Development of LnCP based Home Network System by using high level message between heterogeneous application software

Jong Hoon Chung, Dae Sung Wang, Sang Kyun Lee, Sun Mi Han, Young Hoon Roh and Min Seok Kang*

* HomNet Business Team, LG Electronics, Seoul, Korea
(Tel : +82-2-526-4076; E-mail: paring@lge.com)

Abstract: This paper introduces LnCP(Living Network Control Protocol)-based home network system and proposes high level message which is utilized between LnCP Home network Server and User Control Point. LnCP is very optimized protocol for digital home appliances. Then proposed system and implementation of these ideas are presented.

Keywords: Home network, LnCP, Network-enabled Home Appliances, Home network Server

1. INTRODUCTION

New digital home appliances are being developed rapidly with more new functions for intelligent home life, due to the enhancement of digital signal processing technology, embedded O/S and high-speed transfer media. Consequently, the business of Home Network is growing drastically. Because of the rapid change of Home Network market, home network product developers should have the adaptability and expansibility to the new environment.

To install Home Network System at a certain place, some elements are needed such as digital home appliances, transfer media, communication protocol, Home Server, User Control Point and so on.

We have selected LnCP for the communication protocol. LnCP (Living Network Control Protocol) that is designed by LG Electronics is very suitable for control network protocol.

From the point of view about software development, there can be following types of application software - Home Server, User Control Point and Portal Server. Home Server establishes the LnCP network and provides information services such as each appliance's state and condition. The User Control Point may be PDA, Webpad or PC where user gains necessary information by accessing LnCP services via the Software with UI (User Interface). Portal Server makes it possible for user to access household's internal LnCP services from outside the household by connecting the house to the Internet and providing the required services externally.

In such environments, a new communication rule is needed between the Home Server using LnCP protocol and User Control Point or Portal Server.

As mentioned before, LnCP is so optimized to 8-bit microprocessor that it takes up least memory. On the contrary, it has low readability and is not intuitive. Therefore developing new User Control Point is not easy and takes much time especially for developer who is not familiar with LnCP.

To compensate for this problem, this paper would like to propose a new high-level message, so called LnCPb. By connecting to a new home server and applying LnCPb for implementing User Control Point – which provides the LnCP network services – it was possible to implement Home Network System in shorter development time.

In this paper, the simple Home Server Application Software was established on the Linux basis, and User Control Point Software – which communicates with the Home Server Application Software – was developed on PDA and PC environment.

2. Home Network System using LnCP

The architecture of forthcoming home network will support remote access and control via Internet as shown in Fig. 1. For this possible, basically home network should provide a way to connect home appliances and control other devices at a certain device. When controlling and monitoring devices, it's necessary to classify devices into mainly two types: controlling devices and controlled devices. Normally controlling device should be able to get user input and have a user-friendly interface.

To make all these possible we need a method to connect devices and deliver control command efficiently. Here's LnCP as a solution of them.

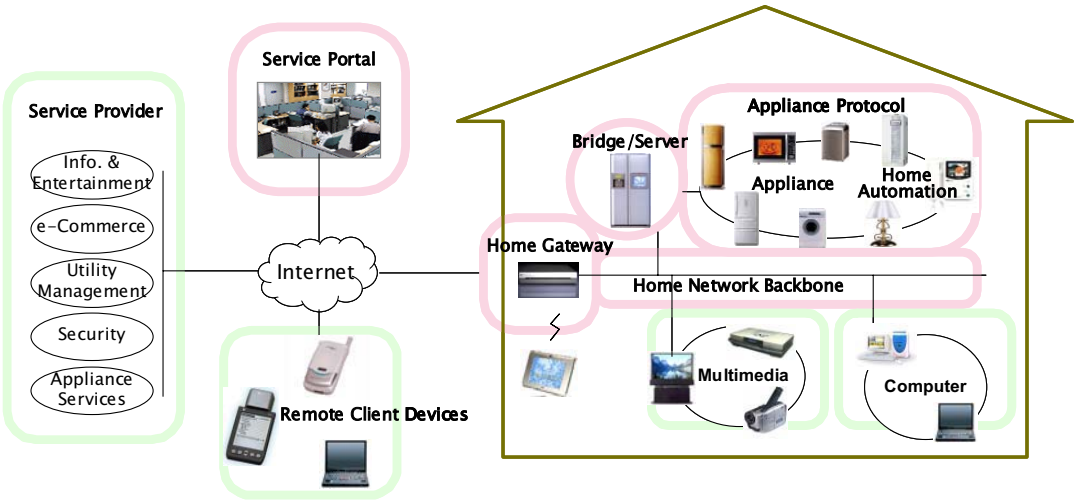

Fig. 1 General home network system architecture

Firstly LnCP connects all appliances in a home and provides controlling and status monitoring over the connected devices and lets all devices know the status of other devices by issuing event notification based on the change of the status of a device. [1]

3. LnCP

3.1 LnCP Feature

LnCP (Living Network Control Protocol) that is designed by LG Electronics is very suitable for control network protocol.

Devices in LnCP networks are categorized into two types; one is slave and the other is master. It's only dependent on device's role in the home network. The main reason to divide LnCP devices is to make the roles of devices in networks simple and light. What slave device should do is to follow the command that is issued by the master device. Thus, master device should know how to control the slave device that user want to control and be able to interpret the command code that is received from the slave device.

One of the outstanding features of LnCP is that it's based on the event-driven communication. To know the status of other devices, there are roughly two methods. One is questioning other devices periodically and the other is notifying the status changes when the changes happen. LnCP adopts the latter one and enables whole devices to be aware of the status updates of other devices by asynchronous notification.

In addition, LnCP permits slave devices controlled by multi masters as well as single master, which is possible with the combination of mentioned features of LnCP. After controlled by a master device, a slave device notifies the change of the status of itself to the other master devices with event notification method. This allows master devices to control slave devices consistently.

LnCP provides variable-length packet structure that is composed of 1-byte command code and input/return arguments. Using this type of message makes it easy to incorporate LnCP into white goods such as air conditioner, microwave oven etc.

The slave devices need to interpret the command codes that it concerns and master devices that want to control slave devices should be able to compose every type of message that has to be interpreted by each slave devices.

Further characteristics and details of LnCP can be found in the articles listed in references. [2~3]

4. LnCPb

4.1 High Level Message

As discussed before, LnCP is not adequate for application S/W level because of its low readability and difficulty to develop. Therefore the necessity of higher-level message emerges, which is named here as LnCPb.

LnCPb is superior in readability, is intuitive and enables only the necessary information to be sent and received between application software in TCP/IP environment; therefore can provide the most suitable methods for any environments.

It was defined so intuitively that developer can easily understand the message from reading just the messages and can implement LnCP into S/W with no difficulty.

Concentration is mainly on providing the LnCP service and additional services for convenient home network scenarios.

In Table 1, the differences between LnCP and LnCPb are summarized.

Table 1 The comparison between LnCP and LnCPb

	LnCP	LnCPb
Target	Device-oriented	App. S/W oriented
Network	LnCP Network	TCP/IP Network
Processor	8-bit MCU	32 bit CPU
Data Type	Byte level	ASCII level

Messages are classified into several groups by the purposes as shown in Fig. 3. Those are Home Control, Home service, Network Management, Server Management, Connection Management and Customized Function.

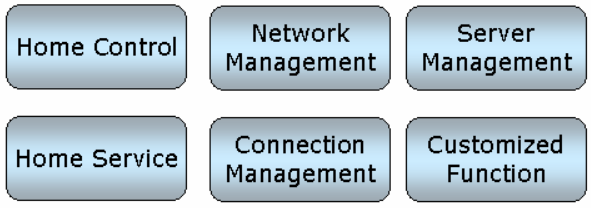

Fig. 3 Message Classification

4.2 Message Format

Message format consist of elements and delimiters. Elements are actual value for services and delimiters are used to sort elements from one message string because the length of messages is variable and the number of elements is also changeable.

Fig 2. illustrates the message format of LnCPb. Macroscopically messages are divided into *header* and *body*.

Header describes the start of message, the type of message, the number of elements, *Cycle ID* and U*ser ID* optionally. *Header* can vary with respect to the connection type. In the unisolated environment like wireless network, U*ser ID* is used to distinguish the target home server with which the User Control Point should communicate. In this case, *SLBi* is used. On the contrary, in isolated environment, no *User ID* is needed and header does not include it using *SLB*. *User ID* should be unique under one portal server. The *SLB* or *SLBi* informs the start of message and the *Number of Elements* shows the number of elements used in one message. The *Cycle ID* of request message and that of response message to former

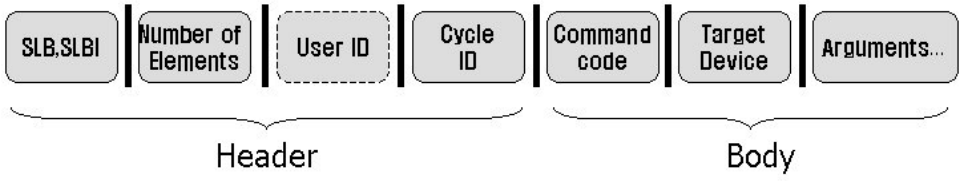

Fig. 2 Message Format

request are same to match the response and the request to follow the characteristic of LnCP that has the request-response type of packet.

Body contains *Command Code, Target Device* and *Arguments*. *Command Code* tells which function to perform and the value of it can be *SET* for control, *GET* for monitoring, *NOTI* for event, *RESP* for responses and so on. *Target Device* is assigned as target of command code. When controlling digital appliances, the ID of appliances will be selected or for network management, the object of management will be assigned. *Arguments* contain the necessary arguments for each *Command Code*. Multiple arguments are allowed.

The examples of message can be as follows in Table 2. Message noted as (1), (2) are for control request and response to turn on the first air-conditioner. (3) shows the event message and (4), (5) is monitoring message for air-conditioner's running mode.

Table 2 The examples of LnCP message for air-conditioner

SLBi|7|user1|1|SET|AC-1|Power=On	(1)
SLBi|7|user1|1|RESP|AC-1|Result=Success	(2)
SLBi|7|user1|1|Noti|AC-1|Power=On	(3)
SLBi|7|user1|1|GET|AC-1|RunMode	(4)
SLBi|7|user1|1|RESP|AC-1|RunMode=Standard	(5)

4.3 S/W Architecture with LnCPb

Fig. 4 illustrates the architecture of Software of Home Network Server and User Control Point when using LnCPb.

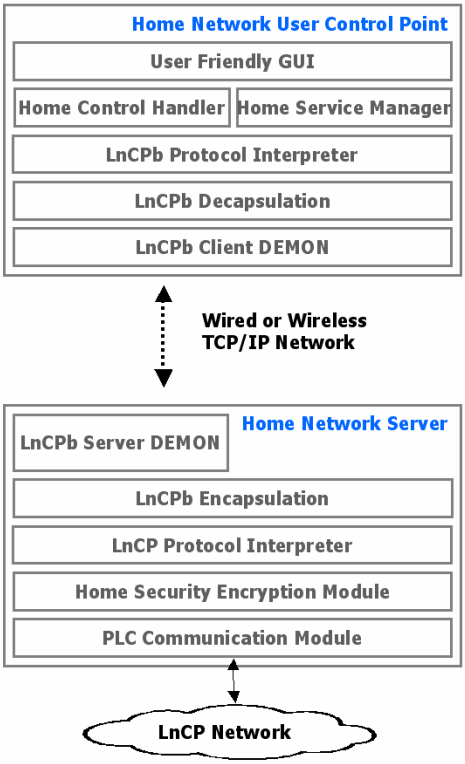

Fig. 4 Software architecture with LnCPb

When Home Network Server receives LnCP packet form LnCP network, interpret and translate it into LnCPb message. Translated message is sent to User Control Point and after the required operation performed, the result is displayed on User Control Point. Similarly, when there is user input, User Control Point composes LnCPb and transfers it to Home Network Server. If necessary, it is translated into LnCP packet and transmitted to LnCP network.

5. IMPLEMENTATION

5.1 Implemented System

In LnCP network, LnCP home appliances and home server that manages home appliances and provide service to user are deployed as shown in Fig. 5.

LnCP-enabled home appliances and LnCP-enabled HA devices communicate with home server and are controlled by control, monitoring, and event functions. Through User Control Point S/W on PDA, users are supplied with home appliances control services and additional services. The additional services are reservation, cross-eventing, mode configuration and so on.

LnCPb is used for communication between home server and User Control Point S/W on PDA. With same method, home server communicates with portal server so that identical services are available on portal server which user can access outside of home.

As LnCP-enabled home appliances, air-conditioner, drum washer, microwave, and gas oven are deployed for implementation. In addition, four electric lights and gas valve are added as HA (Home Automation) device. These will be used to show the way that multiple devices are displayed and controlled as well as single device.

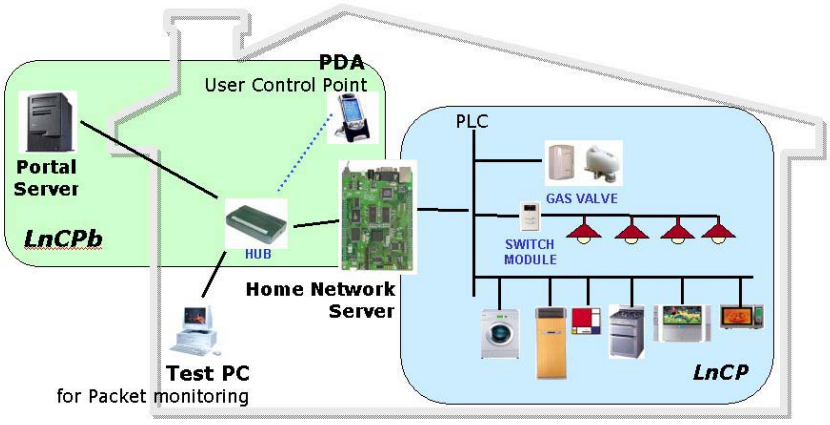

Fig. 5 The implemented system architecture

5.1 Home Server H/W and S/W

As Home Network Server, ARM 10 series test board is used with embedded Linux O/S. Test board has 64MB SDRAM, 512KB Boot Flash Rom, 64MB NAND Flash Rom.

Embedded Linux O/S porting consumed 8MB including application of which size is about 1.2MB. Demon Server S/W is running on embedded Linux. Fig. 6 shows the example of console window on which demon s/w is running. This console window shows the process of LnCP packet and interpretation of LnCPb.

Developer can monitor overall processing procedure on Test PC by telnet connection.

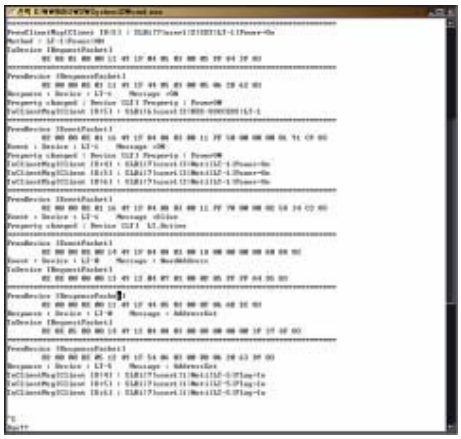

Fig. 6 The Server demon S/W of console window

5.2 User Control Point S/W on PDA

As mentioned before, User Control Point S/W is implemented on PDA. For demonstration, only Home Control functions are implemented on this Software. Other various functions also can be implemented. Fig. 7 shows the main control page of User Interface. List of available Devices are displayed on main window. Displayed Devices are as follows; Air-conditioner, Drum washer, Gas Oven Range, Dish Washer, Microwave, Set top, Light and Gas Valve. By clicking the icon of concerned device, the detail control page of target device can be displayed.

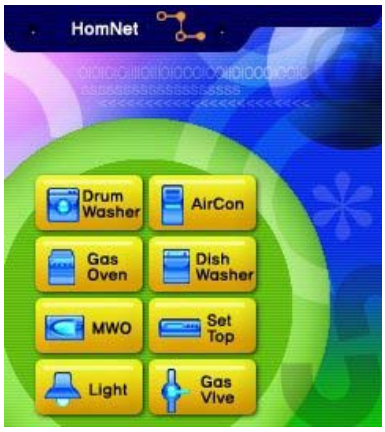

Fig. 7 Device List page

Fig. 8 shows the control page of Air-conditioner. The display tells that the Air-Conditioner is running standard cooling course, desired temperature is set to 18℃ and current room temperature is 26℃. Power, operation course, desired temperature, air-cleaning, and wind strength is can be controlled in this page. If the status of air-conditioner is changed, changes will be updated on this page according to event message sent from Home Network Server. These functions are available for LnCP is event-driven type of protocol.

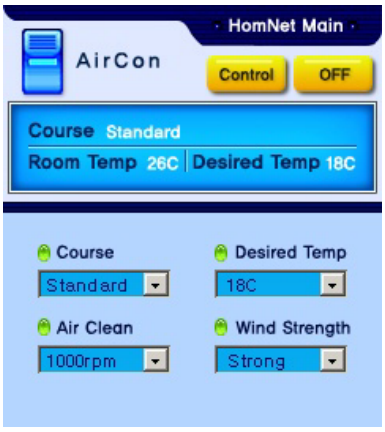

Fig. 8 The control page for air-conditioner

Next is the control page for drum washer shown in Fig. 9. Similarly, change of status is updated by event notification and various function for washer is controllable on this page such as washing course, wash type, rinse type, dry option, temperature of water, etc.

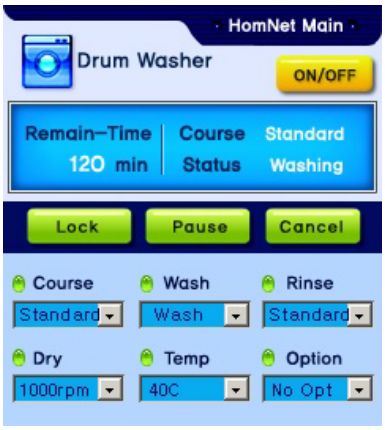

Fig. 9 The control page for drum washer

For the case of multiple same devices, list of each devices are displayed. Each device is controlled respectively and if there is detail control page, it can be accessed. As an illustration, the control page of multiple lights is displayed in Fig. 10. Each light can be turned on or off separately and the change of status is updated with events from each light.

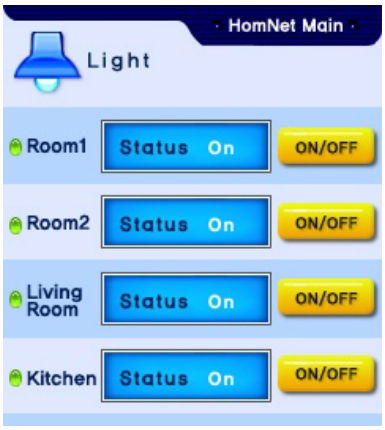

Fig. 10 The control page for multiple lights

5.3 Portal Server and Service

LG electronics provide the portal service with the name as DreamLG. User can access to home network services in his home through this service. Portal server is connected to home server in his home by LnCPb and offer various services. Following Fig. 11 shows the portal site, DreamLG of which URL is http://www.dreamlg.com

Fig. 11 The DreamLG Portal site – http://www.dreamlg.com

6. CONCLUSIONS

As the market of home network grows, the necessity of stable and versatile home network technology is being emphasized.

This paper proposed LnCP-based Home network system, focused on especially in communication between Home Network Server and User Control Point.

LnCP is a very optimized protocol for digital home appliances. The excellence of LnCP-based home network is being verified and the number of installed site is increasing. But its low readability and difficulty for development make it necessary to propose high-level message for application S/W level communication. So in this paper, high –level message, LnCPb is proposed and implementation examples were committed. Compared to previous development process, delivery and easiness of development was enhanced. By this result, the hope is that feasibility of service expansion is guaranteed and co-operation is made easier between supporting companies, therefore market preoccupancy is also possible.

There are a number of issues yet to be addressed for more efficient communication in home network system. Some of the key issues are as follows.

As technology is being developed, functions that are not imagined before become required. To accept this, message class and definition should be easily expansible so that diverse services are can be added. But compatibility with previous services should be fulfilled.

Additionally, to support secure home network service to user from outside of home, relevant encryption algorithm must be applied. For LnCPb is based on TCP/IP communication, there will be many solutions to this.

REFERENCES

[1] Seungcheon Kim, Jeongae Park, Kyoungwoo Lee and Sangwook Lim, "Home Networking Digital TV based on LnCP", *IEEE Transaction on Consumer Electronics*, Vol.48, No. 4, Nov. 2002, pp 990～996.

[2] Technical Paper of LG Electronics Inc., "Living Network Control Protocol (LnCP) ver2.0", Feb. 2004.

[3] K. S. Lee, H. J. Choi, C. H. Kim, S. M. Baek, "A New Control Protocol for Home Appliances – LnCP", *proceedings of ISIE 2001*, May 2001, pp 291~296.