Design of Wireless Object Finding System for the Internet of Things based on WiFi and MQTT Protocols

Huafeng Pang[a], Manli Jia[b], Qian Yin[c], Shenshen Sun*

[a] 2146662825@qq.com, [b]1906858070@qq.com, [c]3222852076@qq.com, *sunshenshen@126.com

School of Information Engineering, Shenyang University, Shenyang 110004, China

Abstract: Bluetooth-based and GPS-based object finding systems have become popular in life,but they have their own limitations.Bluetooth has a small search range and cannot find objects accurately in outdoor environment;while GPS has a large search range but it can't be used indoors.In view of the limitations between Bluetooth and GPS,this article proposes a WiFi-based object finding system.The system has a simple structure and low cost.It uses the ESP8266 WiFi module as the main body.Whether indoors or outdoors, the system can use WiFi network signals and MQTT transmission protocols.Establish a connection with the object-finding device in real time. In addition, CR2032 lithium battery is used to power the finding device, which increases the convenience and battery life of the finding device.

Key words:object-finding system;WiFi;MQTT;ESP8266;CR2032

1 Introductions

With the development of Internet of Things technology and the popularity of smart devices,people 's demand for tracking items in daily life is getting higher and higher.As two common communication technologies,WiFi and MQTT (Message Queuing Telemetry Transport) have been widely used in the field of Internet of Things.As an important form of Internet of Things applications,the object-seeking system can help us quickly find lost items in our daily life.However,there are some problems in the traditional search system,such as distance limitation,inconvenient use and so on.In order to solve these problems,this paper proposes a search system based on WiFi and MQTT protocol.

At present, there are usually some problems in the object-seeking system on the market,such as complex operation,high power consumption and limited functions.Therefore,this paper will focus on solving these problems and design a comprehensive,easy-to-operate and low-power search system.It aims to provide a convenient and easy-to-use search system to help people track items more effectively.Explore the application of communication technology based on WiFi and MQTT in the field of Internet of Things[1].

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2 Systems design

The ESP8266 WiFi module is connected to the Android APP to communicate through the MQTT protocol.In the mobile APP,by controlling the output of GPIO2 and GPIO4,the operation of buzzer and LED lamp is realized,and the control of them is realized.

The main body of the object-seeking device is composed of ESP8266 WiFi module.External buzzers and LED are connected to the ESP8066 WiFi module,and ESP8066 is imported into C++function program and WiFi is configured through Arduino tool,so that the object-seeking device has specific functions as a whole.The Android Studio tool is used to design and beautify the interface of the mobile APP,and the Java language is used to realize the function of the mobile APP to remotely control the object-seeking device.The MQTT cloud server is used to realize the message transmission of the mobile APP and the object-seeking device. After the mobile APP is connected to the WiFi network configured for the object-seeking device in advance,the function of remote control of each device of the object-seeking device can be realized,and the current environment of the object-seeking device can be detected [2]. The overall architecture of the object-seeking device is shown in Figure 1.

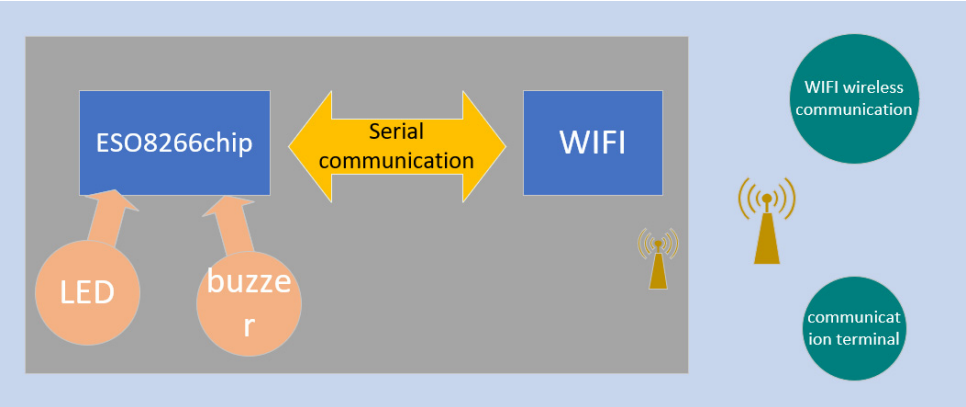

Fig. 1. Overall architecture diagram of the object-finding device.

2.1 Related technologies

WiFi technology is a wireless communication technology used for high-speed wireless data transmission within a local area network.It is based on radio waves and can achieve wireless connection and interconnection between devices.In the search system,wireless communication and data transmission between devices can be achieved through the use of WiFi technology,thereby achieving remote control of buzzers and LED lights[3].

MQTT (Message Queuing Telemetry Transport) is a lightweight,open standard communication protocol specifically designed to achieve reliable and asynchronous communication between IOT devices.In the search system,we can use the MQTT protocol to achieve communication between the Android APP and the ESP8266 WiFi module.By issuing control commands through the Android APP,the ESP8266 WiFi module subscribes to these commands and performs corresponding operations,achieving remote control of the buzzer and LED lights.

2.2 Hardware design

The hardware part of the system includes ESP8266 WiFi module,LED lamp,buzzer,CR2032 lithium battery,3.3V voltage regulator circuit and so on.Figure 2 is part of the hardware schematic diagram.

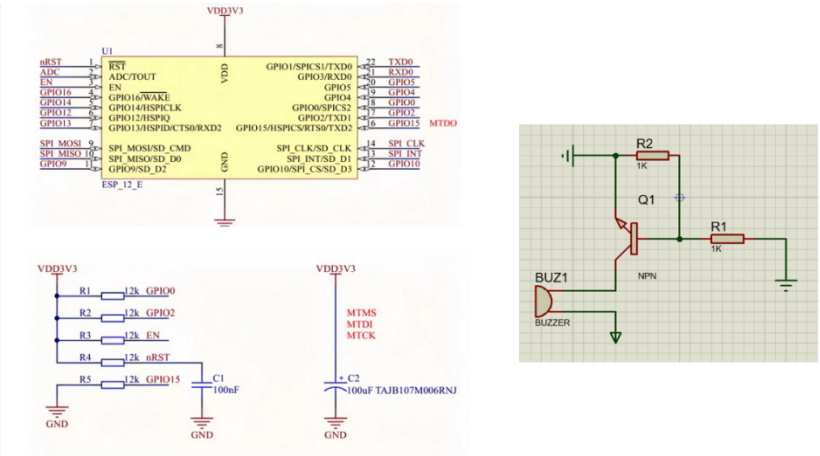

Fig. 2. Hardware design schematic diagram.

ESP8266 is selected as the main body of the object-seeking device.The ESP8266 is a low-cost, low-power WiFi module that reduces power consumption in standby mode and controls power consumption by enabling / disabling different module functions.Its operating voltage is 5 volts ;the recommended input voltage is 5 volts ;the limit input voltage is 4.5 to 10 volts.It integrates a SOC (System-on-Chip) chip, including a high-performance ESP8266 micro controller unit (MCU) and a WiFi wireless network chip.The WiFi standard is 802.11b / g / n, which can be connected to the wireless network and communicate with other devices.It also supports STA (Station) mode and AP (Access Point) mode,which can be used as a client or hot spot for communication.ESP8266 also provides rich interfaces and pins to facilitate wireless communication with other devices,and provides a lightweight TCP / IP protocol stack. It is very suitable for IOT applications and is an ideal carrier for object-seeking devices[4].

Combined with the above relevant knowledge and technical parameters of ESP8266,the main body of the object-seeking device came into being.The hardware of the development board is shown in Figure 3.

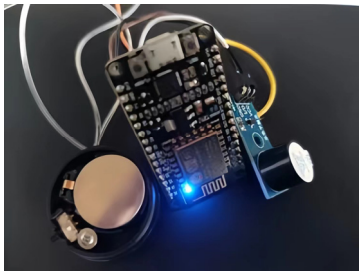

Fig. 3. Physical diagram of the main body of the development board for the search device.

2.3 Mobile APP design

The Android Studio tool is used to design and develop the mobile APP.The page design is simple,and all functions and designs are concentrated in one window without opening multiple windows for jump.The first thing you see when you open the mobile APP is a picture of a detective penguin holding a magnifying glass looking for something,cleverly and vividly showing the user the application scenario of the APP.In addition,the search page also adds the connection status of the current APP and the search device,including the two states of successful connection and disconnection.The current time is recorded below the connection state,which is convenient for users to view.There are two icon buttons at the bottom of the penguin screen.By clicking these two buttons,the function of the search device LED light and the function of the buzzer work are controlled[5].The interface view of the search APP is shown in Figure 4.

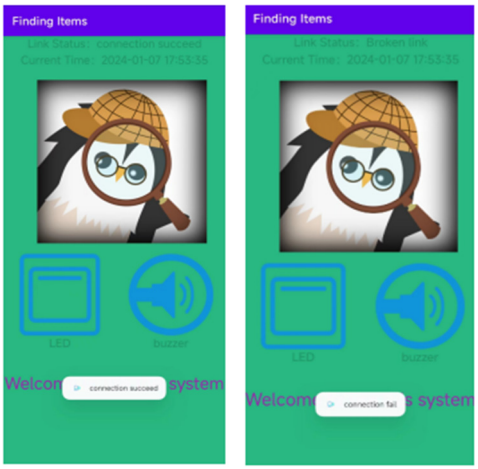

Fig. 4. Display of the search APP interface.

2.4 The Application of MQTT Protocol in Systems

Install MQTT message broker on the server,which will be responsible for the routing and distribution of messages.Inherit MQTT client libraries in mobile APP applications.These libraries can be used to establish connections with MQTT Broker,publish subscription messages,and subscribe topics.On the ESP8266 hardware development board,an embedded MQTT client library that supports MQTT will be used to allow hardware devices to connect to MQTT Broker,publish data,and subscribe to topics that have received instructions from mobile APP[6].The basic principle of its network communication is shown in Figure 5.

2.5 Control of ESP8266 WiFi module

In the program written for the object-seeking device,a unique representation ID number is set for ESP8266 to ensure that the object-seeking device can connect to the server normally,import the WiFi Manager library file, and then configure the WiFi network for ESP8266. Set the network name and connection key to establish a TCP connection with the

cloud server.The user needs to configure the network information when using the object-seeking APP for the first time.The WiFi name of the object-seeking device is found on the WiFi setting page of the mobile phone.The correct input is to enter the key of the object-seeking device first and then enter the WiFi configuration interface of the object-seeking device.After selecting the network to be connected to the object-seeking device, the network configuration of the object-seeking device is completed after correctly inputting the key to be connected and waiting for the successful configuration information to pop up. Since the ESP8266 WiFi chip only supports 2.4 GHz WiFi network,it is necessary to check the relevant information of the network when configuring the network.If the WiFi connection is abnormal or interrupted.The mobile APP will automatically try to reconnect and prompt relevant information on the mobile APP interface [7].The object-seeking device WiFi is shown in Figure 6.

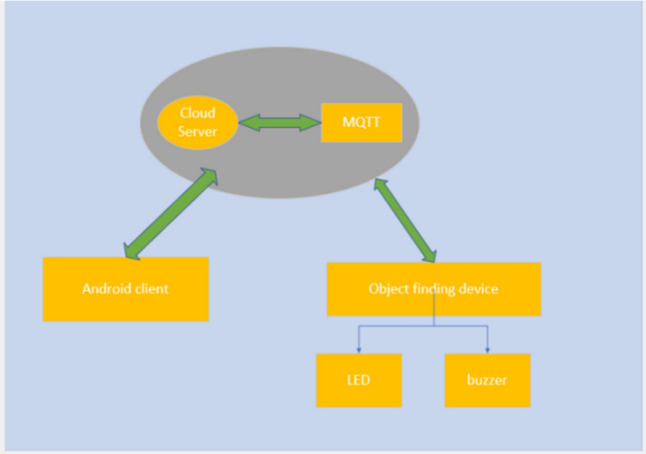

Fig. 5. Network communication schematic diagram of the object seeking device.

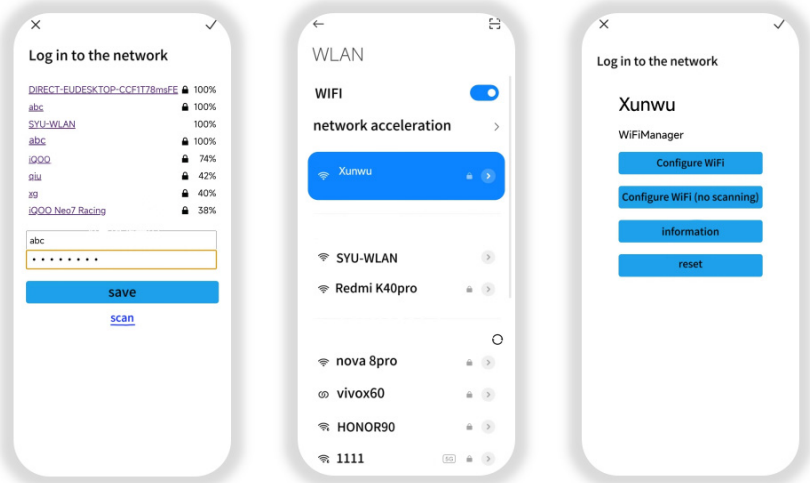

Fig. 6. WiFi network configuration interface

After the success of the first configuration of the network, each time after connecting to the WiFi network, the search device will first check its own cache of WiFi information, if there is a direct connection, if not, it will enter the APP mode, has been listening to the user and the server request, and through the mobile terminal APP The status of the request is displayed on the main interface to facilitate the user to view and check the network configuration information .The display of the modified page is shown in Figure 7.

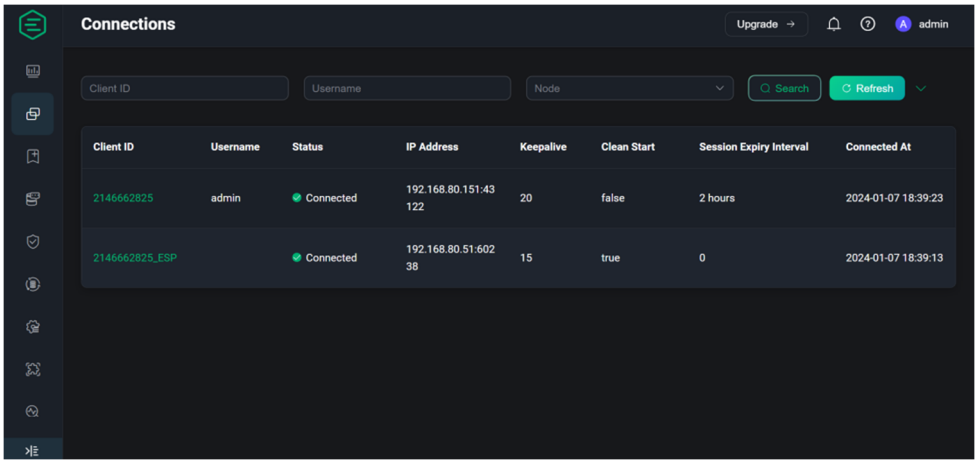

Fig. 7. MQTT server background management.

Fig. 8. CR2032 physical picture

2.6 Design of battery power supply mode

In order to better adapt the finder to different environments and more convenient needs, the finder uses a CR2032 battery with a SMG6603 boost converter to output a stable voltage of 3.3 volts to power it. This party has the advantages of low power consumption within the amplitude, low battery cost, small size, and easy purchase. It increases the use time of the object-seeking device node, and can avoid the limitations of network cables and sockets, and can work independently anywhere[8]. The physical image of CR2032 is shown in Figure 8.

In the finder system, the CR2032 battery can power the ESP8266 WiFi module so that the system can continue to work in a wireless environment.By using CR2032 battery-powered, the finder system can be more portable and flexible,not limited by the power socket[9].

3 System testing and verification

3.1 Establishment of experimental environment

First of all,you need to prepare a host device as a server to receive and process commands from the Android APP.The host device needs to install and configure the MQTT message queue server to establish a connection with the Android APP.At the same time,it is necessary to physically connect the ESP8266 WiFi module,buzzer and LED lamp,and set the corresponding network connection parameters.

3.2 Functional testing

The hardware program is burned into the ESP8266 WiFi module,and the software control program is written to the mobile phone.The mobile phone is used to configure the network for the ESP8266 WiFi module to test whether the connection between the ESP8266 WiFi module and the MQTT message queue server is normal[10].

After the ESP8266 WiFi module and the Android APP are correctly connected to the MQTT server,the buzzer and LED lights connected to the ESP8266 WiFi module are controlled by the Android APP. It is verified that the Android APP can control the buzzer and LED lights through the MQTT server to work properly.Then,the error handling ability of the system is tested,such as whether the system can correctly handle and give corresponding prompts in the case of network connection interruption or instruction transmission failure.After testing,the Android APP will prompt the error information of the disconnected connection and automatically reconnect after any party of the Android APP or ESP8266 WiFi module disconnects the network.

3.3 Performance evaluation

The performance of the system is evaluated by a large number of test data and experimental results,including the response time,stability and energy consumption of the system.

The effective working distance of Android APP and ESP8266 WiFi module under the same network is tested in an open environment.The tester holds a mobile phone equipped with an Android Finder APP to move its own position to control the ESP8266 WiFi module in a fixed position.Each test distance is tested five times,and the test distance starts from 50 meters, gradually increasing the test distance.The test results show that the effective working distance between the device and the Android APP is about 80 meters.The specific test results are shown in Table 1.

Table.1. Test results

degree / distance	1	2	3	4	5	average value
50	0.20	0.20	0.20	0.20	0.30	0.22
55	0.20	0.20	0.20	0.30	0.30	0.24
60	0.30	0.30	0.30	0.20	0.30	0.28
65	0.30	0.30	0.30	0.30	0.30	0.30
70	0.50	0.40	0.40	0.40	0.50	0.44
75	0.60	0.50	0.60	0.50	0.60	0.56
80	0.70	0.80	0.80	0.90	0.80	0.80
85	no-response	no-response	no-response	no-response	no-response	no-response

90	no-response	no-response	no-response	no-response	no-response	no-response

Verify that it can maintain normal operation under continuous operation and high load conditions.After testing,it was found that in a poor network environment,both the buzzer and LED lights were set to work,and both parties were able to communicate information normally. The response time of the message was less than 1 second,which was within the normal range.

Finally,the usage time of the CR2032 battery on the power supply system was measured.After calculating the energy consumption of the homing device working in a silent state for one day, it was found that the homing device can maintain for more than 25 days in a silent state,and the system power consumption meets the expected requirements.

4 Conclusions

Nowadays,WiFi has been popularized in every household,which has strong feasibility.With the development of the Internet of Things and the popularization of WiFi technology,the WiFi-based object-seeking system has broad application prospects.This kind of searching system is suitable for various fields,such as family,business,medical treatment,logistics and so on. In general,the WiFi-based search system will be widely used in various fields and provide people with more convenient and efficient search services.

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