Design of a ZigBee-based intelligent household electricity monitoring and control information system

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Abstract. A ZigBee-Based Intelligent Household Electricity Monitoring and Control Information System (ZBEMCIS) is proposed. The system is composed of hardware and software. The hardware consists of sensors, a ZigBee-based gateway, and a client, while the system software is divided into three layers: the data service layer, the logic layer and the user layer. The sensors collect the data from electric equipment and household environment. Through the ZigBee-based home gateway with routing and external network, the data reach the client, which makes all kinds of home appliances connected into an intelligent system. While the software householders can realize monitoring and metering management of household electrical appliances through browsers, meanwhile, the system can automatically report to users the abnormality warnings by various communication modes. The ZBEMCIS can easily monitor electricity usage with a high level of accuracy, therefore, it can be used for electricity monitoring and controlling for household applications, and also it may make intelligent home appliances more diversified.

Key words. ZigBee, household electricity, monitoring and control, information system..

1. Introduction

With the emergence of innovative technologies, living standards and quality of life have reached an all-time high. A significant part of the modern lifestyle is intertwined with the usage of electronic and electrical devices. In traditional way, if users want to know the household electricity information, they can acquire only the total amount of electricity by bills, internet or telephone, rather than the usage of each electrical terminal. And users have no idea of how to monitor the usage of the terminals and to optimize the electrical consumption performances, not to mention the intelligent household electricity. On the other hand, if there is something wrong with some terminal, or users forget turning off the lamp, or the gas is leaking out, given these conditions, the users cannot get in time.

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With advancement in wireless technologies and through the implementation of distributed sensor networks, intelligent residential systems are concerned more and more. By eliminating the need to run wires in an existing facility, wireless technologies can help reduce the cost of construction in "intelligent" household electricity. Due to their small footprints, wireless nodes can easily be mounted without interruption of current usage and without inconveniencing householders for renovations and changes. Another benefit of wireless technologies that makes them appropriate for residential use is their low energy consumption, because they can be powered by batteries with long service lives.

In order to monitor and control household electrical terminals more effectively, and safeguard in the household, we propose to design this ZigBee-based system combined with wireless sensor nodes to meet the need.

2. System architecture

The ZBEMCIS consists of a ZigBee-based gateway, a client, and sensors. The sensors monitor and control the electricity usage of the electrical terminals and transmit data to the gateway. The gateway's purpose is to connect sensor nodes to an existing home network. The client accept the datum and storage them into database. Users can access the status of electrical terminals by computer or smart phone.

2.1. System hardware architecture

System hardware architecture consists of sensor nodes and a ZigBee-bases gateway, which is the basis of ZBEMCIS. The sensor nodes are divided into electricity measure nodes and environmental monitoring nodes. The measure nodes are based on CC2530 chip with its development kits and can do the following things:

1. Measurement of power parameters, such as the voltage, current, and power of the outlet.

2. Control of the power output of the outlet.

3. Security protection.

4. Transmission of information from each node to the client through ZigBee.

The sensor node is shown in Fig. 2.

The environmental monitoring nodes are mainly used to monitor the home environment information, including temperature, humidity, smoke concentration and gas concentration. Their principle function is to collect the environmental parameters in real time, and get the actual environment parameters by comparison with the reference parameters. When the parameters of the acquisition exceed the threshold range, the alarm signal can be inspired.

The ZigBee-based gateway (its architecture being depicted in Fig. 3) is to encode and process the data from the nodes in accordance with certain rules of encoding
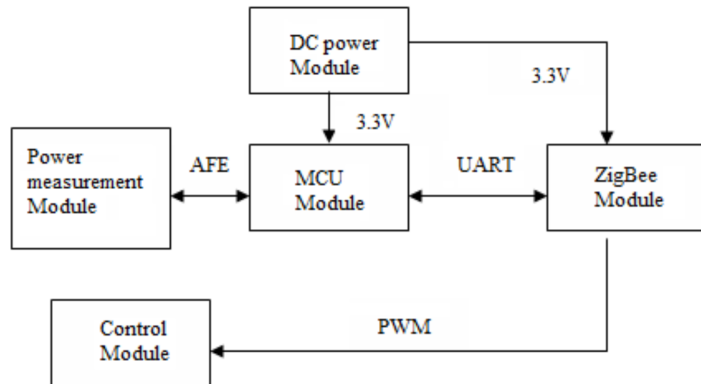
Fig. 1. Block diagram of sensor node

and processing, and then transmit the data through the RF communication module, which is connected with the home network to the client. When it receives instruction from the users, it can decode in the same way.

Fig. 2. ZigBee-based gateway architecture

As a part of data exchange, the ZigBee-based gateway will transmit the data from the home environment to the back-end computer network, which realizes the data acquisition of wireless sensor nodes; through the computer network, the client receives the data, and can store, manage and control the data.

2.2. System software architecture

According to the modular design principle, the system software is divided into three layers: the data service layer, the logic layer and the user layer. The data service layer stores the data from the nodes to the database; the logic processing layer provides a series of data processing interface to merge, eliminate redundancy and do other operation according to the requirements of the system; the user layer interact directly with users, so it accepts the user's request and reports to users if there is any exception.

2.2.1. The data service layer. ZBEMCIS uses relational database MySQL to storage the data. The table structure is shown in Fig. 4.
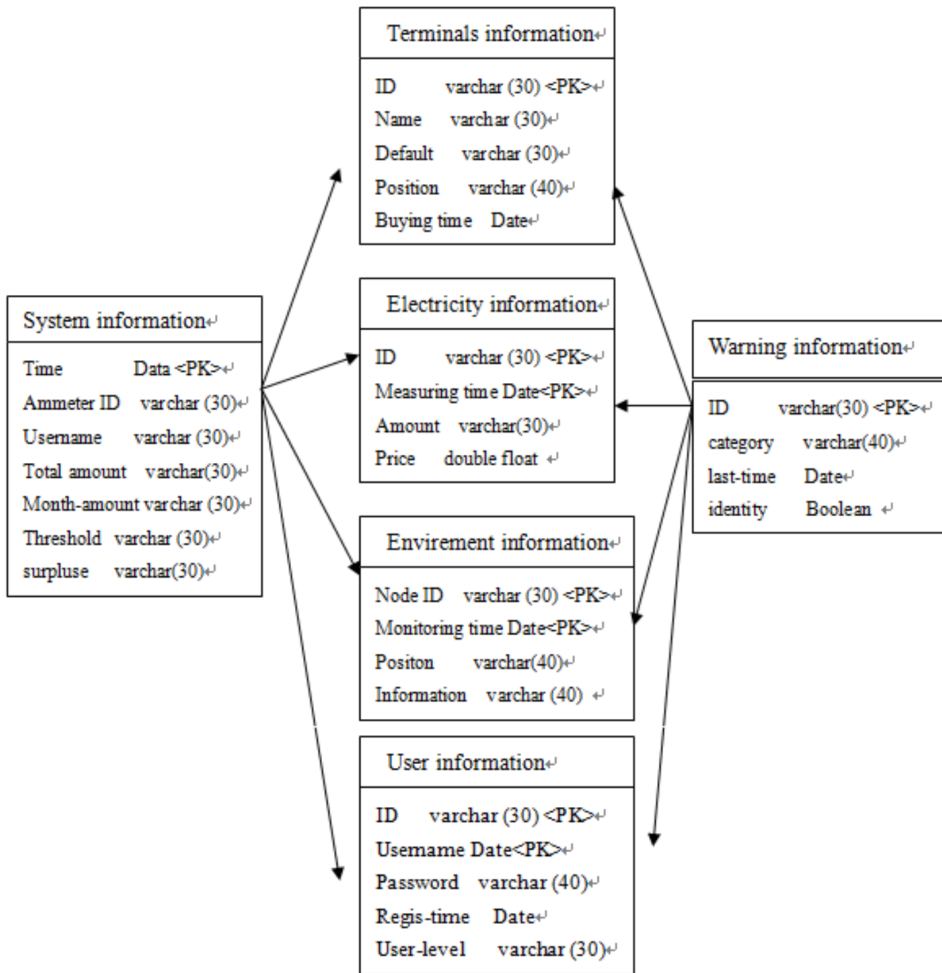

Fig. 3. Database table structures

The database of the system contains six tables used to store all data, and carry out a unified numbering system for the user's meter, electricity terminals, environmental monitoring position and user information. And the unified numbering system is used as the unique identifier to connect each entity.

In order to make the system high cohesion, low coupling characteristics, and easy to operate, we design to integrate Hibernate framework in the system because Hibernate is closed to JDBC, which makes Java programmer use Access Object DAO to operate the database. The system also has a unified interface to access database, so that the database can be realized and hide concrete realization.

2.2.2. Logic layer. The logic layer provides data access interface for the system, which is divided into four business sub modules: the business interface module, the business processing module, the data interface module and the data buffer module, shown in Fig. 5.
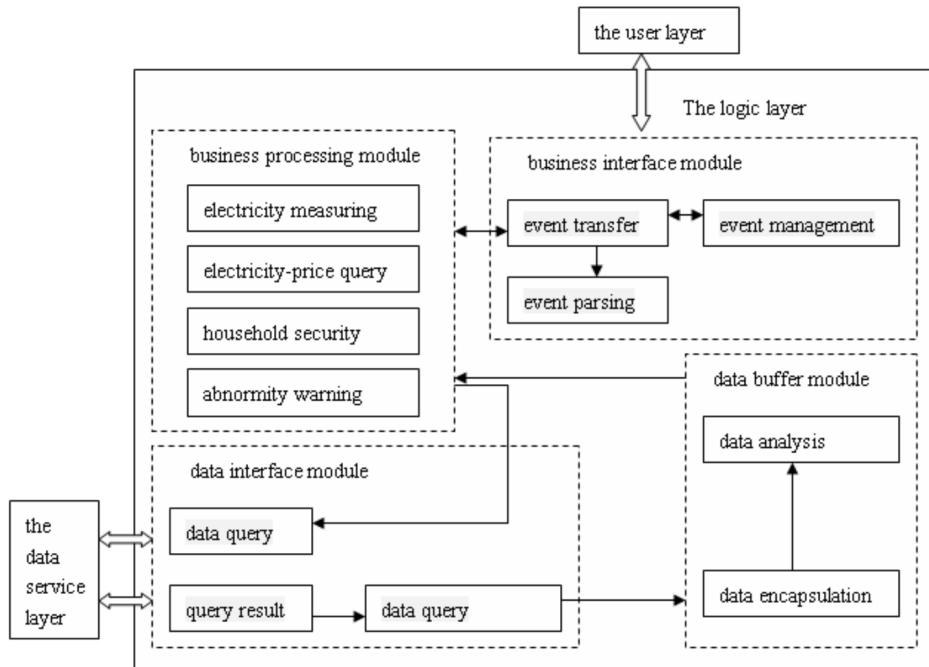

Fig. 4. Logic layer

When the program starts running, the status of each sensor is obtained, which includes the voltage, electricity of the household terminals, the indoor and outdoor environment, the smoke and gas concentration, and then determines whether these conditions are abnormal. If they are, the system will write the relevant information into the database. Otherwise, through the Internet, the system can connect to power network of administration of power supply to get the price. The program can count

the electric charge for users.

2.2.3. User layer. The system uses B/S framework, combining the PHP language and the CSS to develop the user layer. In order to ensure the system has a good response mechanism, the Ajax technology is used in the process of implementation.

3. System functions

The main functions of the system are as follows:

1. Checking usage of the power of the electric terminals in real time, and realize the unified control and management of all household appliances in the home.

2. Change of the parameters of the household terminals through the browser, thereby remotely controlling the switch of the terminals.

3. Automatic generation of electricity bills containing all of the equipment used, including the total number of electricity, the power consumption of the device.

4. Setting the power and energy consumption threshold for each household terminal, when the terminal is used or the total energy consumption exceeds the set default threshold, by sending e-mail to remind, users can decide whether or not to remotely close the power equipment.

5. Monitoring of home environment information system real-time, automatic control of indoor temperature and humidity information.

6. The smoke and gas detection sensors can monitor the indoor gas concentration, if abnormal events occur, there will be timely warning.

4. Conclusions

ZigBee has become a more and more important application of the Internet of Things (IoT) technology in intelligent household. In this paper, the authors propose a cost-effective ZBEMCIS, which can monitor and control the household electricity terminals, and the users can easily access the status and information from sensor nodes, which has a very important role in realizing savings in electricity consumption, monitoring, overload managing and remote control. And also it may make intelligent home appliances more diversified.

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