The Development of Mobile USB Home Control System

Hee-Sun Kim*, Yong-Seok Kim** and Chang-Goo Lee***

* Department of Control and Instrumentation Engineering, Chonbuk University, Chonju, Korea
(Tel : +82-63-270-2476; E-mail: riendtd@empal.com)
** Department of Control and Instrumentation Engineering, Chonbuk University, Chonju, Korea
(Tel : +82-63-270-2476; E-mail: kystory@hanmail.net)
***Division of Electronics and Information Engineering, Chonbuk University, Chonju, Korea
(Tel : +82-63-270-2476; E-mail: changgoo@moak.chonbuk.ac.kr)

Abstract: A term of home automation that was in fashion only a few years ago has not been used any more. Nowadays, We have been used a term of home network or digital home than home automation much. While internet infra is diffused at home, data network corp., communication corp., electric appliance corp. and home automation control system corp. which we did not mind each other particularly constructed consortium, and they have designs on home network market. Also, cellular phone's growth tried home networking by using not only wired internet but also broadband wireless communication. Regardless, many solutions are coming out it is few to be applied to real life because the standard is not determined with the protocol each other. Therefore, we developed home network system using USB(Universal Serial Bus) that has the possibility most in home networking standard. The mobile USB home control system is excellent at expansibility and portability. Also we can complete low cost and stable system using an embedded system.

Keywords: Home Network, USB Home Controller, Embedded System

1. INTRODUCTION

With the rapid growth of internet, it is getting increase using the internet to electric device, control of instrument at home. In particular, the internet and demand of the home network which is based on the network is increasing as development wired and wireless communication technique like PLC(power line communication) and bluetooth. In addition, The mobile home network is enabled to use due to the development of the cellular phone and next generation broadband wireless communication. The mobile home network provide that the domestic appliances and the devices are connected by wired and wireless network for many functions such as domestic safety, the control of instrument, controllable energy, manageable guests and the monitoring of health without limits of the time and places. In other words, it is a kind of arts for the family to make them live with safe, convenient, savable, cooperated with other people and healthy life.

Now, the home network is being studied by many enterprises and laboratories in domestic and international countries, as well as the history of the home network is not short. However, it is rare to apply to the real situation because there are no standard and any protocols between the home network and the real situation, even though many solutions are coming out to solve these problems. Therefore, some representatives, famous enterprises in the world, of the home network are going to make the international standard. If the standard of the home network in each domestic is selected by client terminal and controller generally at home, the home network which is connected to the external internet net will be spreaded and used every home managed by automation and information through the home network.

Thus, to keep pace with these situation, the mobile USB home control system, we have already suggested, is designed by USB which has lots of possibility as the standard to connect and the CDMA module for wireless communication. Wireless communication using the CDMA module is possible to connect with the home network whenever and wherever.

Also, the USB outstandingly makes extensibility and flexibility of the home network. What is more, the Home USB server can guarantees the quite safety as well as reasonable price using embedded system.

2. THE STRUCTURE OF SYSTEM

Mobile USB home control system consists of the embedded home server, the USB home controller and CDMA module like the figure 1. Embedded home server makes home network possible to support external network and the USB home controller manages and controls the home network connecting to the various domestic appliances. Lastly, CDMA module has the character of the mobile which can access the network whenever and wherever.
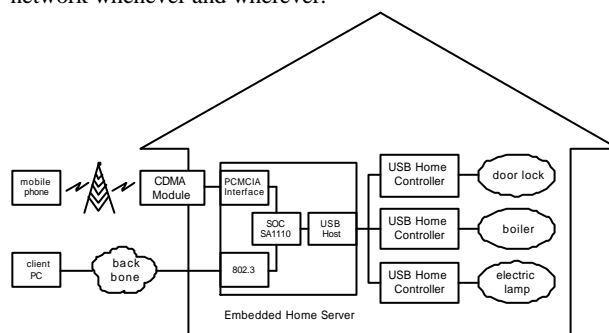

Fig. 1 The overview of system

2.1 Embedded Home Server

The Embedded home server was designed to the board which contains the USB Host, the PCMCIA interface and Ethernet device like the figure 2. MPU(micro processor unit) used SA1110 which is a kind of ARM and memory used flash memory and SDRAM. SA1110 as SOC (system on chip) is easy for implement the embedded system because it includes various controllers such as SDRAM controller, PCMCIA controller, LCD controller and etc. Also the SA1110 is easy to be porting embedded OS because SA1110 has MMU(memory

management unit) and instruction set which can support high level language.

The USB host manages the USB home controller and controls it. The USB host can connect with the USB home controller the maximum number of 126, and there are control transfer, bulk transfer, interrupt transfer and isochronous transfer to transmit the data. The PCMCIA interface is used for wireless communication as inserting wireless communication PC card like CDMA, 802.11, Bluetooth. In basic, design it can support wireless communication using the CDMA PC card. Internet device connects to back-bone network so it can connect to home server from external network. Home server can connect to home network through web browser without the special program because it uses web server and CGI in home server.
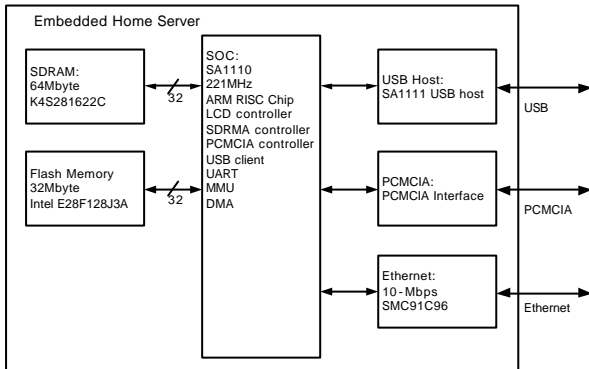

Fig. 2 The embedded home server

2.2. USB Home Controller

The character of USB has high speed of transmission, hot-plug, convenient and expansibility. Because of these, USB is in the spotlight recently. The PHILLIPS's PDIUSB12 is used for the device of USB SIE and USB supports control transfer, bulk transfer, interrupt transfer and isochronous transfer. Control transfer is a protocol to make host read configuration of USB device. Bulk transfer is used for the data transmission of the irregular amount and it can also analyze the errors. Interrupt transfer is a protocol to send regularly the small amount of the data and is used for the simple controller. Isochronous transfer is used for practical application which is more important isochronous data flow than accuracy. Isochronous transfer has some features as follows. 1) It guarantees bandwith of the data transmission. 2) It guarantees the speed of the data transmission. 3) It does not retransmit, even though there are some errors during transmission. So it is used for the data transmission which focuses on real-time, there are some errors during transmission, though.
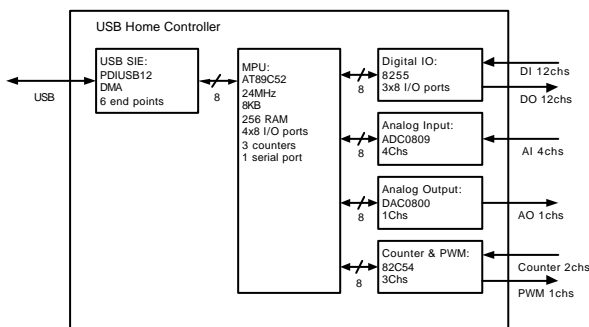

Fig. 3 The USB home controller

USB home controller has digital input 12chs, digital output 12chs, analog input 4chs, analog output 1ch, PWM 1ch and I/O of counter 2chs like the figure 3 and electric spec. of I/O is like the table 1. USB home controller was made to control connected to the various domestic appliances such as auto door lock, heating equipment and boiler etc, because USB home controller supports various features of input and output, and also the way of transmission.

Table 1 The spec. of USB home controller

I/O	Channel	Input spec.	Output spec.	Resolving	Etc
DI	12chs	TTL level (5V)	-	-	-
DO	12chs	-	TTL level (5V)	-	-
AI	4chs	0 - +5V	-	8bit	sampling: 100us
AO	1chs	-	Althernative current	8bits	sampling: 100ns
Counter	2chs	Maximum 8MHz	-	-	16bits couner
PWM	1chs	-	Maximum 8Mhz	-	16bits PWM

2.3. CDMA Module

CDMA module united with data communication as well as sound communication is developing as next generation broadband wireless communication. It will unite with wired/ wireless PSTN and wired/wireless internet as well as international unity, soon. If so, we can connect to Home network using our own mobile terminal without limits the time and places. CDMA module has features like the table 2.

CDMA supports wireless internet using PPP and 1:1 data communication. When home network happens some events like invasion by force, home server sends information to manager's cellular phone using SMS as soon as it happens.

Table 2 the spec. of CDMA module

Connecting method	CDMA
CDMA	IS-95B
Speed	64kbps
Receive method	Double super heterodyne
Receive freq.	869MHz – 894MHz
Receive sensibility	Less than -104 dBm
Transmit method	AM
Transmit freq.	824MHz – 849MHz
Regulated voltage	DC 5V

3. EMBEDDED OS AND DEVICE DRIVER

The meaning of embedded system is defined as the electric control system combined hardware and software for the special function which has already arranged. In other words, the various appliances and controller which are being used for our life include microprocessor as well as the simple electric circuit. Also, there is the program which is to perform the specially limited function operating the microprocessor. This system is called embedded system

3.1. Embedded OS

As the system is getting bigger, multi tasking is being needed and because Network or multimedia tend to become foundation embedded system has lots of things to do and is more complicated and also the simple program can not be satisfied with many complicated demands. Therefore, the

concept of operating system is needed. Now, there are lots of embedded OS, but we should select to suitable OS for the system after examination the character of the system. Embedded Linux, among the embedded OS, was developed for embedded system which has small memory and the low performance processor. Thus, Embedded Linux has to be satisfied with two things as follows.

First, the device of embedded system must have features such as minimum, lightness in terms of the size and the function of Linux and also it has to be customized. Second, the efficiency should be optimized to overcome the condition which is used the low efficient processor. The kernel of embedded Linux is like the figure 4.
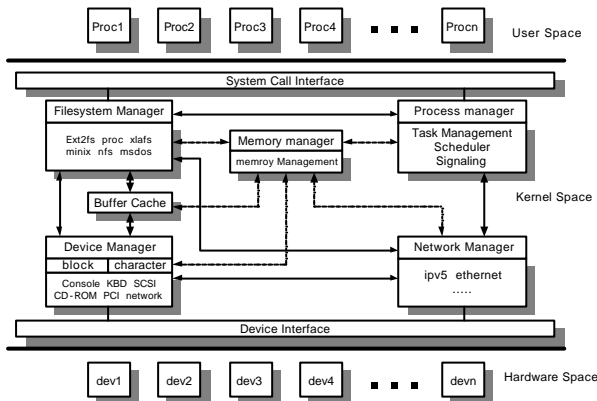

Fig. 4 The kernel of embedded Linux

3.2. Device Driver

The device driver is kernel's inner function which delivers data between device and system memory. In general, there are file system and interface on the top of device driver, and there are device hardware and interface on the bottom of it. The figure 5 is shown device driver and another interface in kernel.

When we examine the structure of device driver, application program operates USB client driver and interface, and USB host controller driver accesses to host controller driver using USB core. USB host controller has already embodied and it is stable. So, the people who want to make device driver embody only USB client driver. The dient device driver of USB home controller is designed to use USB home controller in API.
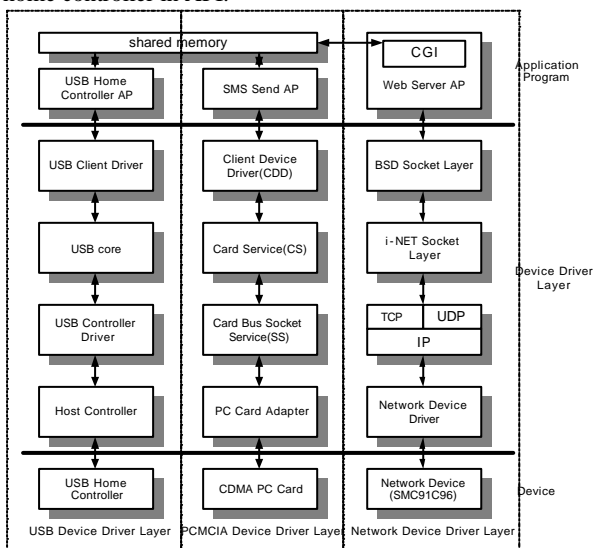

Fig. 5 device driver

The PCMCIA device driver consists of Card Services(CS), Socket Services(SS) and Client Device Driver(CDD). CS provides the standard of API(application programming interface) which is about dependent PC Card client device driver in terms of OS. SS accessed directly to PC card in the system, so it can embody BIOS of the system or the form of device driver to interface with CS. The CDD is device driver which is dependently to CS. In other words, CDD was allotted to source of the system and then can deal with demands using API which is provided by CS. The CDD manages PC card.

When we examine the structure of network in the figure 5, there is BCD socket layer to provide existing BSD socket interface at user application user application, and then it is related to protocol layer using internet protocol layer. Also, it can make network device driver to consistently interface after deciding device driver layer and interface. In fact, the person who makes out network device driver is only interested in the received data, not which protocol comes out at upper level.

3.3. USB home controller firmware

As figure 6, the firmware for the USB Home Controller consists of 6 building blocks. The Hardware Abstraction Layer is the lowest layer code in the firmware, which performs hardware dependent I/O access to PDIUSBD12, as well as the USB Home Controller. To further simplify programming with PDIUSBD12, the firmware defines a set of command interfaces, which encapsulate all the functions used to access PDIUSBD12. The Interrupt Service Routine handles a interrupt generated by PDIUSBD12. It retrieves data from PDIOUSBD12's internal FIFO(First In First Output) to CPU memory, and set up proper event flags to inform Main Loop program for processing. The Main Loop checks the event flags and passes to a appropriate subroutine for further processing. It also contains the code for human interface, such as LED and key scan. The Protocol layer handles standard USB device requests, as well as specific vendor requests such as DMA and TWAIN.
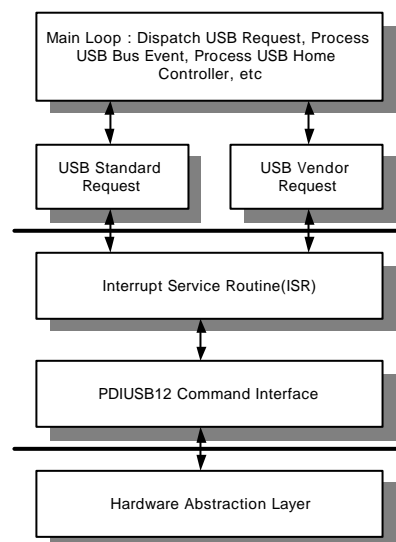

Fig. 6 the firmware of USB home controller

4. APPLICATION AND CGI

As the figure 5, the sort of applications is the USB home controller's application and the application of delivered SMS and vertically it controls device connected to device driver of each kernel. Horizontally, it makes process communication

with CGI using shared memory. CGI processes a command which is requested by customer and has a role to notify the condition of system and carries the configuration of system over to the system.

4.1. Application Program

When the system starts, the application of the delivered SMS operates as back-ground form and also, when power supply is put out or the infinited loop program is operated until ending by force. The sequence of program is like the figure 10. At first, a user read a established configuration data using SMS setup CGI. Information including this data is start flag, phone number receiving messages and information of messages about some events. After that, program decides whether Start flag installed or not, if flag is ready to start, the program estimates whether events happen or not comparing with before data from USB home controller statue date which is from USB home controller application program. When events happen, it sends message about the events to the phone number saving to setup data. After that, processor has conditioned sleep mode for 30 seconds. Processor returns the first routine as "wake up" after 30 seconds again.
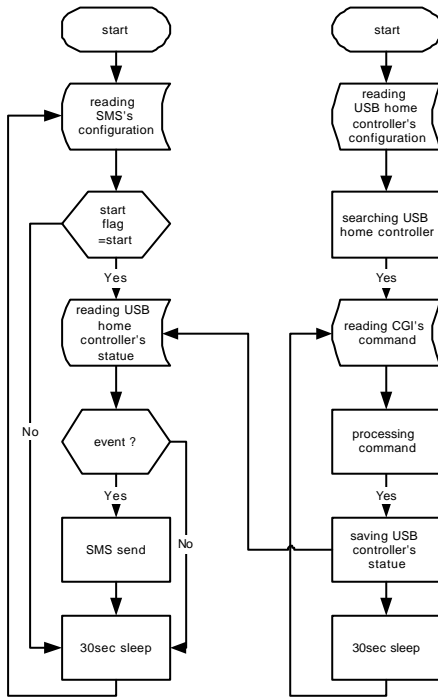
Fig. 7 The flowchart of application

4.2. Web server and CGI

CGI program based on web is designed for users' interface. Although the special client program is not installed, it can be connected by a web browser whenever and wherever. Broadly, CGI program consists CGI managing USB home controller and CGI used for the initialization of the SMS delivery module. The figure 8 is shown the initial webpage

Fig. 8 the first web page

5. CONCLUSION

Mobile USB home controller system consists of embedded home server, USB home controller and CDMA module. USB home controller controls the various domestic appliances and home server manages USB home controller and also supports SMS and wired/wireless internet using network device and CDMA module. What is more, embedded home server can manage each device of device driver because it has the embedded OS porting. Also, it can do easily the home networking through web browser from outside client using web server and CGI. USB home controller is enabled to do flexibility depending on controlled device which has the same character as expansibility, convenience of USB, so it can be designed to get many I/O. Therefore, mobile USB home controller suggests home networking model as ordinary system as well as a special system.

REFERENCES

[1] Steve Furber, "ARM system-on-chip architecture second edition," Addision Wesley professional , 2000.
[2] John Hyde, "USB Design by Example A practical Guide to Building I/O Devices," Intel Press, 2nd Edition May 2002.
[3] Alessandro Rubini, Jonathan Corbet, "Linux Device Drivers, 2nd Edition," O'REILLY, 2nd Edition June 2001.
[4] Jan Axelson, "USB Complete: Everything Yo Need to Develop custom USB peripherals 2nd Edition," Lakeview Research, December 1999.
[5] Daniel P. Bovet, Marco Cesati, "Understanding the Linux Kernel,", O'REILLY, 2nd Edition, Octover 2000.
[6] David Seal, "ARM Architecture Reference manual 2nd Edition," Addison Wesley, 2001