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Design of Smart Home System Based on Linux

[1,2]Wenhua Gao, [2]Wei Yang, [1]Keming Xie, [1]Gang Xie
[1]College of Information Engineering, Taiyuan University of Technology, Taiyuan, 030024, Shanxi, China
[2]School of Electronic and Information Engineering, Taiyuan University of Science and Technology, Taiyuan, 030024, Shanxi, China

Abstract: In this study, a smart home system designed based on Short Message Service (SMS) and Common Gateway Interface (CGI) for embedded Linux platform was presented, just for resolving the problem of management. SMS is a new communication method who has the merits of easy development, low cost, free service and high reliability; CGI is the basic approach, by which the client can communicate with the web server. This article introduces a newly developed remote wireless control based on SMS and explains the properties and design techniques of CGI in the embedded environments. The system realizes the smart control of home appliances.

Key words: Linux, smart home, SMS, CGI, embedded system

INTRODUCTION

With the development of social economy, counting machine, science and technology, information system which based on computer and communication technology is booming. Besides, with the advance of economy and culture, people's demands for life quality and living environment are rising. Meanwhile, in order to manage the increasing domestic appliances, smart home systems are appearing. The difficulty was enhanced for the mount of home electronics and then how to optimize the management becomes an important research subject.

In the dominate system of smart home, the main equipment is the smart control terminal. In accordance with the current research condition in (Wang *et al*., 2012), there are several schemes as follows: the first way which controls the appliance by using keyboard, infrared universal remote controller, touch panel and LCD displayer. This solution is widely used, but it requires the terminal design of software and hardware and the process is complicated, the cost is also very high. Besides, this kind of plan can only be used in locale control. The second way is using personal computer as the control terminal, the disadvantage is that it cannot move and then it is not convenient. The third one is using telephone as the terminal, through using the wireless network, such as Wi-Fi, Bluetooth and GSM. This is convenient and handy, but it was not used widely and most equipment is also complex, the user experience is bad.

This study solves the technical difficulties, such as embedded system, ZigBee wireless communication and appliance control protocol and then analyzes their features and functions which we want to realize. On these bases, we put up the whole design scheme.

OVERVIEW OF THE SYSTEM

According to the functional requirement in (Yu and Ling, 2011) that is comprehensive perception, reliable delivery and intelligent processing, the smart home system can be divided into three layers as follows: perception layer, network layer and application layer. Among them, the function of perception layer is to collect data by using various sensors and then sends these data into network layer, as referred in (Hua, 2009). The network layer requires realizing a home gateway based on embedded web server, on one hand, it can connect the home network and the Internet and on the other hand, it can also coordinate the data from perception layer and the command from application layer. The application layer needs to realize a webpage interface to deal with the data from server and carry on human-computer interaction.

Hardware configuration: The hardware configuration referred in (Marilyn, 2012) of the smart home system is mainly including S5PC100 platform (A8), 11C14 platform (M0) and the ZigBee module. Among them, the S5PC100 platform is based on S5PC100 processor manufactured by Samsung whose kernel is ARM Cortex-A8. It supports various hardware decode, such as MPEG-1/2/4, H.263/H.264, this platform is used to control M0 by using some software. Meanwhile, the 11C14

Corresponding Author: Wei Yang, School of Electronic and Information Engineering, Taiyuan University of Science and Technology, Taiyuan, 030024, Shanxi, China

platform is based on LPC11C14 micro-processor whose kernel is ARM Cortex-M0; it has many advantages, such as low power and low cost. Besides, it has abundant hardware resources and mainly used to simulate the information acquisition and execution unit in the house. The ZigBee module adopts ZICM2410 manufactured by CEL Corporation, it is very convenient to connect with other USB devices and realize networking communication.

Software circumstance: U-Boot transplant: The function of U-Boot is to put the kernel into DRAM (Dynamic Random Access Memory). The U-Boot download from the Internet only has the universal code, could not support and recognize some specific hardware on the platform. Therefore, we need to modify the U-Boot to distinguish the devices. U-Boot transplant can be divided into two stages: in the first stage, we should finish the devices initialized, prepare RAM (Random Access Memory) space for loading the code, set up SP (Stack Pointer) and jump to the C entrance point of the second stage; during the second stage, the work mainly include using assembly language jump to main function, initializing the hardware devices, checking memory map of the system, loading image file and setting up kernel start parameters.

Linux kernel transplant: Linux kernel is a kind of open source operating system and adopts the modular design framework. Here, we retain the necessary functional module and delete the redundant one, then compile the kernel once again, making the hardware resources lessen. In this design, the kernel transplant includes: the network card driver, NAND FLASH driver, USB device driver and SD card driver.

Root file system: Root file system is the basic of other file system; it includes the necessary catalogue and critical file. Making root file system includes establishing the content structure, adding the command program, copying C library and configuring the NFS.

DESIGN OF THE FUNCTION MODULE

This system is based on A8, M0 and PC, combined with the technology of Internet, sensor and Internet of things as in (Zhu, 2010). It enables the user to master and control their home's condition, mainly includes the database module, SMS module and CGI module.

Database module: In this module, we refer to SQLite3 for the database. SQLite3 provides some interfaces of C function, by which people could operate the database through transmitting some specific standard SQL sentences as in (Qu and Shi, 2011). Just like the Access in MS, SQLite3 is a database which belongs to document type. That is to say, the database is a document, you can establish many lists in it, such as index and trigger. Therefore, you can back-up the whole database by using this document. The flow chart of database module is as shown in Fig. 1.

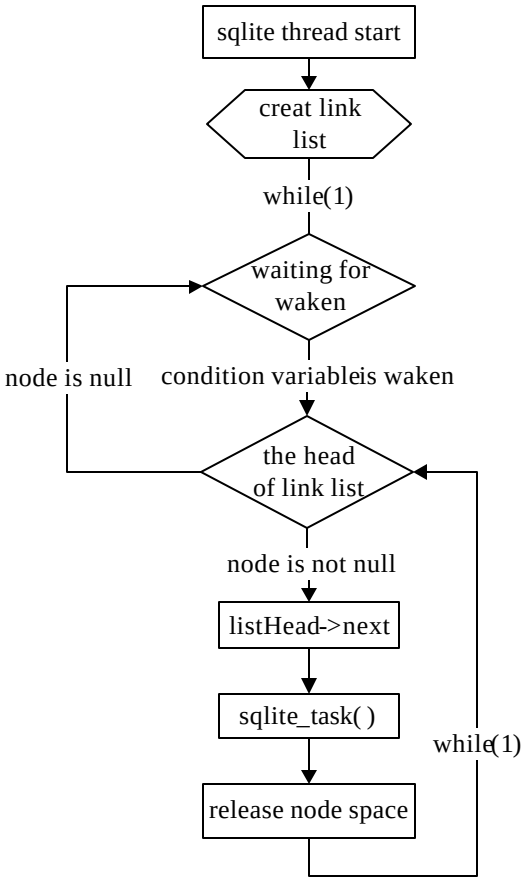

Fig. 1: Flow chart of the database module

After the main program, the assignment threads start to run including the database's pthread_sqlite. At first, the thread setups a link list to store the database operation and then enters into the while(1) circle. In the circle, we use pthread_cond_wait to wait for the signal which comes from pthread_cond_signal and then turn into while(1) circle. Next, we make a judgment whether the head of link list is null. On one hand, if the node is not null, we analyze the first node and then transmit the content into sqlite_task to operate the database. On the other hand, if the node is null, we dap the while(1) circle and then return pthread_cond_wait.

SMS module: In the SMS (Short Message Service) module, we use the function of GPRS (General Packet Radio Service). As assembler command in ARM and shell directive in Linux, GPRS has its own instruction system-AT command. The content of AT command is abundant, including voice call, sending message, storing operation and network communication as in (Guo *et al*., 2002). Generally, sending message through GPRS has two ways including text mode and PDU mode. The text mode is simple and easy to use, but it can only send message in English. However, the PDU mode can send message in Chinese after a serious of data dispose. Before operating, we need to test the SMS module for the later use, the procedure is shown in Fig. 2.

After you enter "AT" in the hyper terminal, if it returns "OK", the SMS module is normal. Otherwise, the module is in malfunction. Sending message in text mode could be divided into three steps: setting send mode AT+CMGF = 1 (while CMGF = 0, PDU mode; while CMGF = 1, text mode); setting the receive number (e.g., AT+CMGS = 182××××1234); importing the content (e.g.,>Hello World!). At the same time, PDU mode also has three steps to send message: setting AT+CMGF = 0; then AT+CMGF = length of the message content; finally, sending the message to the user. SMS module is powerful, in this design, there are two main structures and the codes are as follows:

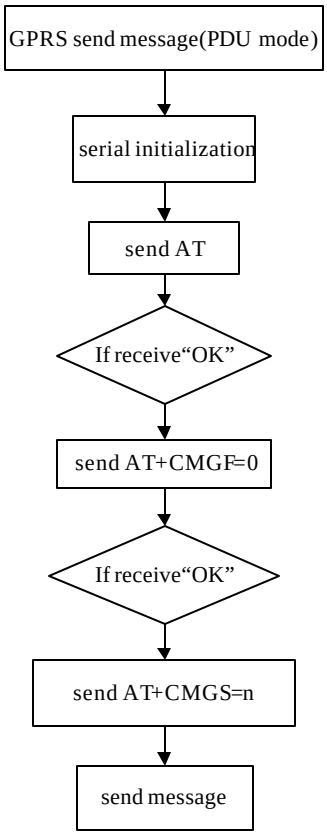

Fig. 2: Flow chart of the SMS module test

```
Structure 1: Struct Message {
        char size[4]; //length of the message content
        char which; //serial number of the message
        char size_ta[16]; //length of the message segment
        char info[32]; //content of the message
} gprs_msg[] = {
{"16", 0,"AT+CMGS=37\r",

"5F53524D6E495EA68D858FC78BBE5B9A4E0A9650FF01"},

{"0e",1,"AT+CMGS=29\r","6709964C751F4EBA95EF5E65FF01"},
{"1a",2,"AT+CMGS=41\r","5F53524D514971675F3A5EA68D858FC78
BBE5B9A4E0A9650FF01"},
{"16",3,"AT+CMGS=37\r","5F53524D6E295EA68D858FC78BBE5B9
A4E0A9650FF01"}
};

Structure 2: struct From_to_send{
        char center_number[16];//setup center number
        char to_number[16]; //setup receive number
}phone_NUM;
```

CGI module: CGI (Common Gateway Interface) is a part of program running on the web server which could provide interface between client and server. It could connect the executive program in web server with the command received from HTML and then the webpage is not in static state, but has interacted function as in (Zhang and Chai, 2003). The program of landing interface is as follows:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include "cgic.h"
int cgiMain()
{
        cgiHeaderContentType("text/html");
        fprintf(cgiOut, "<HTML>\n");
        fprintf(cgiOut, "<HTML><HEAD>\n");
        fprintf(cgiOut,"<TITLE>Login register </TITLE></HEAD>\n");
        fprintf(cgiOut, "<BODY>");
        fprintf(cgiOut,"<H1>Login success£¬jumping<H1>",);
        fprintf(cgiOut, "<meta http-equiv=\"refresh\" content=\"0;
url=../choose.htrul\">");
        fprintf(cgiOut, "</BODY>");
        fprintf(cgiOut, "</HTML>");
        return 0;
}
```

The CGI communication system includes two sections which is HTML webpage on the client and CGI program running on the web server. Normally, transferring data between sever and client is through standard input and output functions which need the cooperation of

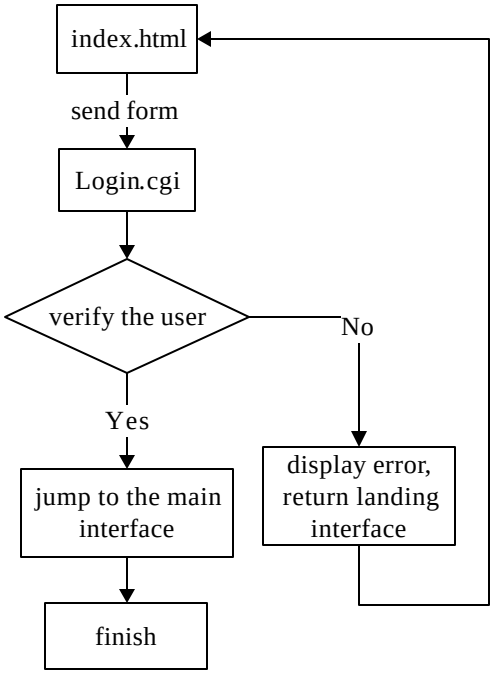

Fig. 3: Flow chart of the webpage landing

environment variable. The setting of environment variables are as follows: At first, the web server makes URL point to the CGI program; next, the server makes preparation for the program; then it executes the CGI program; finally, the CGI make standard output. The landing process is as shown in Fig. 3.

CONCLUSION

By using the designed webpage client, after repeated tests; the webpage could control appliances through the CGI. Meanwhile, people also could receive message from the home electronics by using the SMS. Through the system, people can centralize management and control the equipment at home. This design is universal and easy to transplant which has a certain practical value.

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