Hitachi's IPv6-based Home Appliance Initiatives

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OVERVIEW: With the increasing availability of ADSL (asymmetric digital subscriber line), FTTH (fiber to the home), and other always-on high-speed Internet services, the day is fast approaching when not only personal computers but all sorts of home appliances will be connected to the Internet. This rapidly expanding trend has focused much interest on IPv6 (Internet protocol version 6), the next-generation Internet protocol that extends the Internet address space from 32 bits to 128 bits. The IPv6 protocol has numerous advantages that will affect how quickly and how extensively home appliances become connected to the network. For example, IPv6 enables automatic allocation of IP (Internet protocol) addresses by merely connecting a device to the Internet, safe and simple with built-in security features (IPsec) and protection of transaction data, and access to IPv6-based services with little or no user awareness of the network. As evidenced by Japan's commitment to redefine itself as e-Japan, the government is taking a proactive role in promoting public-private R&D collaborations, trials, and demonstrations that will speed up the proliferation and commercialization of IPv6. Hitachi, Ltd. has already established a firm position as provisioner of IPv6 networking technology with its early development and deployment of the gigabit routers. And the company is now making good headway on a range of technologies to build simple, secure seamless networks from the backbone to ordinary homes, and a robust service platform. And Hitachi is also conducting trials of a prototype of mobile viewer that could serve as a general-purpose monitor, thereby contributing to the proliferation and commercialization of next-generation IPv6-based services.

INTRODUCTION

IPv6 home appliances are generally envisioned their usages in mobile environments based on cell phones and data terminals and in Internet-connected home-network environments based in home appliances: net-television, net-refrigerator, etc. All sorts of applications and services could be provided in these IPv6 environments: video programming could be ordered in advance from outside the home, or video content could be easily played back using video on demand (VoD) from a video recorder located in a different room in the house (see Fig. 1).

For the home network system to spread, Hitachi considers the most essential requirements to be security of the IP layer, which is a key feature of the next-generation IPv6, and a means of making end users unaware of whether a service is based on IPv4 or IPv6. This article gives an overview of recent trials featuring consumers and other R&D initiatives to implement and support home appliances.

NETWORKING HOME APPLIANCES VIA IPv6

Connecting home appliances to the Internet would not only permit users to monitor and control home appliances from outside the home, it would also create new service-development opportunities, such as the remote controlling and maintenance of home appliances. For example, Table 1 shows some of the network services that could be made available to consumers by connecting home appliances to the Internet.

To accommodate home appliances and enable peer-to-peer transactions to support the kinds of services described above over the Internet, which has now clearly emerged as the networking medium, migration to IPv6, the next-generation Internet protocol, is essential. By expanding the address space from the current 32 bits to 128 bits, IPv6 can provide practically an unlimited number of IP addresses and overcome the current address shortage crisis. IPv6 has significant advantages over IPv4 that make it ideally suited for

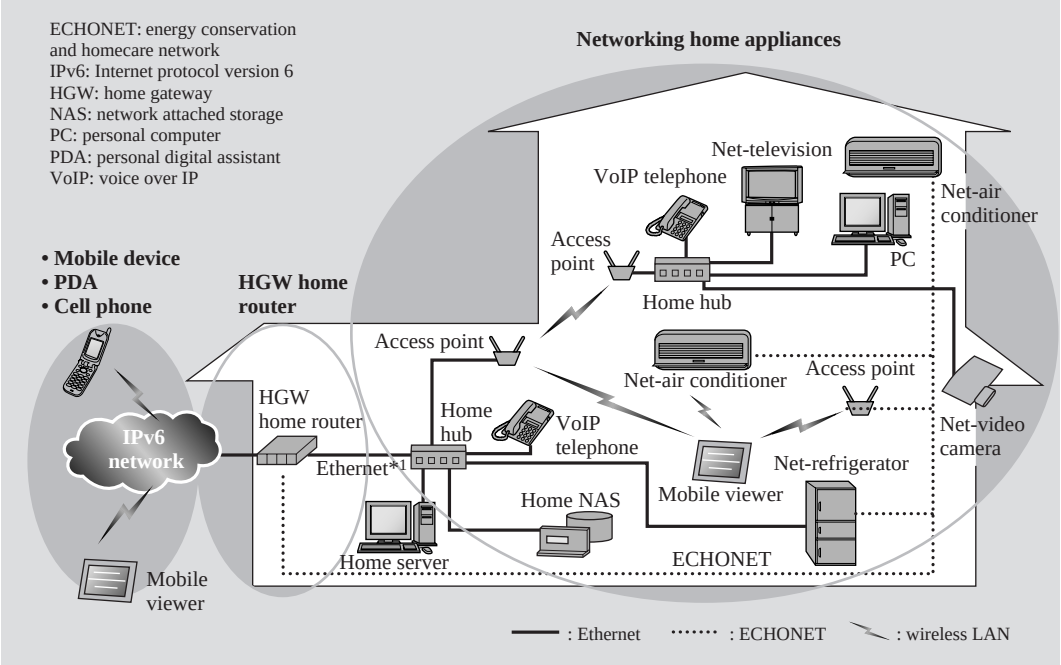

Fig. 1—Future Home Network. In the near future home network, all sorts of home appliances can be connected to various service providers or a mobile device via the IPv6 broadband network as a result of the integrating of all networks into the IP network.

TABLE 1. Classification of Home Network Services
New services can be provided to users without their awareness of network, as result of connecting home appliances to the IPv6 network.

Service classification	Detail (example)
Services within home network	• Control of home appliances (turning on/shutting off) • Cooperation between home appliances (transferring video content from a video machine to a television)
Services between home networks	• Communication (VoIP telephone service)
Services between exterior network and home network	• Control of home appliance from outside (turning on/shutting off) • Notification or delivering of information from home appliances (maintenance service for home appliances at a service center, forwarding video from video camera at home)

the support of intelligent home appliances: the plug-and-play feature of IPv6 enables appliances to automatically be allocated IPv6 addresses just by being connected to the Internet. Moreover, IPv6 provides secure data communication and other security features (IPsec), and quality of service (QoS).

In order to see widespread deployment, intelligent IPv6-based home appliances must satisfy three major requirements[1)]. The appliances must incorporate (1) support for a network interface, (2) IPv6 protocol processing capability, and (3) functions needed to support IPv6 services and applications.

The first requirement for a physical interface to connect home appliances with the Internet could be implemented in a variety of ways, including a wireless LAN (802.11a/b), a wireline LAN (Ethernet), via a power line (ECHONET), IEEE 1394, Bluetooth*2, etc.

To provide IPv6 capability (the second requirement), the IPv6 protocol must be implemented as lightly as possible considering the limited hardware resources (CPU performance and memory capacity) of the appliances and the need to keep costs to a minimum. Adopting an approach that minimizes the IPv6 protocol specifications, a draft proposal is being submitted to the IPv6 Working Group of the Internet Engineering Task Force (IETF) that recommends a lightweight IPv6 protocol spec supporting minimum functions[2)]. An alternative approach would be to implement the IPv6 protocol processing as a single chip or as an LSI (large-scale integrated circuit) integrated in the intellectual property (IP), which could then be embedded in home appliances.

Finally, the third requirement for an IPv6 processing LSI to be incorporated in home appliances, the hardware must be compatible with the applications. To ensure applications are implemented with certain flexibility, they must be written for either Linux*3 or a similar operating system, so IPv6 processing LSIs must possess an interface that is fully compatible with

*1: Ethernet is a trademark of Xerox Corporation, USA.
*2: Bluetooth is a trademark owned by Bluetooth SIG, Inc., U.S.A.
*3: Linux is a registered trademark of Linus Torvalds in the United States and other countries.

such OSs (operating systems). For example, this requirement could be met by implementing an LSI with a socket interface, or by implementing the LSI in such a way that it can select the required applications.

In laying the groundwork for IPv6-based home appliances, the remaining sections of this paper will give an overview of the results of recent trials of applications designed to meet the above requirements, and recent Hitachi efforts to realize an IPv6-processing LSI.

APPLICATION DEVELOPMENT TRIALS

IPv6-compatible applications are not like the current web sites that can be passively viewed with a web browser; rather, they must be communication-type applications that support the mutual exchange of transactions and are capable of initiating data transmissions. Assuming the desirability of communications and data transmission that are not aware of the network, research resources are being focused on video stream processing technologies for new applications.

Hitachi has been closely involved in recent research on an end-to-end communications technology that supports safe and effective interactive transactions with intelligent home appliances. Designated for funding in the revised national budget for FY (fiscal year) 2000, the research on IPv6-based home appliances was sponsored by the IPv6 Promotion Council[3] in cooperation with Ministry of Public Management, Home Affairs, Posts and Telecommunications, and orchestrated by NTT Communications Corporation.

Hitachi's specific contribution was a mobile viewer for the easy-to-deploy wireless LAN environment that is capable of receiving MPEG-4 (moving picture experts group 4) video from anywhere in the house. The mobile viewer was developed and evaluated through field trials conducted in February and March of 2002.

Developed for the trial system were an MPEG-4 content delivery system that can handle Live and VoD, a browser and IPv6 application software for the mobile viewer to enjoy the MPEG-4 streaming video. As illustrated in Fig. 2, the network configuration basically consisted of a server deployed in a datacenter, and a mobile viewer that could be set up in a showroom or in a home.

The mobile viewer had its public debut two months before the IPv6 Home-Appliance Trial on December 15 and 16 at the Net.Liferium2001 exhibit at Pacifico Yokohama. The exhibit gave the public their first glimpse of the next-generation IPv6-based intelligent home appliances. For the purpose of demonstration, a live video stream shot in Osaka was converted to MPEG-4 streaming video and delivered over the IPv6-enabled network for enjoying the mobile viewer at the exhibit booth showcasing IPv6 products.

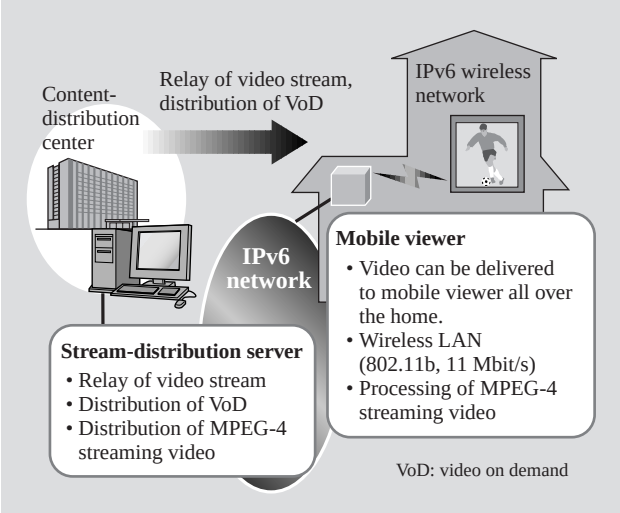

Fig. 2—Trial System for "Mobile viewer."
In this system, MPEG-4 streaming data is distributed to a mobile viewer in a monitor-house via IPv6 network. Both the mobile viewer and the stream-distribution server use IPv6 protocol processing and application software.

DEVELOPMENT OF IPv6 PROCESSING LSI TECHNOLOGY

Classification of Home Appliances

As shown in Fig. 3, network equipment connected to a home network will have different performance and functional requirements depending on how the appliances are used. Our continued R&D has thus been based on the classification of equipment requiring some type of IPv6-processing LSI.

(1) Router equipment

The router is the essential gateway that interconnects the home network with the wider network beyond the home. The router allocates global IP addresses to devices and appliances in the home, performs packet routing within the home network, and provides security vis-à-vis the outside network. With the extension of FTTH, the router will support a maximum throughput of approximately 80 Mbit/s.

(2) Multimedia equipment

This equipment must be capable of handling streaming data, and capable of processing images with a picture quality equivalent to the MPEG-2 class standard [SD (standard definition) 6 Mbit/s or better].

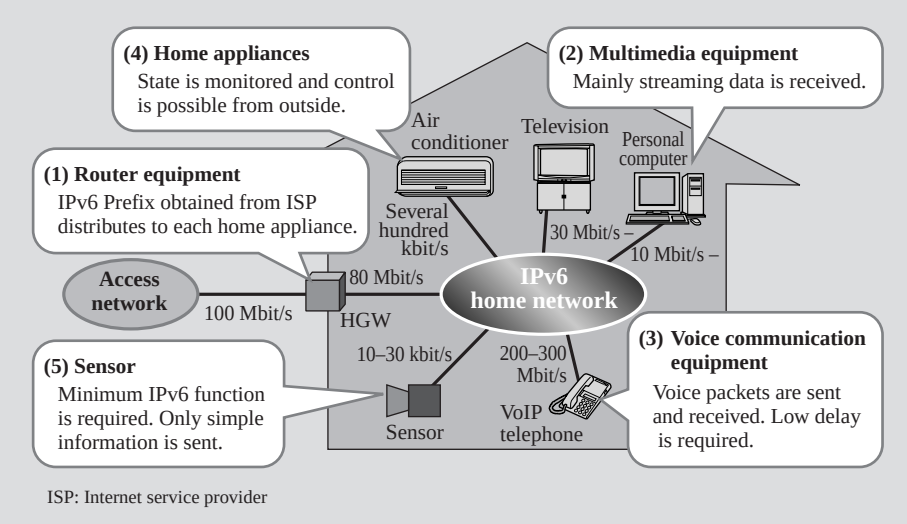

Fig. 3—IPv6 Home Network Configuration.
The optimum specifications for an IPv6 network should be selected and applied to each home appliance by considering the different requirements and usage.

TABLE 2. Classifications of IPv6 Function

Optimum IPv6 function should be selected and applied to each home appliance, considering difference requirements and usage.

Required function level of IPv6
High
Low

Classification	IPv6 functions						Required performance	
	Basic header creation/ analysis	Address auto-configuration	Analysis of PMTU	Forwarding routing	Option header creation/ analysis	ICMPv6	CPU	Throughput delay
Router equipment	○	○	○	○	All	○	SH-4	80 Mbit/s
Multimedia equipment	○	○	×	×	IPsec (AH, ESP)	○	SH-3	30 Mbit/s
Voice communication equipment	○	○	×	×	IPsec (AH, ESP)	○	SH-3	Several hundred kbit/s Delay: under 100 ms
Home appliance	○	○	×	×	IPsec (AH)	○	H8	Several hundred kbit/s
Sensor	○	○	×	×	IPsec (AH)	○	H8	Several dozen kbit/s

○: necessary function ×: unnecessary function PMTU: path maximum transmission unit
AH: authentication header ESP: encapsulating security payload

(3) Voice communications equipment

This equipment must support a quality of speech communication that is at least equivalent to voice over Internet protocol (VoIP) telephony. This equipment requires a low delay, generally defined as less than 100 ms. In addition, low-delay encryption technology is required to protect confidentiality.

(4) Home appliances

This encompasses a wide range of different kinds of devices in the home including among them items such as air conditioners, refrigerators, and other appliances. The home appliances must be network-ready to enable a person who is outside the home to easily monitor and control the equipment. Applications and services are closely linked, and the required functionality will vary from one type of equipment to another. Security and particularly access authentication are essential to prevent home networks from being accessed for ill purposes by unauthorized parties.

(5) Sensors

Because many types of home appliances are equipped with only minimal networking functions for sending and receiving data, sensors are needed to respond when users check the operating status of their appliances remotely. In their role as network equipment, the sensors must at least include a network interface and interface ID data in order to generate IPv6 addresses. Just as noted above for the home appliances, the sensors must also provide security — especially access authentication — to prevent unauthorized access to the home network.

Classification of Home Network Equipment in Terms of IPv6 Processing Capabilities

Based on the guidelines mentioned below, Hitachi classified different types of equipment in terms of the

IPv6 capabilities that the equipment needs to support as summarized in Table 2. We are now committed to bringing these products to market as quickly as possible by smoothly integrating the IPv6 capabilities now being standardized as IETF Requests for Comments (RFCs) into home networks, and by ensuring that the home appliances can be easily connected to the Internet.

(1) Ability to generate and analyze basic header

This capability will be incorporated in all equipment since it is fundamentally important for IPv6 communication processing.

(2) Automatic allocation of IP addresses

It is essential that people with little or no technical knowledge be able to easily connect devices and appliances in their homes to the network. All equipment is thus endowed with plug-and-play functionality enabling appliances to automatically be allocated IPv6 addresses just by being connected to the Internet.

(3) Support for ICMPv6 (Internet control message protocol version 6)

This protocol provides a number of essential functions: simple plug-and-play detection of duplicate IPv6 addresses in the network, ability to easily grasp the operating state of equipment, and the generation and transmission of error messages. By extending these capabilities, it should not be too difficult to implement informational messages and detect equipment failures and problems on home appliance networks, thus opening the way to new service-provisioning opportunities, such as equipment maintenance. Basically, all ICMPv6 functions must be incorporated in all categories of equipment.

CONCLUSIONS

This article provided an overview of Hitachi's recent R&D efforts to develop IPv6-based intelligent home appliances, highlighted the firm's prototype mobile viewer that is able to handle MPEG-4 streaming video and was recently subjected to field trials, and outlined the technologies needed to implement IPv6-processing LSI which are essential to connect home appliance to the Internet.

Hitachi remains fully committed to the further development and deployment of IPv6-based home appliances that consumer can use without technical expertise or even awareness of the network, that are safe and make life more enjoyable, and that enhances the quality of all our lives in the years ahead.

ACKNOWLEDGMENTS

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(3) http://www.v6pc.jp/index_e.html

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