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Design and Realization of Smart Home System based on Internet of Things

Congmin Yu, Mingyi Mao and Yuanheng Jiang
School of Computer and Information Engineering,
Beijing Technology and Business University, Beijing, 100048, China

Abstract: Currently, the internet of things is the hotspot in China's leading information technology research and the Smart Home is an important embodiment in the internet of things of the real life. The smart home is based on B/S structure and its bottom adopts nRF24l01 chip in 2.4~2.5 G Hz ISM band wireless communication technology to collect and control home furnishing information and state. By using MySQL to devise and achieve the database and it recording device state information and the WEB terminal equipment operation; server set up and application of ASP.NET technology in WEB site, the user can intelligently control the furniture through the browser.

Key words: Internet of things, smart home, nRF24l01, ASP.NET

INTRODUCTION

In the electronic information age, the internet of Things (IOT) has become a hot topic of today's information technology. The internet of things is a short-range mobile transceivers embedded in a variety of mobile devices equipment, the establishment of a new dimension of communication between people and objects, from interpersonal communication, expanding to the human and material, things and things associated communication link.

Scientists and researchers try their best to make the home system much smarter than the former research. The Chongqing University at China developed a smart home architecture "Cloud-based smart home" (Ye and Huang, 2011). Son *et al*. (2011) from South Korea improved smart home management system by use the resource-aware management system. Raj (2012) from India proposed a scheme named "security alarm system" Jahn *et al*. (2010) from Germany present a novel smart home system integrating energy efficiency features. But this above proposal did not intelligent enough as the word "smart", so the situation determines the smart home based on IOT. The main application of the internet of things includes intelligent transportation, environmental protection, food traceability, enemy detection and smart home etc.

Based on the foundation of the existing internet of things, this smart home is developed as a set of control system for home users to edit and control the household equipment. Smart home with many years of development, but so far has not been universal. Reasons in addition to the product price factors, the key reason is the smart home services provided, not the people's lives must be, is lower than the desired minimum value of the public to buy. Imperfect technology is an important factor to limit the intelligent home to provide more services, mainly:

- Between the various subsystems of the intelligent home is basically irrelevant, yet to achieve interconnection, interoperability and interoperability. Although there are a lot of standards, but the industry has been no good to follow. This reflects the development of standards and user expectations of large deviations
- Subsystems of the smart home, from the point of view of automation are the actuator. The actuator intelligent execution must rely on the overall perception of the family. Perception of lack of equipment, serious impact on the upgrading of the level of intelligence of the intelligent home and thus cannot provide more services
- Smart home system can automatically perform most simple perception of action. Lack of perception data for further analysis, the lack of artificial intelligence reasoning analysis computing platform is an important reason for this result

In recent years, with the internet of things and cloud computing technology progress, provide new opportunities for the development of smart home. The smart home is the composition of hardware design and

Corresponding Author: Congmin Yu, School of Computer and Information Engineering,
Beijing Technology and Business University, Beijing, 100048, China

firing, integrated wiring technology, network transmission control, database design and development and the front-end visual design. These aspects closely integrated make it developed to be a set of applicability, safety high, as well as low-cost home control system to make people control their household equipment more convenient, faster and comfortable. The research is committed to develop an alternative, more convenient, fast, smart home management system used to implement the home humane, intelligent management.

METHODOLOGY OF THE SYSTEM FRAMEWORK DESIGN

Application in the internet of things includes the three main levels: The perception layer, transport layer and application layer. Figure 1 is a schematic diagram of the structure system frame structure design.

Just as the above Fig. 1, the smart home is an important application of the internet of things, which contains the same frame of this three-tiered design, the perceived layer, network layer and application layer.

Perception layers: In the system the main application is based on the nRF24l01 chip to complete the design and realization in the perception layer. The nRF24L01 is a product by NORDIC and the chip is a single-chip wireless transceiver chip which worked on the 2.4~2.5 G Hz ISM band. A wireless transceiver comprises:frequency generators, the enhanced mode controller named Schock Burst, a power amplifier, a crystal oscillator, a modulator and demodulator. The system realized the function which includes the collection of household information and the control state of the household equipment through nRF24l01. Then, all of the things integrate the formation of the Gateway.

Transport layer: The transport layer is an important link between the database server and the web site, as well as between the database server and the gateway data switching. The database server records the status of the household equipment and the operating records of the household equipment, at the same time, the database server to exchange data with the home gateway, then the web site obtain the appropriate data to publish the data to the Internet. The key point of the transport layer is that the information in the database update. Safeguard the correctness of the data transmission and real-time. Databases and web servers, database and gateway to both sides simultaneously update records, the transport layer is the middle layer and down to the physical layer up is the application layer. It is a data transmission channel of a link to the two layers (Huang, 2011).

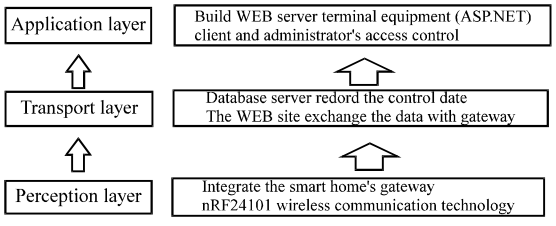

Fig. 1: Structure diagram system frame structure design

Application layer: The application layer's function is to set up a WEB browser to make the operation on the database and the operation of the status of the household equipment visual on it. The system uses the ASP.NET language to link the database, to make preparation of a website front end interface and to achieve administrators and users in the web browser for the real-time control of the home, as well as for household equipment additions and deletions to change search operation. ASP.NET is a unified Web application platform, which provides the services necessary to build and deploy enterprise-class Web applications. ASP.NET can target any browser or device more secure, more scalable, more stable application provides a new programming model and infrastructure (Lin *et al*., 2012).

The hardware design of the entire system is completed by the above three parts, integrated wiring and software design, where the hardware architecture is shown in Fig. 2.

HARDWARE DESIGN

The hardware system design mainly includes wireless sensor network structures, gateway design and realization and the database server configuration. A wireless sensor network structure is based on the layout of the nRF24l01 wireless sensor network. Gateway design is that combine AC, MCU, relay, power supply module, nRF24L01 chip, optocoupler and infrared circuit together to form a gateway. The database server configuration is arranged a MySQL database on the server, used to store information in the process of receiving and sending data.

Wireless sensing network structures: Wireless sensing technology completes wireless data transfer using nRF24l01 chip as the core. The nRF24L01 is a product by NORDIC and the chip is a single-chip wireless transceiver chip which worked on the 2.4~2.5 G Hz ISM band (Wang and Sa, 2008). It has two modes of operation: The standby mode and power-down mode.

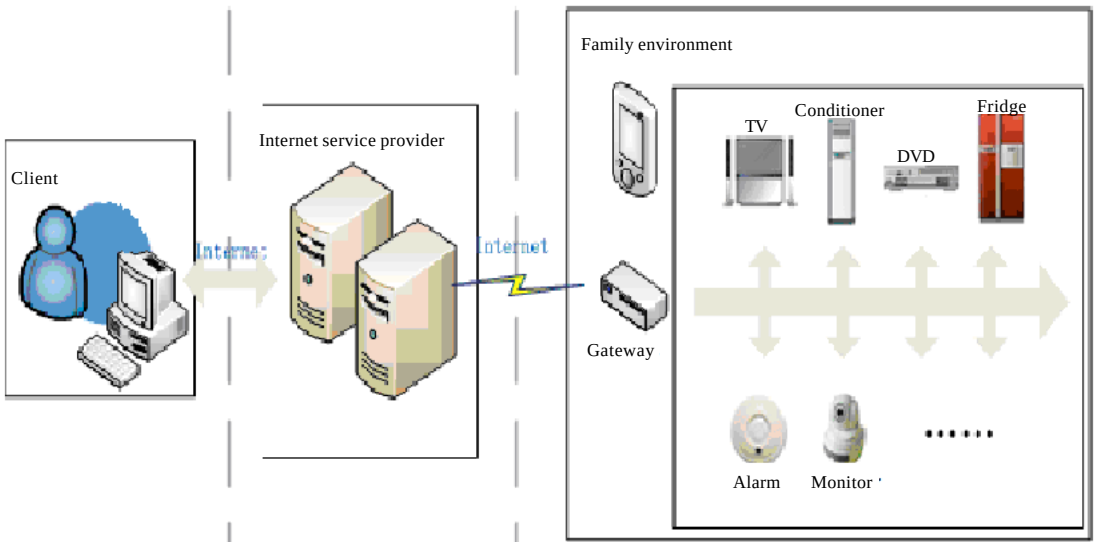

Fig. 2: System framework design

Table 1: Information of the nRF24l01's operating modes

Mode	PWR_UP register	PRIM_RX register	CE	FIFO state
Receive mode	1	1	1	-
Transmit mode I	1	0	1	Data in the TX FIFO register
Transmit mode II	1	0	1->0	Remain in the transmission mode until the data sending
Standby mode I	1	-	0	No data transmit
Standby mode II	1	0	1	TX FIFO is empty
Off mode	0	-	-	-

Standby mode: Standby mode I and Standby mode II: The system can quickly start while reducing average current consumption in standby mode I. While the system runs in the standby mode I, crystal works properly; when the system working in the standby mode, a part of the clock buffer work in the working mode and when the sender TX FIFO register is empty and CE is high. The system enters standby mode II and register configuration word content remains unchanged during standby mode.

Power-down mode: nRF24L01 turned off to maintain the minimum current consumption into the power-down mode, nRF24L01 stop working, but the register contents remain unchanged, the power-down mode by the register in PWR_UP bit control.

In the experiments, the key is suitable to set nRF24l01 chip four parameters. They are receiving mode; transmit mode; standby mode and power-down mode (Chen, 2012). Table 1 shows the nRF24L01 chip in several operating modes.

Based on these modes of operation, the nRF24l01 chip can guarantee the gateway design for low-cost, low-power work and to better meet the requirements of industrial production. The gateway design collects nRF24l01 chips and other related functions chip with together. Assembled in a small similar to the router's wireless signal reception and transmission equipment, have to accept the real-time status information of household equipment and emission control home devices signal function (Xiao *et al*., 2012).

Gateway design: The gateway of IOT is a band connected cognitive network with traditional communication networks. The gateway can achieve protocol conversion between cognitive network and communication networks, as well as the different types of sensing networks-WAN interconnection, or local interconnect. In addition gateway also needs to have the device management functions. Customers or administrators can manage the node of the underlying perception, information about each node and the remote control through the internet of things gateway device. Gateway is a combination of sophisticated technology, embedded technology, 2.4 G wireless short distance communication technology, infrared communication technology, network technology, design a set of standard based on wireless bus protocol

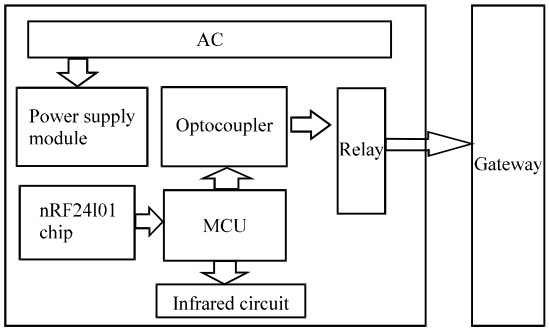

Fig. 3: Structure of the gateway

and the development of the intelligent home control system sensor-gateway. Its function is to receive from the user's computer operation instruction, so as to control relay operation, control of Alternating Current (AC) and through the infrared communication, remote control all with infrared remote control function of the appliances (Li, 2012). Below is the gateway function diagram:

As the Fig. 3 shown, the MCU through the wireless module nRF24L01 receiving operation instruction and then analysis to get the correct order, according to the command options emission infrared signal or operating relay. Power module will convert Alternating Current (ac) AC220 V DC12 V dc and through the two ASM1117 regulated chip, the 12 V voltage regulators to 5 V and 3.3 V, respectively to the single-chip microcomputer and wireless module power supply. Power module can provide the biggest circuit for 360 mA, this has meet intelligent node's working mode.

Database server configuration: The database server configuration is setting up a database system on the internet by the MySQL. The database collects the information of the receiving gateway household equipment in the real-time and records the information of the real-time control of household equipment by client or administrator through the WEB site terminal server. Database ensure customer or administrator can directly control the control equipment through the web browser, also ensure the current state of the household equipment and the expected state is consistent.

SOFTWARE DESIGN

Smart home system software on the basis of the above hardware design, establishes a database and writes the database management system, as well as to use ASP.NET above and achieve the WEB site.

Database design: The system database implements with MySQL as a database management system. MySQL is a small relational database management system developed by MySQL AB Sweden, currently belonging to Oracle Corporation. MySQL is a relational database management system, relational database to save data in different table, instead of all the data in a large warehouse, which thus increases the speed and improve flexibility.

Database devise optimized construct database logic patterns and physical models for a given application environment in the database field and established a database and its application system according to it, so the database devise was able to efficiently store and manage data and meet needs for various user applications, the design including information management requirements and data manipulation requirements. In the system database design, database named SHOITDB (Smart Home Office internet of things), data comes from real status information from the gateway transmission household equipment and records the data which comes from administrator add, delete, modify and update data, as well as the message which customers use to operating customer's data through WEB server. Database connection codes as follows:

```
public MysqlConnection GetMysqlconn(){//Datebase connection
        MysqlConnection conn;
        string strconn =
        WebConfigurationManager.ConnectionStrings["shoitdbConnection
        String"].ConnectionString;
        conn = new MysqlConnection(strconn);
        conn.Open();
        return conn;
       }
public void CloseMysqlconn(MysqlConnection conn){//Free the connection
     if (conn.State == ConnectionState.Open){
              conn.Close();
          }
 }
```

According to the demand analysis of the database, the database has been designed into 13 different tables. The database design has 13 tables. The tables are named: userInfo, user BuyInfo, productInfo, newsInfo, newsTypeInfo, equipmentInfo, custom Equipment Info, user Equipment, user Equipment State Log, user Log Info, admin Log Info, integral Weight and integral Log, to record the status of the household equipment and the operating records of the household equipment. These 13 tables constitute a database. These 13 tables record in all aspects of the data, such as: users, products, news, announcements, Integral, landing logs and so on. When

Table 2: Structure of the userInfo table

Field	Data types	Description
Id	Bigint	Primary key, self-growth (step 1), not null
UserName	Nvarchar (50)	Unique, not null
UserPwd	Nvarchar (50)	Not null
RealName	Nvarchar (50)	Not null
Mobile	Nvarchar (50)	Not null
Phone	Nvarchar (20)	Fixed line
Sex	Nvarchar (5)	Man/woman
Birthday	Nvarchar (20)	YYYY/MM/DD
Identity card	Nvarchar (20)	Not null
Country	Nvarchar (50)	Country
Province	Nvarchar (50)	Province
City	Nvarchar (50)	City
Address	Nvarchar (100)	Address
Zip code	Nvarchar (10)	Zip code
Avatar	Nvarchar (250)	Avatar
Avatar path	Nvarchar (100)	Avatar path
Reg date	Datetime	Registration date
Last login date	Datetime	Last login date
Last login failed date	Datetime	Last login failed date
Integral	Numeric	integral
Login times	int	Times of login

Table 3: Structure of the productInfo table

Field	Data types	Description
Sn	Nvarchar (100)	Product no., unique, not null
Model	Nvarchar (100)	Product model, not null
Name	Nvarchar (50)	Product name, not null
Company	Nvarchar (50)	Mannfacturers not null
Brand	Nvarchar (50)	Equipment trademarks, not null
Picture	Nvarchar (250)	Product drawing
PictruePath	Nvarchar (100)	Product path
Introduction	Nvarchar (400)	Product introduction

first register in the website, user should fill the user information table and at the same time the remaining 12 tables are generated, but the data in these tables are empty. Only when the user actually purchases services, products table will be updated in real time and then the rest of the tables are updated in real time. News table is used to record the information released by the service provider. The main table is: userInfo and productInfo. The following table is the two tables: Table 2 is a user information table and Table 3 product information sheet.

The userInfo table records the information of the website user to authenticate a user logs. The productInfo table records the information of the product to configure and control their own furniture and equipment.

WEB terminal site design: The system design was based on C/S structure in the first stage. While the first phase is completed, it can found C/S structure with high-speed operation, safety and other advantages (Zhang, 2011), but C/S structure needs to install the functional software in order to control system. Due to taking this situation and the expansion on the other terminal equipment into account, however other terminal equipment are unlike PC, with a little of resources-available, such as: Mobile and Pocket PC, so obviously the C/S structure can't better adapt this expansion. At the same time, the biggest advantage of the B/S structure is that the user can operate the equipment everywhere without installing any special software and this is what the need in the pre-system development lacking, so the realization of the system is based on the B/S structure. As long as there is a computer with internet access, clients will be able to use B/S structure without maintenance. The scalability of system is very easy and you can use it on the internet by registering or assigned by the system administrator a user name and password.

WEB site design based on the B/S structure can be achieved by many developed technology, for example: PHP, JSP and PHP development technology (Gao, 2012). ASP.NET technology is a program based on common language compilation and motion, so it has a strong and adaptability, which can make it run in WEB application software developed on almost all platforms. Also, because ASP.NET has many advantages: manageability, high security, easy deployment and mobile device support, all of these enable us decide to use ASP.NET (Yadav and Feng, 2012). Site system flow chart is as follows:

As the Fig. 4 shown, there are three types of mode in website design as shown the above flowchart. They are administrator, customer and guest. Website is devised into three types of modules for these three types. Administrators to manage systems and customer information, customer can view and manage their own information, guest can only view news.

The code of the login function is given below:

```
<p>//Login without Username
<asp:Label ID="UserNameLabel" runat="server"
AssociatedControlID="UserName">UserName:</asp:Label>
<asp:TextBox ID="UserName" runat="server" CssClass="textEntry">
</asp:TextBox>
<asp:RequiredFieldValidator ID="UserNameRequired"
runat="server"
ControlToValidate="UserName"
CssClass="failureNotification"
ErrorMessage="You must fill in the "username"."
ToolTip="Username Missing!!!"
"ValidationGroup="LoginUserValidationGroup">*</asp:RequiredFieldVa
lidator></p>
<p>//successful logining and maintain the status of the landing
<asp:CheckBox ID="RememberMe" runat="server"/>
<asp:Label ID="RememberMeLabel" runat="server"
AssociatedControlID="RememberMe" CssClass="inline">Maintain the
status of the landing </asp:Label></p>
```

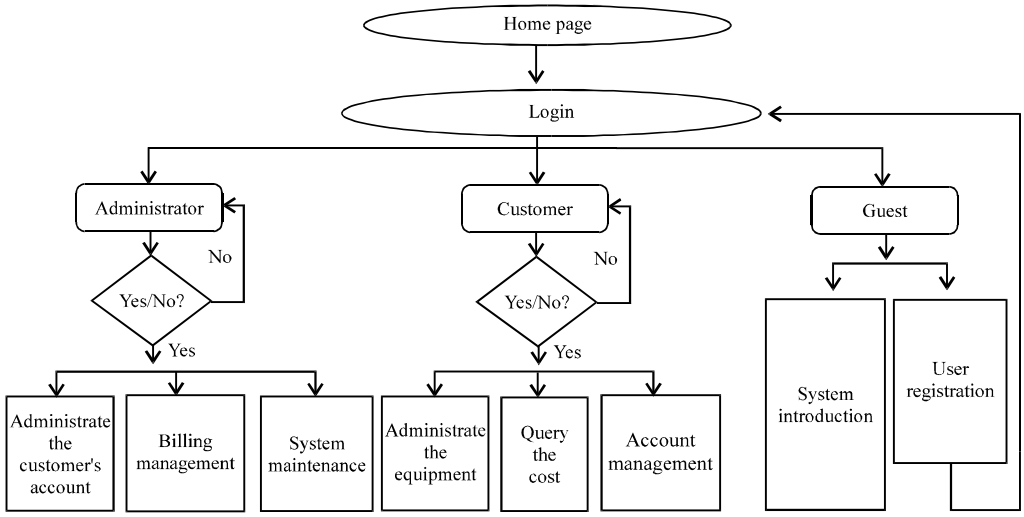

Fig. 4: Process of the website system

CONCLUSION

As the internet of things is increasingly becoming important productivity to promote the rapid development of the world, internet of things gradually reflects the huge market potential. In these applications, smart home is the majority of consumer population base. This has a huge market interest. The system work from the hardware and software proposed realistic smart home control feasible proposal, devised and achieved a smart home system with a low cost, high reliability and high efficiency advantages. The manuscript proposes the construction of smart home based on the internet of things.

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