Hitachi's Activities Regarding Broadband IPv6 Network Systems

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OVERVIEW: Based on IPv4 (Internet protocol version 4), which was standardized in the 1980s, the Internet has developed rapidly into an infrastructure indispensable to today's society. IP (Internet protocol) networks, such as the Internet, continue to be enhanced in terms of both speed and functionality. Progress in speed is particularly prominent in access networks, which now support broadband communications in copper, wireless, and optical fiber transmission mediums. IP networks must provide several functions including provisions for guaranteed QoS (quality of service), mobility, collaboration between servers, and high-value-added services. However, an IPv4-based Internet has limitations in terms of scalability, QoS guarantee, and manageability because IPv4 was originally designed as a network interconnecting researchers and, as such, had not anticipated its current role of providing a social infrastructure. IPv6 is not a mere extension of network address domains over IPv4 but is a key technology to overcome the above-mentioned limitations.

INTRODUCTION

THE number of Internet users in the world continues to increase rapidly. The 2001 White Paper "Information Communication in Japan" estimates that the number reached 407 million by the end of November 2000. The year 2001 is called the first year of the broadband era, owing to the rapid growth in high-speed Internet access through ADSL (asymmetric digital subscriber line), CATV (cable TV), and FTTH (fiber to the home).

As the Internet has grown in both scale and speed in line with this trend, IP networks, represented by the Internet, have evolved from a communications infrastructure into a social infrastructure, which in turn has revealed several problems including a shortage of network address domains. IPv6 (Internet protocol version 6) is now receiving attention as a key technology to solve such problems and, in addition to being evaluated in various experiments[1, 2], is already offered in commercial service[3] and is beginning to be introduced into enterprise networks[4].

Hitachi noted the importance of IPv6 from its early stages and has been involved in various activities to promote its use. For example, Hitachi is already implementing IPv6 in its next-generation network products.

This paper describes Hitachi's concept of IPv6 and their activities related to it.

PROBLEMS WITH THE CURRENT INTERNET

Based on IPv4, which was standardized in the 1980s, the Internet has developed rapidly into an infrastructure indispensable in today's society. IP networks, such as the Internet, continue to be enhanced in terms of both speed and functionality. The progress in speed is particularly prominent in the case of access networks, which now support broadband, regardless of the transmission medium (copper, wireless, or optical fiber). The functions desired in IP networks include provisions for guaranteed QoS, mobility, collaboration between servers, and high-value-added services.

However, an IPv4-based Internet suffers from both technical and operational limitations. This is due to the fact that IPv4 was originally designed for a network interconnecting researchers and, as such, had not anticipated its current role of being a social infrastructure. The problems facing the current Internet are summarized below:

(1) Limitation in scalability

Being originally designed for a small network, the Internet has a flat network structure rather than a layered structure, which is more suitable for a large network. IPv4 lacks addressing space to cover potential requirements worldwide.

(2) Limitation in guarantees in QoS

The current Internet cannot guarantee bandwidth

or delay time for applications, such as those for voice and video, which require real-time transmission. In addition, IPv4 does not have security functions for authentication and encryption, so it is necessary to provide these functions separately.

(3) Limitation in manageability

Connection to the network is essentially done manually, causing the cost of network management to grow tremendously as the network size expands.

IPv6 NETWORK CONCEPT

Characteristics of IPv6

Fig. 1 shows the requirements for the Internet and the IPv6 functions that satisfy them. IPv6 provides two kinds of enhancement: in addressing capability and in networking functionality.

(1) Enhancement in addressing capability

Although the concept of class in IP addressing is reasonable, the total number of bits is limited to 32, which offers far too small a network address domain to cover potential worldwide requirements. The expansion to 128 bits in IPv6 solves the problem concerning shortage of address domains and allows layered addressing, which in turn permits a scalable network and fast searching for routing.

(2) Enhancement in networking functionality

While the IP layer in IPv4 is specialized for information transfer, in IPv6 it takes on additional functions. Some examples are the plug-and-play automatic address allocation function that reduces the workload of the administrator, security functions with standard IPsec (IP-security) capability, QoS control with explicit display of traffic class and flow label, and mobile IPv6 that enables direct communication between terminals without the need to go through a home agent. In the conventional Internet, these functions are provided by external servers. For example, DHCP (dynamic host configuration protocol) servers are used for address management, policy servers for QoS management, and VPN (virtual private network) equipment to ensure security. These functions are incorporated into IPv6 as basic features, so a high-value-added network can be constructed.

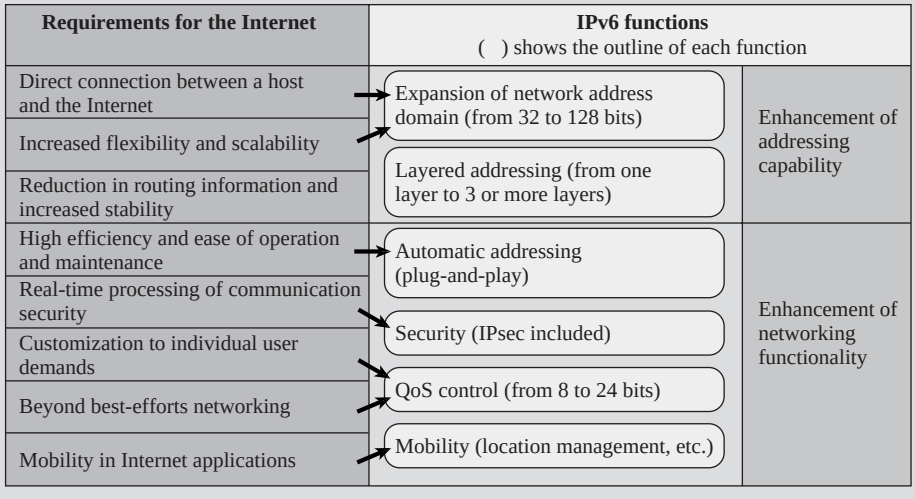
IPv6 Services

Table 1 shows examples of IPv6 services that capitalize on the features of IPv6. The migration service, which is particularly important during the introductory phase of IPv6, mobile service, which is a particularly promising IPv6 service, and VoIP (voice

TABLE 1. IPv6 Services
This table correlates promising IPv6 services with IPv6 features.

	Name of IPv6 service
Network bearer services	Native IPv6
	IPv4-to-IPv6 migration
	Mobile IPv6
	IPv6 multicast bearer
Common network services	IPv6 VPN
	IM
	VoIP
Application services	VoD
	Broadcasting
	Interactive video

IM: instant messaging VoD: video on demand



IPsec: Internet protocol security

Fig. 1—Requirements for the Internet and Corresponding IPv6 Functions.
IPv6 enhances addressing capability and networking capability. The enhanced addressing capability includes the expansion of network address domains and layered addressing capability. The enhanced networking capability includes automatic addressing, security, QoS control, and mobility.

over Internet protocol) service are outlined below:

(1) Migration service

The functions necessary for migration from IPv4 to IPv6 allow progression through a mixed IPv4/IPv6 network. Such functions, which include translation, tunneling, and dual-stack, allow users to progress to IPv6 step by step.

(2) Mobile service

This service transfers all kinds of information, including voice, from mobile terminals over an IP network. One application of this service is a mobile service serving hotspots using wireless LAN technology.

(3) VoIP service

This is an end-to-end VoIP service for VoIP terminals (PCs) capitalizing on a combination of an always-on broadband connection and IPv6. The main technical issues concerning this service include the numbering plan, interconnection with the conventional telephone network, and the construction of a signaling-control network.

Fig. 2 shows the configuration of the IPv6 network providing these services.

HITACHI'S ACTIVITIES ON IPv6

Table 2 lists Hitachi's activities regarding IPv6.

Introduction of Products

Hitachi developed the IPv6-compliant router in 1997. The product has been used widely by researchers of IPv6 and contributed to the accumulation of knowhow about the implementation and use of IPv6. Considering that it is essential to implement IPv6 in terminals as well, Hitachi developed software for IPv4/

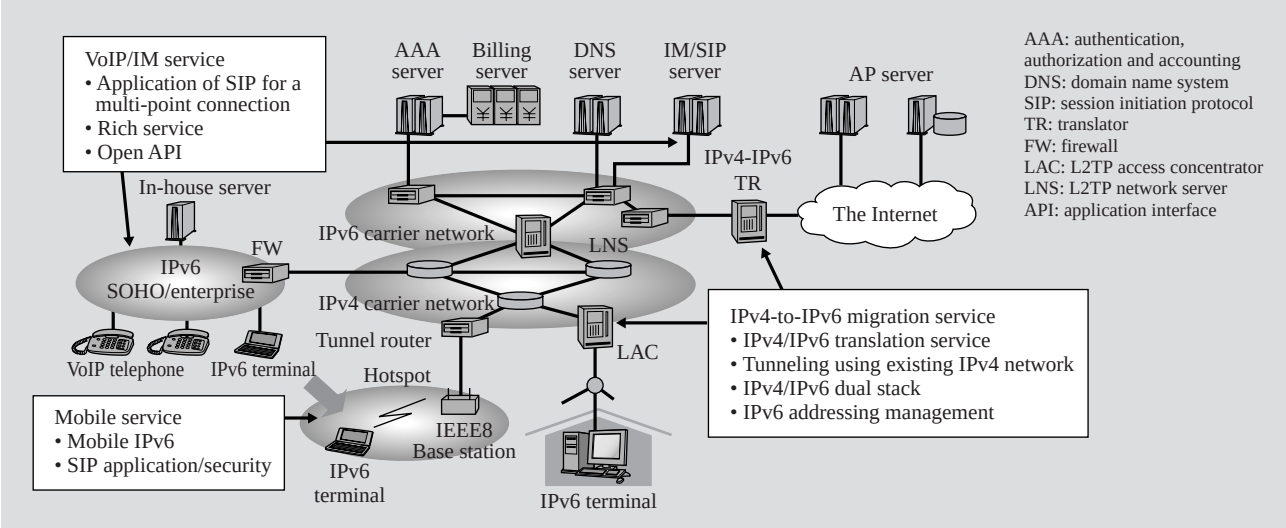


Fig. 2—IPv6 Network Configuration.
A conceptual IPv6 network providing IPv4-to-IPv6 migration service, mobile service and VoIP service.

TABLE 2. Hitachi's Activities Regarding IPv6
Since the adoption of draft IPng, Hitachi has been committed to various IPv6 activities.

	'95	'96	'97	'98	'99	'00	'01	'02
Introduction of products			▲ IPv6-compliant router	▲ Toolnet6		▲ Gigabit router series	▲ IPv6 network solution	▲ Access gateway
Standardization	▲ Draft IPng	▲ Version1			▲ Version2	▲ Standardization of Hitachi's translation technology		
Research projects in Japan		▲ Participation in WIDE IPv6 working group		▲ Participation in KAME		▲ Participation in USAGI		
Interoperability testing		▲ IOL (every year since then)	▲ N+1 (every year since then)	▲ 6Bone	▲ TAHI (Gigabit router series)		▲ ETSI	
IPv6 promotion					▲ IPv6 Forum (founding member)	▲ Internet Forum	▲ IPv6 Promotion Council	

IPng: Internet protocol next generation
IOL: Internet Operability Laboratory
N+I: NetWorld + Interop
6Bone: IPv6 backbone
ETSI: the European Telecommunications Standards Institute

IPv6 conversion, namely "Toolnet6," which runs on Windows*1 95 and enhanced versions. Hitachi offers it free of charge. This product has made it possible for ordinary PCs to be connected to an IPv6 network.

Since 2000, Hitachi has been implementing IPv6 in next-generation network products including gigabit router series and access gateway series.

Standardization

IPv6 is standardized by IETF (Internet Engineering Task Force). Hitachi has been contributing to the IETF activities on standards and proposed an IPv4-IPv6 translation system in 1997. In 2002, the IPv4-IPv6 translation technology used in "Toolnet6" was adopted as an RFC (request for comments) for the first time in Japan.

Participation in Research Projects in Japan

Japan's WIDE (widely integrated distributed environment) Project[5] has been playing a world-leading role in the development of IPv6. To support the activities of the project, Hitachi has participated in the IPv6 Working Group from its outset and has also participated in the following projects that contribute to IPv6 development:

- KAME Project[6]: development of an IPv6 protocol stack that runs on BSD;
- USAGI Project[7]: development of an IPv6 protocol stack that runs on LINUX*2;
- TAHI Project[8]: technology for interoperability testing.

Interoperability Testing

For IPv6 to be widely used, it is essential that IPv6-enabled devices can be interconnected without any problems. Testing was initially conducted in the Internet Operability Laboratory (IOL) at the University of New Hampshire (U.S.A.). Hitachi participated in the testing there from 1996, running a conformance test and interoperability test, and so accumulated much knowhow.

In addition, since 1996, Hitachi has been participating in the showcases of NetWorld+Interop for interoperability testing. In particular, since 2000 Hitachi has been providing gigabit router series. The experience gained in the showcases has been useful in ensuring reliability of the product.

In Japan, the TAHI Project was established under the WIDE Project for interoperability testing, and has been conducting interoperability experiments. Hitachi's participation in this project has been contributing to the development of interoperability testing technology.

Furthermore, in 2001, as IPv6 promotion activities mounted in Europe, Hitachi joined ETSI (the European Telecommunications Standards Institute)'s interoperability testing program conducted in France.

IPv6 Promotion

In addition to the standardization of specifications and the development of technology and products, Hitachi recognizes the importance of activities to promote the widespread use of IPv6 and, thus, has been involved in the establishment and activities of IPv6 promotion organizations, both at home and abroad.

Hitachi is a founding member of the IPv6 Forum[9], a global consortium established in 1999 with the aim of promoting IPv6. Hitachi is also active in the Global IPv6 Summit organized by the forum.

In Japan, Hitachi cooperated with five other private companies to form the Internet Forum[10] to promote IPv6. In addition, Hitachi is a member of the IPv6 Promotion Council[11] in Japan and has been promoting IPv6 in the Net.Liferium 2001 held in Yokohama, Japan and at other events in Japan.

IPv6-RELATED SOLUTIONS

Hitachi defines the common functional elements as a business platform, the common functional elements to those systems that support the latest requirements of the business environment, i.e., increased speed and globalization. And by identifying these elements and their structures, Hitachi has been proposing the construction of systems that can be applicable to the changing business environment[12].

According to this business platform, Hitachi has been developing products providing the elements and implementing IPv6 capability.

This special issue introduces products in the network, which is the lower layer of the business platform, as well as a list of solutions available for elements in network operation and information infrastructures in the upper layer of the platform (see Fig. 3).

CONCLUSIONS

This paper has described Hitachi's conception of IPv6 and activities related to its introduction. Hitachi

*1: Windows is a registered trademark of Microsoft Corp. in the U.S. and other countries.
*2: Linux is a registered trademark of Linus Torvalds in the United States and other countries.

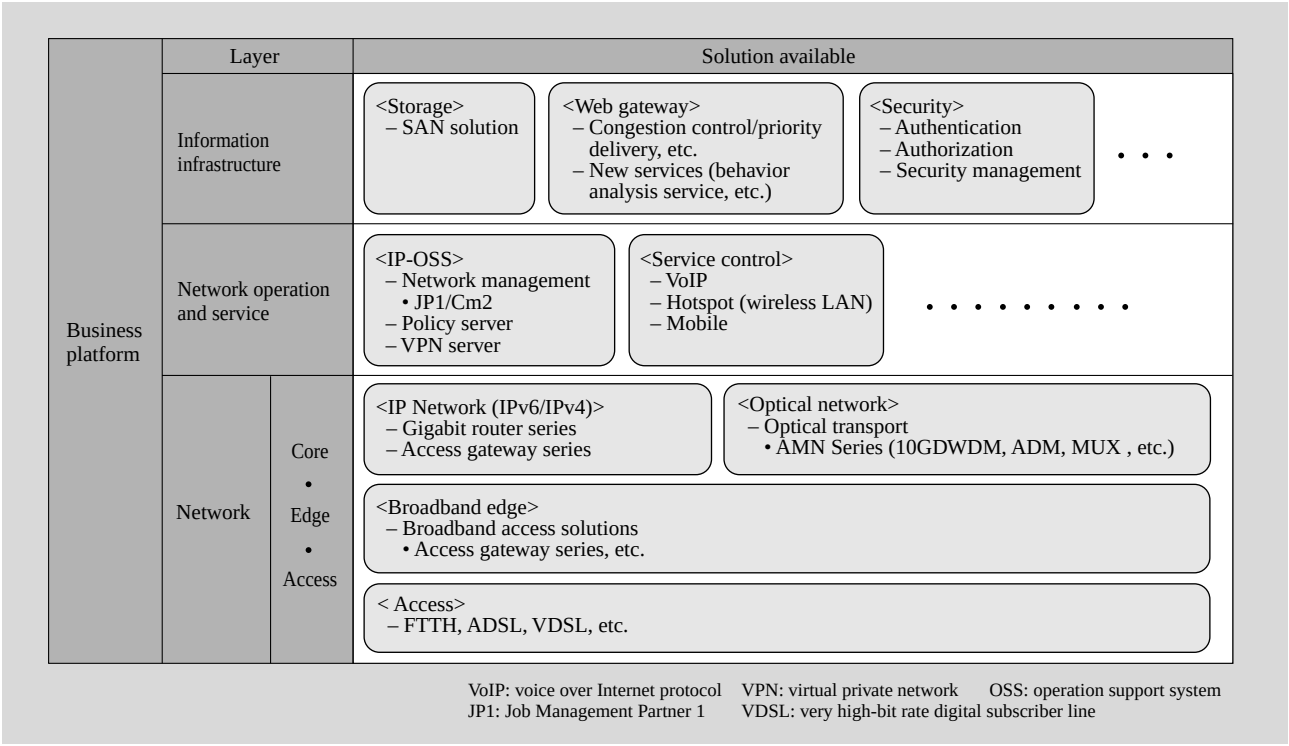


Fig. 3—IPv6-related Solutions.
This figure shows a list of available solutions related to IPv6. The products have been developed in accordance with Hitachi's conception of a business platform.

will continue to develop IPv6-related products and promote widespread use of IPv6 in order to bring about the early deployment of IPv6 networks.

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