

Remote Instant Interactive of Smart Building Home Equipment Based on Dynamic IP

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Abstract

Remote control of smart building home has been the one of core research in smart home. Currently, Smart home control terminal and controlled terminal in the internet environment has been separated, outside of the network cannot be achieved two-way interaction with multi-terminal inside. In addition, there are drawbacks that multiple home users cannot unify management of their entire house. To solve these problems, designing a solution based on android terminal, to achieve the purpose that two-way interaction in inner and outer net and multi-dwelling management through model tests.

Keywords: *dynamic IP, smart home, more terminal, remote interaction*

1. Introduction

Intelligent building is a stage that oriented system design, The system put a variety of communication equipment, household appliances, alarm device which related to information add to network node, through the family distribution bus, for centralized monitoring and management, keep coordination between household appliance and environment, provide an efficient and comfortable home environment, and make sure life and property security[1-2].At the same time, In order to improve the air quality it could concentrate and remote control household environment temperature, humidity, wind and check the speed of air composition, etc. [3].

At the same time, the mobile internet have more and more functions in smart home, the user of intelligent terminal increase year by year, the data released by the MIIT in January 2014 that mobile internet users reached 838 million[4]. Mobile phone will become part of smart home is inevitable trend in the future of smart home system development [5-6], Therefore, the study of smart home based on mobile internet is very necessary.

Usually in the construction of smart home system, intelligent terminal visit home equipment from the scope of local area network (LAN), or put smart home devices with independent IP address [7-11]. The traditional communication, visit home equipment by the intelligent terminal has following problems:

- (1) The problem about two-way alternate between dynamic IP indoors and control of remote intelligent terminal;
- (2) The problem about two-way alternate communication immediately between control terminal and controlled terminal.
- (3) To solve the problem that unified management of users many residences.

To deal with the problems, this article build a set of system that use handsets to realize two-way interaction between intelligent terminal and intelligent household equipment by dynamic IP in building homes.

2. The Network Building Based On Dynamic IP of Intelligent Building Home

2.1. Design Idea

The smart home system consists of intelligent control terminal, account server, control host, controlled terminal. After the intelligent control terminal installed control program, to communicate with the controlled terminal through wireless network; The account server is responsible for communication services between the intelligent control terminal and the controlled terminal, and fuse and process all the received data, It put the network port mapping for dynamic IP through the account management mode, build an interactive information channel, as shown in figure 1.

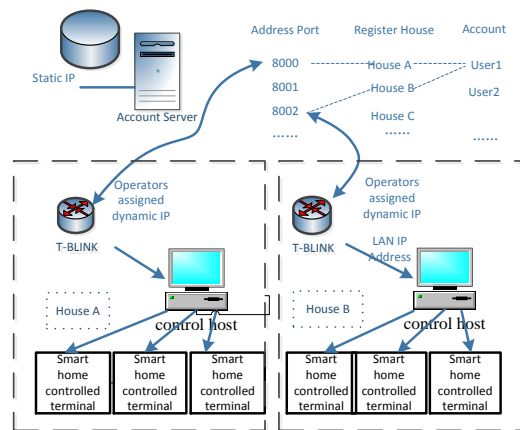


Figure 1. Network Address Mapping Control

A solution aimed at the problem: Set an account server with independent IP or domain name, for network mapping. The intelligence control terminal and the control host each occupy one port, and have its own dynamic IP. The control host connects each house controlled terminal with the account server. The intelligence control terminal sends commands and display results; the household controlled terminals perform the commands and feedback the execution result.

2.2. Network Topology

The function of smart home has three main parts: control、controlled and account server, the network topology is shown in figure 2:

(1) Control

It can be based on C/S or B/S architecture of PC, or intelligent terminal equipment, etc. It divided into indoor role and outdoor role by control area. The operator outdoors can interaction with intelligent home out the residence, sign in the remote account server and use account control mode to realize the communication, shown in figure 1. The operator indoors uses LAN.

(2) Controlled

The Controlled consists of control host、sensor node、control SCM (single chip microcomputer), etc. The control host become external gateway nodes of the full system inside house, has its own independent ID, has function of parse external information and collect and forward information from controlled nodes(control SCM).

Sensor node is responsible for collect information from each message patch, such as temperature, humidity, etc.

Control SCM is responsible for receive and process information from sensor node,

and forward to control host.

(3) Account Server

Account server's main functions are user registration; manage house, port mapping, web services, and the background services.

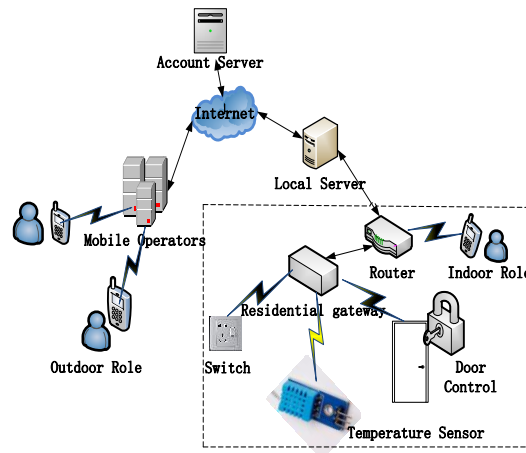


Figure 2. Smart Home System Network Topology

3. System Function Design

3.1. Account Server Operation Design

3.1.1. Account Management

Both the control and controlled port use account management strategy, which can solve the problems that bidirectional interaction between the two ports and unified management of users many residences.

(1) Account register

All ports need to register account server, the account server verifies this application for registration, after verified, and the information on the controlled side will be shown in the control side. Verify is based on the registration information, one to one, the way of register use web services.

(2) Account binding

The controlled side is real-time online after registered, that is to say it will login to the server when in an energized state. The control side login as required, shown in flow chart 3.

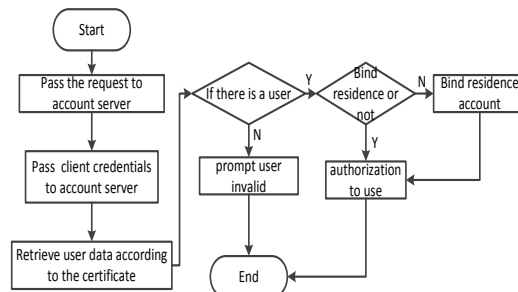


Figure 3. User Login Process to Obtain Authorization to Operate

3.1.2. Runtime Environment of Account Server

Account server mainly provides identity registration function; user authentication

and resources remote access function, according to different purposes, there are some certain differences of running environment.

- (1) Set up the web service. Account registration service using web service mode.
- (2) Establish Server software. Service software authenticates users by port monitoring, user login service, and creates information channels between the control side and the controlled side.
- (3) The database system. The system involves account, safe handling and storage and read background data.

3.2. Control Terminal Design

3.2.1. Control Terminal Classification

In control terminal, control scheme is divided into B/S structure and C/S structure of intelligent control terminal, two kinds of schemes have same function design in use, but the C/S structure is more savings of network resources to remote access, so the C/S structure of intelligent control terminal will have more users.

3.2.2. Control Terminal Function Design

Main interface of the control terminal are registered users, user login, modify and binding residence, intelligent control, etc. For the intelligent control function not only need to send commands, but also need to feedback information about state of controlled terminal. Residence registration, binding as shown in figure 4

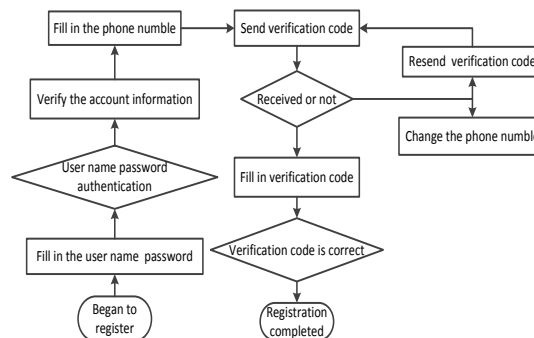


Figure 4. Residence Registration, the Binding Process

3.3. Controlled Terminal Functional Design

3.3.1. Control Host

Control host, as a gateway, forward internal and external network information, receive and send information from the remote account server and C51 single chip microcomputer. Each control host has the only accounts in the account server.

3.3.2. Controlled Terminal

Controlled terminal is consist of microcontroller, wireless receiving unit, micro switch, sensors and controlled household equipment model, etc. The microcontrollers as a gateway, transfer control instruction and feedback information.

4. System Structure and Implementation

4.1. The Hardware Environment

The system hardware constitute is shown in table 1:

Table 1. The Function Of Hardware Constitute List

Component name	Control terminal	Account server	Control host	Controlled terminal
Functional description	Operate the controlled terminal, send instructions and receive the state returned from the controlled terminal	Responsible for communication services between intelligent control terminal and the smart home control host	Achieve information transfer between account server and controlled terminal	Household equipment model. They connected by wireless module
Hardware reconstitute	Android mobile phone	PC/ARM	SCM (C51)+ WIFI module(NRF2401)	Slave1 (Light) Slave2 (Door guard) Slave3 (Temperature monitoring) + LED light + Relay module + Temperature sensor + Nixie tube

(1) Account server

Account server use the exclusive server, has the independent IP network address.

(2) Control terminal design

Control terminal use web page or Internet-connected intelligent terminal equipment. The web services provided by the account server, the intelligent terminal uses android mobile terminal and terminal connect to the Internet through GPRS / 3 g and WIFI network.

(3) Controlled terminal

Controlled terminal is consists of control host, sensor nodes, SCM, etc. control host as a gateway, receive and send information from remote account server and C51 SCM, as shown in figure 5.

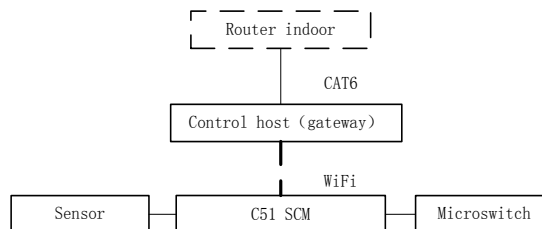


Figure 5. Charged Terminal Connection Diagram

Gateway design contains RJ45 network interface and RS232 serial port, RJ45 interface connection with household router, RS232 interface connected to SCM which contains sensors or micro switch.

4.2. System Running Environment

System running environment is as shown in table 2.

Table 2. The Programming Environment and Running Environment List

Systemfunction	Running environment		Program language	Functions described
Account server	VisualStudio2010		C#	Make the communication between control terminal and controlled terminal can realize, and record data communication
Control terminal	Program tools	Eclipse+Android sdk (jdk+jre)windows7	Java	Send commands and receive feedback information and display it
Control host	Keil C51		C language	Control the controlled terminal, and transmit the commands
Controlled terminal	Keil C51		C language	Execute the command and feedback results

4.3. Communication Protocols Define

At the smart home controlled terminal, in the communication between micro-controller and controlled terminal, the micro-controller (C51 MCU + NRF24L01 wireless) control and receive feedback information by sent via wireless chips and receive data. The main program initialize NRF24L01 and the serial port, there are three circulation process: 1). Set the NRF24L01 to accept state, to receive data; 2).When received data, sent it to the serial port; 3).If there are serial port interrupt, send the data to the serial port, choice to send the host ID depending on the type of sending command; The agreement and the command format in the communication unified to use bytes sending system. At first divide the system equipment by type, so each device have a device number belong to their own, convenient for other equipment to identify, device number of the signal convey center should be a standard to judge the beginning of the information, the definition of command interaction protocol are shown in table 3.

Table 3. Defining Communication Protocol

Frame header	Device type	Device number	Command	Feedback State
#	1 (Light)	1(Light 1)	1(Level 1)	11(Level 1)
			2(Level 2)	12(Level 2)
			3(Level 3)	13(Level 3)
	2 (Door Control)	2 (Door 2)	0(Off)	0(Off)
			1(Open)	1(Open)
			0(Close)	0(Close)
3(Temperature Detection)	1	1	1	

Illustrate:

1. Light on/off, temperature detection, door control, order 1.
2. Frame # has nonsense, just as to check the data frame effective or not.
3. Such as, the client sends a frame to turn on the first light, frame format is: # 111; Controlled terminal executing the command and feedback # 111, means the lamp has been opened.

5. Operation Interface and the Function Display

The system implementation for change light indoor, temperature data collection, entrance guard, for example, for the prototype design, as shown in figure 6.

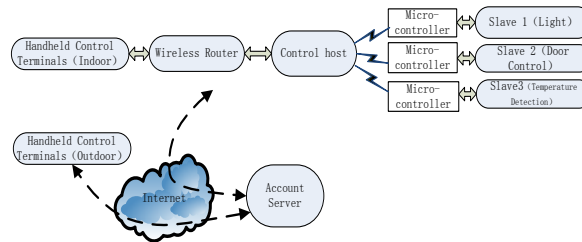


Figure 6. Hardware Architecture of Smart Home System

Transplant the designed client and account server on android handset and computers and run, and carry on the overall operation and debug. The experimental results are shown, The system run stably, realized the expected function. On the one hand, It can control household devices through landing the android handset client software, this intelligent household devices do not need independent IP address; On the other hand, It can achieve two-way information interaction between control terminal and intelligent household devices ,can receive feedback information from household equipment, and can shows temperature and other environmental information indoors in the android client; At the same time can also achieve a client to manage multiple intelligent residence.

The login screen, the binding interface and the main function interface of android mobile terminal of the system as shown in figure 7:

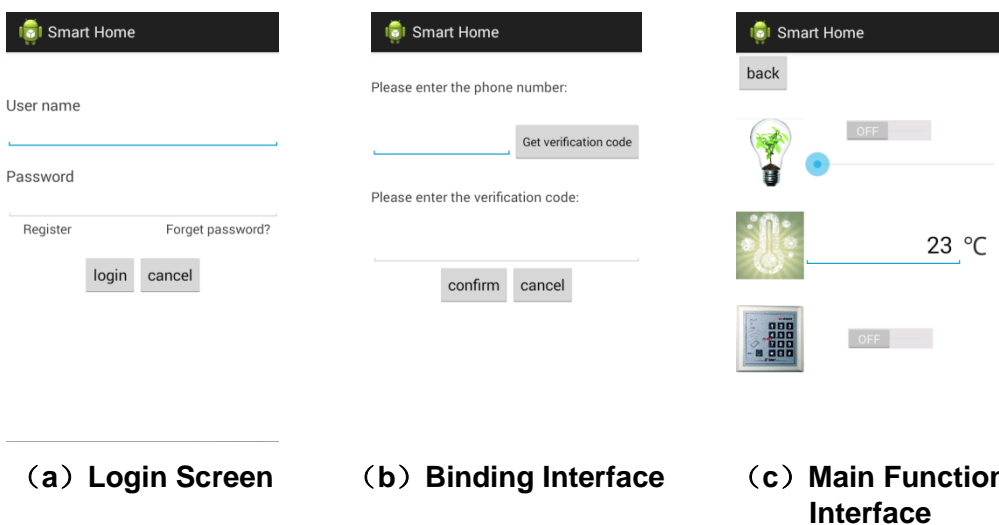


Figure 7. Login Binding and Function Interface

6. Summary

In this paper, we study the multiple terminal remote intelligent household systems, not only through the network to realize remote control, but also achieve two-way information interaction. To achieve the system function integration, users to use more blockheads and the market of common, the main advantage of the scheme are:

- (1) Easy installation: Because of all the devices connected by wireless, so there's no need to laying pipeline, the installation process is simple and fast. In addition, it do not affect the furniture decorate style.
- (2) Simple operation: Only need the mobile phone can complete all operations.
- (3) Convenient and flexible: This scheme, can according to their own economic ability and intention to use, and can flexible purchase the equipment, and adds functionality.

Acknowledgements

The Project was supported by the Special Fund for Basic Scientific Research of Central Colleges (CHD2012JC013), Chang' an University, by the Special Fund for Basic Research Program of Chang' an University and by the open Fund for Shaanxi Road Traffic Detection and Equipment Engineering Research Center.

References

- [1] [1] C. Zhou, W. Huang and X. Zhao, "Study on architecture of smart home management system and key devices", 2013 3rd International Conference on Computer Science and Network Technology (ICCSNT), (2013), pp. 1255 – 1258.
- [2] W. xuan, "Design and Implementation of Smart Home's Home gate Based on Android", Chengdu, School of Computer Science and Engineering, (2013).
- [3] D. -M. Han and J. -H. Lim, "Design and Implementation of Smart Home Energy Management Systems based on ZigBee", IEEE Transactions on Consumer Electronics, vol. 56, no. 3, (2010) August ,pp. 1417 – 1425.
- [4] "MIIT, The total of China mobile Internet users in January 2014 has reached 838 million", [ob/ol].<http://www.199it.com/archives/200174.html>.
- [5] L. -Y. Yang and J. -H. Wang, "The Design of Household Intelligent Control Terminal Based on Android Platform, Chinese Industrial Engineering Institution, CMES Institute of Electrical and Electronic Engineers Beijing Section, Proceedings of 2012 IEEE 19th International Conference on Industrial Engineering and Engineering Management (IE&EM 2012), Chinese Industrial Engineering Institution", CMES Institute of Electrical and Electronic Engineers Beijing Section (2012), pp. 3.
- [6] H. Wang, J. Saboune and A. E. Saddik, "Control your smart home with an autonomously mobile smartphone", 2013 IEEE International Conference on Multimedia and Expo Workshops (ICMEW), (2013) July , pp. 1-6.
- [7] J. Hosek, P. Masek, D. Kovac, M. Ries and F. Kröpfl, "IP home gateway as universal multi-purpose enabler for smart home services", e & i Elektrotechnik und Informationstechnik, vol. 131 no. 4-5, (2014), pp. 123-128.
- [8] G. -J. Horng, C. -K. Lin, C. -H. Tseng, C. -H. Wang and J. -F. Yang, "An Agent-Based Smart Home System and Its Service-Scheduling Mechanism: Design and Implementation", Wireless Personal Communications, vol. 78, no. 1, (2014), pp. 521-542.
- [9] L. Wei, L. Wei and L. Xin, "Design and Implement On Smart Home System", 2013 Fourth International Conference on Intelligent Systems Design and Engineering Applications, (2013) November 6-7, pp. 229 – 231.
- [10] C. -L. Wu, "Member, IEEE, and Li-Chen Fu.Design and Realization of a Framework for Human-System Interaction in Smart Homes", IEEE Transactions on Systems, Man, and Cybernetics—Part A: Systems and Humans, vol. 42, no. 1, (2012) January, pp. 15-31.
- [11] S. -H. Baeg, J. -H. Park, J. Koh, K. -W. Park and M. -H. Baeg, "Building a Smart Home Environment for Service Robots Based on RFID and Sensor Networks", International Conference on Control, Automation and Systems (2007) , pp. 1078 – 1082.

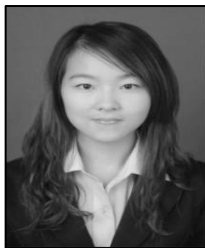
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