Research and Design of Smart Home System Based On Zigbee Technology

Xiang Gao, Li Zhao
Automation College
Nanjing University of Posts and Telecommunications, NJUPT
Nanjing, China
e-mail: gaox@njupt.edu.cn, qushizhaoli@163.com

***Abstract*—A system of wireless Smart home sensor network based on ZigBee technology was proposed in this paper. A common control unit and binding idea are used in design of this system, which improves the development efficiency and makes it easy to expand and upgrade various functions. The proposed system has high availability and reliability. It could meet the requirements of daily life such as the control of commonly used household appliances and the real-time monitoring of family environment.**

Keywords—Smart home;ZigBee;binding;common control

I. INTRODUCTION

Smart Home System is an intelligent home network combined with advanced communication technology, sensing control technology and some embedded systems to carry out effective control and information exchange. While currently the Smart Home System [1] is mainly used in a number of upscale communities and has not been widely used for ordinary people. ZigBee [2] [3] technology is an emerging wireless communications technology based on IEEE 802.15.4 standards with the characteristics of low-cost, low power, low-rate. Besides, compared to other wireless communication technologies, such as Ir-DA infrared and Bluetooth technology, the advantage of large network capacity, Safety and reliability, excellent real-time and low cost make it more suitable for home network and will accelerate the popularization of smart home.

II. SYSTEM ARCHITECTURE

A. ZigBee Network Topology Selection

ZigBee network [4] topologies are mainly three kinds: star, tree and mesh networks. Star network is appropriate for small-scale, low-complexity home applications with simple and low power consumption features. Mesh network has a high adaptability and fault tolerance capability, but its complexity is highest. While tree network is somewhere in between. Application of star network in smart home network will get a higher cost performance.

B. System composition

Wireless transceiver modules based on ZigBee chips can be embedded into a variety of household devices to composite home wireless control network. Then Sub-nodes of the network would provide data transmission through the wireless transceiver module [5], with the help of which, wireless devices within the family can be inter-connected so that they can run automatically and cooperate with each other. The system composition is shown in figure 1 as below.

Common control unit is used to control a variety of devices and transmit the feedback information to the host controller such as home PC or handheld terminal. Home gateway provides remote control access between the system and mobile networks or Internet. Home gateway adopts ARM9 chip which can not only gain access to external networks with a GPRS or Ethernet module, but also manipulate various devices through the serial port RS-232 connected with ZigBee wireless transceiver module. The operator can provide data access and status monitor of home terminal nodes [6] by any computer or mobile phone that connecting to Internet. Hand-held remote control is responsible for decoding pulses sent by infrared remote-controller and makes appropriate response via infrared remote control decoding and control section. Common control unit can either respond directly to home user's request, or make judgments and respond to control commands of remote users through a wireless network to control various home appliances.

978-0-7695-4225-6/10 $26.00 © 2010 IEEE
DOI 10.1109/AICI.2010.183

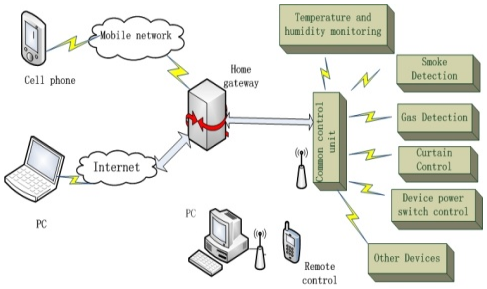

Figure 1. System composition diagram

III. HARDWARE DESIGN

For convenience of the expansion and simplification of this system, this design adopts a common control unit [7], which is mainly used to accept the host controller's instructions and collect Field data, control signal output and feedback functions. In order to achieve the purpose in common use, the interface adopts standard components to facilitate the docking with different function units. In the hardware design, the interfaces must be reserved enough: such as A/D conversion interface, D/A conversion interface, debugging and radio frequency circuit interfaces. According to the actual requirement, you can implement different functions by configuring different software system and debugging it into the corresponding functional unit.

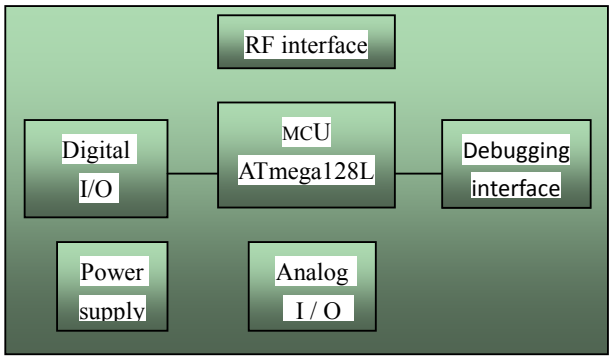

Figure 2. Hardware block diagram of common control unit

MCU will be chosen with A/D and D/A modules as the processor of the whole unit. In this paper ATmega128L MCU is chosen to control sensors and relay and get information feedback. ATmega128L is a high-end 8-bit micro-processor of ATMEL Company, which can provide programmable Flash with128K bytes. Besides, it has a simplified and efficient RISC instruction system, 53 programmable general I/O ports and 8-bit general registers up to 32. When working at frequency band of 16 MHz, the transmission and access rates can be up to 16 MIPS with characteristics of high performance and low power consumption.

RF interface adopts Chipcon's latest RF transceiver CC2430 complying with IEEE802.15.4 standard. CC2430 chip integrates ZigBee RF front-end, memory and microcontroller. It contains an 8-bit 8051MCU, 32/64/128KB programmable Flash, 8KB RAM, ADC, 32KHz crystal oscillator sleep mode timer and 21 programmable I/O pins which can be used as general I/O port or as peripheral I/O port connecting ADC, Timers or USART by setting a group of SFR registers' bits and bytes.

Digital I/O interface is input and output channel for digital signals, such as the switch signal‘s output and I2C communication with display, etc. Analog I / O interface is input and output channel for analog signals, such as analog signal input in signal acquisition. Debug interface is used for program debugging and upgrading. A 3V battery and a standard DC power interface are both provided that users can utilize different power supply according to different occasions.

The introduction of the common control structure design makes it easy to control various types of sensors and relays, such as the collection of temperature and humidity, gas detection, curtains and lighting control, are all realized by the ATmega128L microcontroller via writing corresponding control program to ATmega128L. While ATmega128L exchange data with the CC2430 RF transceiver through the serial communication .The format for the data packet can be described as the following format:

head flag	bit 1	bit 2	……	bit n	tail flag

Therefore, a queue can be defined to receive data packets. When the system receives a data packet, it firstly determines whether the data head flag is correct. If the flag is wrong, the data packet would be discarded immediately. Data and extract necessary elements would not be received unless both of the head flag and tail flag are correct, or the system would discard the packet and re-receiving the data. Such nodes in the structure and self-defined communication mechanism introduced into

this system not only facilitate the expansion of the node functions, but also greatly simplify the ZigBee protocol stack development, and thus make a variety of Zigbee-based application [8]development easier and more efficient.

IV. SOFTWARE DESIGN

The design is carried out on ZigBee2006 protocol stack [9] and user task events are added into the application layer. The task events scheduling of every layer are achieved by a simple task-based operating system in TI Z-Stack protocol. After system initialization, osal_start_system loop function is called to schedule various system tasks continuously. This function is an infinite loop function, in each loop, each task event will be inquired and dealt with. While the user's applications, such as UserAppWAP_ProcessEvent, will be round-robin scheduled here.

Two projects were implemented in the IAR Embedded Workbench IDE. One is HomeAutoApp_WAP project, namely the wireless management interface application, which is the wireless interface of communication between the ZigBee network and host computer. Host computer is connected to WAP through the USB and then host computer can communicate with ZigBee network via wireless ZigBee modules of WAP. When a new device joins the network, WAP wireless interface will assign a unique node network ID to it as well as the corresponding unique sub-device ID in the whole network. The other is HomeAutoApp_GEN_DEVICE project, namely ZigBee network node function realization project. The entire network can properly work when the programs are downloaded to the corresponding module. The software design flow chart of the common control unit is as below in Figure 3.

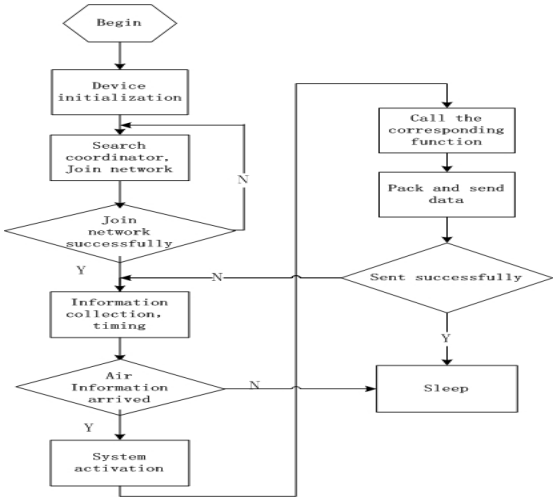

Figure 3. Common control unit software flow chart

The innovation of this design is to introduce the idea of binding, through which you can achieve a variety of functions with a variety of facilities bound together. Since the same device can participate in a variety of functions, you are allowed a flexible control of different devices. Take lighting control for example, you can achieve dimming function with lights and curtains to bind. The specific process is below: you can set the value input from the host computer and send it to the node, and then the node samples current indoor light intensity through the light-sensitive sensor and compares with the setting value. If less than the setting value, light can be dimmed through the relay to open or close indoor lights or curtains until light intensity meets the setting value.

Devices join the network and initialize global variables of device properties, binding relationship linker and binding relationship realization linker. Then the device application programs take relevant action through the linkers and call control functions to achieve the corresponding function according to different sub-device ID, sub-function serial number and binding types. Binding process is shown in Figure 4.

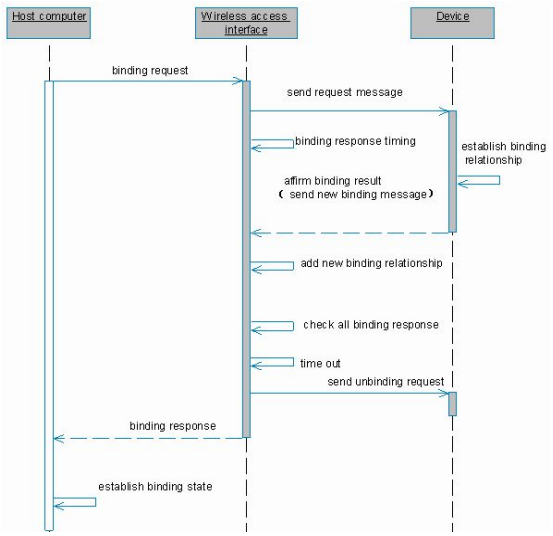

Figure 4. Binding process interaction diagram

V. SUMMARY

The main innovations in this design of smart home system lie in two: Firstly, in the design of the common control unit, various types of function control are achieved through the ATmega128L MCU. ATmega128L and the CC2430 RF transceiver send and receive data packets to achieve the command transmission through the serial communication. Therefore, the complexity of application development will be partly transferred to the MCU development which is already very mature. This is not only greatly enhanced the development efficiency, but also facilitate the expansion of future functions; In addition, the provision of data packet format and the definition of a queue to receive data packets enable it determine the packet received correct or not in accordance with the format. This mechanism effectively prevent the data packet loss and shield errors of data transmission during the underlying transfer process and thus provide correct and complete packets for the upper modules .Secondly, the introduction of binding ideas. When devices join the network, initialize global variables of device properties, binding relationship linker and binding relationship realization linker, then the device application execute relevant operation through the linkers and call control functions to achieve the corresponding function according to different sub-device ID, sub-function serial number and binding types. As a result, combination control of a variety of functions and facilities will be implemented with high flexibility and efficiency.

REFERENCES

[1] Wen-Yang Wang ,Chih-Chieh Chuang, Yu-Sheng Lai, A context-Aware system for smart home applications[J]. Lec-ture Notes in Computer Science, 2005, 38 (23): 298 -305.

[2] FUKUI KIYOSHI, TANIMOTO AKIRA, FUKUNAGA SHIGERU,ZigBee technology for low-cost and low-power radio communication systems[J].Journal of the Institute of Electronics Information and Communication Engineers, 2005, 88(1): 40-45.

[3] Chen, B., Wu, M., Yao, S., & Binbin, N.(2006). ZigBee technology and its application on wireless meterreading system. Industrial Informatics, 2006 IEEE International Conference on, August 2006, 1257-1260.

[4] William Stalling, "Wireless Communication and Networks", Fourth Edition, Pearson Publication Limited, 2004, Pp 39-118.

[5] Sheng-Fu Su, The Design and Implementation of the ZigBee Protocol Driver in Linux, White Paper dated 26 July 2005.

[6] Schlessman, J., Shim, J., Kim, I., Baek, Y. C.,& Wolf, W. (2006). Low power, low cost, wireless camera sensor nodes for human detection. Proceedings of the 4th International Conference on Embedded Networked Sensor Systems, October 2006, 363-364.

[7] Frenzel, L., A Supplement to Electronic Design, Wireless Control That Simply Works, January 12, 2004.

[8] P. Kinney, ZigBee Technology: Wireless Control that Simply Works, White Paper dated 2 October 2003.

[9] ZigBee Alliance,ZigBee Specification.Version 1.0 ZigBee Document 053474r06, December 14th, 2004.04.