Abstract

To make the traditional lighting equipment keep up with today's 'intelligent' pace and save energy, a design of intelligent lighting control system based on MQTT (Message Queuing Telemetry Transport) protocol and wireless technology is implemented. The ESP8266 is the control module of the system. On the one hand, the lighting equipment can be controlled through the light intensity sensing and human infrared induction; the other hand, the intelligent lighting equipment which is based on MQTT protocol and WIFI technology can be remotely controlled by the APP terminal. The system improves the way of the traditional lighting control and achieved 'intelligent', at the same time, the system has the advantages of low cost, convenient control, energy saving and so on, which would have a wide application prospect.

Keywords

MQTT; lighting control; ESP8266; WIFI.

1. Introduction

The advancement of science and technology has promoted the development of society and improved people's living standards. Therefore, people have made higher demands on all aspects of life [1]. The design of smart lighting control system that is both convenient and energy-saving has received more and more attention from researchers. The traditional lighting control is mainly realized by a person directly pressing a switch on the wall. When the weekend or the winter time, people often want to easily control the lights according to their own requirements when lying on the bed or the sofa, so that they do not have to get up [2]. This article designed an intelligent lighting control system based on the MQTT protocol and wireless technology. This system combines today's widespread WiFi and Android technologies to liberate people's hands to some extent. The system can automatically control the light on and off according to environmental changes; or when people use Android devices, they can remotely control the light switches. The system is easy to operate and provides convenience for people's daily life.

2. Overall architecture

At present, most of the intelligent lighting control systems are implemented through ZigBee technology. However, ZigBee modules have effect like high cost, small transmission range, low data transmission rate and so on, and the advantages of the ad hoc network's practicality and network capacity cannot be highlighted in this system. There are also a small number of intelligent lighting control systems implemented via Bluetooth technology, but remote control via Bluetooth technology is not possible. Therefore, the system has selected a WiFi technology with low cost, wide coverage, and high transmission speed. The communication protocol uses the MQTT (Message Queuing Telemetry Transport) protocol, which is a message queue telemetry transmission protocol. It is a lightweight transmission protocol. The MQTT protocol is a protocol based on the TCP/IP protocol that delivers messages through publish/subscribe [3]. There are only two roles in the MQTT protocol, the MQTT client and the MQTT broker. The structure is shown in Figure 1.

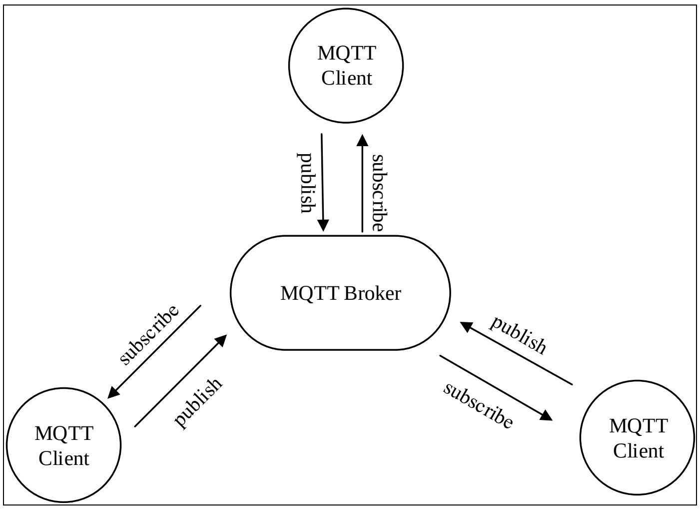

Fig.1: MQTT protocol structure diagram

From the structure diagram, it can be found that the MQTT client can be a subscriber or a publisher. An MQTT broker is a device or program that is interconnected with an MQTT client and it receives or transmits messages between multiple clients which connected to it [4]. There is no direct messaging process between the clients. If the topic names of the publisher and the subscriber are the same, they are equivalent to indirectly establishing the connection. The main process of communication is that whenever a user wants to check or view any data, it sends the request to the broker as a subscriber with a certain topic name; the broker will send a message to the subscribers immediately that is sent by the publisher witch has the same topic name with the subscriber. As a result, data transmission is secure during the entire publishing and subscription process [5].

The entire system consists of lighting equipment, control module, MQTT cloud broker and mobile terminal. The MQTT cloud broker plays the role of a proxy server, both the control module and the mobile terminal are clients. In order to connect to the MQTT broker, the control module must connect to the router first. And the smart phone should connect to the router or cellular network. And the overall architecture of the system is shown in Figure 2.

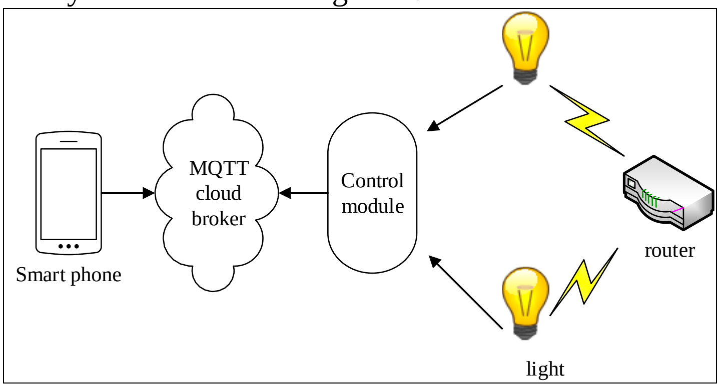

Fig.2: The system architecture diagram

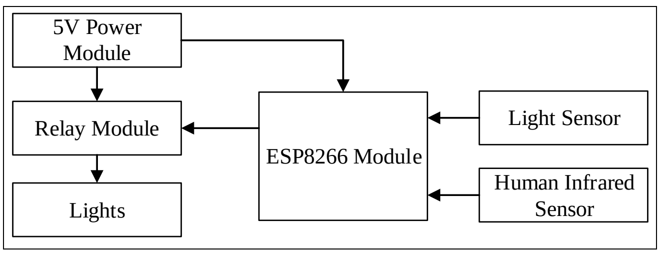

Fig.3: The hardware block diagram

3. Hardware Design

The design of intelligent lighting control system is one of the characteristics of smart home. The hardware of the system mainly includes power supply module, relay module, light sensor, human infrared sensor and ESP8266 WiFi module. And the hardware block diagram of the system is shown in Figure 3.

The ESP8266 WiFi module in the figure uses an ESP8266-12E development board with enough GPIO interfaces for this system. It is an ultra-low power UART-WIFI module based on Lexin ESP8266. It is widely used in the Internet, industrial control, Smart home and other fields. The WiFi module's power supply is 5V. It includes a small processor that allows it to work independently and does not require an additional Arduino development board, which has a huge advantage [6]. The WiFi module receives messages from the light sensor, the human infrared sensor, and the MQTT cloud broker, and then controls the on/off of the relay according to the contents of the message, thereby realizing the control of the lighting equipment.

4. Software Design

4.1 The Control Module Software Design

Controlling the writing and programming of the ESP8266 WiFi module code is mainly performed in the Arduino IDE compilation environment. And the system uses C++ language for programming. The RX and TX interfaces of the ESP8266 WiFi module are connected to the USB-TTL TX and RX interfaces to download the code. This article mainly introduces the main control flow chart and timing part of the software design. The main flow chart of the system module control is shown in Figure 4.

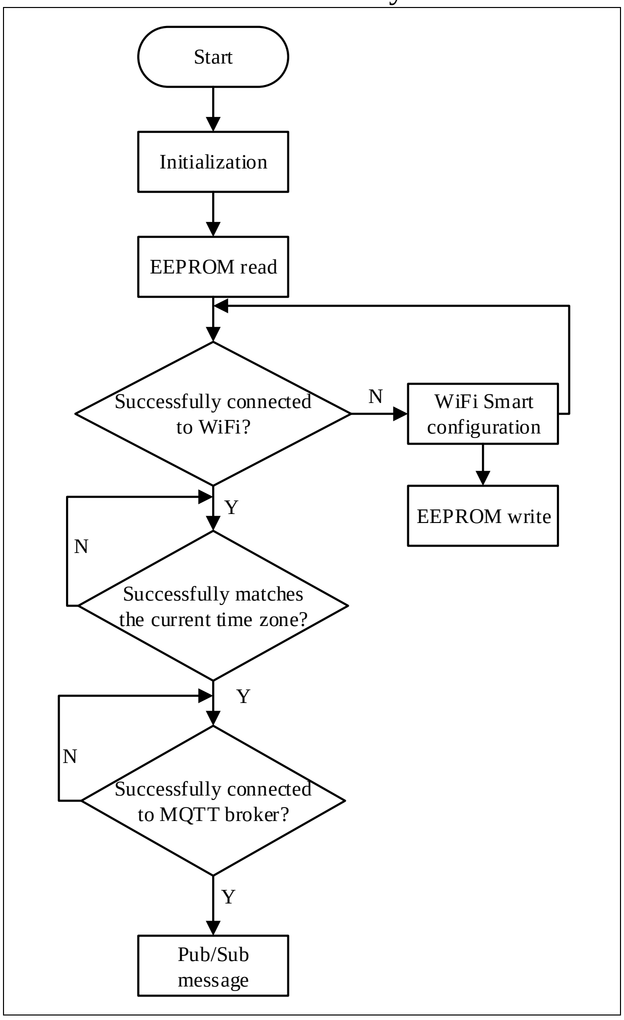

Fig.4: The software block diagram

The step of the main control software is that after the initial setup, the WiFi connection is first performed. The WiFi module first selects the saved WiFi information in the EEPROM to connect. If the connection fails, it will tart smart configuration of WiFi, and then stored the configured WiFi information in the EEPROM, so that the stored data will not lose when the power failure occurs. After ensuring that the WiFi is successfully connected, then match the current time zone, and the function of the matching time zone is to control the timing of the device. What follows is the connection of the MQTT cloud broker. Only when the broker is successfully connected, can the news be subscribed and published.

The timing part of the process is: After completing the initial setup of the timing, the time stored in the EEPROM is read, and if the detected time is the same as the saved time, the on/off operation is performed; if the subscription is related to the timing related message, the contents of the message will be written to the EEPROM and overwrite the contents of the previous EEPROM. For on/off control of lighting equipment by sensing the environment, it is achieved through the combination of a light sensor and a human infrared sensor. When the light intensity sensed by the light sensor is lower than the set threshold, and at the same time the human infrared sensor senses a person, the light will automatically turn on; in any other case, the light is kept off.

The timing control flow chart of the lighting equipment is shown in Figure 5.

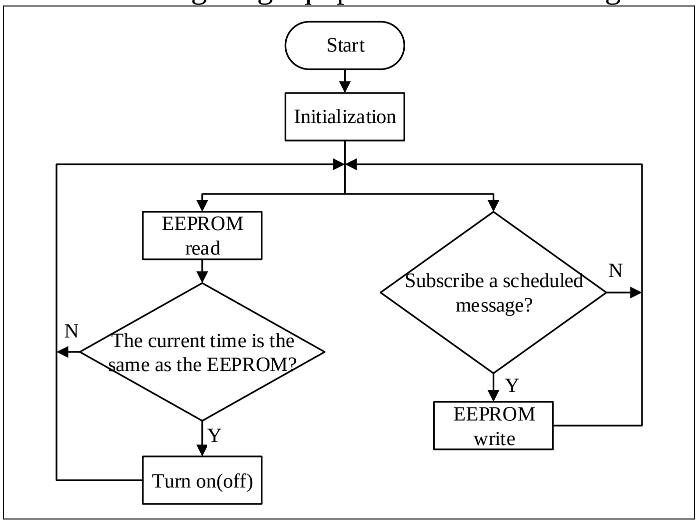

Fig.5: The timing control flowchart

4.2 The Design of Android APP

Because Android has a broad market prospect and hundreds of millions of users, this article uses an Android mobile phone as the control terminal of the intelligent lighting control system [7]. The main function of the APP is to intelligently configure the WiFi of the current environment for the lighting equipment, connect the MQTT cloud broker, and publish commands on the cloud broker to achieve indirect control of the lighting equipment. The Android terminal APP design and development tool of this intelligent lighting control system is the Eclipse integrated development environment [8]. Part of the APP design code is as follows:

```
myMqttClient=new MqttClient("tcp://"+ HOST+":"+PORT, Client_id, null);
MqttConnectOptions conOptions=new MqttConnectOptions();
conOptions.setCleanSession(CLEAN_SESSION);
myMqttClient.setCallback(this);
myMqttClient.connect(conOptions);
myMqttClient.publish("smartlight/control/bedroom",("Lon").
getBytes(),0,false);
```

The role of the above code is to connect the MQTT broker and then publish a message with the topic name "smartlight/control/bedroom" and the content "Lon" to control the opening of the lights. This system mainly designed several interfaces such as WiFi intelligent configuration, room list, and room lamp switch control. The smart configuration is to detect the surrounding WiFi through the mobile phone. After successful detection, the WiFi password can be configured. After the configuration is complete, the interface will pop up the corresponding result. Once the configuration is successful, you can use the APP to control the lighting device.

5. Test results

This test is to control the lighting equipment by sending control commands through the mobile phone APP. The test contents were: 50 tests for smart configuration, on, off, timing on, and timing off. The number of successful controls was recorded. The test data record table of the system is shown in Table 1.

Table. Test Data Record Table

Test Content	Test Times	Success Times	Failures
Smart configuration	50	48	2
ON	50	50	0
OFF	50	50	0
Timing on	50	49	1
Timing off	50	50	0

After 50 times tests, the designed mobile phone APP can successfully issue instructions, and the control module of the lighting equipment can also successfully subscribe to the instructions and make corresponding processing. The reason for the failure of the intelligent configuration part is that the lighting device has automatically connected to the current WiFi and does not need to be configured. Through testing, the system has achieved the desired results.

6. Conclusion

This article combines WiFi technology and Android technology, designed the intelligent lighting control system based on MQTT protocol, and successfully realized the remote and automatic control of the light. The test results show that the system has feasibility and practicability and has certain reference value in smart home. The next goal is to optimize the system to further reduce costs, reduce system size, and reduce power consumption.

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