Standardization Activities on Home Network Architectures

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Abstract

This article describes standardization activities related to home network protocols and architectures. Such protocols enable "Plug & Play" and "interoperability among devices made by different vendors" on a network in a user's home. Various home network protocols (e.g., UPnP and ECHONET) have been proposed. Home network architectures enable interoperability among the different *de facto* standards.

1. Introduction

"Plug & Play" and "interoperability among devices made by different vendors" are very important concepts in that they allow various devices to communicate with each other on a network in a user's home. Plug & Play makes devices automatically available when they are connected to the network. This technology requires functions for:

- automatic address setup
- advertisement or detection of connected devices.

Interoperability among devices requires agreement about:

- formats of messages transmitted between devices
- contents of messages (interface name, argument name, etc.)
- processes used to transmit messages between devices.

Various home control protocols with these functions and agreements have been proposed and some of them have become *de facto* standards. Moreover, standardization of home network architectures is in progress. Home network architectures define such factors as the functional composition, network structure, and method of network operation with a view to achieving interoperability among these *de facto* standards.

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2. Standardization activities related to home network protocols

There are five major *de facto* standards for home network protocols.

2.1 UPnP

UPnP (Universal Plug and Play) [1] achieves Plug & Play on an IP (Internet Protocol) network with standard Internet-related protocols such as SOAP (Simple Object Access Protocol), SSDP (Simple Service Discovery Protocol), HTTP (Hypertext Transfer Protocol), TCP (Transmission Control Protocol), and UDP (User Datagram Protocol). **Figure 1** is an operation diagram for UPnP, which has a device model based on Devices and Services. When a UPnP device is connected to the network, it obtains an IP address from the DHCP (Dynamic Host Configuration Protocol) server or sets the IP address itself using Auto-IP. The device then sends an advertisement to all the controllers on the network using HTTPMU (HTTP messages encapsulated in multicast UDP packets). This message describes the URL for the Device Description of the Root Device.

For device control, the controllers obtain Device Descriptions from the target devices. These Device Descriptions describe the URLs for Service Descriptions, etc. Moreover, the controllers obtain the required Service Descriptions from the target devices. The Service Descriptions describe Action names (corresponding to the interface names), Argument names, etc. The controllers send SOAP messages (describing the required Action names, Argu-

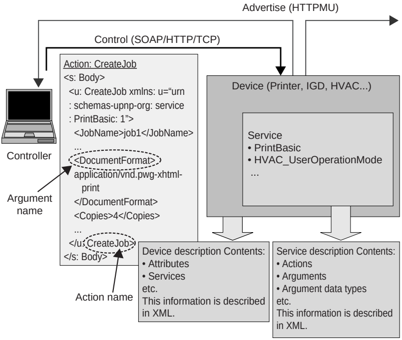

Fig. 1. Operation diagram for UPnP.

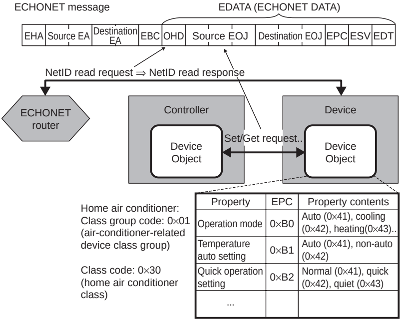

Fig. 2. Operation diagram for ECHONET.

ments, etc.) to the target devices using HTTP/TCP/IP.

UPnP is being standardized by the UPnP Forum. UPnP Device Architecture Version 1.0.1 Draft was released in December 2003. The Device and Service Descriptions (for Internet Gateway Devices, Printer Devices, MediaServers, HVAC (heating, ventilation, and air conditioning) Systems, Lights etc.) were released as standards. Products on the market that support UPnP include Windows XP, Internet Gateway Devices, and printers.

2.2 ECHONET

ECHONET [2] is another technology capable of achieving Plug & Play and easy application development without the need for new wiring. An operation diagram for ECHONET is shown in **Fig. 2**. An ECHONET device has one or more Device Objects, which are logical models for information managed by the devices and functions that can be controlled and are stipulated as a Device Object Class for each device type. When a device is connected to the network, it begins to set up the ECHONET Address (constructed from one byte of NetID and one byte of NodeID).

- NodeID is made from the MAC (Media Access Control) address.
- ECHONET message "NetID read request" is broadcast within a subnet managed by an ECHONET router.
- NetID is assigned to the device by the ECHONET router.

For device control, the controllers transmit ECHONET messages to the target devices. The messages include descriptions of ECHONET Objects (EOJs: identifier codes for the Device Objects), ECHONET Services (ESVs: corresponding to the interface names), ECHONET Property Codes (EPCs: corresponding to the argument names), and ECHONET Data (EDTs: corresponding to the values of the arguments). The available parameters (EOJs, ESVs, EPCs, EDTs etc.) for each device type are stipulated by "Detailed Stipulations for ECHONET Device Objects" in ECHONET SPECIFICATION.

ECHONET is being standardized by the

ECHONET Consortium. "ECHONET SPECIFICATION version 3.2.0" was released in January 2004. Products supporting ECHONET (e.g., air conditioners, refrigerators, microwave ovens, lights, and sensors) have been on the market in Japan since last autumn.

2.3 LonWorks

LonWorks [3] is a network platform technology using LonTalk (EIA-709.1) developed by Echelon Corp. Logical addresses (NodeID, SubnetID, etc.) must be assigned to the devices to control them. The assignments are performed automatically by exclusive tools or by designers. For device control, the controllers use Network Variables (NVs: corresponding to the interfaces) provided by functions. The functions are provided by the devices. To achieve interoperability between the LonWorks devices, Standard Network Variable Types (SNVTs) as standard NVs and Functional Profiles as standard templates of functions are stipulated. Available SNVTs are stipulated for each of the Functional Profiles. LonMark International is establishing standards for interoperability among LonWorks devices. A considerable number of products supporting LonWorks are on the market. They are mainly facility-related devices for buildings and homes.

2.4 Jini

Jini [4] is a Java-based technology that enables distributed objects to cooperate. When a Jini device is connected to the network, it registers its objects and service discovery information into the Lookup service. The controllers discover the required services by using the Lookup service and obtain the objects. Then, the controllers control the target services with Java RMI (Java Remote Method Invocation). Jini Specification version 2.0 was released in June 2003. Although the Jini specifications are still being considered, there has been little product implementation.

2.5 HAVi

HAVi (Home Audio/Video interoperability) [5] is a specification for middleware designed to achieve interoperability among digital AV (audio-visual) devices. It is being standardized by the HAVi Organization. HAVi Specification version 1.1 was released in May 2001. HAVi products on the market in North America include HDTVs (high-definition television sets) and HD Digital VCRs (high-definition digital video cassette recorders).

3. Digital Home-network Forum (DHF)

DHF [6] is a trade association that was established in Japan in July 1999 and had 65 members as of May 2004. DHF is considering the following themes.

- a home network basic architecture
- a directory independent of the Proprietary Domains
- messages used in the IPCable2Home Domain

3.1 Home network basic architecture

DHF's investigations showed the need to consider the situation where various *de facto* standards exist on the same home network. DHF proposed the required basic network structure, functions, and function arrangements as a basic home network model. This model was proposed to ITU-T and was recommended as the basic home network architecture (J.190) [7], which is almost the same as DHF's proposal. The basic architecture is shown in **Fig. 3**. This architecture categorizes the Proprietary Domains into four planes (AV, PC, TEL/FAX, and Home appliance planes) and connects these Proprietary Domains to the IPCable2Home Domain. A Home Client (HC) connects Proprietary Domains to the IPCable2Home Domain. Home Access (HA) connects the IPCable2Home Domain to the access network.

3.2 Directory

Directory manages information (e.g., addresses and services provided by devices) and contributes to service discovery. DHF has been considering the description formats of the directory information and the directory management protocols as one way to achieve interoperability among Proprietary Domains.

3.3 Messages

DHF has been considering the message formats, the message transmission process, etc. as one way to achieve interoperability among the Proprietary Domains.

3.4 Future activities of DHF

DHF is summarizing the results of its considerations in documents (stipulations, guidelines, etc.). It is also planning to perform verification experiments and promote its activities. DHF is also writing specifications for experiments. It then plans to make proposals to ITU-T and other organizations to standardize the content in the stipulations and guidelines.

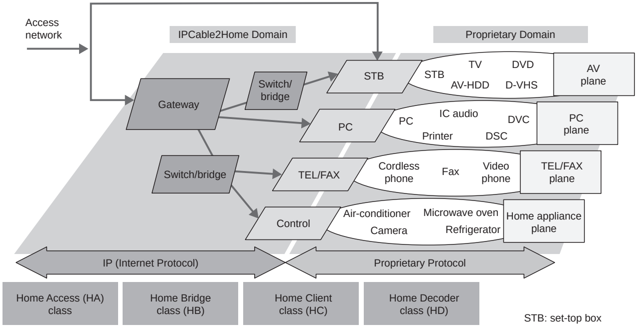

Fig. 3. Basic home network architecture.

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[1] http://www.upnp.org
[2] http://www.echonet.gr.jp/english/index.htm
[3] http://www.lonmark.org/
[4] http://wwws.sun.com/software/jini/index.html
[5] http://www.havi.org/
[6] http://www.dhf.gr.jp/ (in Japanese)
[7] ITU-T Recommendation J.190, "Architecture of MediaHomeNet that supports cable-based services," 2002.

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He received the B.S. and M.S. degrees in physics from Okayama University, Okayama in 1995 and 1997, respectively. In 1997, he joined NTT Access Network Systems Laboratories, Ibaraki. In 1999, he moved to NTT Access Network Service Systems Laboratories. He has been engaged in research on home network architectures and distributed resource management. His current research involves unified device control methods to achieve interoperability among heterogeneous device control protocols. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).

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He received the B.E., M.E., and Ph.D. degrees in precision engineering from Hokkaido University, Sapporo, Hokkaido in 1979, 1981, and 1989, respectively. In 1981, he joined NTT Ibaraki Electrical Communication Laboratory, where he engaged in research on optical fiber cables and their connections. In 1987, he joined the Network Systems Development Center. After spending a year at UC Irvine from 1989 to 1990, he joined NTT Access Network Systems Laboratories and engaged in research on home network systems. He moved to the Planning Department of NTT Information Sharing System Laboratory Group, Musashino, as a Senior Manager. He is currently involved in R&D of user network systems as the project manager in the Customer Systems Project. He is a member of IEICE, the Japan Society for Precision Engineering (JSPE), the Japan Society Mechanical Engineering (JSME), and IEEE. He is also a secretary of Technical Group on Optical Fiber Technology (OFT), IEICE and the secretary-general of the Digital Home-network Forum. He had received the "Young Engineer Award in 1987" from IEICE and the "Best Contribution Award in 1999" from ITU-AJ for seven years of activity in SG-6.