Design and Development of Intelligent Street Lamp and Service Platform for Villages and Towns

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Abstract: In order to solve the problems of existing street lamps in villages and towns, such as few functions, low maintenance efficiency, inconsistent management, obstacles in agricultural information transmission, and lack of safety monitoring system, a intelligent street lamp and service platform for villages and towns is developed.Combine new generation information technologies such as Internet of Things, GIS, mobile Internet and cloud computing, and establish four subsystems including smart lighting system, operation and maintenance GIS management system, government information release system, security and environmental information monitoring system. The design of intelligent street lamps meets the development needs of information construction in villages and towns, and comprehensively improving the information level of villages and towns. At the same time, the service platform is also an important entrance to the new rural construction, which has a good demonstration function and popularization value.

Keywords: street lamps; villages and towns; smart lighting;GIS

1 Introduction

The construction of street lamp has always been the key content of urban infrastructure construction. In recent years, many scholars have combined the latest electronic technology and computer technology to develop intelligent street lamp. Literature[1]has developed an efficient LED driver, which can reduce the power consumption while keeping the brightness constant. Literature[2]uses street lamps and relies on satellite positioning technology to realize the positioning of street lamps. Literature[3]has designed a street lamp with wireless communication function, realizing the large-area coverage of WiFi signals. Literature[4]develops street lamps with strong penetration for foggy weather. Judging from the existing achievements, most of the research focuses on the street lamps used in cities and towns, but few scholars have studied the street lamps used in such specific places in villages and towns. With the implementation of the "rural revitalization" project in China, the information construction of villages and towns is one of the important contents of the new rural construction. As one of the largest infrastructure facilities, street lamps will undoubtedly be the natural carrier and the collection source of all kinds of information in the information construction of villages and towns. Street lamp construction is bound to become an important part of rural construction in the future, but there are many problems with street lamps in

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villages and towns at present.

The problems of street lamps in villages and towns are as follows[5]：(1)The message transmission of government decrees is not timely. At present, the traditional way of communicating government decrees is oral communication by the village chief or broadcast announcement by the loudspeaker set in the village. Due to the aging of the equipment or the long distance, it is difficult for the villagers to hear or understand the relevant government policies in time. At the same time, agricultural related information lags behind, such as environmental information, crop planting technology and other information, which brings economic losses to villagers.(2)Lack of safety monitoring system. Theft incidents happen from time to time. As there is no monitoring to trace, the vast majority of stolen money and articles cannot be recovered, which directly endangers the safety of villagers' lives and property.(3)The function and control mode of street lamps are single. At present, the street lamp terminal only has the lighting function, and its control mode is mainly manual, light control, timing, etc., which is easily influenced by natural factors such as seasons and weather. Often, it does not light when it is on, and it does not go out when it is off, resulting in energy waste and financial burden.(4)Low maintenance efficiency of street lamps. After the installation of street lamps, due to the high degree of dispersion and limited maintenance personnel, it is impossible to arrange special personnel for timely maintenance and management. As a result, no one comes to repair and replace the street lamps for a long time after they are broken, which becomes a display and brings inconvenience to villagers' night trips.(5) The planning management is not unified. There is a lack of unified management in the planning and construction of street lamps, as well as comprehensive professional management and supervision in the aspects of scheme design, lamp selection, bidding and procurement, and construction. There are some problems that affect the lighting image, such as unreasonable network planning and design, non-uniform construction standards, inadequate safety and quality supervision, etc.

2 Overall system design

In order to solve the above problems, a intelligent street lamp and service platform for villages and towns is developed, which integrates the functions of distributed monitoring, data collection, centralized management and information release[6][7]. Establish four subsystems: intelligent lighting system, operation and maintenance GIS management system, government information release system, security and environmental monitoring system, as shown in Figure 1. Among them, intelligent lighting system and operation and maintenance GIS management system solve the problems of road lighting and street lamp maintenance. The information release system of government affairs realizes the openness of government affairs and the release of agricultural products market information through LED display and broadcast. And the environmental monitoring system realizes environmental monitoring and village security monitoring through video monitoring and sensor information. The system adopts modular architecture design, and can selectively deploy functional modules according to energy consumption and task requirements, so as to realize personalized customization.

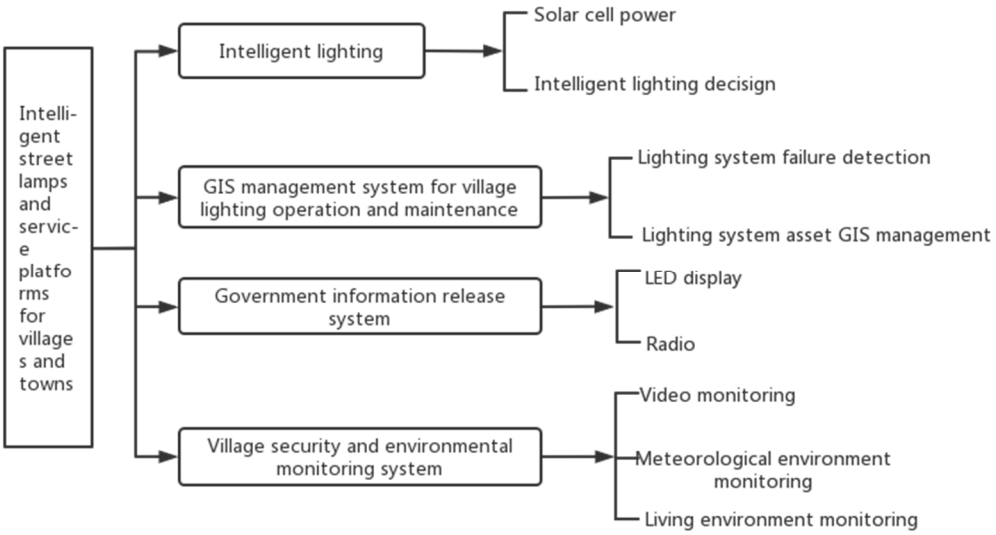

Figure 1. System module diagram

3 Hardware design

3.1 Intelligent lighting control terminal

The intelligent street lamp control terminal comprises communication network terminal, MCU, environment detection sensor, status detection circuit and LED driver circuit[8]. The system structure diagram is shown in Figure 2.

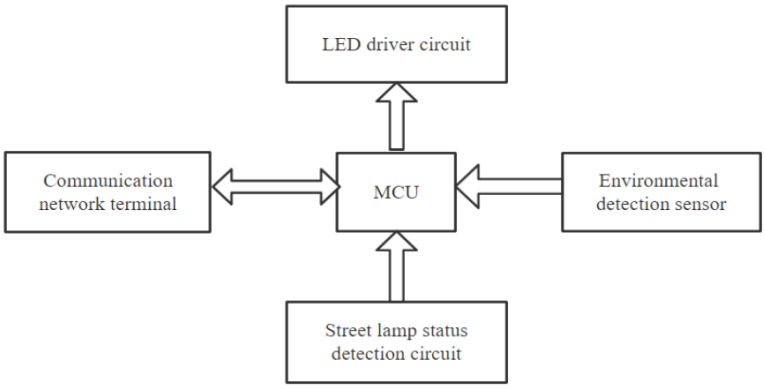

Figure 2. Lighting control terminal structure diagram

The communication network terminal is responsible for data communication with the centralized controller. Environmental sensors include illumination sensor, human infrared

sensor and ultrasonic sensor. These sensors are mainly responsible for collecting environmental information such as light intensity, moving speed and direction of human body, and transmitting them to the server, so as to generate control strategies. The status detection circuit can collect the voltage, current, power and temperature of important observation points, so that the service platform can analyze and judge the fault types. The LED driven circuit mainly realizes the switch and brightness level of street lamps. MCU is responsible for coordinating the work of the above modules.

3.2 Communication network terminal

To ensure the stability and operability of the system, it is proposed to adopt a similar C/S architecture, as shown in Figure 3. The centralized street lamp controller is deployed not far from the street lamp group[9-11]. This module not only undertakes the interaction with the street lamp terminal, but also keeps in touch with the operation management platform server through the relevant network. LoRa module is used in the design to keep the network of the terminal controller unblocked.

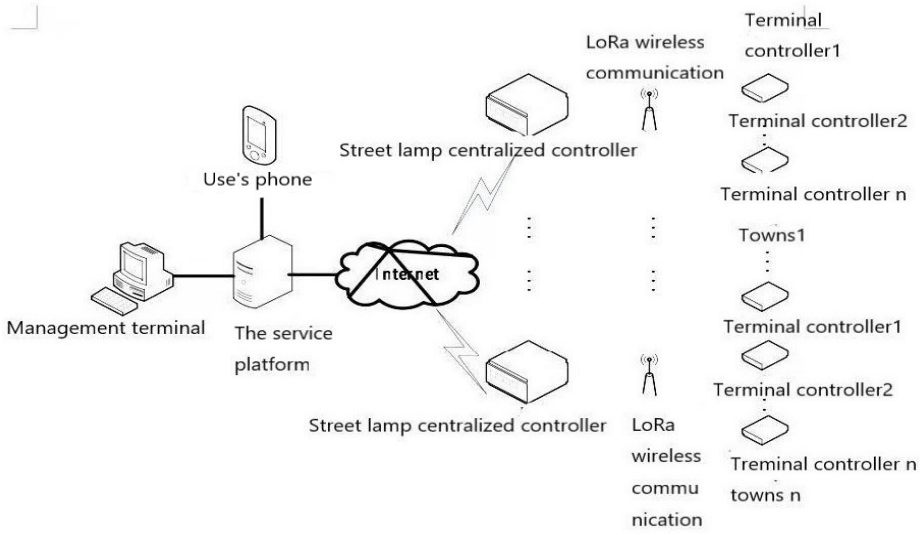

Figure 3. Communication network terminal

3.3 Fault detection circuit

The fault detection circuit is responsible for detecting the state of voltage, current and temperature of the circuit observation node. The specific structure is shown in Figure 4.AC transformer is used to collect the AC signal of power line, voltage and current sampling circuit is used to detect the voltage or current value of key components, and temperature sensor is used to detect the working temperature of core chip to realize fault monitoring and early warning.

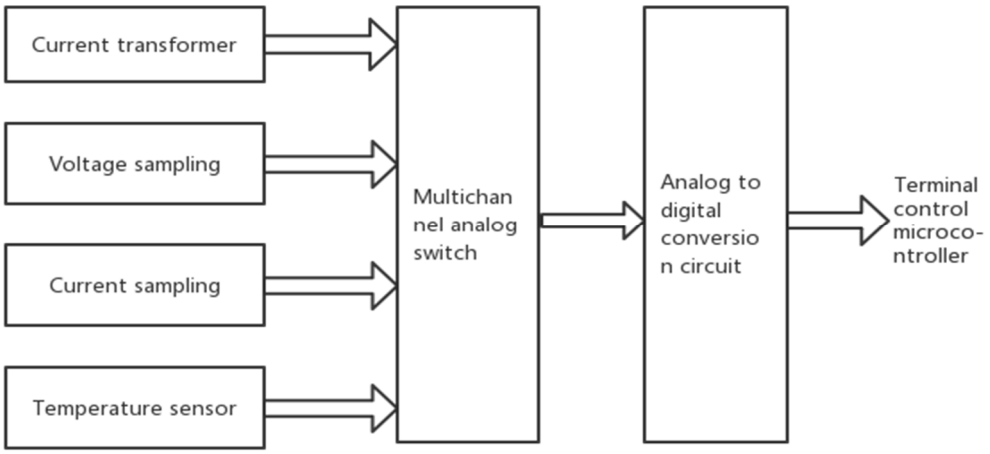

Figure 4. Fault detection circuit

3.4 Environmental monitoring system

For key areas of villages and towns with large flow of people, deploy environmental monitoring systems. Monitor the temperature and humidity, wind direction, wind speed, atmospheric pressure, PM2.5, PM10 and drinking water quality respectively, and transmit them to the service platform by LoRa wireless communication. The video monitoring module monitors the living environment of villages and towns (such as garbage dump areas) through cameras.

3.5 Government information release system

LED display and broadcast shall be set on the street lamp to release the notice issued by the government in real time and make a significant reminder, and display the planting technology, sales price and other information of agricultural products.

4 Software design

4.1Main control software system

The main control software system realizes the receiving and sending of terminal data based on serial port programming. The communication between the master program and the server adopts Web service technology[12]. The upper computer software system is mainly composed of three parts: main control computer program, cloud server program and mobile terminal program. Its software structure is shown in Figure5. The main control computer program is responsible for collecting terminal data, issuing control commands and providing alarm information. The cloud server program is mainly responsible for various functions such as data storage, transfer and statistical analysis of human traffic. The mobile terminal program mainly provides the way of smart phone and iPad to deal with policy control, single point control,maintenance management,etc.

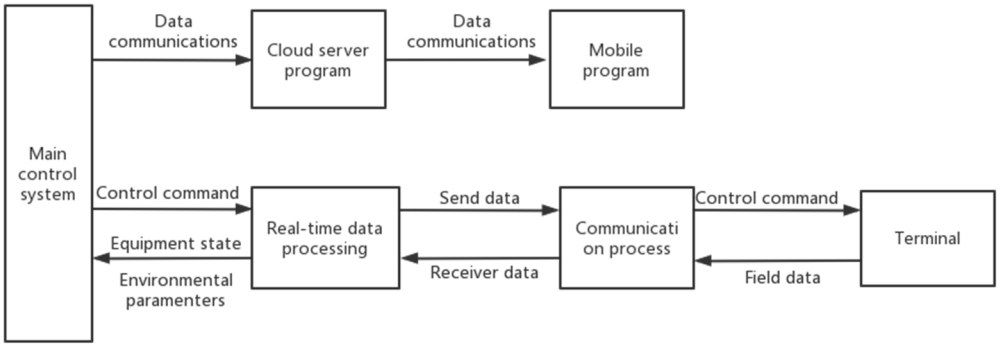

Figure 5. Structure diagram of main control software system

4.2 Lighting Facility asset GIS management system

Based on SOA architecture, it involves a variety of hardware, software and network environments, including server devices and storage devices. The system architecture is shown in Figure 6. The software system is divided into five levels, the bottom layer is hardware equipment, network equipment and storage equipment; The database stores all kinds of spatial and non-spatial data, provides data support for business logic running programs through data engine middleware, and then provides various users with operations and applications through application subsystems and websites. Software development will adopt a variety of development tools, middleware and GIS secondary development tools. Complete the collection, verification and processing of lighting geographic information data, realize the visualization of lighting business information, and build a unified lighting geographic information database including lighting geographic information and business information coding database, lighting basic geographic information database, lighting asset attribute database, lighting business special database, real-time and historical dynamic information database, graphic symbol database, etc.

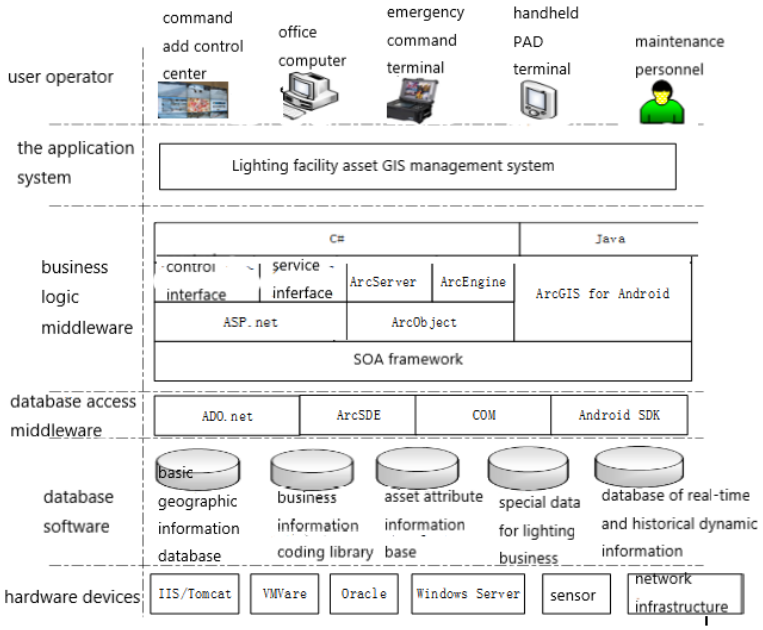

Figure 6. Asset GIS management system diagram

4.3 Street lamp fault analysis software

The fault analysis software mainly realizes the functions of extracting fault characteristic values, establishing expert database, and comparing fault types. Its flow chart is shown in Figure 7. The core of fault analysis software is the establishment of fault feature expert database[13][14].

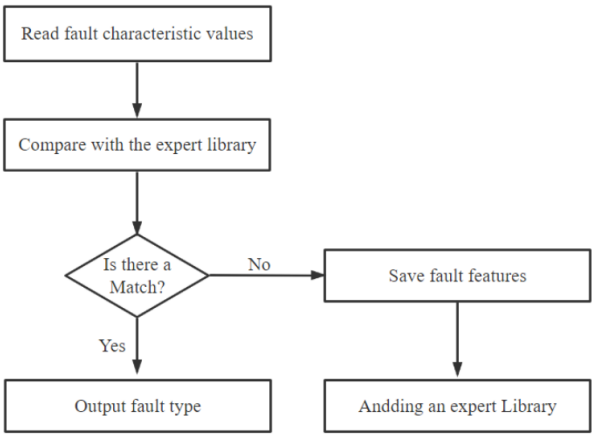

Figure 7. Fault analysis flow chart

5 Application Cases

In order to meet the demand of street lamps in villages and towns, the prototype of street lamps has been developed and the service platform has been built.

Figure 8. Example of intelligent street lamp

As shown in Figure 8, street lamps are installed in Yeji District, Lu'an City. The electric energy of street lamps comes from solar energy and municipal electricity.Compared with the existing intelligent street lamp, its core difference lies in the terminal controller set below the street lamp pole, the data collected by the environmental monitoring sensor and camera set above the street lamp is transmitted to the terminal controller, and the data is transmitted to the street lamp centralized controller through the Lora communication module set in the terminal controller.

In order to test the availability of the service platform, we also upgraded some street lamps in suburb of Lu'an City, as shown in Figure 9, the service platform includes intelligent light pole management system, asset management system and other systems.

Figure 9. Street lamp service platform

As shown in Figure 10,in the intelligent light pole management system, managers can control the working status of the street lamp, view various information collected by the sensors set on the street lamps by clicking on different sensors in the platform， and also can click asset management to get the asset information of the current street lamp. Through the system shown in Figure 11, managers can check the damage of street lamps in the current area. When a street lamp fails, the street lamp will go offline and send out a fault warning, which is convenient for maintenance personnel to check and repair in time.

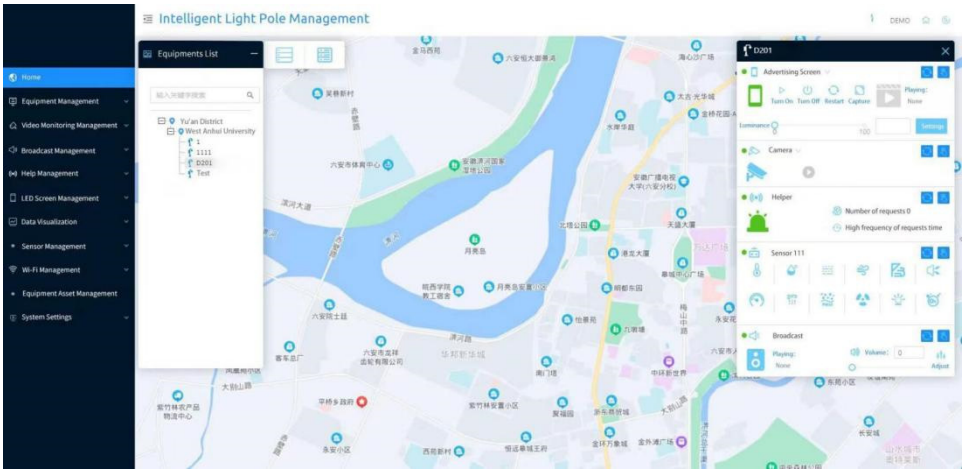

Figure10. Light pole management

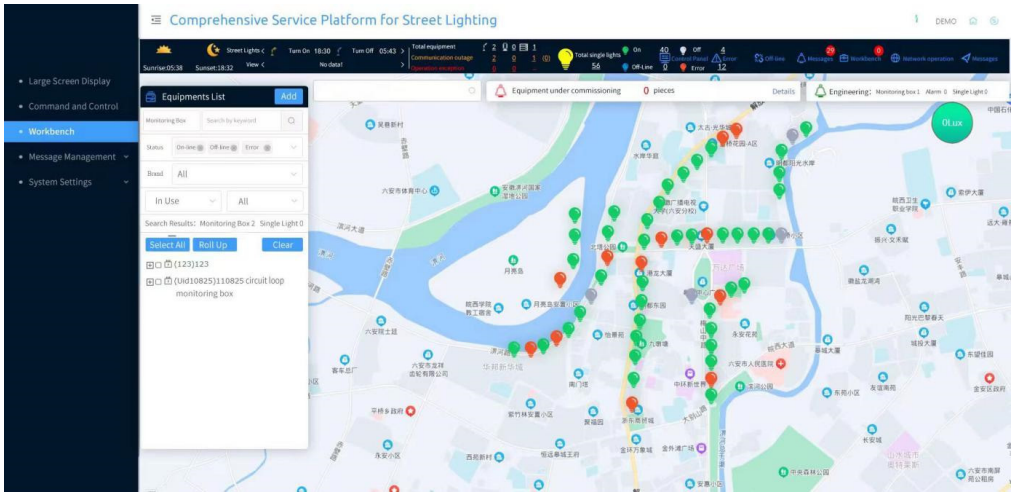

Figure11. Street lamp maintenance system

6 Conclusion

In order to solve the problems of street lamps in villages and towns,this paper develops a intelligent street lamp and service platform for villages and towns, adds functions such as distributed monitoring, data acquisition and centralized management on the basis of the original street lamps, and establishes four subsystems: smart lighting system, operation and maintenance GIS management system, government information release system, security and environmental information monitoring system. It is well adapted to the needs of smart lighting in villages and towns,and play a great role in promoting the information construction of villages and towns, has great promotion significance, and can be appropriately adjusted through functional modules and extended to cities.

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