Information Appliances | Home Network | PUCC

Technology Reports

Special Articles on Technology toward Further Diversification of Life-Style Mobile

Home Network Control from Mobile Terminals for Creating New Use Scenarios of Life-Style Mobile

We explain technology for home network control from a mobile terminal we have developed to expand the use scenario for Life-Style Mobile and our activities in PUCC, which is a consortium for de facto standardization and development of that technology toward practical use. The PUCC main specifications have adopted the home network control technology developed by NTT DoCoMo.

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1. Introduction

Since the proposal of home networks in the 1990s, there have been various attempts at standardization and product development. With the advanced functions that information appliances have begun to offer in recent years, however, we can expect that home networks will finally come into wide use. A very important factor in encouraging the widespread use of home networks is interconnectibity of devices, and there has been progress in standardization for Audio-Visual (AV) home electronics, home appliances and other such individual devices. Now, the evolution of mobile terminals has focused attention on using mobile terminals to connect to home networks. This situation motivated our R&D of technology for unified control from a mobile terminal of various devices that are connected to a home network, which may range from AV home electronics and home appliances to door phones and electronic keys, etc. This technology enables use of a mobile terminal for remote operation such as turning on air conditioners and other devices before returning home, and checking to make sure that the front door is locked, thus increasing even further the usability of the mobile terminal as Life-Style Mobile (**Figure 1**).

In this article, we first explain the current trend in existing home network standardization. We then describe issues with standardization with respect to mobile terminals and describe, as a solution to those issues, technology for using mobile terminals together with Peer-to-Peer (P2P)[*1]/ overlay network technology[*2] for unified control of the various devices connected to home networks.

We also describe the setting of the first edition of the PUCC specifications as

*1 **P2P**: A communication model in which computers exchange information on equal footing in contrast to the server-client model. In this article, mobile terminals and surrounding digital devices all exchange information on equal footing.

*2 **Overlay network technology**: A network in which virtual nodes are connected directly. Lower-layer communication technology is hidden, and the provided API (see *18) is used to easily connect nodes.

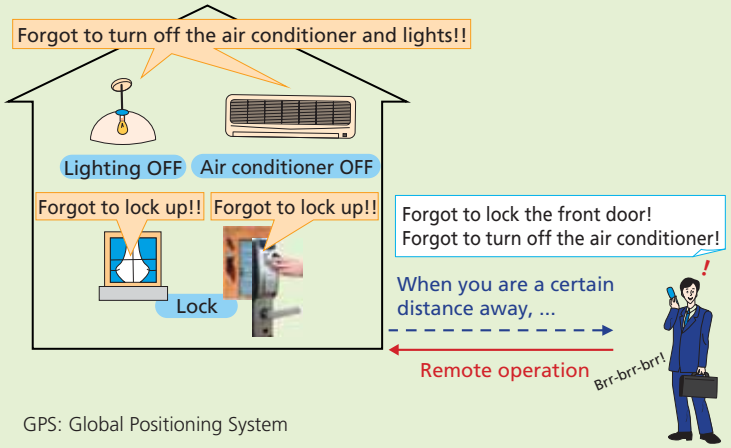


Figure 1 Interworking with GPS to operate home appliances and facilities

an activity of Peer-to-peer Universal Computing Consortium (PUCC), which was established to set a de facto standard for this technology and to spread its use. We also describe demonstration exhibits at Combined Exhibition of Advanced TEChnologies 2006 (CEATEC 2006) and the Consumer Electronics Show 2008 (CES 2008), which were held with the support of Ministy of Economy, Trade and Industry (METI), the Communications and Information network Association of Japan (CIAJ)[*3], and the Japan External TRade Organization (JETRO)[*4]. We conclude with a description of studies toward practical application of this technology.

2. Toward Standardization of Home Networks

We describe the trend in existing home network standardization and the situation regarding product development.

2.1 DLNA/UPnP

Universal Plug and Play (UPnP)[*5] is a technology that allows the use of standard Internet technology for connections between networked devices. The Digital Living Network Alliance (DLNA)[*6] has established design guidelines for the sharing of video and other digital content by home appliances, personal computers, and mobile devices through the use of UPnP and other standard Internet technology. Digital Media Players (DMP), which present content for user enjoyment, use a protocol such as Simple Service Discovery Protocol (SSDP)[*7] to discover Digital Media Servers (DMSs)[*8] or other such servers that have content, and retrieve a list from a Content Directory Service (CDS)[*9]. Then a request for the desired content is sent and the content is streamed from the server via the LAN to the player for viewing.

The DLNA Guidelines 1.0 were set in October 2004, and progress in device compliance is being made, focusing on PCs, Hard Disk Drives (HDD) and recorders, etc. DLNA is also conducting a logo certification program to ensure interconnectivity of the products of various manufacturers, which has been a issue for information appliances. To preserving copyrights in the transfer of content, the Link Protection Guidelines[*10] for Digital Transmission Content Protection over IP (DTCP-IP)[*11] were established in October 2006. We expect that DLNA-compliant products will be developed in the future to allow the sharing of downloaded digital broadcasting content, etc.

2.2 ECHONET

Energy Conservation and HOmecare NETwork (ECHONET) is a standard for control of air conditioners, lighting and other home appliances and facility devices such as power consumption monitors and other sensors.

Version 1.0 of the ECHONET specifications was set in March 2000, and some manufacturers have compliant products on the market, but the specifications have not yet spread throughout the industry as a whole. Because the most recent trend is to implement consistency with specifications for AV devices, version 3.60 of the ECHONET specifications, which include gateway[*12] specifications that allow conversion between ECHONET and UPnP,

*3 **CIAJ**: An industrial organization whose objective is to develop and promote industries concerned with information communication networks, by proposing policy, conducting surveys, supporting overseas business of Japanese companies, and organizing exhibitions, etc.
*4 **JETRO**: An independent administrative agency for investigating matters related to foreign trade and promoting the results.
*5 **UPnP**: A technical specification for the mutual provision of functions between information appliances and telephones and other communication devices at home connected via a network. Based on standard Internet technology and designed for use by simply connecting to the network without any complex operation or setup.
*6 **DLNA**: An organization of manufacturers in the fields of information appliances, mobile terminals and PCs that promotes activities for standardization to ensure interconnection in the digital age and establish technical specifications called DLNA guidelines.
*7 **SSDP**: A protocol for detecting devices on a network.
*8 **DMS**: A device class specified in the DLNA guidelines. A server that stores content.
*9 **CDS**: A specification concerning content search and list display.

was published in December 2007.

2.3 OSGi

Open Services Gateway initiative (OSGi) was founded in March 1999 and has since been working on standards for mechanisms for the remote and dynamic addition and changing of home gateway functions. OSGi middleware is installed on home gateways that run Java®*13, allowing various functions to be used by downloading specific-use software components called bundles from the servers of bundle providers. OSGi release 4, established in 2005, extended the specifications for mobile devices.

2.4 HDMI

High-Definition Multimedia Interface (HDMI) is a high-speed interface specification for AV devices that can transmit HiVision video streams, allowing the sharing of high-quality content between devices. It is equipped with High-bandwidth Digital Content Protection system (HDCP)*14 copyright protection technology for preventing the unauthorized copying of content, so it can also be used as a connection interface for Blu-ray®*15 or other next-generation DVD technology. Because a single cable can transmit video, audio and control signals at the same time, coordinated control of products connected by HDMI is possible. For example, using the remote control of a player device to turn on the device power can also turn on the TV at the same time.

3. Home Network Control Technology

Various standards have been established for different classes of information appliances for the home network described in Chapter 2. Two issues posed by this situation are described below (**Figure 2**).

Issue 1: Different devices have different interfaces

The current situation is that there is no

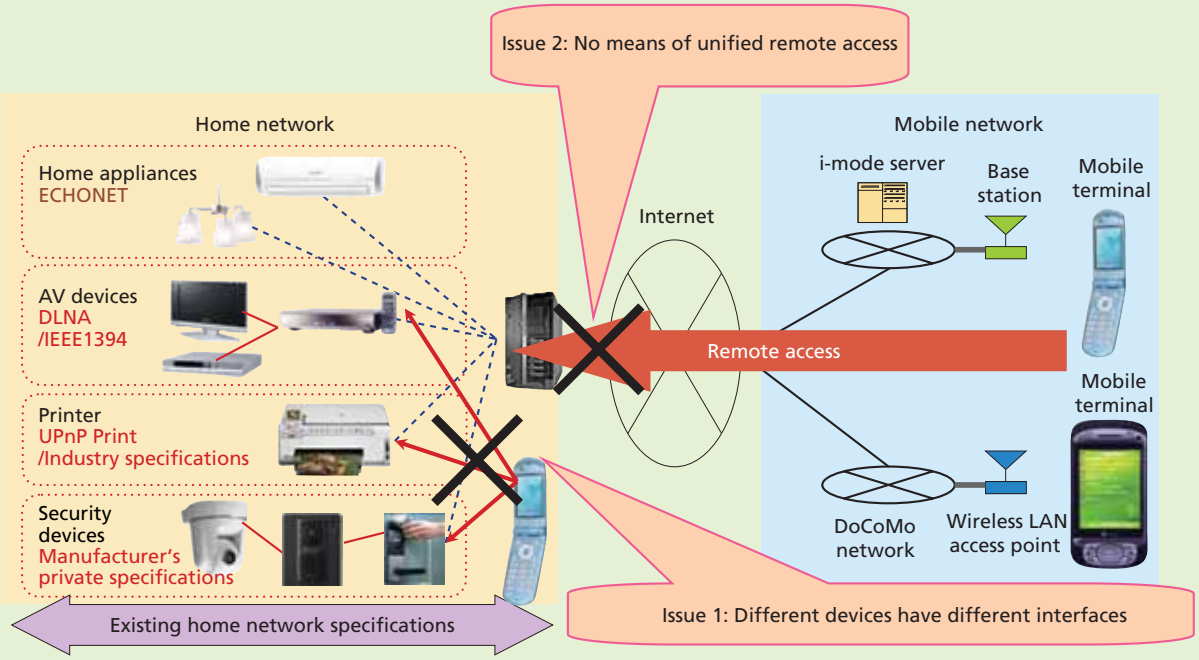


Figure 2 Issues facing control of home electronics from a mobile terminal

*10 **Link Protection Guidelines**: Guidelines for secure transfer of content between DLNA compliant devices. DTCP-IP is mandatory and Windows® Media DRM 10 is optional.
Windows® Media is a registered trademark of Microsoft Corporation in the United States.

*11 **DTCP-IP**: Technology for secure transmission of content protected with copyright technology within an IP network.

*12 **Gateway**: An intermediate device that has functions such as protocol conversion and data transfer to allow communication between devices.

*13 **Java®**: An object-oriented programming language. Applications written in Java can be run on a virtual machine, and can thus run on different platforms.
A registered trademark of Sun Microsystems, Inc. in the United States.

*14 **HDCP**: A technology for protecting copyrights by prevention of copying through encryption of the communication path.

*15 **Blu-ray®**: A registered trademark of Sony Corp.

compatibility among the various specifications. To control information appliances that comply with the various different specifications, a mobile terminal must also comply with multiple specifications, but the limited processing capability and memory capacity of mobile terminal makes that difficult.

Issue 2: No means of unified remote access

One of the largest issues concerning remote access to a home network from a mobile terminal via a mobile network is the lack of unified specifications.

To solve those issues, we collaborated in research with Nippon Ericsson K. K., Kyoto University and Keio University to develop technology for control of home networks from a mobile terminal using P2P/overlay network technology for unified control of various devices connected to the network.

3.1 P2P/ Overlay Network Technology

The architecture adopted for the P2P/overlay network is shown in **Figure 3**. This architecture defines a P2P protocol as a layer above the mobile network, Bluetooth®*16, Institute of Electrical and Electronics Engineers 1394 (IEEE 1394)*17, TCP/IP and other existing communication specifications. It serves as an overlay network in the application layer. This P2P protocol allows construction of a P2P network across different types of network to achieve device interconnectivity.

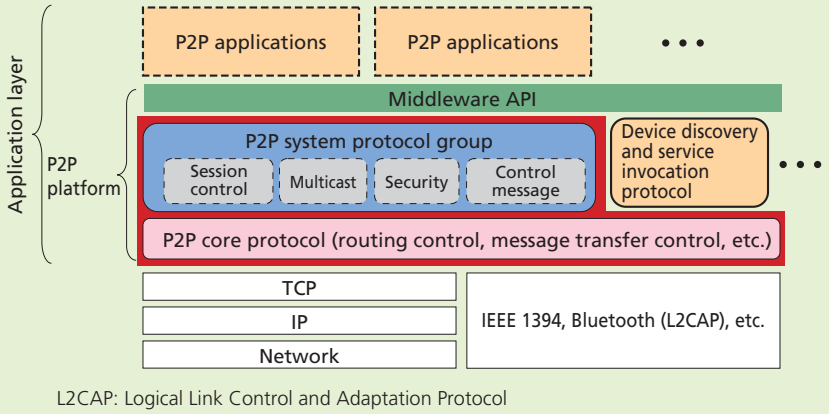


Figure 3 Architecture for the overlay network

The P2P platform provides this protocol as application-independent, general-purpose middleware. The P2P platform implements the P2P protocol group required for P2P communication and runs on various transport networks. The platform also provides a middleware Application Programming Interface (API)*18 for accessing the P2P protocol stack, allowing the implementation of various P2P applications on the P2P platform. The P2P platform protocol stack comprises the two layers of the P2P core protocol and the P2P system protocol group (Fig. 3). The P2P core protocol implements communication based on the P2P communication model, and so implements P2P routing on various lower-level transport networks. The P2P system protocol group above the P2P core protocol is used in common by P2P applications and is defined for each P2P communication function, including a session control function for constructing relations among P2P node, a multicast function for constructing the P2P multicast distribution tree, a security, and a control message function for error handling, etc. When P2P applications are implemented on this platform, a P2P application protocol is defined for each application on the P2P core protocol, and the middleware API is used to implement the P2P application.

3.2 Device Discovery and Service Invocation Protocol

To control devices that are connected to a home network, it is first necessary to select a device that is connected to the network according to the capabilities of the device and the services that the device

*16 **Bluetooth®**: A short-range wireless communication specification for wireless connection of mobile terminals, notebook computers, PDAs and other portable terminals. Bluetooth specifies various profiles for individual devices, but a P2P platform is implemented on L2CAP, which is device-independent.
A registered trademark of Bluetooth SIG Inc. in the United States.

*17 **IEEE 1394**: A specification for a high-speed serial bus standardized by IEEE in 1995 and adopted by many video cameras, video decks, TVs and other information appliances, printers and PCs. It implements video streaming between devices. IEEE 1394 AV/C specifies a protocol for device control.

*18 **API**: An interface that makes the functions provided by the OS, middleware and other such software available to upper-level software.

offers.

Control protocols for the various services offered by the device are also required. We therefore define a device discovery and service invocation protocol to serve as the P2P application protocol of the P2P platform.

An overview of this protocol is shown in **Figure 4**. The protocol uses general-purpose metadata[*19] templates that can be applied to various devices. The metadata that is defined for each device is used as a basis for finding and controlling devices and the services they offer. As shown in Fig. 4(a), each device on a network has metadata that describes its capabilities and the services it offers. The user searches for devices by broadcasting a search request message over the P2P network that contains functions, types, or key words as search parameters. Each device that receives the search request message compares its own metadata description with the search parameters and returns a reply message that contains the metadata if they match. As shown in Fig. 4(b), the user selects the service to be invoked from the services described in the metadata and then instructs control of the device. The mobile terminal automatically creates a control user interface on the basis of the information in the metadata, giving access to various devices and services. An event notification function is also provided to inform mobile terminals and devices when an event occurs so that a service can be invoked upon the occurrence of events set as conditions in the metadata.

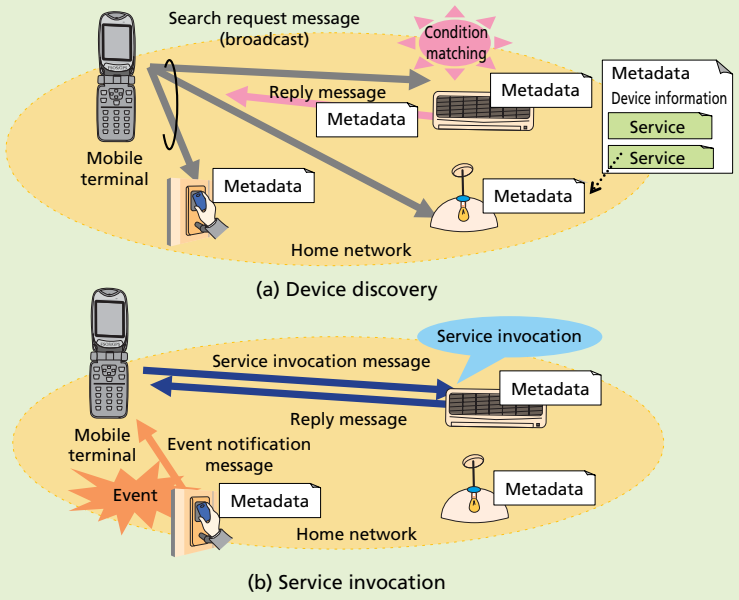


Figure 4 Device discovery and service invocation protocol

3.3 Device Metadata

Examples of the metadata description used in home network control are shown in **Figure 5**. The metadata describes the device name, type, attributes and the services the device offers in eXtensible Markup Language (XML)[*20] format. The various functions provided by the device are abstracted and defined as service metadata. When defining an abstract service, it is possible to specify a series of operations. For example, a "view video" service could specify that the TV be turned on, the input set to video, and the video player be turned on. Each service has a unique Uniform Resource Identifier (URI)[*21], and that URI is used as an ID for service search and invocation. The device description comprises static information about the device such as the device name and type, state variables that set event conditions, a service list and a Primitive device list. The service description defines the service name and the names and data types of the service input-output parameters. The Primitive devices are for defining individual components in multi-function devices, such HDD recorders. Multi-function device metadata is defined as a combination of Primitive device metadata.

This metadata is compatible with UPnP metadata to ensure interconnectibity with UPnP-compliant devices,

*19 **Metadata**: Data that describes other data rather than serving as data itself. In this article, it refers to data that describes information on home appliances.

*20 **XML**: A mark-up language proposed by W3C for describing the semantic structure of documents and data. It is extensible with user-defined tags.

*21 **URI**: An identifier that represents a Web resource as defined by Request For Comments 3986 (RFC3986).

and has been designed for expansibility to allow application to other devices as well. It can therefore be used to express functions defined by various existing home network specifications, thus allowing interconnectibity with devices that conform to different existing home network specifications. When controlling such devices, the home gateway converts the device discovery and service invocation protocol into the existing home appliance control protocol.

To provide an example of protocol conversion, the configuration of an AV device control system is shown in **Figure 6**. In this example, a mobile terminal

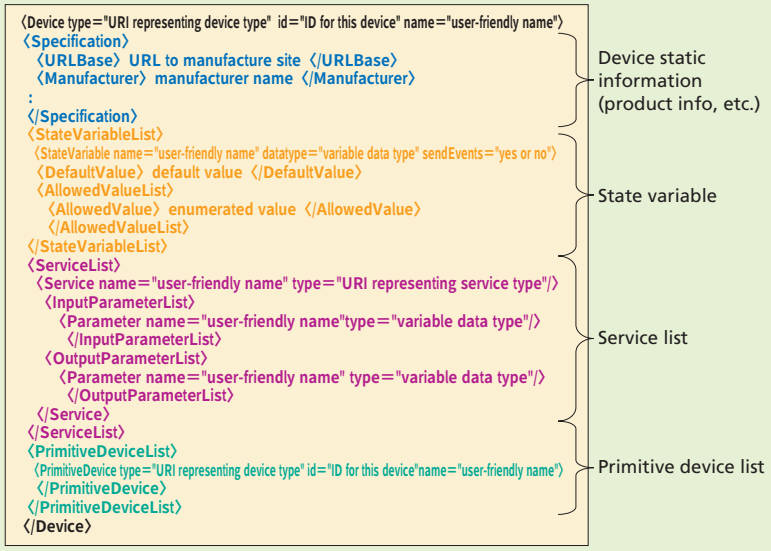


Figure 5 Metadata examples

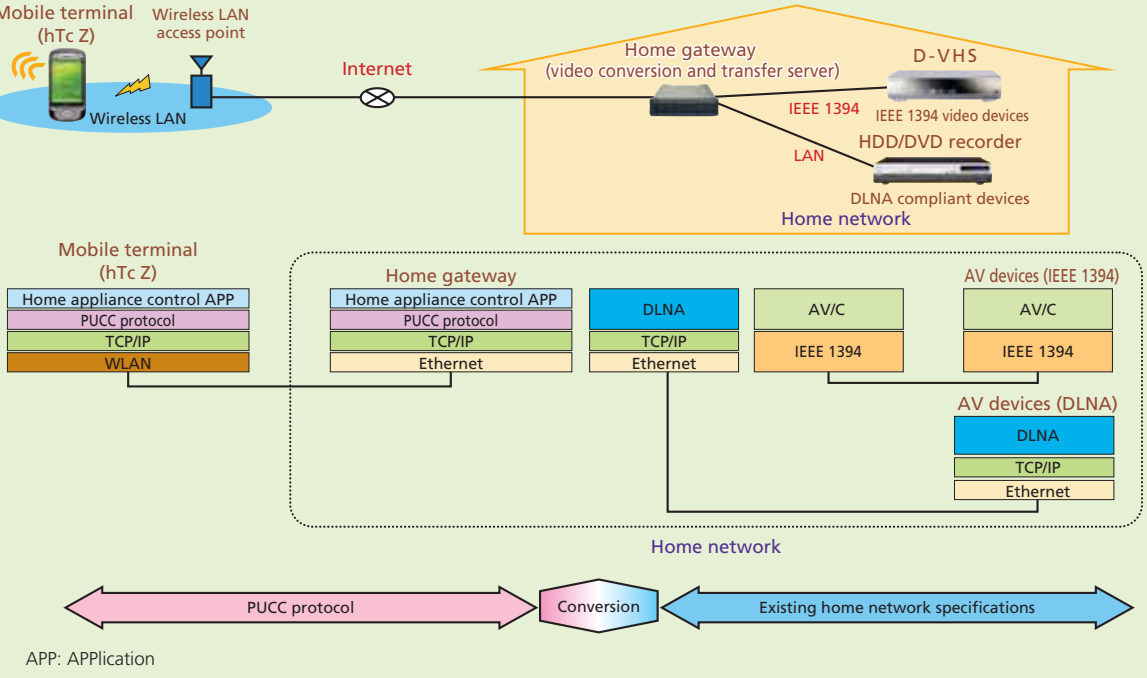


Figure 6 Configuration of the AV device control system

(hTc Z®[*22], etc.) with a wireless LAN connects to the home gateway via the Internet to view video stored on a DLNA-compliant HDD/DVD recorder with an IEEE1394-compliant Data Video Home System (D-VHS)[*23] player that reside on the home network. In this configuration, the PUCC device discovery and service invocation protocol is used for the part from the mobile terminal to the home gateway, and the home gateway converts from the PUCC protocol to the existing protocols such as IEEE 1394 Audio Video/Control (AV/C) commands and UPnP.

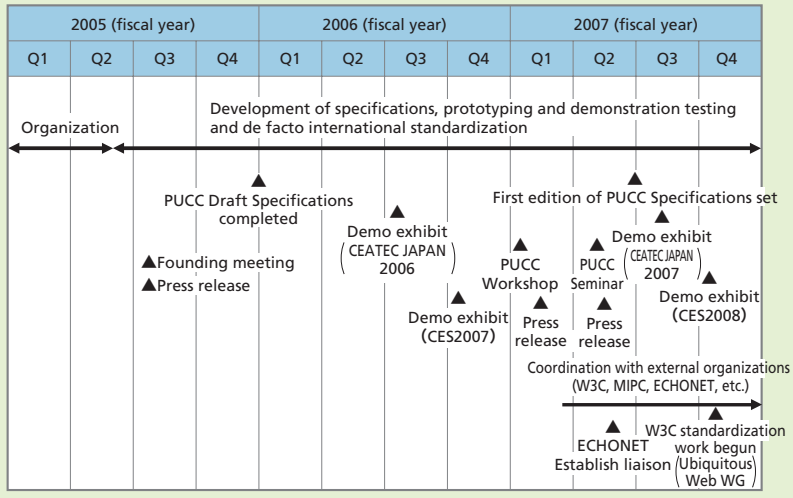
4. PUCC de facto Standardization and Demonstration Experiments

To achieve a protocol for seamless connection between various devices such as mobile terminals and information appliances, we set up the PUCC consortium of device vendors, universities and other relevant organizations in 2005. We have been cooperating with the participating members to establish a de facto standard based on the technology developed in Chapter 3, and to make the practical use and promote its widespread adoption.

4.1 Overview of PUCC

PUCC is a consortium that was established for the development of technology for the interconnection and operation of various devices through cooperation with the various vendors of home appliances, printers, home gateways, mobile terminal middleware and so on, with telecommunication operators and others in the communication industry and with universities that conduct basic technological research. The activity schedule of the consortium up to the present is shown in **Figure 7**. The consortium was established in December 2004. The participants include 17 corporations, and nine universities as of March 2008. The consortium has multiple working groups for cooperating with relevant organizations to study specifications and conduct demonstration experiments concerning specific topics. The 13 classes of specifications shown in **Table 1** were set as the first edition of the PUCC architecture and PUCC protocol specifications in September 2007. The home network control technology developed by NTT DoCoMo and others described in Chapter 3 was adopted for the platform technology of those specifications, and the comments of vendors and other relevant parties were reflected in the specifications.

To verify the technology of the specifications set by the consortium, the various vendors cooperated to conduct demonstration experiments with implementations of the PUCC protocol for mobile terminals and home gateways, etc. As shown by the schedule in Fig. 7, the prototypes used in the experiments have been exhibited annually at prominent home appliance exhibitions in Japan and abroad (CEATEC JAPAN, International CES, etc.) [1]. The CES 2008 demo



W3C: World Wide Web Consortium
MIPC: the Mobile Imaging and Printing Consortium

Figure 7 PUCC activity schedule

*22 **hTc Z®**: Registered trademark of High Tech Computer Corp.
*23 **D-VHS**: A digital format video recording system for use with consumer video tape recorders.

exhibit supported by JETRO drew great attention as new technology developed in Japan. It was taken up by major world media, including the media in Europe and the US, and the PUCC booth attracted over 1,500 visitors (**Photo 1**).

The consortium also participated in the "Next-generation home network demonstration experiments" sponsored by the Ministry of Internal Affairs and Communications and others in March 2008, conducting demonstration experiments of the PUCC protocol with a home gateway on which OSGi middleware was installed.

4.2 PUCC Demonstration Experiments

Some of the demonstration experiments related to home appliances control conducted by PUCC are described below.

Table 1 PUCC Specifications, first edition

PUCC Architecture
PUCC Basic Protocol
PUCC Basic Protocol - Light Profile
PUCC Device Discovery and Service Invocation Protocol
PUCC Printing Protocol
PUCC Streaming Protocol
PUCC Metadata Template Specification
PUCC Metadata Specification - Home Appliance Part 1 IEEE1394 Devices
PUCC Metadata Specification - Home Appliance Part 2 UPnP Devices
PUCC Metadata Specification - Home Appliance Part 3 ECHONET Devices
PUCC Metadata Specification - Home Appliance Part 4 Other Devices
PUCC Security Architecture
PUCC Security Protocol

1) Home Appliance Control

An overview of the experimental system for home appliances control from a mobile terminal is shown in **Figure 8**. The experimental system involves using an i-mode terminal, M1000[*24], or other such mobile terminal to control an ECHONET compliant air conditioner, lights and other home appliances via a home gateway. The i-mode terminal connects to the home gateway remotely via the mobile network and the M1000 connects locally via a wireless LAN. The home gateway implements a function for converting the PUCC protocol to the ECHONET protocol and the ability to control ECHONET products with the PUCC protocol was verified. The demonstrations at the CEATEC JAPAN 2006 exhibit included an application for remote control of home appliances that works with FeliCa®[*25]. When a FeliCa-equipped mobile terminal is used to pass

Photo 1 PUCC exhibition at CES 2008

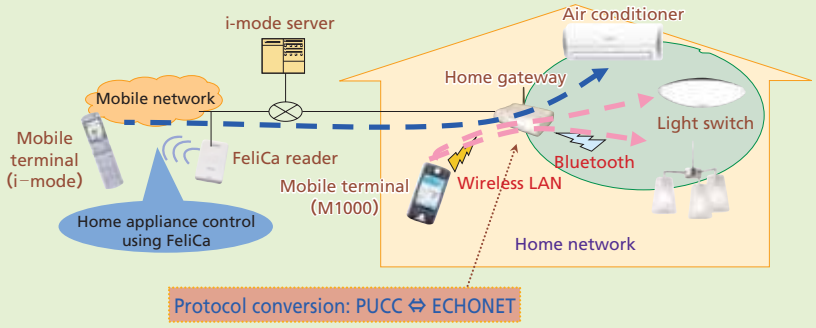


Figure 8 Demonstration system (home appliance control)

*24 **M1000**: A NTT DoCoMo business-oriented FOMA-compliant mobile terminal that is equipped for wireless LAN and Bluetooth.
*25 **FeliCa®**: A contactless IC card technology developed by Sony Corp. A registered trademark of Sony Corp.

through the ticket gate of a train station close to home, the mobile terminal automatically turns on the home air conditioner and light switches.

2) AV Streaming

An overview of the experimental system for AV equipment control from a mobile terminal is shown in **Figure 9**. This experimental system involves the transfer of video content that is stored in a DLNA-compliant HDD/DVD recorder from an IEEE1394-compliant D-VHS video player on a home network via the home gateway to a mobile terminal for viewing. The PUCC protocol is implemented on an hTc Z mobile terminal, which retrieves the content list and controls content play, fast-forward, and rewind. Control is performed by the PUCC protocol between the mobile terminal and the home gateway, and the home gateway converts to the IEEE 1394 protocol for the D-VHS video player and to the DLNA protocol for the HDD/DVD recorder. PUCC protocol establishes the path and controls the AV devices. The data streaming is done with an existing Real-time Transport Protocol (RTP, etc.). The home gateway transcodes the output of the Moving Picture Experts Group phase 2 (MPEG-2)[*26] encoded content in the AV devices to MPEG-4[*27] for transmission to the mobile terminal.

3) Home Security

An overview of the experimental system for controlling security cameras from a mobile terminal is shown in **Figure 10**. This experimental system involves reception of a home security camera video stream for monitoring on a mobile terminal. The orientation, zoom level and other settings of the security camera can be controlled from the mobile terminal. This technology allows real-time monitoring of conditions in the home through remote control of security cameras from a mobile terminal when triggered by an intrusion sensor, etc.

5. Application to Home Network Control Services for Mobile Terminals

Here we describe the application of the home network control technology that has

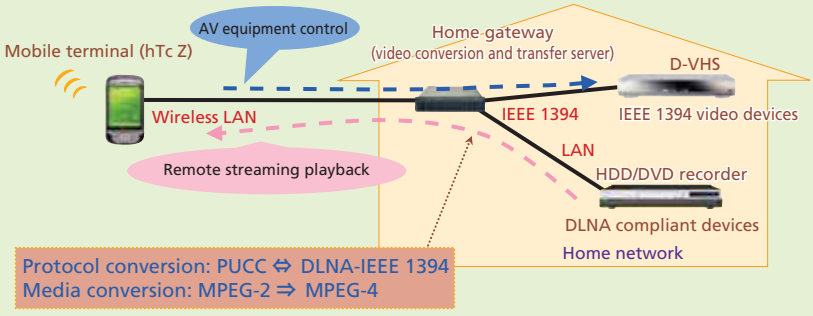


Figure 9 Demonstration system (AV streaming)

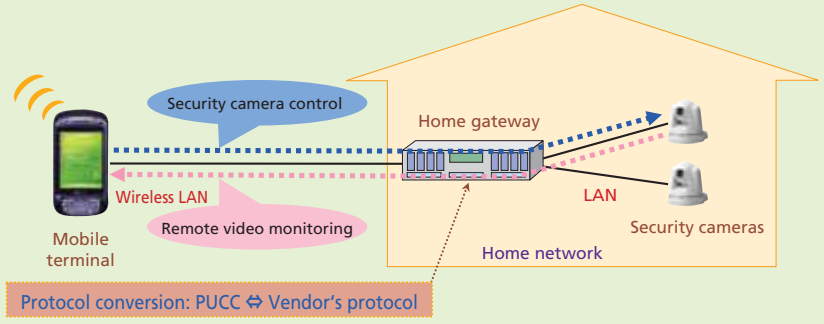


Figure 10 Demonstration system (home security)

*26 **MPEG-2**: A coding system for moving-picture data used for DVD and other storage media, as well as satellite broadcast.

*27 **MPEG-4**: A coding system for moving-picture data used for delivering video over relatively slow communication circuits as in mobile terminals.

been developed mainly by NTT DoCoMo and made a de facto standard by PUCC to home network control services for mobile terminals. Taking as an example the Home Automation (HA) system, which increases the convenience of comfort in homes by using IT facilities to control home appliances, we can consider services such as control of the power switches of home air conditioners, lighting and other equipment in the home from a mobile terminal, notification of alarms from a home intrusion sensor or smoke detector and notification of the arrival of visitors. Taking the AV network as another example, we can consider such services as remote viewing of still and motion picture content that is stored on a home PC or HDD recorder. Also, as shown in **Figure 11**, applying the PUCC protocol technology to home network control services that use i-appli makes it possible to implement an information appliance service platform that has the features described below.

1) Dynamic Generation of GUI by i-appli

Installing applications for device operation (remote control) that use the PUCC device metadata specifications allows implementation of i-appli, which has a function for dynamically generating a Graphical User Interface (GUI)[*28] as devices are added or removed. We also aim for efficiency in application development by wrapping the protocol interpreter in a module.

2) Device Control Protocol for Home Appliances

The PUCC device control protocol allows unified operation of home appliances that conform to multiple home network specifications (HA terminal[*29], ECHONET, UPnP, etc.). It is also possible to easily connect new home appliances and adopt future standard home net-

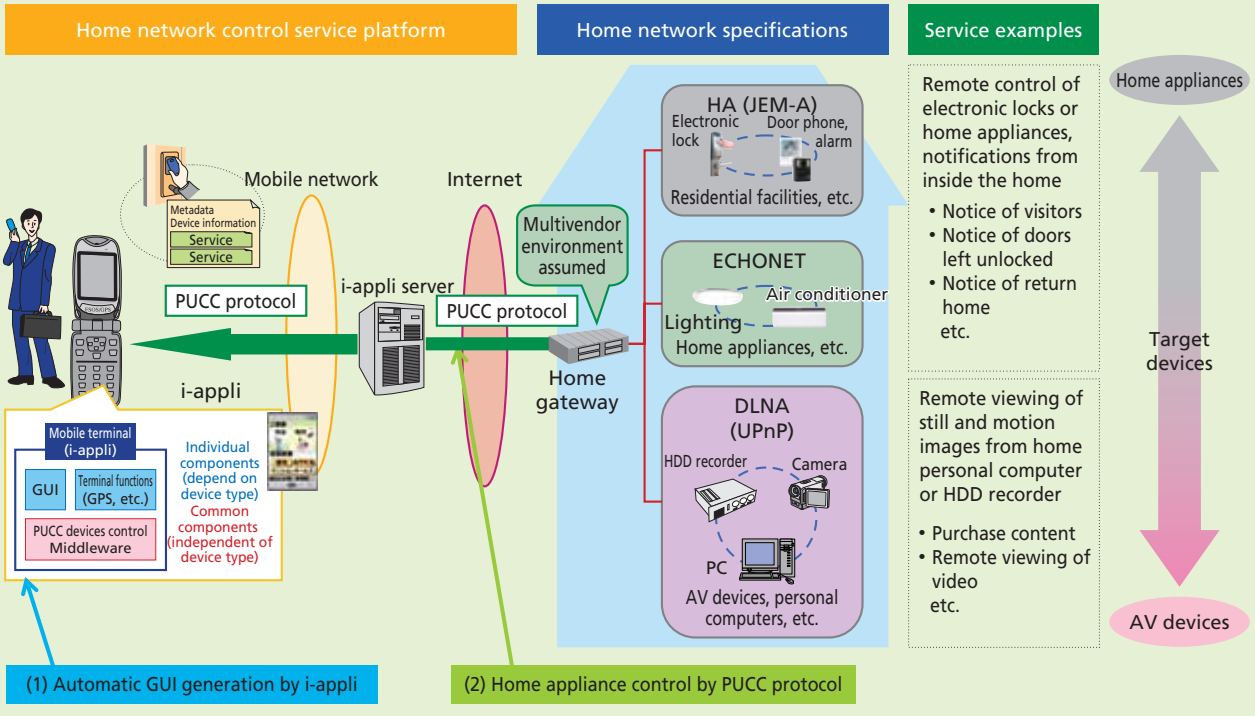


Figure 11 Application to home network control services for mobile terminals

*28 **GUI**: A user interface that uses many icons and other graphics on which basic operations are performed mainly with a pointing device.

*29 **HA terminal**: A home automation electrical terminal specified by Japan Electrical Manufacturer's Association (JEMA) that is also known as a JEM-A terminal. These specifications set a standard for control signal and monitor signal input and output for home appliances and devices that are controlled and monitored by a home automation system and whose operating states can be represented by binary ON/OFF value. Home appliances devices that can be plugged into an HA terminal include air conditioners, electric shutters, electronic locks, in-floor heating, hot water heaters, etc.

work specifications by simply replacing the home gateway system or updating the software.

Developing a service platform that use the PUCC technology as described above makes it possible to provide universal and expansible home network control services for mobile terminals.

6. Conclusion

We have described technological development related to the control of home networks from mobile terminals to even further expand the use scenarios and utility of the mobile terminal as Life-Style Mobile. We described the trend in standardization of existing home networks and the development of technology that applies an overlay network for home network control from a mobile terminal as one approach. We then described how that technology was made a de facto standard by the PUCC consortium and its application to home network control services for mobile terminals. In future work, we intend to add functions to the PUCC specifications to cope with new standard such as HDMI, promote PUCC activities to expand adoption even further, and do field tests and other studies to improve practicality for introduction to actual services.

REFERENCE

[1] H.Sumino et. al: "A Demonstration Experiment by PUCC of Controlling Information Appliances and Printers from Mobile Terminals," NTT DoCoMo Technical Journal, Vol. 8, No. 4, pp. 11-15, Mar. 2007.