The Implementation of EIA 709.1 Standard Protocol Based Home Control System Architecture having Network Configuration Function

Chang-Eun Lee, June-Hee Park, Young-Sung Son, Kyeong-Deok Moon

Electronics and Telecommunications Research Institute
161 Gajeong-Dong Yuseong-Gu, Daejeon, 305-350, Korea

Abstract: This paper proposes a home control system architecture that have network configuration function. The proposed home control system architecture is implemented with partly hardware and software. For implementation of this system architecture, we developed ECONICS which is home automation controller. ECONICS consists of main board and communication modem. This communication modem supply the power line communication. The physical layer and the MAC layer software of EIA 709.1 standard protocol are implemented in communication modem. The upper layer software of EIA 709.1 standard protocol and home configuration software for home network installation, management, diagnostics, control and monitoring are implemented in main board of ECONICS. We verified the commercial feasibility of the proposed system through the home network configuration and operation. As a result, we have concluded that the proposed home control system architecture provides all the key function necessary to easily manage and control home network nodes.

Introduction

EIA 709.1(LonTalk) standard protocol follows the International Standards Organization Open System Interconnect(ISO OSI) reference model for network protocols, which support flexible addressing and multiple communication channels. The LonWorks technology is a complete platform for implementing intelligent distributed control network system using a common, message-based LonTalk protocol. These networks consists of intelligent devices or nodes that interact with their environment, and communication with one another over a variety of communication media, including twisted pair, power line, radio frequency, infrared, coaxial cable, and fiber optics. Fig.1 shows LonWorks environment. Individual nodes contain application code that deals with objects tailored to the LonWorks environment, including network variables, which provide a well-defined interface between the nodes in a LonWorks application and input/output objects which provide a common interface to application I/O devices. All node typically consists of a Neuron Chip shown in Fig.2, a power source, a transceiver for communication over the network medium, and circuitry for interfacing to the device being controlled or monitored. Neuron Chip is composed of three 8bit processors. LonWorks technology includes the following four elements required to design, deploy, and support intelligent control devices. The first element is Neuron Chips and associated firmware, including support for the LonTalk protocol. The second element is LonWorks transceivers providing the physical connection between the Neuron Chip and the communication medium. The third element is LonManager network services tools for configuration of network nodes. The last element is LonBuilder and NodeBuilder development tools for application development with Neuron Chips. Even though LonWorks technology is getting more attractive and likely to be an essential part of any fieldbus system such as building automation, factory automation and home automation, this solution have not been widely adopted for fieldbus system due to high cost, less flexibility and other barriers. The major reasons are as follows. First the price of the LonWorks network configuration tools(LonManager network configuration tools) is very high. Secondly, although the LonTalk protocol is an open standard protocol, the flexibility of the LonWorks system is diminished by the limitations of the specific processor(Neuron Chip) and the specific software(LonBuilder development software and Neuron C language) to be used. Therefore we proposed the control network of new node architecture not using neuron chip that increase the flexibility and decrease the cost of the system. The proposed network node architecture has made it possible to materialize the control network which can perform various and complex applications requiring high performance processing at a lower cost.

LonWorks Environment

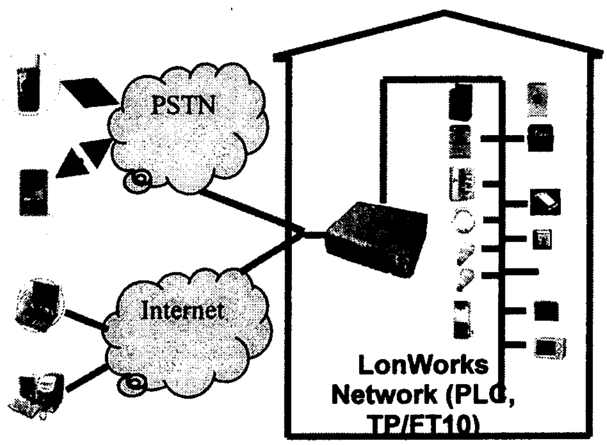

Fig 1. LonWorks Environment

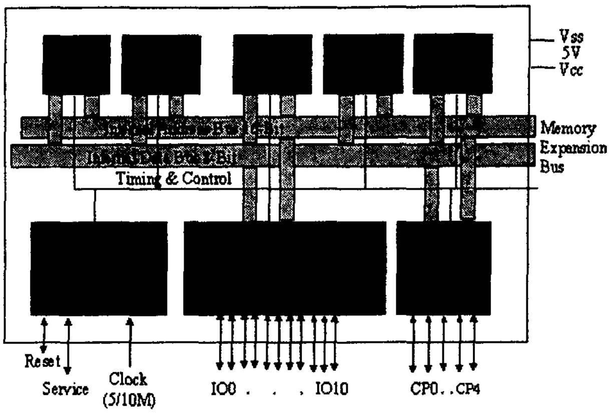

Fig.2 A block diagram of the Neuron Chip.

The Proposed Architecture

The flexibility of existing LonWorks system is diminished by the limitations of the specific processor (Neuron Chip) to be used. This Neuron Chip can not implement complex application because of hardware limitation of low speed computing power(10Mhz) and 2Kbytes data memory, 42Kbytes code memory address range. Therefore we propose the home control system architecture that increase the flexibility and decrease the cost of the system. Fig.3 show the hardware block diagram of the proposed home control system architecture, which is called ECONICS.

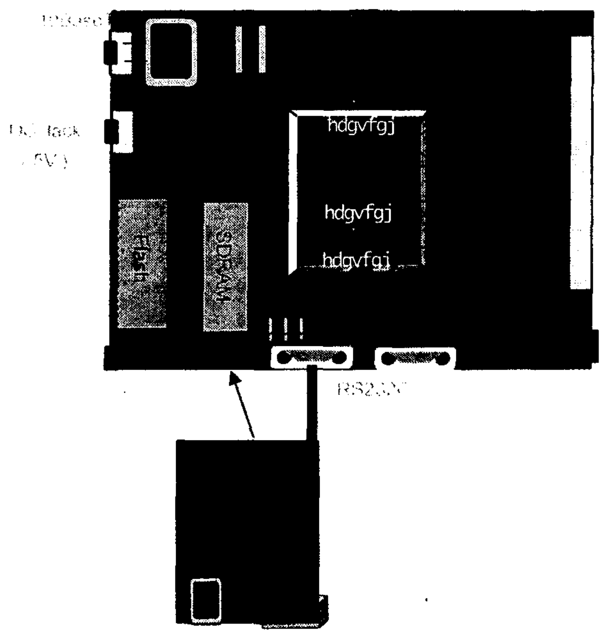

Fig.3 The proposed hardware of home control system architecture

As part of efforts to verify the proposed control network node architecture, a communication modem is implemented by using power line media. On the main board are mounted a high performance embedded processor and a large capacity memory with I/O port for application. In this figure, PLC(Power Line Communication) modem consists of low cost 8 bit processor and Echelon company PLT-22 transceiver. PLT-22 transceiver provide reliable power line communication, eliminating the need for dedicated wiring and greatly reducing installation costs. Fig.4 shows the software stack of the proposed home control system which is implemented in main board of ECONICS.

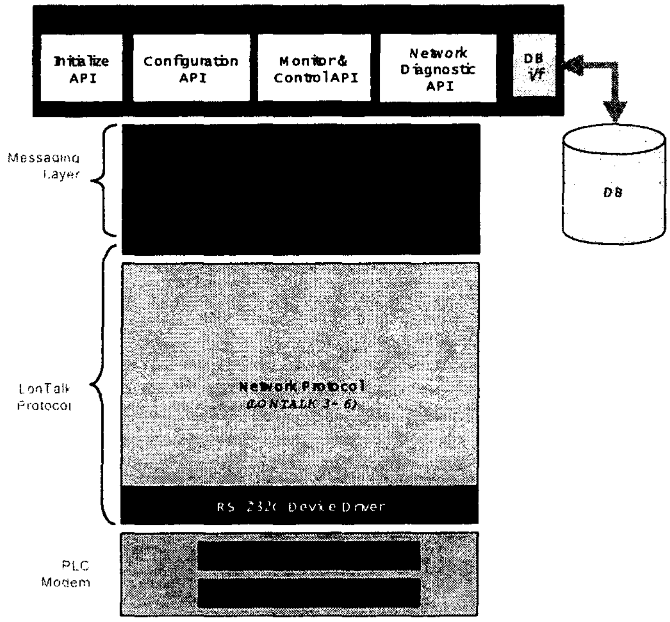

Fig.4 The proposed software stack of home control system

In this figure, the physical layer and the MAC(Medium Access Control)layer of the LonTalk protocol are implemented in the PLC modem which provides interoperability between the mainboard and the LonWorks network. The functions of the implemented PLC modem are: a collision avoidance by "predictive p-persistent CSMA(Carrier Sense Multiple Access)", interface between the MAC layer and the link layer, power line data transfer and false data detection caused by power line noise. The interface between LonTalk protocol link layer of main board and LonTalk protocol MAC layer of the PLC modem is the RS232C. The upper link layer of the LonTalk protocol and well-defined API(Application Programming Interface) for application device developers to easily access and control are implemented with software (C Language) on the main board of ECONICS. The functions of the implemented software are: a packet delivery within a single domain, packet ordering and duplicate detection, authentication of the message sender's identity and request-response mechanism for access to remote servers, network management function. This structure is suitable for the node which has to support the various communication media(power line, twisted-pair, coaxial cable, Fiber, RF..). For the main board of ECONICS, the same board can be used and the modem composed differently depending on the communication media can be used in the form of the board. Therefore this is a additional advantage of the proposed architecture.

Implementation of the proposed architecture

Fig.5 shows how the LonTalk protocol is implemented in the proposed home control network node. Each layer is programmed to perform functions defined in the LonTalk protocol and processed packet in each layer is transmitted to next layer by function call. Input queue included in each layer stores the datum received from the lower layer and takes the form of PDU(Packet Data Unit) of the relevant layer. And various parameters needed to process message other than PDU data are stored together. Output queue is designed to store data to be transmitted to the lower layer from the relevant layer and values of various parameters needed to generate PDU relevant to such layer together.

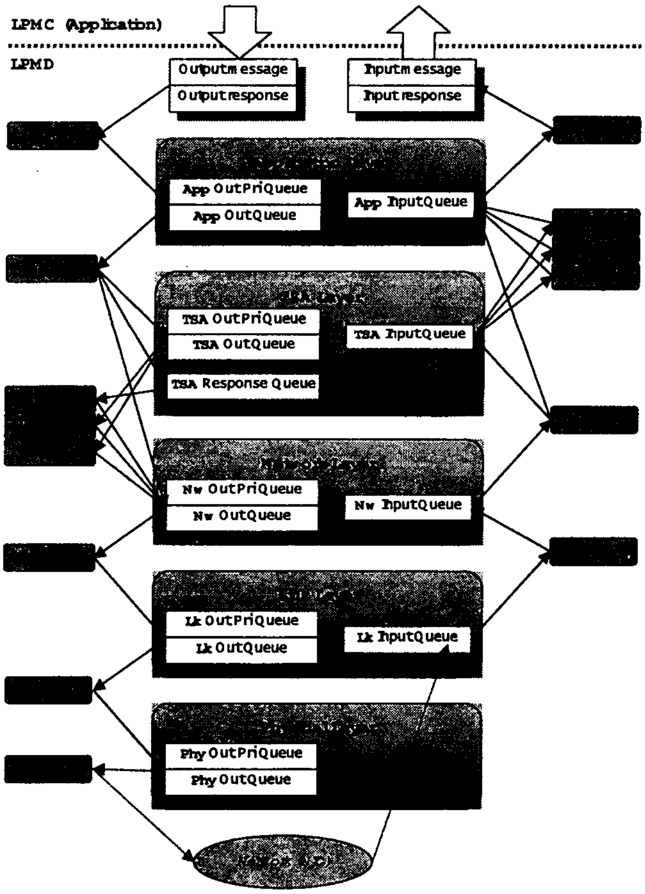

Fig.5 Block diagram of implemented LonTalk Protocol

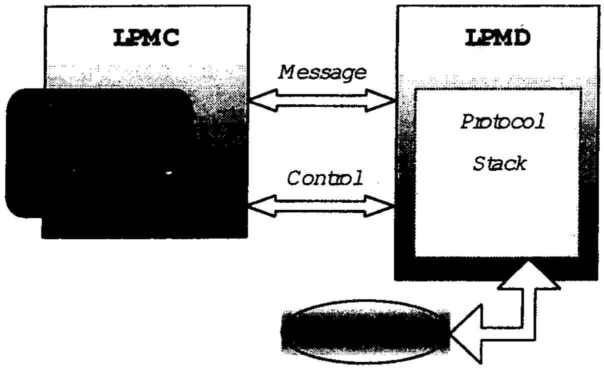

Fig.6 The relationship between LPMC and LPMD

Fig.6 shows the relationship between LPMC and LPMD. In this figure, IPC communication is used and LPMD always must have running status.

Fig.8 and Fig.9 show network management and diagnostic messages The LonTalk protocol provides network management services for installation and configuration of nodes, downloading of software, and diagnosis of the network. Network management and network diagnostic messages may be delivered using request/response service.

NM Messages	Request Code	Success Response	Failed Response
Query ID	0x61	0x21	0x01
Respond to Query	0x62	0x22	0x02
Update Domain	0x63	0x23	0x03
Leave Domain	0x64	0x24	0x04
Update Key	0x65	0x25	0x05
Update Address	0x66	0x26	0x06
Query Address	0x67	0x27	0x07
Query NV Config	0x68	0x28	0x08
Update Group Address Data	0x69	0x29	0x09
Query Domain	0x6A	0x2A	0x0A
Update NV Config	0x6B	0x2B	0x0B
Set Node Mode	0x6C	0x2C	0x0C
Read Memory	0x6D	0x2D	0x0D
Write Memory	0x6E	0x2E	0x0E
Checksum Recalculate	0x6F	0x2F	0x0F
Wink	0x70	0x30	0x10
Memory Refresh	0x71	0x31	0x11
Query SNVT	0x72	0x32	0x12
NV Fetch	0x73	0x33	0x13
Device Escape Code	0x7D	0x3D	0x1D

Fig.8 Network management messages

ND Messages	Request Code	Success Response	Failed Response
Query Status	0x51	0x31	0x11
Proxy Command	0x52	0x32	0x12
Clear Status	0x53	0x33	0x13
Query XCVR Status	0x54	0x34	0x14

Fig.9 Network diagnostic messages

Fig. 10 and Fig.11 show the home control network configuration process. The first process discover the devices from the home control network by service pin or Query ID network management message. After the first process, get the all device information through request and response mechanism. The last process is binding process that connect both nodes for generation of appriate service.

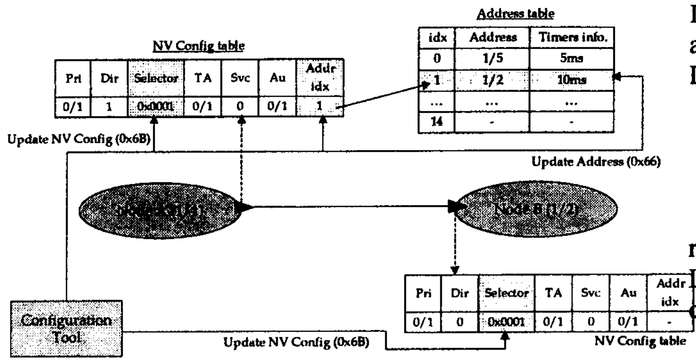

Fig. 10 Binding Process

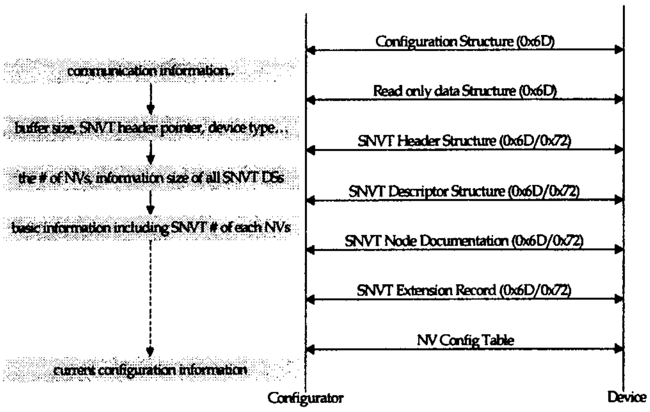

Fig.11 ETRI home control network configuration process.

Configu ration process	Lonware APIs	summary
NIC Open / Close	initialization_lonware	DB Initialize, NI open
	close_lonware	NI close, DB close
network initialize	lookup_device,	Device search by Query ID management message
	get_node_info_from_n ode	Get information of devices
	get_node_info_from_fil e	Get information of devices by XIF file
	set_node_address	New logical address assignment
Service Generati ng	bind_nv	Both node cooperation
	release_bound_nv	Un bound
Monitor & control	get_nv_value	Monitoring
	update_nv_value	Control

Fig.12 LonWare APIs

Fig. 12 show well-defined API (Application Programming Interface) for application device developers to easily access and control are implemented with software (C Laguage) on main board of ECONICS.

Conclusion

In this paper, we have proposed a new home control network software architecture to improve the conventional LonWorks networks and implemented home automation controller which is called ECONICS and PLC modem.

It has improved weaknesses of the method for using the existing Neuron Chip and it is possible to use home automation system for white appliance, which can support various and complex applications.

As a result, we have concluded that the proposed home con

trol system architecture provides all the key functions necessary to easily manage and control home network nodes through power line communication with the capabilities that can increase the flexibility and decrease the cost of the system.

References

[1] Echelon Co., "Neuron Chip Data Book," February 1995.

[2] Echelon Co., "LonTalk Protocol Specification ver 3.0", 1994.

[3] The CEBus standard User's Guide.

[4] LonMark Interoperability Guideline, "LonMark Application Layer Interoperability Guidelines", 1999.

[5] Echelon, "Control Network Protocol Specification," *ANSI/EIA-709.1*, April. 1999.

[6] Adept Systems Inc, "A C Reference Implementation of the LonTalk Protocol on the MC68360," ASI, July 1998

[7] Echelon Co., "LonMark External Interface File Reference Guide, revision 4.0A," Apr., 2000.

[8] Echelon, "Enhanced Media Access Control with LonTalk," LonWorks Engineering Bulletin, 1992.

[9] Motorola Inc.,"LonWorks Technology Device Data Book, revision 2," 1996.

[10] Koon-Seok Lee et al., " A new control protocol for home appliances-LnCP," *Industrial Electronics, 2001. proceedings ISIE 2001. IEEE International Symposium*