

# Embedded Smart Home System Based on ZigBee

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**Abstract**—As information technology philosophy of life is gradually recognized, smart home system as a new consumer demand will have broad market space. Based on the ZigBee wireless communication technology and embedded systems, a wireless smart home control system is build. In this paper, the inside networking of the smart home and the ZigBee-based wireless information collection and transmission as well as the multi-mode control is studied, and the security control, appliance control as well as remote control of the smart home system are realized.

## Introduction

With the rapid development of computer network technology and electronic information technology, the living standard of the domestic consumers has been raised continually. At the same time, people pay more attention to the quality of life. The demand for housing has become increasingly high, which has not satisfied with simple living functions, also hope to have a high quality life, such as automation, safe, efficient and comfortable etc. The higher level requirements of housing directly contributed to the birth of the smart home system.

The smart home system refers to the family comprehensive services and management integrated system, which built up by the home security system [1], the network service system and the home automation system. Smart home system uses the advanced computer technology, communication and control technology to provide comprehensive security protection, family housing convenient communications network and comfortable living environment. A complete smart home system in general has lighting control, electric control system, security access control system, fire alarm system and remote control system etc., which realizes the function of information acquisition, input and output, centralized control, remote control and linkage control etc. Compared with the traditional home system, the smart home system pays more attention to the person's subjective initiative, the use of high-tech emergent and the coordination with the living environment, which can arbitrarily control the living environment to achieve the intelligent, convenient, efficient and the comfortable etc.

## The Technology of Smart Home System

ZigBee is a new two-way wireless communication technology proposed recently, which has advantages such as close communication, low complexity, low power consumption, low data rate and low cost. ZigBee is mainly suitable for the field of automatic control and remote control [2], which can meet the need of the wireless networking and control of small cheap devices. According to the function of the network, ZigBee equipment can be divided into three kinds: the network coordinator, the routing node and the terminal node. The network coordinator and the routing node are all FFD, which can communicate with any other node. The terminal node is RFD.

The network coordinator is responsible for coordinating the establishment of the network and the other functions include: transmission the network beacon, management of the network nodes and the network storage node information, and provide the routing information association between the nodes. In addition, the network coordinator stores some of the basic information, such as node data equipment, data forwarding and equipment association table etc. The function of routing node

searches for the available networks, which transmits the data and request data to the network coordinator according to the demand. The terminal node is generally in the network edge, which play a subordinate role. The design and implementation of the terminal node is in a dormant state at most of the time. The terminal node can't carry on point to point communication. As a result, it can't act as a parent node. Tab.1 shows the main technical characteristics of ZigBee.

TABLE I. MAIN TECHNICAL CHARACTERISTICS OF ZIGBEE

Characteristic	Value
Data rate	868MHZ: 20kbps; 915MHZ: 40kbps; 2.4MHZ: 250kbps;
Communication range	20-100m
The communication delay	>15ms
The number of channels	869/915MHZ: 11
Addressing mode	64 IEEE Bit address, 8 Bit network address
Channel access	CSMA/CA and time-oriented CSMA/CA
Temperature	-40°C-85°C

ZigBee standard adopts hierarchical structure. Each layer provides a series of special service for the upper layer, such as the data entity provides data transmission services and management entity will provide all other services. All the service entity provides an interface for the upper layer through the service access point (SAP) and every SAP can support a certain number of the service to implement the functions [3]. IEEE802.15.4 defines two physical layers (PHY), respectively, to work in two frequency bands: 868/915MHz and 2.4GHz. The low frequency of physical layer covers 868MHz's European frequency band and 915MHz frequency band of the United States and Australia and other countries. High frequency band is universal.

The IEEE 802.15.4 MAC layer adopts CSMA-CA mechanism to control channel access, which is mainly responsible for transmitting beacon frames, synchronization and provide reliable transmission mechanism. The main responsibility of network layer includes providing the mechanism for a device to join and leave the network, security mechanism and routing mechanism of transmission. In addition, it has the functions of finding and keeps the routing between the devices and finding a neighbor and storage of potential neighbor's information. The NWK layer of ZigBee coordinator must also be responsible for the initiation of a new network and assign the address for the new context devices. The protocol stack architecture of ZigBee is shown in Fig.1.

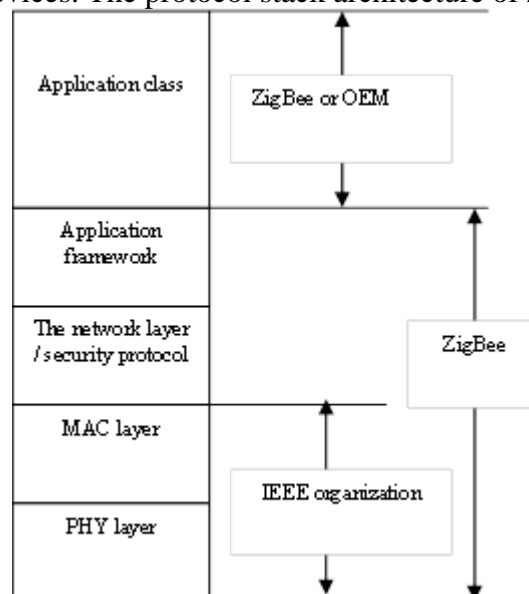


Figure.1 Protocol stack architecture of ZigBee

The ZigBee application layer includes the APS, AF, ZDO and user define application object [4].

APS is responsible for the maintenance of the device binding table and the data transmission between the binding devices. The device binding table is used for matching devices and storing the information of the related devices according to the service and the demand between the devices. ZDO is responsible for defining the role of the devices in the network, putting forward the request or response and establishing the security relation among the devices in the network. ZDO is also responsible for network device discovery and judge the other side provide what kind of service.

### The Program of the Smart Home System

The smart home system proposed here is designed by the family controlled apparatus and the remote control devices. The controlled devices of the family mainly include the computer which can access the internet, the coordinator, the monitoring node and the selective controller. The remote control devices are mainly composed of the remote computer composition. The smart home system can be shown as Fig.2.

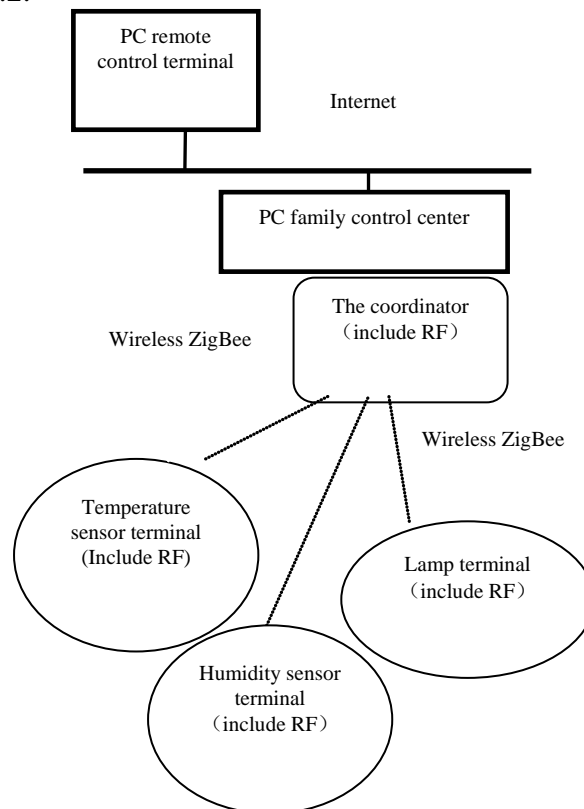


Figure.2 Architecture of smart home system

The main function of the smart home system include: (1) Browsing the client page and the background information management. (2) The remote PC through Internet to achieve remote control switch of household electrical appliance, security and light control. (3) Transmitting the information collected by the appliance terminal to the host computer through the coordinator module. At the same time, the coordinator module accepts the instructions of the host computer and sends to the appliance terminal. (4) Through the central control and management system software to complete the interior lighting and appliance of local control and status display. (5) Completing the storage of the personal information and indoor equipment state by using the file and through the central control and management system is convenient for the user to query the indoor equipment state.

The CC2530 of TI Company is selected as the controller of the ZigBee module [5]. It is a high performance and low power 8051 core microcontroller, and it is also an IEEE802.15.4 compliant 2.4GHz RF devices [6]. The hardware of CC2530 support carrier sense multiple access / collision detection (CSMA/CA), the working voltage of 2.0-3.6V is conducive to the realization of low power system. The entire monitoring node and the selected household electrical appliance controller

can be taken as the terminal node to join the network. The hardware block diagram of the smart home system is shown in Fig.3.

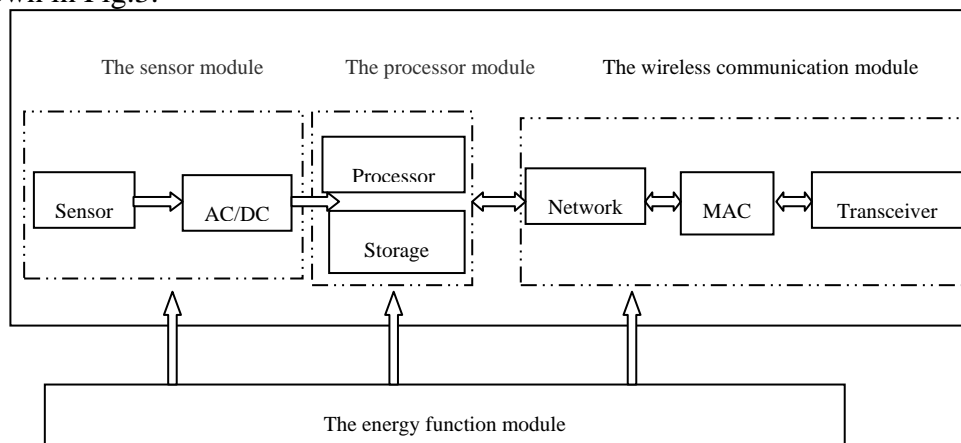


Figure.3 Hardware implementation diagram. The control of the household electrical appliance is implemented according to the functions. Here, take the lamp as an example. The implementation of the light control is that the coordinator transmits the control instructions of the coordinator to the light control terminal through the ZigBee network. Different appliance identification codes are different, this agreement shall close the identification code of the electric lamp is 23078#, the identification code to turn on the light is 23178#, so as to realize the recognition of different home appliances control center. But for the same instruction code, different home appliances executive function is not the same.

Program design of ZigBee terminal nodes is defined by the ZigBee coordinator control of wireless ZigBee, which is referred to choose the household electrical appliance controller to add to the system. The ZigBee terminal node initialization also includes application layer initialization, interrupt and initialize the I/O mouth open. And then the controller try to join the ZigBee network, the need to emphasize is that only and ZigBee coordinator and the terminal node setting consistent can add to the network. If the ZigBee terminal node attempts to join a network failure, every two seconds to try again, until successfully added to the network. After the success of joining the network, ZigBee terminal node transmits the registration information to the ZigBee coordinator, and then the registration information is transmitted to the control center MCU by ZigBee coordinator to complete the ZigBee terminal node registration. If the ZigBee terminal node is the monitoring node, the system can realize the lighting and the security control function. Program and ZigBee coordinator is similar, and the different is only that the monitoring nodes need to send the data to the ZigBee coordinator, and then the ZigBee coordinator transmits the data to the control center MCU. If the ZigBee terminal node is the electric fan controller, it only needs to receive PC data without the need to upload status, so it can be directly completed during the wireless data receiving interrupt. In the wireless data receiving interrupt, all the terminal nodes translate the received instructions to the control parameters, and there is nothing treatment of the wireless instruction in the node main program.

## The Results of Experiment

The smart home system proposed in this work consists of three main modules: ZigBee network module, PC control module and sensor module. The system model is shown in Fig.3. This system implements the functions as follows: smoke control function, household appliances and lighting control function, security control function and remote control function. These functions form a complete smart home system.

In this paper, the function of smart home system described as follows:

**Smoke control functions:** real-time monitoring of fire and smoke occurrence. If there has fire occurrence, the smoke sensor can send out alarm, and the home gateway can collect the related signal and send out the alarm. The alarm information will be transmitted to the PC machine, and then PC machine can also send a message to the remote control end. The state of emergency will be started to obtain the realization of active prevention.

Household appliances and lighting control function: realizing the remote appliance switch and the state detection operation. The light can change along with the demand of the user, and the user can freely operate the home appliances.

Security control function: realizing the protection of indoor property. If there is illegal invasion, the corresponding sensor can send out sound and light alarm.



Figure.4 Architecture model of smart home Figure.5 Control terminal interface and remote login interface

## Conclusion

The ZigBee wireless communication technology and embedded system are combined together and the various subsystems are integrated into a family by using the network communication technology. The smart home system solves the complexity problem of the internal information transmission, which constructed a wireless smart home complete control system. The system mainly studied the smart home internal network, the wireless information acquisition and transmission based on ZigBee and the multi-mode control, which realizing the security control, home appliance control, the remote control and the other functions of the smart home system.

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