

Development of the Broadband PLC Home Controller using JINI Surrogate

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Abstract: The Home network system means that information appliances, Home PCs, etc., using wired or wireless network method enable to control and share with peripheral devices such as internet, shared data, a scanner and a printer, and it is networking solution, which intelligent communication will be possible as the system which can do a remote control such as TV Set, refrigerators, air conditioners, DVD players, digital camcorders based on external network using an internet, a potable information terminal and a mobile phone whenever, wherever and freely. In this study, the home network interface solution is used one of the wired network standards, PLC (Power-Line Communication) technology, so we can construct of intelligent home network's home controller without re-build a network at home. On keeping with current waves of thought, we will focus on a home controller development with great interest which is enabled to do an effective managed control, applying intelligent home network technology which can be new paradigm like a cyber apartment.

Keywords: Home network, information appliances, intelligent home, PLC

1. INTRODUCTION

These days, it is possible to do a remote control of digital information devices and information appliances owing to an internet solution for broadband service with infra expansion of the information communication, so it changes a digital-life style that is a paradigm of a new life style. It is the Home network that information appliances and Home PCs, etc., using wired or wireless network method can control and share with peripheral devices such as internet, shared data, a scanner and a printer, and it is networking solution which constructed a digital home of the future home environment, not only a possibility of the intelligent communication as the system which can do a remote control such as a TV Set, refrigerators, air conditioners, DVD players, digital camcorders based on external network using an internet, a potable information terminal and a mobile phone without the limits of time and places, but also a home security, saving energy and health care, etc.

The resent, technology of the home network interface forms that wired and wireless technique, home RF, blue-tooth, PLC, IEEE1394, Ethernet, etc., make relation with complement and competition. Well-known companies' own technology is trying to be approved as an international standard of the home network technology.

In this paper, we have constructed a digital home system by means of designing a home controller using PLC technique, one of the wired network technologies which can be cost-effective because of constructing network at home or offices. This technology can transfer high-frequency signal with a high speed, and doesn't have any effect on general electric devices due to using low-power signal. However we must solve the problems of the speed, stability, security and capacity of the share, etc.

There are UPnP(Universal Plug and Pay), a standard technique which is controlling a home appliance over the Microsoft windows 2000 OS, HAVi (Home Audio and Video

Interoperability) proposed by SONY and European companies and Sun Microsystems' Jini which is possible to identify the devices on the network as middle-ware technique of the home network system.

We designed and produced the compact type of the home controller with reasonable prices applying to Jini network surrogate system technology which is used Jini network PnP, and have constructed a digital home network system that we have suggested. This paper describes the total structure of the home network system and also a PLC method based on TCP/IP, characters of the broadband PLC home controller and peripheral I/O devices in detail.

Next, we show total middleware structure of the home control system using Jini network, IP interconnect surrogate system technology, and web browser services for user interface.

2. BROADBAND PLC HOME CONTROL SYSTEM

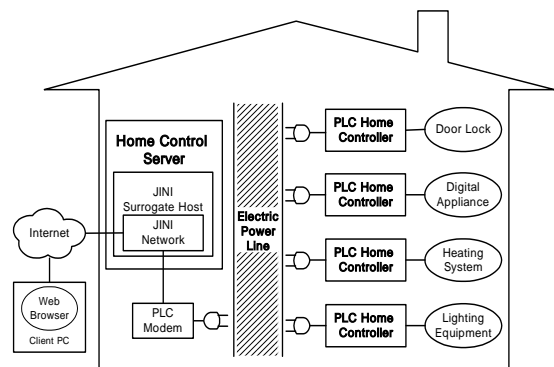


Fig. 1 The structure of the PLC Home Control System

The broadband PLC home control system proposed in this paper consists of the Jini network, Jini surrogate host, the broadband PLC home controller and digital information appliances enabled to control as shown in Figure 1.

The Jini network is able to interface a client with Jini surrogate system via internet and CDMA such as network communication medium so that can control and monitor various appliance devices.

The PLC communication modem connected with Jini surrogate host directly using a protocol based on TCP/IP is a PLC device, which manages control and state signal of the other PLC home controller.

The broadband PLC home controller consists of PLC module managed PLC communication, low-cost embedded system and I/O device part connected to control and manage digital information appliances. Digital information appliances using the broadband PLC home controller are not only general home appliances such as a boiler, a refrigerator, a washer, etc., but also various life appliances such as home entertainment and home health care devices, etc.

3. BROADBAND PLC HOME CONTROLLER

The broadband PLC home controller is designed PLC module which is managing communication using an Ethernet controller based on IEEE 802.3 TCP/IP protocol via electric power lines, a main system embedded a compact and low price Ethernet controller and an I/O device part connected to control and manage digital information appliances.

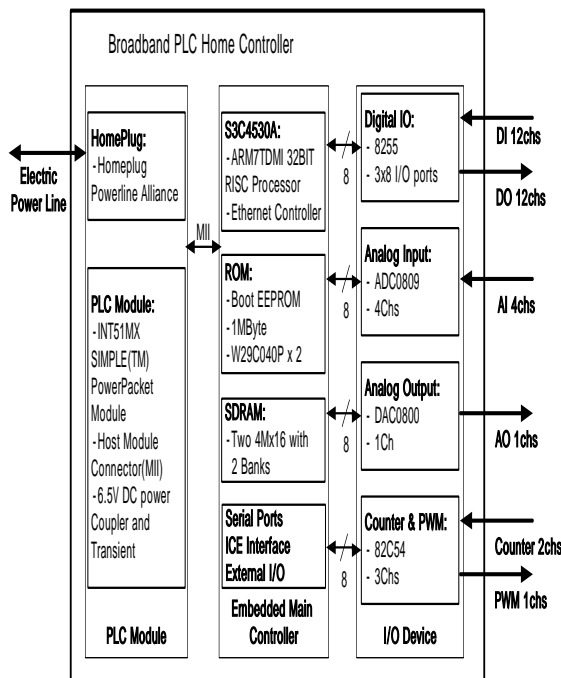


Fig. 2 Broadband PLC Home Controller

3.1 Broadband PLC Module using HomePlug

The PLC (power line communication) is technology implemented data communication via AC (an Alternating

Current) power lines networked at home. The AC Power line is not data communication services but supply of electric power, so there are many problems of the loading effect and a noise, variable reduction, impedance level and selected character of the frequency etc.

Recently, However HomePlug Powerline Alliance, an international standardize organization, has developed high speed-data transmission technology implemented over the AC electric power lines.

HomePlug Powerline Alliance adopted PowerPacket technology of the Intellon Corporation, which provides data rates of up to 14Mbps over existing power line based on OFDM (Orthogonal Frequency Division Multiplexing), so the PLC home controller is equipped with Intellon's INT51MX SIMPLE PowerPacket Module.

The HomePlug technology includes an effective and reliable method of performing adaptation that achieves high rates on typical channels, but which adjusts the bit rate to fight through really harsh channels.

Any workable solution to reliable communication on the power line medium must include both a robust physical layer (PHY) and an efficient media access control (MAC) protocol. The MAC protocol controls the sharing of the medium among multiple clients, while the PHY specifies the modulation, coding, and basic packet formats.

The HomePlug PHY uses OFDM (Orthogonal frequency division multiplexing) as the basic transmission technique and occupies the band from about 4.5 to 21 MHz. The MAC protocol in the HomePlug technology is a variant of CSMA/CA (carrier sense multiple access with collision avoidance) protocol. The bit rate delivered to the MAC by the PHY layer is about 14 Mbps.

3.2 Embedded Main Controller

The embedded main controller is a platform that is equipped with Samsung's S3C4530A 16/32-bit RISC microcontroller for Ethernet based system which has low cost and high performance. This S3C4530A consists of 16/32-bit RISC(ARM7TDMI) processor, Ethernet controller with 3-channel buffered DMA, 2-channel GDMA, a UART, two 32-bit timers, programmable I/O ports, interrupt controller. It also supports JTAG boundary scan for the application system testing.

The embedded main controller consists of S3C4530A, a Flash Rom (boot EEPROM, 1Mbyte), a SDRAM module (16Mbyte), serial communication ports, an Ethernet interface controller, status LEDs and can be debugged using the Embedded ICE interface. The ethernet controller operates at 10/100 Mbps Ethernet interface using auto-negotiation, communicates between MAC (Media Access Controller) of the S3C4530A and PHY (Physical line interface chip) of the embedded main controller via MII (Media Independent Interface).

The embedded main controller implements TCP/IP protocol communication using not a general embedded linux but the uClinux (micro-Controller Linux: Linux kernel 2.0.38) because of ARM7TDMI processor type which has no MMU (Memory Management unit).

3.3 I/O specification of the PLC Home Controller

The broadband PLC home controller has a digital input of

12chs, a digital output of 12chs, an analog input of 4chs, an analog output of 1ch, a PWM of 1ch, and I/O of counter 2chs, and the electric specification of I/O is shown in Table 1.

We are able to adapt easily a door status or a door open control of the Digital Door Lock using Digital I/O port.

Table 1 The I/O spec. of the PLC Home Controller

I/O	Channel	Input Spec.	Output Spec.	Resolution	Etc
DI	12 Chs	TTL level (5V)	-	-	-
DO	12 Chs	-	TTL level (5v)	-	-
AI	4 Chs	0 - +5V	-	8 bits	Sampling 100us
AO	1 Ch	-	Alternative Current	8 bits	Sampling 100ns
Counter	2 Chs	Maximum 8MHz	-	-	16 bits Counter
PWM	1 Ch	-	Maximum 8MHz	-	16 bits Counter

4. IMPLEMENTATION OF THE JINI SURROGATE

Jini as a network middle-ware technology of the Sun Microsystems informed network of component objects of the device's software or hardware supported Jini network and offered information about its resources, moreover was possible directly to access other devices over the network.

However, because Jini service used the Jini discovery and Jini join protocol and computing procedure such as downloading of the java class file, etc., it is not incongruent on the compact type digital appliances such as digital door lock and lightning equipment, etc., with small memory.

Therefore we proposed Jini surrogate system that is implemented instead of Jini protocol to connect compact type devices with Jini network.

Using the surrogate architecture, devices that are not directly connected to a Jini network, or are otherwise unable to have direct access to the Jini technology infrastructure, can supply surrogates—written in the Java programming language—that can access the Jini network and have access to the Jini technology infrastructure.

4.1 Embedded software of the PLC Home Controller

There is software, IP interconnect API and I/O Control API, under uClinux OS based on TCP/IP communication on the PLC home control server.

IP Interconnect API is connected the logical and physical method with the surrogate host's Interconnect Adapter via PLC module ,operates network PnP function of the PLC home controller using surrogate protocol and is registered automatically on the home control system. IP Interconnect protocol consists of Discovery, Retrieval and Liveness.

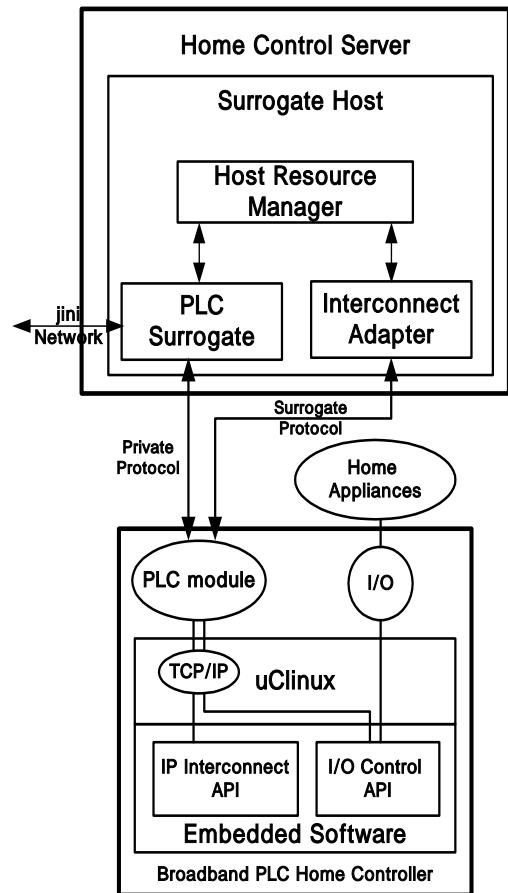


Fig. 3 The use of Surrogate in Jini Architecture

The Discovery is the mechanism that the surrogate host and the device use to find each other on IP Interconnect. The Retrieval of the surrogate is accomplished using the registration request protocol. The registration request protocol defines the messages and mechanism used by the device to request that a surrogate host load the device's surrogate JAR file. There are two components of the Liveness. First, the surrogate host needs to know if the device for which it is hosting a surrogate is still reachable on IP Interconnect. Second, the device needs to know if its surrogate is still resident and active in the surrogate host.

The surrogate host handles appropriate I/O information on the digital appliances connected with IP Interconnect, and communicates with PLC module via private protocol. And then, the PLC module communicates I/O Control API with TCP/IP protocol each other. I/O Control API processes software of the digital appliances connected to I/O method.

In this study, we control and monitor the Door Lock System via I/O Control API using private protocol after connecting to the Digital Door Lock by means of Digital I/O method. This table defines a private protocol according to the I/O specification.

Table 2 Definition of the private protocol on I/O specification

Description	Preamble	Device	Port SEL	R/W	Transmit	Receive	CRC				
Big Endian	BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7	BYTE8	BYTE9	
	1byte	1byte	1byte	1byte	1byte	2byte	2byte	1byte			
8255	READ	04	fb	00	00	Hex 8bit data			
					01						
	WRITE	04	fb	00	00	01	..	Hex 8bit data	..		
					01						
					02						
					03	setup	--	--	Control Word		
8254	READ	04	fb	01	00	Hex 16bit data			
					01						
	WRITE	04	fb	01	00	01	..	Hex 16bit data	..		
					01						
					02						
					03	setup	--	--	Control Word		
AD converter		04	fb	02	00	Hex 8bit data		
					01						
					02						
					03						
					04						
					05						
					06						
					07						
DA converter	04	fb	03	--	--	--	--	Hex 8bit data	--		

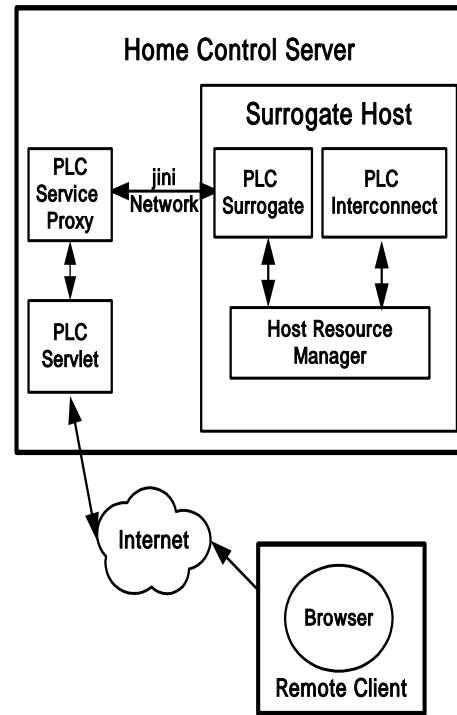


Fig. 4 PLC Service on the Jini network

4.2 Jini surrogate system of the PLC Home Controller

The PLC surrogate of the surrogate host manages digital appliances' control, arrows Java class objects to download by using the PLC service proxy for resources implemented on the surrogate connected with the Jini network, and is able to access the Jini network and surrogate objects each other.

As shown Figure 4, clients access to the PLC service proxy via web browser, can control and manage devices such as digital appliances joined the Jini network using Java servlet. When devices join the Jini network, this following Table 3 shows that Java component class executed to download from the PLC service proxy on the surrogate host.

Table 3 Java component and function

PLC.adapter.jar	
PLCAdapterImpl.java	Entry into JINI Surrogate Host
PLCInterconnect.java	PLC IP Interconnect implementation
PLC.surrogate.jar	
PLCSurrogate.java	Discovery and Join Protocol
PLC.service.jar	
PLCService.java	Search for activated state of the PLC controller using ProxyServer
PLCServiceProxy.java	
PLCServiceServer.java	Control and Management of the PLC Home Controller
PLC.servlet.jar	
PLCServlet.java	Web browser application for user client

5. APPLICATION

A user interface is designed by java servlet based on web browser. The servlet is an object which is implemented Java Servlet API and Http Service is able to access to designed servlet via Http. Client terminal such as a PC or a PDA which is possible to internet is able to connect with web server without specific client program install using web browser at anytime and anyplace.

As shown Fig 5, a servlet main web page offers Java servlet program that is able to arrow and disapprove the Door Open Instruction according to the Door Status.

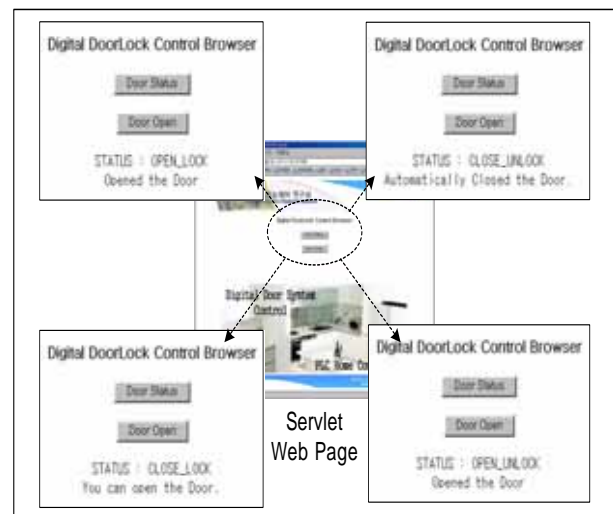


Fig. 5 User interface on the Jini network servlet

6. CONCLUSION

The broadband PLC home controller consists of the PLC module which is operated a network signal, the embedded main controller which is communicated to other devices after porting uClinux based on TCP/IP communication and I/O ports which are operated an analog and a digital signal to control various digital appliances via electric power lines.

This is possible to apply not only various digital appliances as a low-price and a compact type PLC home controller which can be easily used because of constructing network at home via electric power lines but also the digital home system such as entertainment, health care and security, etc.

The PLC home controller's network solution used Jini surrogate's IP interconnect protocol using Jini technology designed by means of access to easily a home network system without a limitation of the devices.

A client application program is supported java servlet program to manage and monitor the home controller via web browser of a PC or a PDA, etc.

On this study, we showed an advantage of the PLC controller and interface of the Jini network by means of using the home controller, one of the wired networks, controlled and managed digital appliances on the home network system. Therefore we will support possibility and chance which can be applied to real environment using the compact typed broadband PLC home controller module.

REFERENCES

- [1] "S3C4530A 32-bit cmos microcontroller Application Notes & User Manual", Samsung
- [2] Alessandro Rubini, Jonathan Corbet, "Linux Device Drivers, 2nd Edition", O'REILLY, 2nd Edition June 2001.
- [3] Michael J. Donahoo, Kenneth L. Calvert, "The Pocket Guide to TCP/IP Sockets", SciTech, 2001
- [4] David Seal, "ARM Architecture Reference manual 2nd Edition," Addison Wesley, 2001
- [5] Scott Oaks, Henry Wong, "Jini in a Nutshell (Java S.)", O'REILLY, March 2000.
- [6] "Jini Technology Surrogate Architecture version 1.0 standard", Sun-microsystems, October 2003
- [7] "Jini Technology IP Interconnect Specification version 1.0 Draftstandard3", Sun-microsystems, October 2001
- [8] Jason Hunter, William Crawford, "Java servlet programming", O'REILLY, 2001
- [9] "INT51X1 Integrated Power Line MAC/PHY Transceiver Technical Reference Manual", Intellon
- [10] "HomePlug 1.0 Technical Paper & Service Providers White Paper", <http://www.homeplug.org>